



Organizer



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Souvenir



RAICGC 2025

Research Advancements and Industrial
Challenges in Glass and Ceramics 2025

89th session of The Indian Ceramic
Society

Venue:

27th-29th November 2025
VMCC, Indian Institute of Technology Bombay

PREFACE

It is with great pride and pleasure we present the Souvenir and Abstract Book of the 89th Annual Session of the Indian Ceramic Society and the International Conference on “Research Advancements and Industrial Challenges in Glass and Ceramics (RAICGC 2025)”, being held at IIT Bombay, Mumbai, during November 27th – 29th, 2025. This prestigious event is organized by the InCerS–Bombay Metropolitan Region (BMR) Chapter, in collaboration with the Indian Institute of Technology (IIT Bombay), BARC and COEP Technological University, Pune.

Like many other materials, development of Glass & Ceramic materials is critical to a nation’s technological growth, enabling numerous consumer, industrial and strategic applications. RAICGC 2025 continues this legacy by placing conversation between the industry and the academia — acknowledging them not just as beneficiaries, but as the drivers of change. The conference highlights the significance of equipping young professionals and students with cutting-edge skills, fostering an innovation-driven mindset, and promoting entrepreneurship.

This souvenir and abstract book are a reflection of the intellectual depth and thematic diversity of the conference. It encompasses lead lectures and scientific abstracts that delve into processing and applications of ceramics in strategic as well as traditional areas namely defense and space, energy, healthcare, tiles, tableware and sanitary ware. These contributions are a testament to the enthusiasm, creativity, and commitment to ceramic research and innovation.

Over the next three days, we have curated a comprehensive scientific program featuring insightful keynote addresses, thought-provoking panel discussions with experts from the industry and the academia, diverse research presentations. For the first time, representatives of the industry and academia will share their journeys in the fields of entrepreneurship, careers in research, academic and topics such as special potteries, dental ceramics and sustainability. A unique session has been organized in which Ceramic Practitioners have been invited to share their experiences from their journey which will hopefully inspire the participants.

A survey has been carried out to seek views of students and professionals in the industry to get their views on current state of ceramic education and changes that may be considered. The results of the survey will be presented in a session on Ceramic Education along with a panel discussion on this theme which is important to our ceramic community. A quiz for students (InCerS Materials Bowl) is being organized during the conference.

An attempt is being made to have a Technology/Product Show Case during the conference to encourage researchers who may have reached TRL 4 – 5 in their work and young entrepreneurs by providing a free stall to exhibit their products / technologies. We hope this platform will foster the exchange of innovative ideas, stimulate collaboration, and inspire new perspectives in Ceramics.

We extend our sincere appreciation to all our speakers, sponsors, and partners for their enthusiastic support. Our heartfelt gratitude also goes to the dedicated members of the organizing committee, volunteers whose untiring efforts have been instrumental in bringing this event to fruition. We also thank all our sponsors for the generous support that has made this event possible.

Organizing Committee

RAICGC 2025

About Indian Ceramic Society (InCerS)

Indian Ceramic Society, is the one and only Society in India for the propagation of the art, science and technology of ceramics, refractories, glass, and related materials and was founded on April 15, 1928 under the dynamic guidance of Pt. Madan Mohan Malaviya, a great educationist, with the primary objective of promoting the advancement of ceramic science, arts and technologies, by bringing into close contact those engaged in these pursuits with a view to developing a synergy among them. At present, the Society has 14 local chapters, one international chapter and 5 student chapters with a membership of over 2400. The quarterly publication of the Society, 'Transactions of the Indian Ceramic Society,' has an impact factor of 1.5 and it's co-published with Taylor & Francis Group (T & F), UK. InCerS is in collaborative partnership with The American Ceramic Society (ACerS) as also with The European Ceramic Society (ECerS). For more details visit: www.incers.org

Key Highlights of the Conference

- More than fifty invited speakers from academia and industry.
- Fourteen different sessions covering multiple industry verticals/applications.
- A special session to hear experiences of Ceramic Practitioners.
- Panel discussion at the end of each session.
- Special plenary inspirational talks by academicians, industrialists, and start-up founders on their journeys.
- Panel discussion on Ceramic Education.
- InCerS Materials Bowl - Quiz for students

"Technology/Product Show-Case": A Special Stall to:

- Display Products Developed by Researchers (TRL 4-5).
- Display Products Launched by "Infant" Entrepreneurs (company formed within five years).
- Showcase Technologies Available for Transfer.

Conference Schedule

27 th November 2025	Day 1				
Time	Contents				
08:00 AM – 9:00 AM	Breakfast and Registration				
09:00 AM – 10:00 AM	Inaugural Session				
10:00 AM – 11:00 AM	Memorial Lectures				
	Bhagat Memorial: Ceramics and Glasses for Nuclear Sector by Prof. A K Tyagi (HBNI)				
	Sahaj Memorial: Beyond Handicrafts by Dr. Leela Bordia (Neerja International)				
11:00 AM – 11:30 AM	Inauguration of Industrial Exhibition and High Tea				
11:30 AM – 12:30 PM	Plenary Talks				
	Ceramic Nuclear Fuels for Nuclear Power Reactors by Dr. C. Ganguly (Padma Shri Awardee)				
	Innovations in Advanced Materials for Sustainable Society: Bridging Basic Science with Strategic, Societal, and Industrial Needs by Prof. Bikramjit Basu (Director CGCRI)				
12:30 PM – 1:30 PM	Indian Ceramic Society Awards				
1:30 PM – 3:00 PM	Lunch				
3:00 PM – 5:00 PM	Parallel Technical Sessions				
	Traditional Ceramics	Ceramics for Semiconductor Industry	Ceramics for Advanced Batteries	Ceramics for Sustainability	Ceramics for Nuclear Applications
5:00 PM – 6:00 PM	Registration / Tea				
5:15 PM – 6:15 PM	Student led session				
6:00 PM – 7:00 PM	Quiz for students				
6:00 PM – 7:00 PM	AGM (Location: VMCC, Board Room, 4th Floor) All members of the Indian Ceramic Society				
7:00 PM – 8:30 PM	Cultural Program Dr. N. Rajam, Violin (Hindustani Classical Concert)				
8:00 PM – 10:00 PM	Gala Dinner (Location: Guest House Lawns)				

28 th November 2025	Day 2				
Time	Contents				
08:00 AM – 9:00 AM	Breakfast and Registration				
09:00 AM – 10:00 AM	Plenary Talks				
	Journey of a Young Entrepreneur by Atul Baldi, Minovation				
	Journey of an Industrialist by Atul Dalmia, Rubamin				
10:00 AM – 11:00 AM	Panel discussion on Ceramic Education				
11:00 AM – 11:30 AM	Registration / Tea Break				
11:30 AM – 1:30 PM	Parallel Technical Sessions				
	Refractories- I	Glass & Glass- Ceramics – I	Functional Ceramics – I	Ceramics for Health Care and Dental Applications – I	Ceramics for Defence & Aerospace Applications– I
1:30 PM – 3:00 PM	Lunch				
3:30 PM – 5:00 PM	Parallel Technical Sessions				
	Refractories- II	Glass & Glass- Ceramics – II	Functional Ceramics – II	Ceramics for Health Care and Dental Applications – II	Ceramics for Defence & Aerospace Applications– II
5:00 PM – 5:15 PM	Tea				
5:15 PM – 7:00 PM	Poster Session on All Conference Themes				
7:00 PM – 8:30 PM	Cultural Program Marathi Folk Dance (PC Saxena Auditorium)				
8:00 PM – 10:00 PM	Gala Dinner (Location: Guest House Lawns)				

29 th November 2025	Day 3				
Time	Contents				
08:00 AM – 9:00 AM	Breakfast and Registration				
09:00 AM – 11:00 AM	Plenary Talks				
	Advancements in Refractory Materials for Enhanced Performance in Glass and Metal Industries by Dr. Kartik Kumar, SGRI				
	PMN-PT Single Crystal Growth: Advancing Strategic Piezoelectric Ceramics for Next-Generation Defense and Industrial Applications by Dr. Sudeep Verma, SSPL				
	A Journey to ‘Glass’: Fundamental Research to Technology Development by Dr. K Annapurna, CGCRI				
	From Cast Iron Melting to Field-Assisted Ceramic Processing: An Unplanned Journey by Prof. Mohammad Imteyaaz Ahmed, IIT BHU				
11:00 AM – 11:30 AM	Tea				
11:30 AM – 1:30 PM	Parallel Technical Sessions				
	Refractories-III	Additive Manufacturing of Ceramics	Electronic & Magnetic Ceramics	Shape forming of Ceramics	Advanced Ceramics
1:30 PM – 3:00 PM	Lunch				
3:00 PM – 4:00 PM	Plenary Talks				
	Drawing Inspiration from Ceramic Practitioners		Vithal Hirpara (Digident, Indore)		
			Sohit Kumar Prajapati (Pottery)		
			Hiren Sanghvi (Mesacon)		
4:00 PM – 4:30 PM	Plenary Talks: Journey of entrepreneurs in ceramic domain				
	Innovating with Purpose: Lessons from the Metwiz Journey by Rashmi Dharmadhikari, Metwiz Materials				
	From classroom research to award-winning innovative product of Earth Tatva by Shashank Nimkar, Earth Tatva				
4:30 PM – 5:30 PM	Valedictory Session Followed by High Tea				
	Awards for posters/oral students’ session, Brief talks by poster award winners (2 min) & High Tea				

DAY-1, 27th November, 2025

Registration	8:00	VMCC ground floor	Registration desks near VMCC entrances
Breakfast		VMCC second floor	Breakfast at the VMCC canopy area

Inaugural Session B. Nag Auditorium	9:00	Welcome address by the Chairman, Local Organizing Committee	Prof. A R Kulkarni
		Address by Director, IIT Bombay	Prof. Shireesh Kedare
		Address by The President, InCerS	Dr. Atanu Ranjan Pal
		Address by The Guest of Honour, CEO, Speciality Alumina, Hindalco	Shri. Saurabh Khedekar
		Inaugural Address by the Chief Guest, Chair Professor HBNI	Prof. J.B. Joshi (Padma Bhushan Awardee)
		Vote of thanks by Secretary, Local Organizing Secretary	Prof. Parag Bhargava

Memorial Lectures B. Nag Auditorium Session Chair: At. R. Pal (President, InCerS)	10:00	Bhagat Memorial	Ceramics and Glasses for Nuclear Sector	Prof. A. K. Tyagi (HBNI)
	10:30	Sahaj Memorial	Beyond Handcrafts	Dr. Leela Bordia (Neerja International)

Inauguration of Industrial Exhibition	11:00	VMCC Ground floor		
High Tea		VMCC Second floor		

Plenary Talks B. Nag Auditorium Session Chair: Prof. A. K. Tyagi, HBNI	11:30	Ceramic Nuclear Fuels for Nuclear Power Reactors		Dr. C. Ganguly (Padma Shri Awardee)
	12:00	Innovations in Advanced Materials for Sustainable Society: Bridging Basic Science with Strategic, Societal, and Industrial Needs		Prof. Bikramjit Basu (Director CGCRI)
Indian Ceramic Society Awards	12:30	Distribution of awards		The President of InCerS / Other Dignitaries

Lunch	13:30	VMCC Second floor		
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Traditional Ceramics Seminar Room No. 21, Second Floor, VMCC, Session Chair: Dr. P. Agarwal, CGCRI	15:00	Invited	India's Path from Gujarat to Global Benchmark in Sanitaryware Manufacturing	Mr. Venkatmani Manavalan, Imerys
	15:15		Dust Pressed Ceramic Tiles: India's Manufacturing Edge and Global Alignment - A Strategic Outlook from Morbi to the World	Mr. Khodi Das, L.E. College, Ceramic Eng., Morbi
	15:30		Bone China Tableware: Manufacturing Realities and Global Benchmarks – A Strategic Outlook for India's Ceramic Future	Mr. Masroor Usmani, Claycraft Limited
	15:45		Raw Material Challenges – Glass & Ceramics and Research Advances in Clay Mineral	Dr. Sanjeev Bhasin, Ashapura
	16:00	Contributory	Problems and Prospects of Indigenous Raw Materials for High-Temperature Applications	Dr. Somnath Sinha Mahapatra, CSIR-CGCRI
	16:15		Comparative Studies on Fluxing Characteristics of Different Coloured Granite Waste with Feldspar Used in the Manufacturing of Glazed Vitrified Tiles	Asha Anil, CSIR-CGCRI Naroda
	16:25		Breaking Bonds, Building Flow: A Rheological Tale of Alumina and Montmorillonite	Soumya Maiti, CSIR-CGCRI

	16:35	Panel Discussion		Moderator: Dr. Parvesh Agrawal Panelists: Dr. G. G. Trivedi, Dr. Shreevats Pandey, Mr. Praveen P.K.
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Ceramics for Semiconductor Industry Seminar Room No. 22, Second Floor, VMCC Session Chair: Dr. S. Rao, CTO CUMI	15:00	Invited	CUMI's Advanced Ceramics: Enabling the Semiconductor Ecosystem	Prathap Kumar, CUMI
	15:20		Ceramic Coatings for Chipmaking Equipment	Gayatri Natu, AMAT
	15:40		Electroplated copper filled 3D Interconnects in Glass and Alumina	Pradeep Dixit, IIT Bombay
	16:00	Contributory	Development of CVD-grown seamless monolayer 2DMoS ₂ for Electronics and Energy devices	Sumit Pratap Singh, IIT BHU
	16:15		High-Purity Alumina: Material Insights and Tailoring Properties	Shankha Chatterjee, Almatiss
	16:30	Panel Discussion: Ceramics for Semiconductor Industry		Moderator: Dr. Shyam Rao, CUMI Panelists: Invited speakers

Ceramics for Advanced Batteries Seminar Room No. 23, Second Floor, VMCC, Session Chair: Prof. A. Mukhopadhyay, IITB	15:00	Invited	Advancements in Sodium-Ion Battery Technology: Novel Materials and Manufacturing Innovations	A.S. Prakash, CECRI
	15:20		Li-Ion Dynamics in Halo-Spinel based Low-Cost Solid Electrolyte	Abhik Banerjee, RISE, TCG-CREST
	15:40		Critical Material-Free Batteries – From Lab-Scale to Pilot Scale and Beyond	Nitin Muralidharan, IIT Madras
	16:00		PAPERATOR and PARELYTE: Functionalized Cellulosic Separators Enabling Paper Cell Technology	Mir Wasim Raja, CSIR-CGRI
	16:20		Materials for the Energy Transition: Hindalco's Role in the Battery Revolution	Somya Vashishtha, Hindalco
	16:40		Panel Discussion Moderator: Prof. Amartya Mukhopadhyay, Panelists: Invited speakers	

Ceramics for Sustainability Seminar Room No. 02, Ground Floor, VMCC Session Chair: Prof. Ravi Kumar, IIT Madras	15:00	Invited	Tapping the cloud: Unlocking Water and Energy from Ceramic Spray Dryer Exhaust	Arghya Mukherjee, H & R Johnson
	15:25		Enabling Sustainability Through Innovations in Diamond Tools	Isabel Toldo, Hilti Manufacturing India Pvt. Ltd.
	15:50		Solid Oxide Cell technology in India and the perspective of CSIR in Green India Initiative	Jayanta Mukhopadhyay, CGCRI
	16:15	Contributory	(Na _{1-x} K _x) _{0.5} Bi _{0.5} TiO ₃ (BNKT) - Based Piezo catalysis: A Sustainable Solution for Wastewater Remediation	Pravin Varade, COEP Technological University and IIT Bombay
	16:30		Panel Discussion	Moderator: Prof. Ravi Kumar & Panelists: Invited Speakers

Ceramics for Nuclear Applications Seminar Room No. 03, Ground Floor, VMCC, Session Chair: R. Tewari, BARC	15:00	Invited	Development of Lithium-based Ceramics for Fusion Reactor Application	Amit Sinha, BARC
	15:20		Silicon carbide and its Composite for Nuclear Applications – present status and developmental activities in BARC	Abhijit Ghosh, BARC
	15:40		Challenges in processing of Boron-containing ceramics for nuclear applications	Tarasankar Mahata, BARC

	16:00	Contributory	Tuning Photoluminescence in ZnS:Ag,Cl Phosphors through Ag Ion Doping for Scintillation Applications	M Buchi Suresh, ARCI
	16:15		Effect of Composition, Green Density and Temperature on Reaction Bonded -SiC Prepared by Si Infiltration	Rohini Garg, BARC
	16:30	Panel Discussion		Moderator: Dr. R Tewari Panelists: Invited speakers

Registration/Tea	17:00	VMCC Ground floor/ Second floor	
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Student led session	17:15	Room No. 23, Second Floor, VMCC	Shortlisted students
Quiz for students		Room No. 21, Second Floor, VMCC	Sairam, Kartikey
AGM	18:00	Board Room, Fourth Floor, VMCC	All members of the InCerS
Cultural Program	19:00	P C Saxena Auditorium	Dr. N. Rajam, Violin (Hindustani Classical Concert)

Gala Dinner	20:00	Guest House Lawns	
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DAY-2, 28th November, 2025

Registration	8:00	VMCC Ground floor	Registration desks near VMCC entrances
Breakfast		VMCC Second floor	Breakfast at the VMCC canopy area

Plenary Talks B. Nag Auditorium Session Chair: Prof. P. Bhargava, IITB	9:00	Journey of a Young Entrepreneur	Atul Baldi, Minovation
	9:30	Journey of an Industrialist	Atul Dalmia, Chairman Rubamin

Session on Ceramics Education B. Nag Auditorium Session Chair: Prof. A. Gandhi, IITB	10:00	Panel Discussion	Prof. Ashutosh Gandhi & Panellists
	11:00	Registration / Tea Break	Ground Floor, VMCC Second Floor VMCC

Refractories – I Seminar Room No. 21, Second Floor, VMCC, Session Chair: Prof. C. Patil, JSW	11:30	Invited	Low carbon Al_2O_3 – C refractories : a study on use of only nano-carbon	Ritwik Sarkar, NIT Rourkela
	11:50		New Generation Ceramic Welding Powders for Hot Repairs in Glass Furnaces	K. G. Venkatesan, Fosbel India
	12:10		Assessing the Effect, a Refractory Insulation Lining has on EAF Energy Consumption	Mario Taddeo, Pyrotek
	12:30	Contributory	Enhancing Relining Efficiency and Durability in Reheating Furnace Skid and Post Beams: A Novel Plastic Refractory Solution	Prakash Patil, JSW Steel
	12:45		Effect of in-situ Formed $MgAl_2O_4$ Matrix of MgO -C Refractory in Steel Ladle Lining Performance	A Rouf, SAIL, Ranchi
	13:00		Effect of Sintering Atmosphere on the Densification Kinetics of Calcined Magnesia	Adarsha Maji, CSIR-CGCRI
	13:15		A Sustainable Strategy to Maximize the Utilisation of Spent MgO -C Refractory	Aarya Bhardowaz, CSIR-CGCRI

Glass & Glass-Ceramics-I Seminar Room No. 22, Second Floor, VMCC, Session Chair: Dr. M.R. Ajith, YSSC, ISRO	11:30	Invited	High-Performance Glass and Glass-Ceramic Materials for Mission Critical Space Applications - Progress report by ISRO	C. Venkateswaran, ISRO
	11:55		Glass-supported hybrid gold nano islands for multifunctional applications	Amarnath Allu Reddy, CSIR-CGCRI
	12:20		Quasi-high-entropy alumina-based amorphous oxides in 3-D forms with enhanced stability	Ashutosh Gandhi, IIT Bombay
	12:45	Contributory	Sintering and Thermal Characteristics of BaO - $CaOAl_2O_3$ - SiO_2 Based Glass System	P. Barick, ARCI
	13:00		Studies on the Electrical and Mechanical Properties of LTCC Tapes with Changes in the Dielectric and Organic Constituents	Sahil Yadav, COEP Technological Univ.
	13:15		Structural, Thermal, Photoluminescence, and Electrical Studies of CoO -Doped Lithium Zinc Phosphate Glasses	Sunil Kumar M B, Bangalore Univ.

Functional Ceramics-I Seminar Room No. 23, Second Floor, VMCC, Session Chair: Dr. D. Das, University of Hyderabad	11:30	Invited	Large electro strain in polycrystalline piezoceramics: A critical analysis	Rajeev Ranjan, IISc.
	11:55		Perovskite Solar Cells as Organic-Inorganic Hybrid Ceramics	Satoshi Uchida, Univ of Tokyo
	12:20		Plasmon-Driven Phase Transformation in MoS_2 by $AgAu$ Nanocrystals for Enhanced Hydrogen Evolution and Sensing	Santanu Das, IIT BHU
	12:45	Contributory	Therma Fill – Almatiss' Alumina Solutions for Superior Thermal Management	Sourojit Pal, Almatiss Alumina Pvt. Ltd.
	13:00		Influence of Lanthanide Metal Doping on the Properties of $Ba_5Y_2-xGdxAl_2SnO_{13}$ ($x=0.0, 2.0, 4.0, 6$) Electrolytes for Proton-Conducting Solid Oxide Fuel Cells	M Buchi Suresh, ARCI
	13:15		Unveiling the Role of Ceramic Based Perovskite $Na_{0.5}Bi_{0.5}TiO_3$ at Graphene Interface for Enhanced Photocatalytic Water Splitting	Soumita Samajdar, CSIR-CGCRI

Ceramics for Health Care and Dental Applications-I Seminar Room No. 2, Ground Floor, VMCC, Session Chair: Prof. S. Dhara, IIT Kgp	11:30	Invited	Bio ceramic material development for specific clinical needs	H. K. Varma, SCTIMST
	11:50		Bioactive Glass in Chronic Wound Healing and Rapid Coagulation of Profuse Bleeding: Breakthrough in Healthcare at Affordable Cost	Jui Chakraborty, CSIR-CGCRI
	12:10		Development and therapeutic use of [90 Y]Y-glass microsphere ('Bhabha Sphere') for affordable treatment of liver cancer	Tapas Das, BARC
	12:30	Contributory	An Indigenous Innovation Journey of CSIR-CGCRI towards Strategic Self-Reliance in Advanced Multifunctional Biomaterials: Harnessing Ceramic-Glass-Polymer Synergy and Sustainable Healthcare with Biogenic Ceramics	Vamsi Krishna Balla, CSIR-CGCRI
	12:50		Enhancing Ti-6Al-4V Biomedical Implant Performance through TiO_2 , Ta_2O_5 , and Hybrid TiO_2/Ta_2O_5 Coatings: Evaluation of Wear, Corrosion Resistance and Biocompatibility	Kartikey Chaturvedi, IIT Gandhinagar
	13:05		The Evolving Landscape of Oral Care: Applications and Commercial Trajectory of Nano-Hydroxyapatite	V. More, M Kulshrestha, Ceramat Pvt Ltd

	13:20		Engineered Calcium Phosphate Bio ceramics for Orthopaedic Applications: ISO-Compliant Development, Scale-up and Clinical Validation	Abhinav Saxena, Ceramat Pvt Ltd
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Ceramics for Defence & Aerospace – I Seminar Room No. 03, Ground Floor, VMCC, Session Chair: Dr. Anil Kumar, ASL	11:30	Invited	Performance of zirconia based thermal barrier coatings at temperatures above 1200°C	Prof. Robert Vassen, Forschungszentrum Jülich
	11:50		Significance of Ceramic Raw Materials and Consumables for Investment Casting process	Dr Venkat Yakatpure, DMRL
	12:10		High Performance Ceramics for Strategic Applications (Defence, Nuclear and Aerospace)	Niraj Bhukanwala, Bhukanwala Industries
	12:30	Contributory	Electrical, Thermal, and Ablative Properties of Spark Plasma Sintered ZrB ₂ -SiC-LaB ₆ Composites	Sunil Kumar Kashyap, IIT Jammu
	12:45		Dynamic Behaviour and Deformation Micro mechanisms of Engineered Ceramics for Armor Applications	S. Acharya, CSIR-CGCRI
	13:00		Structural-Property Correlation of ZrB ₂ -SiC Composites Fabricated by Pressure-Less Sintering of Green Bodies	Virushni SN, IIT Kharagpur

	13:15		Spectroscopic Mapping of Residual Stress in Thermal Barrier Coatings for Aero Propulsion Applications	Srikanth Batna, IIT Bombay
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Lunch	13:30	VMCC Second Floor		
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Refractories – II Seminar Room No. 21, Second Floor, VMCC, Session Chair: Vasant Kumar Koppad, JSW	15:00	Invited	Improvement in corrosion and oxidation resistance with higher hot strength of Magnesia Carbon bricks for increasing the lining life of converters and steel teeming ladles in Indian steel plants	Swapan Kumar Garai, Champion Ceramics Pvt. Ltd.
	15:20		Hydrogen Fuel and the Durability of Refractory Linings: Mechanisms, Risks, and Material Strategies	Kaushik Dana, CSIR-CGCRI
	15:40		Vesuvius's Advanced Refractory Spinel Base Solutions for Induction Furnace	Shrijit Kulkarni, Vesuvius
	16:00	Contributory	Development of Porous YSZ using Foam Template for Thermal Insulation Applications	Akhilesh Kumar, BARC
	16:15		Grain Growth Control and Thermal Aging Behaviour in Zirconia-Toughened Alumina Fibers Synthesized by a Low Temperature Route	Thamarai Selvi Natarajan, IIT Bombay
	16:30		Development of Composite Collector Nozzle (CNT) for 350 Ton Steel Ladle at JSW Dolvi SMS 2	Akshay kumar More, RHI Magnesita

	16:45		Innovative Approach Adopted for KR Impeller Refractory Life Improvement	Harsh Joshi, JSW Steel Ltd
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Glass & Glass Ceramics – II Seminar Room No. 22, Second Floor, VMCC, Session Chair: Dr. S. Kapoor, Sterlite Tech.	15:00	Invited	Influence of phase separation and melt size on property variation in GeSe ₂ -As ₂ Se ₃ -PbSe glasses for infrared gradient refractive index (GRIN) applications	Anupama Yadav, Delhi University
	15:25		Innovating Opal Glass for Sustainable and Long-Life Furnaces	Biswananth Sen, Borosil
	15:50	Contributory	Improvements of Mechanical and Functional Properties of Aluminosilicate Glass/ Glass-Ceramics Composites	Vivek Kumar Saroj, IIT BHU
	16:05		Synthesis of Glass-Foam from End-of-Life Photovoltaic Materials	Nivedita S. Iyer, IIT Bombay
	16:20		Challenges in usage of high cullet in float glass production	Shrikupa S, Saint Gobain
	16:35	Panel Discussion		Moderator: Dr. Saurabh Kapoor, Panelists: Invited Speakers from both sessions

Functional Ceramics – II Seminar Room No. 23, Second Floor, VMCC, Session Chair: Dr. Amit Sinha, BARC	15:00	Invited	Self-Assembly Kaolin Platelets and Processing of Mullite Ceramic Micro/Macro Spherical Granules	Ananthakumar S, IIIST
	15:20		Single crystal elastic constants from polycrystalline ceramics	Ravi Kumar, IIT Madras
	15:40		Preparation of Ceramic Metal Matrix Composites to Enhance Its Wear Resistance Properties for ZTA Reinforced High Chromium Cast Iron	C. D. Madhusoodana, CTI, BHEL
	16:00	Contributory	Alumina Entrenched Polymer Composite Material for the Applications in Thermally Conductive Interface (TIMs): Correlation between Thermal, Mechanical and Morphological Properties	Vikas Patil, Hindalco Industries Ltd
	16:15		High Entropy Oxide Based Flexible Ceramic Tribopositive Electrodes for Micromechanical Energy Harvesting	Muthukumar Abishek Dhamotharan D, IIT Madras
	16:30		Reflectivity and Emissivity Properties of ZnO Silicone Composite Coatings for Passive Daytime	M.V. Danush, CSIR-NAL

			Radiative Cooling Application	
	16:45		Panel Discussion	Moderator: Dr. Amit Sinha, Panelists: Invited speakers from both sessions

Ceramics for Health Care & Dental Applications – II Seminar Room No. 02, Ground Floor, VMCC Session Chair: Dr. H.K. Varma	15:00	Invited	Ceramics in Dental Practice: Efficiencies, Deficiencies, and Pathways to Proficiencies	Dr. Mohit Kheur, M.A. Rangoonwala College of Dental Sciences & Research Centre
	15:20		Dental Prosthetics by Machining of Ceramic Dough Shaped Green body - Improved Strength and Aging Resistance	Prof. Santanu Dhara, IIT Kharagpur
	15:40	Contributory	Gastrointestinal and Renal Health Monitoring Using High Entropy Oxide-Based Gas Sensors By Ammonia Detection	Yadanala Pranay Kumar, NIT Surathkal, Karnataka
	15:55		Solution Combustion Processed Screen Printed (MoZnCoCrMn)3O4 High Entropy Spinel Oxide for Ammonia Gas Sensing Applications in the Fertilizer Industry	Eashwaren Vishnu Namboothiri, NIT Surathkal, Karnataka

	16:10		Endothelial Cell Responses and Molecular Mechanisms Induced by TiN-Coating on L605 Cardiac Implants	P.B. Reshmi, Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST)
	16:25		Quantitative Structure-Property Analysis of Polycrystalline Alumina: A Virtual-Based Modelling Approach	Prajakta Subhedar, Pillai College of Engineering
	16:40		Panel Discussion	Moderator: Dr. H.K. Varma, Panelists: Invited speakers from both sessions

Ceramics for Defence & Aerospace – II Seminar Room No. 03, Ground Floor, VMCC, Session Chair: Prof. N. J. Balila, IIT B	15:00	Invited	AC Electric field assisted sintering of gadolinium doped ceria	Prof. Apurv Dash, DTU, Denmark
	15:20		High-Temperature Materials for Propulsion, Reentry, Hypersonic and Stealth Systems: Challenges, Strategies, and Future Directions	Dr. Alex Daniel, ASL

	15:40	Contributory	Insights into Hypersonic Structural Properties of 2DBN Ceramics	Shirshendu Chakraborty, CSIR-CGCRI
	15:55		Effect of Rapid Thermal Cyclic Loading on TBCbond Coat System Deposited on Hastelloy-X Superalloys	Suraj Kumar, IISc
	16:10		Vacuum Brazing of Zirconia and Titanium along with Micro-structural Evaluation of Joint Interface	Abhishek Upadhyay, TBRL
	16:25		Joining of TaC-SiC Ceramics Without Filler by Spark Plasma Sintering	B.V. Manoj Kumar, IIT Roorkee
	16:40		Panel Discussion	Moderator: Prof. Jaya Balila, Panelists: Dr.M.R. Ajith, Invited speakers from both sessions

Poster Session (On All Conference Themes) & Tea	17:00	VMCC Third Floor Foyer
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Cultural Program	19:00	PC Saxena Auditorium Marathi Folk Dances
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Dinner	20:00	Guest House Lawns
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DAY-3, 29th November, 2025

Registration	8:00	VMCC Ground floor	Registration desks near VMCC entrances
Breakfast		VMCC Second floor	Breakfast at the VMCC canopy area

Plenary Talks B. Nag Auditorium Session Chair: Prof. A.R. Kulkarni, IITB	9:00	Advancements in Refractory Materials for Enhanced Performance in Glass and Metal Industries	Dr. Kartik Kumar, SGRI
	9:30	PMN-PT Single Crystal Growth: Advancing Strategic Piezoelectric Ceramics for Next-Generation Defense and Industrial Applications	Dr. Sudeep Verma, SSPL

Plenary Talks B. Nag Auditorium Session Chair: Prof. G.P. Kotiyal, Ex-BARC	10:00	A Journey to 'Glass': Fundamental Research to Technology Development	Dr. K Annapurna, CGCRI
	10:30	From Cast Iron Melting to Field-Assisted Ceramic Processing: An Unplanned Journey	Prof. Mohammad Imteyaz Ahmed, IIT BHU

Tea / Coffee Break	11:00	VMCC, Second Floor
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Refractories – III Seminar Room No. 21, Second Floor, VMCC, Session Chair: Mr. M. Hossain, JSW	11:30	Invited	Interaction of MgO-C refractory with steel and slag and its effect on inclusion in low-carbon Al-killed steel	Prof. Deepoo Kumar, IIT Bombay
	11:50		Innovative Refractory Lining Solution: Minimizing Downtime During Shutdown Through Out of Box Approach	Ravi Ranjan, Reliance Industries
	12:10	Contributory	Vesuvius's Advanced Plastic Refractory Solutions	Shrijit Kulkarni, Vesuvius India Ltd
	12:25		Environment Friendly Snorkels for RH Degasser	Junling Xiao, Puyang Refractories
	12:40		Operational Strategies & Advance Maintenance Techniques for Maximizing BOF Campaign Life: A Case Study in Steel Plant Efficiency	Partha Das, Sarvesh Refractories
	12:55	Panel Discussion		Moderator: Prof. Deepoo Kumar Panelists: Invited speakers from all three sessions

Additive Manufacturing of Ceramics Seminar Room No. 22, Second Floor, VMCC, Session Chair: Prof. G. Singh, IIT B	11:30	Invited	Advancing Ceramics through 3D Printing: Technologies, Applications, and Case Studies with a Focus on DLP-based Mass Production	Jin Kim, 3D Controls Co.Ltd/ Dhavaa Technical Ceramics
	11:50		Development of sustainable functional ceramic using additive manufacturing	Chandra Sekhar Tiwary, IIT Kharagpur
	12:10	Contributory	Direct Ink Writing of Silicon Nitride: From a Novel Ink Formulation to Liquid Phase Sintering for Biointerface Applications	Govind Kumar Verma, IIT BHU
	12:25		Structural, Microstructural & Magnetic Properties of 3D Printed La-Co Co-doped Strontium Hexaferrite for Permanent Magnet Applications	Dibakar Das, University of Hyderabad
	12:40		Simulation of Pyrolysis-Induced Shrinkage and Stress in 3D-Printed SiCN Ceramics	Shikher Verma, IIT Madras

12:55	Panel Discussion	Process Optimization and Defect Evolution in 3-YSZ Components Fabricated via DLP-Based Additive Manufacturing	Pranith Kumar Reddy, IIT Bombay
13:10			Moderator: Prof. Gurminder Singh Panelists: Invited speakers

Electronic & Magnetic Ceramics Venue: Seminar Room No. 23, Second Floor, VMCC, Session Chair: Prof. Satoshi Uchida, The University of Tokyo	11:30	Invited	Studying the Electronic Structure of Semiconductors from Charge Transport Measurements	Prof. Titas Dasgupta, IIT Bombay
	11:55		Influence of Entropy Engineering on the Energy Storage Properties of Novel Lead-free Ferroelectric Ceramics	Prof. Dibakar Das, Univ of Hyderabad
	12:20		Elimination of Dimensional defect phenomena of EP21 in T38 through TPM QM pillar 10 steps: A structured Problem-Solving approach	Dr. Somen Goswami, EPCOS Ferrites

12:45	Contributory	High Entropy Approach for Tuning Structure and Magnetic Properties of B-Site Disordered Perovskite Oxides	Vishesh Tiku, IIT Delhi
13:00		Design, Synthesis and Functional Properties of Spinel Multicomponent Equimolar Oxides (MEOs)	Varad N. Joshi, IIT Bombay
13:15	Panel Discussion		Moderator: Prof. Dibakar Das, Panelists: Invited speakers

Shape Forming of Ceramics Seminar Room No. 02, Ground Floor, VMCC Session Chair: A. Ghosh, BARC	11:30	Invited	Effect of Porosity on Microstructure and Mechanical Properties of SiC Foams by Aqueous Gel casting	Dr. Dulal Chandra Jana, ARCI
	11:55		SiC-in situ Zr ₂ CN Composites: Tribology in Different Wear Regimes Under Extreme Conditions	B. Venkata Manoj Kumar, IIT Roorkee
	12:20		Alumina Ceramic Shape Forming using Natural Rubber Latex as a Sustainable Binder	Prof. K. Prabhakaran, IIST, Thiruvananthapuram
	12:45		Net Shape Forming of Advanced Ceramics by Colloidal Processing	Santanu Dhara, IIT Kharagpur

	13:10	Panel Discussion	Moderator: Dr. Abhijit Ghosh Panelists: Invited speakers
Advanced Ceramics Seminar Room No. 03, Ground Floor, VMCC, Session Chair: Prof. S. Butte, COEP Technological Univ.	11:30	Invited	Design of preceramic polymer derived nanostructured anodes for lithium-ion batteries Shantanu K Behera, NIT Rourkela
	11:50		Multifunctional Nanocomposite Sensors: A New Frontier Shrabanee Sen, CGCRI Kolkata
	12:10		Scalable synthesis of ultra-thin a-MoO ₃ films for energy-efficient devices Prof. Tanushree Choudhury, IIT B
	12:30	Contributory	Synthesis and Characterisation of Na(Li _{0.1} Ti _{0.5} Ni _{0.4})O ₂ , a Layered-Transition Metal Oxide, as a Cathode Material for Sodium-Ion Batteries Piyush Dudani, ICT, Mumbai
	12:45		Densification of Zinc Oxide (ZnO) Ceramics at Low Temperature by Hydrothermal Cold Sintering Process Rohini Garg, BARC, Mumbai
	13:00		Influence of Sintering on Elastic Anisotropy of Cubic Ceramics via Miniaturized Mechanical Testing Sabyasachi Panda, IIT Madras

	13:15	Panel Discussion		Moderator: Prof. S. P. Butee Panelists: Invited speakers
Lunch		13:30		VMCC Second floor
Plenary Talks B. Nag Auditorium Session Chair: Prof. P. Bhargava		15:00	Drawing Inspiration from Ceramic Practitioners	Vithal Hirpara (Digident, Indore), Sohit Kumar Prajapati (Pottery), Hiren Sanghvi (Mesacon)
Plenary Talks B. Nag Auditorium Session Chair: Dr. Lekha P.	16:00	Innovating with Purpose: Lessons from the Metwiz Journey	Rashmi Dharmadhikari (Metwiz Materials),	
		From classroom research to award- winning innovative product of Earth Tatva	Shashank Nimkar (Earth Tatva)	
Valedictory Session (B. Nag Auditorium) Followed by High Tea		16:30	Awards for posters/oral students' session, Brief talks by poster award winners (2 min) & High Tea	

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List of Poster Presentation Titles

I. Traditional Ceramics

1. Dr Chandresh Agarwal "Processed Raw Materials -Need of Hour for Ceramic Manufacturing" (Mactus Mineral, LLP, Dubai, UAE)
2. Smriti Halder, Kausik Dana "Efficient Removal of Harmful Organic Molecules by Partly-Intercalated Montmorillonite Clay"

II. Ceramics for Semiconductor Industry

1. M. Dotiyal, E. Panda "Designing VO₂ films with variable transition temperatures: effect of chemical strain"
2. Raj Ankit, Rahul Kumar, Sachet Shah, Vineet Shah, Jayant Kolte, "Tuning of Electrical properties of Barium titanate-based ceramics for the semiconductor industry"
3. Rajat Mittal, Anoop Kumar Mukhopadhyay and Ashok Kumar, "Prospects and challenges of Molecular Dynamic Simulations for Advanced Glass and Ceramic Materials"
4. Lekha Peedikakkandy, Aman Prakash, Parag Bhargava, "Hybrid and Nanostructured Materials for Chemical Mechanical Planarization"

III. Ceramics for Advanced Batteries

IV. Ceramics for Sustainability

1. Sourav Ranjan Satpathy, and Sunipa Bhattacharyya, "Preparation and characterization of clay-based geopolymer for adsorptive dye removal"
2. Ashwani Gautam and Md. Imteyaz Ahmad "Influence of Calcium Addition on the Stability, Structure and Photocatalytic Properties of (Mg, Co, Ni, Cu, Zn)O High Entropy Oxide"
3. S. Mukherjee, R. B. Meshram, S. K. Nath, "Paver block and composite cement development using CO₂ sequestered LD-slag through mineral carbonation"
4. Susant Mohapatra, Sunipa Bhattacharyya, "Development of sustainable adsorbent for cationic dye removal: A fresh start for waste valorization"

V. Ceramics for Nuclear Applications

1. S.R.C. Murthy Tammana, D.S. Arati, Rahul Sreekumar, J.K.Sonber, Sairam K, Sanjib Majumdar, "Synthesis, Densification, and Characterization of NbB₂ and TaB₂ for High-Temperature and Nuclear Applications"
2. Biranchi M Tripathi, Amit Sinha, Tarasankar Mahata, "Synthesis of Nanocrystalline γ -LiAlO₂ Powder: Enhanced Sinterability and Microstructure Control"
3. Jyothi Sharma, Biranchi M Tripathi, P.K. Patro, Deep Prakash, T. Mahata, "Thermal properties of aluminium borate whisker reinforced Alumina matrix composites"

VI. Refractories

1. Sovan Khan, Atanu Suvrajit B, Suzuki Haruy, Manasi Parichh, Sthitapragyan Das, "Effect of novel binder in dolomite-C refractory to improve the performance for clean stainless-steel production"
2. G Ghosh, D K Sahu, T Agrawal, P Chaudhury, B Singh "Redesigning of Burner Port by PCPF blocks in Sinter Plant"
3. Rishabh Singh, Manish Kumar, Ram Ashish, Abhishek Mani, M.R. Majhi, "Microstructural and Tribological Behaviours of High Alumina Nano-Bonded Refractory Castable for Petrochemical Industry"
4. Avishek Mitra*, Ankita Das, Dr. Saumen Sinha "Effect of Alternate Fuel on Refractory Performance in Cement Rotary Kiln"
5. Dillip Kumar Sahu*, Deepshikha Brahma, Goutam Ghosh, Tushar Agrawal, Brijender Singh "Record-Breaking Performance of ASC Refractory Lining in Torpedo Ladles (2335 Heats): A Comparative Study with High Alumina Refractory"
6. Arnab Halder, * Nenavath Siddhu, "MgO-C Brick production by Single pressing"
7. MK Kujur, I Roy, S Aman, A Paul "Import Substitution through in-house Development for Pilot Coke Oven of RDCIS"
8. Satrughna Nayak, Atanu Ranjan Pal, Manila Mallik, "Utilization of BOF Slag in the Synthesis of High-Temperature Refractory Materials"
9. Samir Kumar Hembram, Soren Mrinalini, Soma Hansda* "Preparation and Characterization of Alumina fiber"
10. P. Kameswara, * V.R. Akhil Raj, B. Biswajit, B. Sanjeev, S. Manan "Utilization of aluminium dross to prepare dense mullite aggregates for refractory applications"
11. A. Bhardwaz, A.Das, S.Sinhamahapatra*, "Recovery of Magnesia from Waste MgO-C Refractory Fines via Chemical Treatment"
12. M. Kundu, K. Dana, and S. Sinhamahapatra* "Interaction of Hydrogen with Refractory Materials at High Temperatures"
13. Santhosh Banoth, Krushna Bansode, Deepoo Kumar, "Interaction of MgO-C refractory with steel and slag and its effect on inclusion in low-carbon Al-killed steel"
14. R. N. Nandy "Refractory Selection Consideration for Aluminium Melting & Holding Furnace"
15. Shrijit Kulkarni*, Rajesh Patil, Jagdish Gutti, Srinivas NVL "Vesuvius's Fused Silica based Concept for Aluminum launders"
16. Abdur Rouf, Krishna Priya Yagati and Manab Mallik "Microstructural and mechanical properties of MgAl₂O₄ spinel ceramics prepared from commercial grade oxides"

17. A. Nag*, A. Jana, A. Mondal, A. Maity, V. Solanki, A. Banerjee, M. Bhadu "Development of graphite-silica based anti-stick coating for LD slag pot"

VII. Glass & Glass-Ceramics

1. P Y Deshmukh *, S Kumar, S B Misra, "APPLICATION OF POTASSIUM CRYOLITE (PAF) IN ALUMINUM, CERAMICS AND GLASS INDUSTRIES"
2. Jahnvi Bhagavath G and Eraiah B* "Nd³⁺-Doped Phosphate Glasses Derived from Bio-Waste for Photonic and Optoelectronic Applications"
3. K M Shwetha and B Eraiah* "Study of Electrical Properties of Silver Oxide and gadolinium (III) Oxide doped Borate Glasses"
4. Jalajakshi B R and B. Eraiah* "Study of electrical properties of Erbium doped Boro-Tellurite glasses"
5. Anupama, Eraiah. B* "Optical properties of Zinc Borate Glasses in the presence of Gallium and Gadolinium oxide"
6. Nikhil Raj Devgan, Vivek Kumar Saroj and Subrata Panda* "Glass & Glass-Ceramic based Radomes: A Critical Review"
7. Nayana N and B. Eraiah* "Optical Characteristics of Silica-Based Glasses Synthesized from Rice Husk Ash (RHA) via a Sustainable Route"
8. Mukta Rajotia, Pragya, Sudip Mukherjee, and Subrata Panda* "Fabrication of Rice-Husk Silica Mediated Bioactive Glass for Antibacterial and Wound Healing Applications"
9. Shubham Joshi, Biswanath Sen and Jeetendra Sehgal "AI-Deployed Glass Production: Defect Analysis and Process Parameter Optimization"
10. Aurelia Moriyama-Gurish, Aadi Anaskure*, Amit Datye, Udo D. Schwarz "Investigation of creep and recovery in Zr-based Bulk Metallic Glasses using constitutive creep models"

VIII. Functional Ceramics

1. D Lakshmi Priya, M Buchi Suresh*, Asit Kumar Khanra and B P Saha, "Alternative B-site-doped La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8-x}Ni_xO_{3-d} & La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2-x}Ni_xO_{3-d} (x=0, 0.1) as a novel cathode material for IT-SOFC"
2. Jakkampudi Chandrika, Arun Chowdhury, S. K. Pratihara* "Tuning Electronic Structure of LaFeO₃ for Efficient Oxygen Evolution Reaction"
3. Abhilash Mishra, * Swadesh K Pratihara, Arun Chowdhury "Effect of Calcination Temperature on Structural, Morphological, and Electrocatalytic Properties of Sol-Gel Derived LaCoO₃"
4. Rehana Batool, Srinivasan N.* "Processing and Characterization of Ceria-Zirconia Structured Catalyst for Sustainable Hydrogen and CO Generation"
5. Subhajeet Sen, Anant Kumar Gupta, Pawan Kumar Jyani, Srinivasan Nedunchezian* "Large-scale Processing of High Entropy (MgCoNiCuZn)O Ceramics for Catalytic Applications"
6. Manjesh D. M., Kunal Roy, Tathagata Sardar, Manikanta P N , Dinesh Rangappa*, M. Navya Rani * "One pot Solvothermal Synthesis of Phase-Controlled and Defect-Rich α -NiS and Evaluation of their Supercapacitors, Electrocatalysis, and Sensing Properties"
7. Jyothis Shaji, Vishesh Tiku, Abhishek Sarkar* "High Entropy Spinel Oxides as potential Co-free electrodes for Li-ion batteries"
8. P. Hemani, * E. Panda "Design and optimization of AlN/Al/AlN multilayer coatings for low-Emissivity energy saving window applications"
9. Chiranjit Chaliha, Parveen Kumar, and Mamata Maisnam, "Two-Step Sintering of Lead-Free ferroelectric ceramics for Solid-State and Pyroelectric Energy Harvesting Applications"
10. Shaona Chatterjee, M. Biswas, S. Ghosh*, S. Chakraborty* "Role of Boron nitride nano sheet-metal oxide interface in photo- electro chemical water splitting"
11. Priyanshu Singh, Subhadeep Saha, Rabindranath Bhowmik, Dibakar Das*, "Optimizing Electrostatic Energy Storage in BiFeO₃ through Nd/Nb Co-Doping"
12. Ayushi, P. Saha, R. Mazumder* "Enhanced phase stability and ionic conductivity of Mg Doped - Na₃Zr₂Si₂PO₁₂ Solid Electrolyte - Synthesized via Solution Combustion Method"
13. Shantanu K Behera, Smita Sowmya Bishoyi, "Microstructural design of silicon-carbon nanostructures for LIB anodes"
14. J. Mallick, A. Sangle, A. Gandhi, * "Dielectric and Optical Properties of a new class of 'High Entropy' Perovskite Oxides"
15. Kumar Sanket*, Shantanu K. Behera "Nanostructured Si/C composite as an advanced anode material for Li-Ion Batteries"
16. Sanisa Samant, Aagam Shah, Pratiksha Pawar, Krishna Dagadkhair, Paresh Salame2* "Synthesis and Characterization of Na_xFe[Fe(CN)₆].nH₂O, a Prussian Blue Analogue, as a cathode material for Sodium-Ion Batteries."
17. P. K. Sinha*, S. Majumdar, R. Samaddar, V. K. Singh, and M. Bhattacharjee, "High Entropy Oxides: A Journey from Fundamental Understanding to Future Possibilities"
18. Kshitij Kumar Sharma*, Abhishek Tewari, "Comparative Study of Al and Mg Doping in ZnO: Effects on Grain Boundary Segregation and Thermoelectric Performance"

19. Illa Mani Pujitha, Sreyanka Karmakar, Bibek Samanta, Sushobhan Kobi, Shivam More, Amartya Mukhopadhyay, "Exploring the structural, ion transport, water stability properties upon aliovalent Boron substitution in the NASICON-structured $\text{Na}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$ -based solid electrolyte"
20. Bhoomika Yadav*, Kamal K Kar, Devendra Kumar, Suresh Sundaramurthy, "Analysis of electrochemical characteristics of cost-effective $\text{CaCu}_3\text{Ti}_4\text{-xZr}_x\text{O}_{12}$ /rice husk activated carbon composite for supercapacitor electrode application"
21. Ashwani Gautam, and Md. Imteyaz Ahmad* "Synergistic effect and defect engineering in $(\text{Fe}, \text{Co}, \text{Ni}, \text{Cu}, \text{Zn})\text{O}$ High Entropy Oxides for Oxygen Evolution Reaction"
22. Paramananda Jena, Pankaj Kumar Patro*, " $\text{Nd}_{1-x}\text{Ba}_x\text{Co}_{1-y}(\text{Fe}, \text{Ti})_y\text{O}_{3-\delta}$ material for cathode application in Solid Oxide Fuel Cell (SOFC)"
23. Mudar Youssef Taha* Ravi Kumar Peetala, "Techno-Economic Assessment of Concentrated Solar Power Systems: A Review of Simulation Tools and DOE-Based Optimization Methods"
24. Kunal Kishore*, Tanmoy Maiti, "Optimization of device parameters in Thermoelectric Generator for Enhanced Waste Heat Recovery in Industrial Systems"

IX. **Ceramics for Health Care and Dental Applications**

1. Sarmistha Bhattacharjee*, Kartikey Chaturvedi, Priya Mahato, Emila Panda, "Cost-effective technique of fabricating porous TiO_2 , Ta_2O_5 , and $\text{TiO}_2\text{-Ta}_2\text{O}_5$ composite films and comparative evaluation for use in biomedical applications"
2. Abhinav Saxena*, Sabyasachi Roy, Subrata Mukherjee and Bikramjit Basu, "Engineered Calcium Phosphate Bioceramics for Orthopedic applications: ISO-Compliant development, scale-up and clinical validation"
3. Md E A Raghav Khan, Somedutta Maity and Dibakar Das*, "Design, Synthesis, and Evaluation of pH-Responsive Calcium Carbonate Nanocarriers for Targeted Drug Delivery Applications"
4. Syed Nazia Shah, Md E A Raghav Khan, Somedutta Maity, Dibakar Das* "A comprehensive study of molecular docking with TYLC Gemini-Virus coat protein"
5. Sayan Das1, Shabbir Hussain, Samir Das, Saikat Biswas, Baisakhee Saha, Soudip Karmakar, Santanu Dhara*, "3D printed Hydroxyapatite Scaffold impregnated with Gelatin-AgNPs Microgel as Potential Skeletal ECM Analogue"

X. **Ceramics for Defense and Aerospace Applications**

1. Anant Kumar Gupta, Srinivasan Nedunchezian, "Synthesis of Rare Earth High Entropy Oxides Using Reactive Decomposition Method for High Temperature Applications"
2. Abhishek Panwar, Sunil Kumar Kashyap*, "First-Principles Investigation of Mechanical Strength and Thermodynamic Stability in High-Entropy $(\text{Hf}, \text{Zr}, \text{Ta}, \text{Ti}, \text{Mo})\text{B}_2$ for Extreme Environments"
3. Buragadda V Rajasekhara,b, Deepa Devapalb, and Ramesh Babu N*a "Synthesis of mixed non-oxide UHTCs of ZrC , ZrB_2 and SiC by PDC route and fabrication of Ceramic Matrix Composites"
4. Sunirmal Karmakar*, Alokjyoti Dash, Soumavo Sikhdar, Santanu K Behera, Arindam Paul, "Influence of Sintering Temperature on Hierarchical Structure and Mechanical Properties of Bio-inspired Alumina-PMMA Composite"
5. Gudla Surendra Kumar, Brahma Raju Golla* "Low Temperature Processing of $\text{Si}_3\text{N}_4\text{-SrTiO}_3$ ceramics" Shreyasee Nath, Barun Haldar, S. Mandal, I. Srikanth, Shirshendu Chakraborty*, "Fabrication and Property Evaluation of β SiAlONs with Z value variation"
6. Thamarai Selvi Natarajan and Ashutosh Suresh Gandhi, "Synthesis of Rare Earth Phosphates for High Temperature Protective Coatings"
7. Mohammed Nazeer, Siddhartha Roy, Tapas Laha "Effect of Y_2O_3 and Gr additives on thermal shock resistance and mechanical properties of B_4C reinforced Al_2O_3 composite for cutting tool applications"
8. Sairam Ramachandran*, Zafir Alam, Ashutosh S. Gandhi "Engineering Phonon Scattering: Multicomponent Oxides with Low Thermal Conductivity as Thermal Barrier Coatings"
9. Alokjyoti Dash*, Sunirmal Karmakar, Soumavo Sikder, Shantanu K. Behera, Arindam Paul, "Hierarchically Structured Biomimetic Alumina/Epoxy Composite with Enhanced Strength and Toughness"
10. M. Kandari, K. Masson, O. P. Thakur, A. K. Shukla*, "A- and B- site co-doped Modified PZT pyroelectric ceramics for IR detector application"
11. A D Manohar, R Mohan Rao, Venkat, "OVERVIEW- INVESTMENT CASTING OF NICKEL-BASED SUPERALLOY COMPONENTS"
12. M. Abhinesh, L. Rangaraj,1 M. Stalin, * "Sustainable Chemistry of MXenes: Fluoride-Free Synthesis and Characterization of $\text{Ti}_3\text{C}_2\text{T}_x$ "
13. Rajat Jain, * P Subhash Chandra Bose, "Modelling and Optimization of Laser-Assisted Turning Operations on Fused Silica-based Ceramic Composites"
14. Nilesch. V. Dorkar, B.Venkata Manoj Kumar,* "Understanding the Temperature-Driven Transition in Erosive Wear Mechanism of Hot-Pressed SiC -35 vol%hBN Composites"

XI. **Shape forming of Ceramics**

XII. **Additive Manufacturing of Ceramics**

1. Ayyappan Murugesan and Koushik Biswasb "Microstructural evolution and phase analysis of SS410-Al₂O₃-SiC multilayered functionally graded composite fabricated through laser cladding"
2. Adesh U. Mundhe, Dhananjay N. Mali, Chitradeep Jash, Manish D. Shinde, Govind G. Umarji, Sandeep P. Butee, Sunit B. Rane¹, * "Induction Plasma-based Synthesis of Nanoscale and Spheroidized Ceramics for Additive Manufacturing Applications"
3. Aakanksha Bharti, Santosh Kumar, "Rheological Behaviour of TiO₂-MgO Composite Inks for Direct Ink Writing"

XIII. Electronic & Magnetic Ceramics

1. Vishesh Tiku, Jyothis Shaji, Abhishek Sarkar, "High entropy approach for tuning structure and magnetic properties of B-site disordered perovskite oxides."
2. Dushyant Dabhi*, Emila Panda, "Fabricating Niobium Nitride Thin Films with High Superconducting Transition Temperature"
3. Saurav Singh Bisht, * Soumya Bandyopadhyay, Saswata Bhattacharya, MP Gururajan "Phase-field modelling of domain evolution in BZCT using CUDA"
4. K.R. Kambale*, J.D. Sharma, A.R. Kulkarni, N. Venkataramani, S.P. Butee, "Correlating Statistical Nature of Activation Energy of Sintering to Underlying Mechanisms"
5. Rahul Kumar,* Parag Bhargava, "Glucose-derived carbon-coated nickel oxide (GDCC-NiO) as an efficient electrode material for supercapacitor applications"
6. Aayushi, Jayant Kolte and Prabal Pratap Singh Bhadauria* "Optimization of KNN-based piezoelectric ceramics for actuator application"

XIV. Advanced Ceramics

1. S. V. Jamale, * N. J. Balila, A. S. Gandhi, "Mechanical behaviour of high entropy oxides"
2. Rahini Ghosh "CERAMIC METAL COMPOSITES: THE START OF A NEW ERA"
3. Parth Shah,* Kabeer Jasuja, "Sonochemical-assisted synthesis of Chemically Functionalized Borophene quasi-2D nanomaterials from AIB₂"

XV. Student Session

1. D. Ghosh¹, A. Roy, A. Banerjee, R. Dutta, A. Nag* "Investigation of SS316L coated mild steel substrate in accelerated galvanizing and acidic corrosion conditions"
2. A. Roy, D. Ghosh, A. Singh, D. Brahma and A. Nag* "Impact of a novel thermal coatings on heat Retention in torpedo ladle system"
3. Riya Das¹* "Improvement of the refractory life of basic oxygen Furnace"
4. Ayanava Maji* "Effect of Fabutit-734 On ULCC Castable"
5. Riyanka Das "Steel Meets Sustainability: The Rise of Hydrogen Fuel"
6. Ezaz Ul Haque* "From Bone Grafts to Drug Carriers: Evolving Role of Bio Ceramics"
7. Indrajit Patra* "Green Energy Converges With Ceramics: Advancements In Microbial Fuel Cells Technologies"
8. P. Nandy*, B. Pal "Ceramic Oxides in Modern Semiconductor Devices: From SiO₂ to Functional Composites"
9. Shekar S Rathod, Shashi Bhushan, Baburao N. Sherikar "Synthesis of Cobalt (Co) Tin(Sn) and Aluminum(Al) co doped Zinc Oxide (ZnO) Nano powders by Solution Combustion Method for Photocatalytic Degradation of Textile dye"
10. Dr.Veeresh P Mallapur, MS.Guddi, Nikitha Reddy, Nandini Badiger "SYNTHESIS OF GEOPOLYMER CONCRETE FROM SOLELY GROUND BLAST FURNACE SLAG AND ITS CHARACTERIZATION."
11. Soumyadeep Malakar* "Eco-Friendly Refractory Ceramics: Transforming Industrial Waste into High-Performance Materials"
12. Abhishek Pandit "Low Temperature Sintering Additive Strategies for Energy Efficient Refractory-production: a Path to CO₂ Reduction in refractory Industries"

XVI. Non-oxide Ceramics

1. Jhaya Gomathy S, * T.S.R.C.Murthy, J.K.Sonber, Shovit Bhattacharya, Sanjib Majumdar, "Influence of Sintering Additives on Microstructure Evolution and Densification of High-Entropy Borides"
2. G. Chinni Sai Mohan Babu, Branko Matovic, Vladimir Urbanovich, Jelena Maletaskic, Aleksa Lukovic, Jelena Ercic, Ravi Kumar, "Sintering and characterisation of additive-free B₄C/SiCw composites using high-pressure techniques"

Contents

S. No	Contents	Pg. No.
1	Messages	19
2	Memorial Lectures	26
3	Plenary talk abstracts	28
4	Abstracts	
	i. Traditional Ceramics	36
	ii. Ceramics for Semiconductor Industry	51
	iii. Ceramics for Advanced Batteries	64
	iv. Ceramics for Sustainability	71
	v. Ceramics for Nuclear Applications	85
	vi. Refractories	97
	vii. Glass & Glass-Ceramics	139
	viii. Functional Ceramics	165
	ix. Ceramics for Health Care and Dental Applications	206
	x. Ceramics for Defense and Aerospace Applications	228
	xi. Shape forming of Ceramics	260
	xii. Additive Manufacturing of Ceramics	266
	xiii. Electronic & Magnetic Ceramics	280
	xiv. Advanced Ceramics	295
	xv. Student Session	308
	xvi. Non-oxide ceramics	329

MESSAGES



भारतीय प्रौद्योगिकी संस्थान मुंबई

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शिरीष ब. केदारे, निदेशक

Shireesh B. Kedare, Director



MESSAGE

It gives me great pleasure to note that the 89th Annual Session of the Indian Ceramic Society and International Conference on "Research Advances and Industrial Challenges in Glass and Ceramics (RAICGC 2025)" will be held at the IIT Bombay campus during 27th-29th November 2025. It is heartening to note that this prestigious event is organised by the InCerS-Bombay Metropolitan Region (BMR) Chapter, in collaboration with the Indian Institute of Technology (IIT Bombay), BARC and COEP Technological University, Pune. The Indian Ceramic Society was founded on April 15, 1928 under the dynamic guidance of Pt. Madan Mohan Malaviya, a great educationist, with the primary objective of promoting the advancement of ceramic science, arts and technologies, by bringing into close contact those engaged in these pursuits with a view to developing a synergy among them.

This particular year, the focus is on interaction between academics and the industry, fostering learning, networking, collaborative opportunities spanning many critical and interdisciplinary areas of national importance and strategic self-reliance, including ceramics for semiconductor industry, electronic and magnetic ceramics, advanced batteries, refractories, healthcare, and nuclear, defense and aerospace applications, besides new areas such as additive manufacturing and development of advanced technical ceramics for the future. Especially of interest are panel discussions in every session, which are expected to give directions for future research and product development efforts, along with unique efforts to learn about the journeys of practitioners and people in the field on challenges they have overcome, as well as showcase of products by budding 'infant' entrepreneurs across the country, as well as a career-fair and a materials quiz for students and young researchers. There is also a particular focus on sustainability as visible from some of the technical talks and use of recycled materials being used for the badges for delegates in the conference.





With over 450 delegates participating in the conference, I hope that this melting pot of scientists, students, researchers, and industry and field experts will enjoy listening to each other, interacting with more than 15 stalls, exhibits and over 100 posters, discussing ideas over great food, and take a tour of the beautiful campus of IIT Bombay in the process.

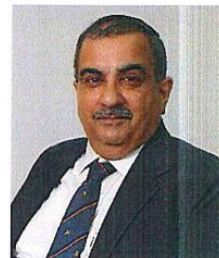
Wish you all a pleasant, delightful stay in our hallowed campus, a productive, fruitful 3 days of conferencing, and a memorable experience of interactions that you will take back with you.

(Shireesh Kedare)

विवेक भसीन
Vivek Bhasin



निदेशक, भाभा परमाणु अनुसंधान केंद्र
Director, Bhabha Atomic Research Centre
सदस्य, परमाणु ऊर्जा आयोग
Member, Atomic Energy Commission



MESSAGE

I am indeed happy that BMR chapter of Indian Ceramic Society in association with IIT Bombay, BARC and CoEP Technological University is organizing the International conference on Research Advancements and Industrial Challenges in Glass and Ceramics (RAICGC 2025) on the occasion of 89th Annual Session of the Indian Ceramic Society at IIT Bombay, Mumbai, India, during November 27-29, 2025. Further I am delighted to note that the conference has been thoughtfully conceived to bring together the expanding application domains of ceramics and related materials in nuclear, defence, aerospace, and semiconductor technologies. It is particularly encouraging to see the organizers giving special emphasis to the recent advances in additive manufacturing, refractories, healthcare, energy generation and storage, and materials machining among others. This is indeed an opportune moment to underscore the growing importance of glass, ceramics, and allied materials, which continue to play a vital role in technological progress and have already established a strong presence across industries including nuclear, defence, aerospace, petroleum refining, automotive, electronics, optoelectronics, and biomedical engineering. Equally commendable is the inclusion of themes such as Industrial Challenges in Glass and Ceramics and sharing of experiences of Ceramic Practitioners, which bridge the gap between academic research and real-world industrial needs. Such interactions are essential to ensure that innovations in materials science find meaningful translation into practical solutions and commercial applications.

The conference's plan to feature talks by acclaimed researchers and industry experts, along with panel discussions at the end of each session, will no doubt enrich the dialogue and foster deeper understanding across academia and industry. Moreover, such discussion will pave the way for possible technology transfers that can transform laboratory results into actual use, thereby fulfilling the Make in India vision in a significant way. The exchange of ideas and solutions toward industrial challenges will certainly lead to meaningful outcomes and strengthen the link between research and practical realization.

I take this opportunity to extend my greetings to the participants and wish the Organizers a great success in their efforts to organize RAICGC 2025 and congratulate BMR chapter of Indian Ceramic Society, IIT Bombay, BARC and CoEP Technological University on this timely initiative.


(Vivek Bhasin)

14.11.2025



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Prof. Sunil Bhirud
Vice Chancellor



Message

I am extremely delighted to welcome you for the 89th Annual Session of the Indian Ceramic Society and International Conference on **“Research Advances and Industrial Challenges in Glass and Ceramics (RAICGC 2025)”** organized by the In CerS –Bombay Metropolitan Region (BMR) Chapter, in collaboration with the Indian Institute of Technology (IIT Bombay), BARC and COEP Technological University, Pune.

The theme of the conference is weaved to unite academicians, industrialists, entrepreneurs and researchers on a common platform to exchange knowledge and values. Special theme symposia on several areas of interest to the ceramics fraternity such as advanced batteries, additive manufacturing, aerospace & defence applications, dental & healthcare developments, electronic, functional and magnetic domains, nuclear field, refractories, specialty glass-glass ceramics and challenges for ceramics semiconductors are included in this conference. The conference will certainly going to be a thought propagation treat to all the delegates.

Further, the conference has several other interesting features like honouring achievements of distinguishedceramics researchers, scientists, industry people and students, display of products developed by researchers, career fair for job aspirants, special plenary inspirational talks from achievers, special session from ceramic practitioners and a unique materials quiz for student participants.

I am sure that the deliberations in this conference will eventually lay a roadmap and endow with guidelines to all concerned for betterment of the materials, and in particular ceramics domain.

On behalf of COEP Technological University Pune, I extend a hearty welcome to all the participants and wish a grand success to the conference. May this conference be rewarding and may it unfold the domains of technological advancements to meet the needs of our country and world.

(Dr. Sunil Bhirud)

Vice Chancellor,

COEP Technological University, Pune



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Dr Atanu Ranjan Pal
President, Indian Ceramic Society

November 10, 2025



MESSAGE

It gives me immense pleasure and joy to extend a warm welcome to all distinguished dignitaries, delegates, invitees and participants at the 89th Annual Session of the Indian Ceramic Society and the International Conference on "Research Advancements and Industrial Challenges in Glass and Ceramics (RAICGC 2025)", being held at IIT Bombay, Mumbai, during November 27–29, 2025.

This prestigious event is organized by the InCerS–Bombay Metropolitan Region (BMR) Chapter, in collaboration with the Indian Institute of Technology (IIT Bombay), BARC, and COEP Technological University, Pune.

The conference is envisaged as a vibrant congregation of academicians, researchers, professionals, engineers, educators, administrators, and students. RAICGC 2025 provides an excellent platform for sharing ideas, exploring new technologies and identifying future trends in the glass and ceramics sectors with special emphasis on recent developments and future trends.

The conference uniquely emphasizes bridging academia and industry, fostering collaboration, and promoting innovative ideas that will help shape the future roadmap of ceramics research and product development.

I am confident that the deliberations, discussions and exchange of ideas will inspire participants to take up new challenges and initiatives in their respective areas of expertise.

I convey my heartfelt appreciation and warm greetings to all sponsors, exhibitors, advertisers, and well-wishers whose support, motivation, and encouragement have been instrumental in organizing this event. I am equally grateful to the Organizing Committee of RAICGC 2025 for their dedicated efforts and teamwork in giving this international conference its well-deserved color and vigor.

May RAICGC 2025 be a grand success and a milestone event in the continuing journey of the Indian Ceramic Society toward promoting excellence in Ceramic Science, Technology and innovation.

(Atanu Ranjan Pal)
President, Indian Ceramic Society

Registered under UP Societies Registration Act XXI of 1860 : Registration no. 52 of 1945-46



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Dr Sitendu Mandal
Honorary Secretary, Indian Ceramic Society

November 10, 2025



MESSAGE

It is a matter of great pride and delight to be a part of the 89th Annual Session of the Indian Ceramic Society and the International Conference on “Research Advancements and Industrial Challenges in Glass and Ceramics (RAICGC 2025)”, being held at IIT Bombay, Mumbai, during November 27–29, 2025.

The conference, jointly organized by the InCerS–Bombay Metropolitan Region (BMR) Chapter, IIT Bombay, BARC and COEP Technological University, Pune, reflects the Society’s continued commitment to advancing scientific understanding and promoting collaboration across academia, research institutions, and industry. We look forward to enthusiastic participation from both academia and industry alike.

RAICGC 2025 provides an invaluable opportunity to deliberate on the current trends, innovations, and future challenges in the glass and ceramics sectors. By bringing together professionals from diverse backgrounds, it aims to strengthen the interface between research and industrial practice and to inspire young minds to pursue excellence in this ever-evolving field.

This conference is not merely a platform for technical exchange but also a celebration of the spirit of collaboration that defines the Indian Ceramic Society. It symbolizes our collective endeavor to translate research into practice and ideas into innovation. RAICGC 2025 will thus serve as an excellent forum to explore the role of innovative technologies in the science and engineering of glass and ceramics with special emphasis on recent developments and future trends.

I take this opportunity to extend my sincere appreciation to the Organizing Committee for their tireless efforts and meticulous planning in shaping this international event.

With best wishes for the grand success of RAICGC 2025.

(Sitendu Mandal)
Honorary Secretary, Indian Ceramic Society

Registered under UP Societies Registration Act XXI of 1860 : Registration no. 52 of 1945-46

Memorial Lectures

Bhagat Memorial Lecture Ceramics and glasses for nuclear sector

A. K. Tyagi

Homi Bhabha National Institute

An aided institution of Department of Atomic Energy, Mumbai

Most of the materials deployed in nuclear industry need to withstand extreme condition such as high temperature, hostile chemical environment, high radiation field, prolong use etc. In particular, ceramics and glasses are extensively used in front and back end of nuclear cycle, as well as during operation of nuclear reactors. This requirement necessitates for design of special materials with compositional and structural constraints to enable them to retain integrity under extreme conditions along with desired functional requirements. Thus, the physical and chemical concepts become very important to design materials with appropriate structure and composition for application in nuclear sector. In this presentation, an overview of our work on thorium and uranium-based fuels, inert matrix fuels, materials for nuclear waste immobilization (glasses and ceramics), radiation stable ceramics materials for advanced applications, molten salts for MSBRs, nanosorbents and crystallographically designed inorganic ion-exchangers for separation of radio-nuclides from nuclear waste will be presented.

Acknowledgement: I sincerely acknowledge contributions of my colleagues, students and collaborators from different Divisions of BARC

Sahaj Memorial Lecture Beyond Handicrafts

Dr. Leela Bordia

Neerja International

Plenary Talks

Ceramic Nuclear Fuels for Nuclear Power Reactors

Chaitanyamoy Ganguly

Retired Distinguished Scientist, Chairman & Chief Executive, Nuclear Fuel Complex, Hyderabad Former Head, Radio-Metallurgy Division, BARC, Mumbai. Department of Atomic Energy, Government of India

Nuclear fission energy has emerged as a matured carbon - free option for energy security and climate goal. Nuclear power and related uranium fuel cycle technologies have attained industrial maturity in most countries in the West, Russia, China, Japan, Republic of Korea and India. India has set an ambitious target of 100 GWe nuclear power by 2047 from the present level of some 8 GWe. Natural uranium (99.3 % fertile U238 + 0.7 % fissile U235) is the basic material for nuclear fuels, which is a judicious mixture of fissile (U235 and Pu239) and fertile (U238) materials. U235 is the only fissile material in nature and fuel for most of the operating and upcoming nuclear power reactors in the world. Low enriched uranium ($\leq 5\%$ U235) and natural uranium (0.7 % U235), in the form of high-density uranium oxide pellets, is the driver fuel for all Light Water Reactors (LWRs) and Pressurized Heavy Water Reactors (PHWRs) respectively. LWRs consisting of Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs) account for more than 85 % of the reactors and PHWRs contribute to more than 10 % of the reactors. The U235 atoms in LWRs and PHWR fuel when bombarded with neutrons undergo fission and split up into two fission products and release enormous amount of heat energy and 2 to 3 neutrons. The heat energy is utilized for generating steam and in turn electricity. One of the released neutrons sustain the controlled fission chain reaction and out of the remaining neutrons, some transmute fertile U238 to human -made fissile isotope Pu239. The Pu by – product recovered by reprocessing spent LWR and PHWR fuels is best utilized in sodium cooled Fast Breeder Reactors (FBRs) in combination with Depleted Uranium (Dep U: $< 0.7\%$ U235) from tailings of U235 enrichment plant or spent PHWR fuel. Mixed uranium plutonium oxide (MOX), containing 20 -30 % PuO₂, has been the reference fuel for most of the demonstration, prototype and commercial FBRs constructed and operated so far. Mixed uranium plutonium monocarbide and mononitride are considered as advanced FBR fuels, because of their higher breeding ratio and higher thermal conductivity compared to MOX. In India, PHWR is the backbone of nuclear power program. Today, India has the highest numbers of PHWR units in operation and under construction: 22 reactors in operation and 12 reactors under construction or in pre-project stage. The Nuclear Fuel Complex at Hyderabad is one of the largest UO₂ fuel fabrication plants in the world. In addition, India has two BWR 160 MWe and two VVER 1000 MWe (PWRs of Russian design) in operation. 4 VVER 1000 are under construction. The VVERs use imported enriched uranium oxide fuel assemblies from Russia. India has three operating spent PHWR fuel reprocessing plants. The plutonium oxide from this plant, in combination with reprocessed depleted uranium oxide, is being used as feed materials for fabricating the FBR fuels. India is the only country in the world to develop and use hitherto untried plutonium rich (U, Pu) C advanced FBR fuel in the 40MWt/13MWe Fast Breeder Test Reactor (FBTR) at Kalpakkam. MOX fuel cores for the upcoming Prototype Fast Breeder Reactor 500 MWe (PFBR 500) at Kalpakkam have also been fabricated. PFBR fuel loading is underway and criticality will be attained soon. The present paper summarizes the status of conventional and advanced ceramic nuclear fuels for PHWR, PWR and FBR, highlighting the author's experience in UO₂, (U, Pu) O₂, (U, Pu) C and (U, Pu) N.

Innovations in Advanced Materials for Sustainable Society: Bridging Basic Science with Strategic, Societal, and Industrial Needs

Bikramjit Basu

Science Technology Innovation Cluster on Engineering Ceramics, Glass and Optical Materials Technologies, CSIR-CGCRI, India.

The advanced materials and manufacturing will continue to play a pivotal role in India's journey in Science, Technology and Innovation (STI) space, to become the World's one of the emerging economies. The central focus of my presentation will be to share our deep understanding of the interconnections among engineering design, additive manufacturing, and interactions of new biomaterials with key components of living system (proteins, cells, bacteria, blood, tissues), based on my independent research programs at IIT Kanpur (2001-2011) and the Indian Institute of Science, Bangalore (2011-present). This will be followed by three success stories of our technologies to cross TRL 4-7 spectrum, using system-level approach spanning across fundamental science, pre-clinical and clinical studies, to address human diseases, including orthopedic, dental and, cranio-maxillofacial reconstructions. In my current role at CSIR-CGCRI, I shall present illustrative examples to showcase the CGCRI's capability to demonstrate the lab-scale to pilot-scale developments in space-grade optical glasses and infrared/ radiation shielding window glasses. This presentation will close with my vision as the field of Ceramics and Glass will progress in the next few decades, which will have a significant impact in India's journey to become 'Self-Reliant India' and finally to emerge as 'Developed Bharat'.

Journey of a Young Entrepreneur

Atul Baldi
Minnovation Group

This seminar, “Journey of a Young Entrepreneur,” to be delivered by Atul Baldi (B.Tech. 2007 Rajasthan University) at IIT Bombay during the 82nd Annual Conference of the Indian Ceramic Society, delves into the deeper meaning of entrepreneurship, sacrifice, and lasting impact. It presents an inspiring real-life account of how conviction, resilience, and purpose can transform personal ambition into a vehicle for social good.

Baldi shares his transition from a software engineer, working for GE and AMEX, to an entrepreneur in the mineral processing industry, driven by a belief that true success lies in creating livelihoods rather than pursuing personal gain. The talk reflects on the philosophical foundation of entrepreneurship—that one’s limited time on Earth should be devoted to giving, building, and contributing to collective progress.

Through the story of his initial business failure in 2011-2015 and subsequent revival starting in 2016 with minimal resources, he illustrates the importance of patience, ethical conduct, and faith in one’s vision. His journey of rebuilding culminated in the founding of the Minnovation Group, which now operates multiple plants and quarries serving global clients.

The seminar emphasizes that entrepreneurship is not merely about profit, but about building organizations that endure, employ generations, and uplift communities. It encourages young professionals to pursue ventures rooted in purpose, perseverance, and moral strength — reaffirming that genuine success comes to those who align enterprise with service to society and the nation.

Journey of an Industrialist

Atul Dalmia
Chairman & Managing Director of RUBAMIN

Advancements in Refractory Materials for Enhanced Performance in Glass and Metal Industries

Kartik Kumar, Centre Director
Saint-Gobain Research India Private Limited
IIT-Madras Research Park, Chennai – 600113.

Refractory materials play a critical role in high-temperature, high-load environments such as glass and metal melting furnaces, where durability and efficiency are paramount. This talk addresses the performance requirements for refractories used in furnace crowns, with particular emphasis on thermomechanical stability, heat conduction, resistance to vapor corrosion, and emissivity—key factors for energy efficiency at extreme operating temperatures. Notably, SEFPRO "BP Mullite HE" demonstrates superior emissivity and creep resistance compared to conventional silica, facilitating more effective heat transfer and enhanced longevity. In the context of induction and smelter furnaces for steel, the chemical composition of refractories is crucial for corrosion resistance against aggressive slag chemistries. Neutral Ramming Mass offers improved slag corrosion resistance over silica, leading to more efficient melting and greater throughput with improved quality of steel. Collectively, these advanced refractory solutions contribute to increased furnace operating efficiency, higher production rates, and reduced energy losses, supporting the sustainability goals of the glass and metal industries.

PMN-PT Single Crystal Growth: Advancing Strategic Piezoelectric Ceramics For Next-Generation Defense and Industrial Applications

Sudeep Verma, Scientist F, Solid State Physics Laboratory, DRDO, Delhi

Lead Magnesium Niobate–Lead Titanate (PMN-PT) single crystals represent the pinnacle of piezoelectric performance, far surpassing conventional PZT ceramics. Their exceptional piezoelectric charge and strain coefficient, electromechanical coupling and dielectric properties make them indispensable for advanced sensors, sonar transducers, precision actuators and high-resolution ultrasonic imaging—all critical to strategic and defense technologies. This work will highlight the scientific and technological aspects of PMN-PT single crystal growth, addressing challenges in composition control, phase stability, and vapor pressure management. Emphasis is placed on process optimization for achieving high crystal yield and uniformity, enabling reliable device fabrication. The study underscores the role of such advanced functional ceramics in driving national self-reliance and next-generation smart material technologies.

A Journey to 'Glass': Fundamental Research to Technology Development

K. Annapurna*

Specialty Glass Division, CSIR-Central Glass and Ceramic Research Institute, Kolkata-700032, WB, India

'Glass' has become vital and integral part of our daily life for its unique and versatile properties. Besides its usage in windows or containers, its application extends common optics to advanced and strategic fields. The glasses possessing striking properties which are used for specific applications are termed as specialty glasses. Notable specialty glasses, such as laser glass, optical glass, and chalcogenide glasses hold immense importance in strategic sectors. India, despite its strong research base, has long relied on imported specialty glasses due to the absence of indigenous manufacturing processes. Addressing this gap has been a key motivation behind our sustained efforts at CSIR-CGCRI.

My research journey has been deeply rooted in exploring these specialty glasses—from understanding their fundamental structure–property relationships to developing process technologies that bridge laboratory science with advanced applications. CSIR-CGCRI being a premier National Institute dedicated in Glass research is actively involved in the development of indigenous technology for the production of Nd³⁺ doped phosphate laser glass suitable to use in high energy and high-power high-energy laser system to meet the national demand. Presently, process technology has been demonstrated in 5 litre melting capacity while the up-scaling of process technology in pilot plant to 15 litre melt scale is in progress to produce large sized laser glass discs along with edge cladding glass in collaboration with RRCAT, Indore.

The Institute is also engaged towards the development and supply of five varieties of optical glasses (2 flint and 3 crown) to VSSC, ISRO for their satellite tracking applications. CSIR-CGCRI has undertaken this activity and established a State-of-the art facility (5L induction heating glass melting facilities of 1450°C and 1650° C) for development cum production of optical glasses with stringent optical properties in terms of refractive index and Abbe number with optical homogeneity of the order of 10⁻⁵. In another breakthrough, CSIR-CGCRI has developed arsenic-free chalcogenide glasses with an extended transparency window beyond 12 µm. These glasses present opportunities for mid-infrared transmitting windows for thermal imaging, as well as optical fibers suitable for applications such as biomedical research, low-level sensing, environmental monitoring, and defense.

This presentation will discuss the challenges encountered while scaling lab-scale research to pilot-scale production, tracing the evolution of this research journey—from exploratory studies on structure–property correlations to the translation of basic scientific understanding into indigenous technologies of specialty glasses with national strategic importance.

From Cast Iron Melting to Field-Assisted Ceramic Processing: An Unplanned Journey

M. Imteyaz Ahmad

Indian Institute of Technology (BHU), Varanasi, Uttar Pradesh, India 221005

I studied materials science as an auxiliary course during my diploma days, but my actual experience with materials began with my first job, where I worked as a melting furnace supervisor in a cast iron foundry. I had no plans, just curiosity and a willingness to learn. Thanks to the guidance from mentors and lucky turns, I ended up working on ceramic processing. Along the way, I gradually explored a range of processing techniques, such as gas phase nanopowder synthesis, single crystal growth, electric field-assisted processing, and rapid thermal annealing for various applications, from IR windows to solar cells.

The talk will be a reflection on that journey—not a straight line, but a series of small steps, lucky turns often without a clear plan. My academic journey is not exceptional, but it might resonate with others navigating their own paths, especially when the destination isn't always clear.

Innovating with Purpose: Lessons from the Metwiz Journey

Rashmi Dharmadhikari (Founder & Director, Metwiz Materials Private Limited)

In this presentation, Rashmi Dharmadhikari, Founder & Director of **Metwiz Materials Private Limited**, shares the story of building Metwiz — a deep-tech enterprise born out of a simple belief that India can design and manufacture its own advanced material equipment.

From early challenges to building a sustainable organization, her journey reflects the persistence, collaboration, and curiosity that drive innovation in the real world. Drawing from experiences in research, entrepreneurship, and leadership, Rashmi highlights how purposeful innovation can shape organizations, empower people, and contribute to India's growing culture of technological self-reliance. This session is a reflection on what it truly means to innovate — not just to create new products, but to create meaning, capability, and resilience for a nation that's ready to lead.

Journey of entrepreneurs in the ceramic domain

Title: From classroom research to award-winning innovative product of Earth Tatva

Shashank Nimkar (Founder & CEO of Earth Tatva)

The session takes you through the journey of Earth Tatva, of how the sight of a ceramic landfill during an industrial visit sparked a question about the non-biodegradable nature of ceramics in a student's mind. Taking the inquiry further through the graduation project for the Master of Design thesis at National Institute of Design (NID), the research paved way to TatvaMix - a stoneware-based clay body that contains up to 60% glaze-fired recycled content. Making conscious creation accessible to makers enabling resource protection without compromising quality production.

Traditional Ceramics

INVITED SPEAKERS

India's Path from Gujarat to Global Benchmark in Sanitaryware Manufacturing

Venkatmani Manavalan

Technical Manager – Sanitaryware

The Indian sanitaryware industry has grown rapidly in recent decades, with Gujarat emerging as the country's leading production hub. From small-scale units to large integrated plants, the region has played a crucial role in shaping India's market presence. However, when compared to global leaders in sanitaryware manufacturing, significant gaps remain in technology adoption, product quality, and process efficiency.

Globally, sanitaryware manufacturers have achieved slimmer, lighter, and more durable products by using high-purity and well-processed raw materials. Their advanced production systems—ranging from automated casting to energy-efficient tunnel kilns—enable consistent quality, low rejection rates, and enhanced productivity. In contrast, Indian manufacturers often rely on semi-processed raw materials and labor-intensive practices, which result in heavier products, higher variability, and increased wastage.

The future of the Indian sanitaryware sector lies in bridging this gap through technology adoption, process innovation, and global benchmarking. With improvements in raw material beneficiation, automation in casting and glazing, and modern firing technologies, India has the potential to move from being a cost-competitive supplier to a recognized global standard setter. Gujarat's manufacturing base can serve as the launchpad for this transformation, enabling Indian sanitaryware to compete not only on price but also on quality, sustainability, and design.

This presentation will highlight the key differences between the Indian and global sanitaryware industries, outline pathways for technology and process upgradation, and propose a roadmap for Gujarat—and India at large—to achieve global benchmark status.

Key Differences: Indian vs. Global Sanitaryware Industry

Aspect	Indian Industry	Global Peers
Raw Materials	lower consistency, higher impurities	Fully processed, refined raw materials with high consistency
Product Weight	Heavier, thicker walls due to material limitations	Slimmer, lightweight products with high strength
Rejection Rates	Relatively high due to variability in casting and firing	Very low due to stable processes and advanced QC
Casting Techniques	Mostly manual or semi-automatic casting	Fully automatic casting systems with robotic support
Kilns & Firing	Older kiln designs, less energy-efficient	Modern, high-efficiency tunnel kilns with digital controls
Automation	Limited automation in glazing, handling, and packing	Extensive use of automation and robotics
Design & Innovation	More focused on mass production and cost	Focused on design, ergonomics, and international standards
Sustainability	Limited focus on energy recovery & recycling	Strong emphasis on eco-friendly processes, energy saving
Global Competitiveness	Cost advantage but lower perceived quality	High brand value, benchmarked on quality and innovation

Dust Pressed Ceramic Tiles: India's Manufacturing Edge and Global Alignment – A Strategic Outlook from Morbi to the World

Khodi Das, L.E. College, Ceramic Engg., Morbi

India's ceramic tile industry, anchored in the vibrant manufacturing hub of Morbi, has emerged as a global contender in dust pressed tile production. This presentation offers a strategic overview of India's capabilities, challenges, and alignment with international best practices, with a focus on technological modernization and sustainable growth.

Dust pressing technology, central to ceramic tile manufacturing, enables high-volume, precision-based production. Morbi, contributing over 90% of India's tile output through 900+ units, has rapidly adopted digital printing, large-format pressing, and energy-efficient firing techniques. However, gaps remain in automation, environmental compliance, and R&D investment.

The presentation compares India's practices with global leaders such as Italy, Spain, Turkey, and Vietnam, highlighting advancements like pelletized powders, AI-driven sorting, low-emission kilns, and smart factory integration. A comparative matrix outlines differences in automation, tile formats, sustainability, and digital precision.

A detailed SWOT analysis reveals India's strengths in cost-effective production and domestic demand, while underscoring weaknesses in fragmented industry structure and dependence on imported machinery. Opportunities lie in expanding exports to emerging markets, adopting green manufacturing, and leveraging government support for infrastructure. Threats include rising energy costs.

Strategic recommendations include transitioning to low-carbon kilns, investing in advanced tile bodies, upgrading to Industry 4.0 standards, and recycling polished tile waste. Building a global brand identity and strengthening certification infrastructure will be key to long-term competitiveness.

The presentation concludes with a call for collaborative action among industry, academia, and government to position Morbi—and India—as a global leader in ceramic innovation, sustainability, and design excellence.

Bone China Tableware: Manufacturing Realities and Global Benchmarks – A Strategic Outlook for India's Ceramic Future

Mr. Masroor Usmani, Clay Craft India

Bone china, prized for its translucency, whiteness, and refined strength, represents the pinnacle of ceramic tableware. This presentation offers a strategic overview of its manufacturing processes, global benchmarks, and India's position within this evolving landscape.

Composed primarily of bone ash (30–50%), kaolin, and feldspar, bone china has its origins in 18th-century England and has since become a global standard for luxury tableware. The presentation outlines the complete production cycle—from raw material preparation and slip casting to firing, glazing, decoration, and quality control—highlighting the precision required to achieve export-grade quality.

India's bone china clusters, notably in Khurja and Jaipur, showcase artisanal craftsmanship and cost-effective labour. However, the sector faces persistent challenges: inconsistent raw material quality, limited automation, and difficulty meeting international standards. In contrast, countries like China, Sri Lanka, and several European nations are advancing through robotic glazing, sustainable bone ash alternatives, and eco-certification.

A comparative analysis with porcelain and stoneware clarifies bone china's unique market positioning. A detailed SWOT analysis reveals India's strengths in heritage and skilled labor, but also its weaknesses in infrastructure and branding. Opportunities lie in export expansion, design collaboration, and sustainable innovation, while threats include rising competition and regulatory shifts regarding animal-derived materials.

To compete globally, India must invest in synthetic bone ash R&D, modernize manufacturing infrastructure, establish centralized testing labs, and initiate skill development programs. Strategic branding and storytelling will be essential to elevate Indian bone china's identity on the world stage.

The presentation concludes with a call for collaboration among industry, academia, and government to transform India's bone china sector into a globally recognized symbol of quality, innovation, and cultural pride.

Raw Material Challenges – Glass & Ceramics and Research Advances in Clay Mineral

Dr. Sanjeev Bhasin

Ashapura

The glass and ceramics industries rely heavily on natural raw materials such as silica sand, kaolin clay, feldspar, limestone, soda ash and alumina. These minerals/materials are essential for producing everything from flat glass and tiles to advanced refractories and semiconductors where purity plays a very important role depend on the application. The primary challenges faced by the glass and ceramic industry are as follows:

1. Supply Shortages and Dependence on Critical Raw Materials (CRMs).
2. Rising Mining Costs and Price Volatility.
3. Environmental and Sustainability Pressures
4. Quality Control and Processing Inconsistencies

Clay minerals (e.g., kaolinite, smectite/montmorillonite, halloysite, illite) are phyllosilicates with layered structures, offering high surface area, ion exchange capacity, and adsorption properties. Research trends during last 10 years has accelerated in the clay mineral modification and applications, driven by needs in environmental remediation, nanotechnology, and sustainable materials.

1. Environmental Remediation and Pollution Control.
2. Nanotechnology and Advanced Materials
3. Industrial and Geotechnical Applications
4. Sustainability and Circular Economy

Apart of the various challenges with raw material, glass and ceramics industry in India slow down post COVID since 2024. The market size of tile industry is likely to reach 632.36 billion in 2032 with the projected growth rate of 7.1% CAGR during 2025-32. Additionally, research advancement added values in clay/non-clay minerals research to develop high value new products will raise different level future challenges of raw material with high purity, its beneficiation and process sustainability.

Problems and Prospects of Indigenous Raw Materials for High-Temperature Applications

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India possesses substantial reserves of refractory raw materials; however, their associated impurities compromise thermal stability and limit high-temperature applicability through the formation of deleterious low-melting phases. The type and extent of these impurities vary widely with the geographical source of the deposits, rendering a single remediation strategy inadequate. A multipronged approach encompassing beneficiation, purification, upgradation, and recycling is therefore essential to ensure the sustainable and reliable utilisation of indigenous refractory resources. This paper discusses the challenges linked to Indian refractory raw materials and outlines potential strategies for their upgradation and for mitigating the problems currently faced by the industry.

CONTRIBUTORY SPEAKERS (ORAL)

Comparative studies on fluxing characteristics of different coloured granite waste with feldspar used in the manufacturing of glazed vitrified tiles

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India is one of the world's highest producer of granite with wide array of colours, ranking third after China and Brazil. Indian granite industry generates large amount of granite waste during mining (~50%) and these wastes are lying unutilized resulting wastage of valuable natural resources. On the contrary, vitrified ceramic industries in India are in search of alternate materials to feldspar, which is used as a flux in higher proportion in glazed vitrified tile body manufacturing. As granite also contain feldspar mineral, in the present study, an attempt to compare fluxing characteristics of different coloured granite waste to feldspar being used in glazed vitrified tile industries were taken up. Characterization of granite waste and feldspar samples were carried out in terms of wet chemical method, XRD, specific gravity and fluxing characteristics were assessed by PCE test. Fired properties such as fired colour, whiteness index and LAB colour co-ordinates were also assessed after firing pellet samples under industrial condition at $1200\pm 5^{\circ}\text{C}$ to assess the suitability of granite waste as a replacement for feldspars being used in glazed vitrified tile body manufacturing. Results showed that different coloured granite samples have different K_2O to Na_2O ratio and Fe_2O_3 content showed ascending order from light to dark coloured granite. Granite showed fluxing behavior similar to different types of feldspar being used in glazed vitrified tile manufacturing, depending upon chemical constituents and mineralogical composition.

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Breaking Bonds, Building Flow: A Rheological Tale of Alumina and Montmorillonite

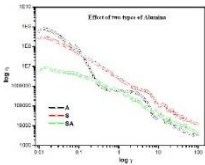
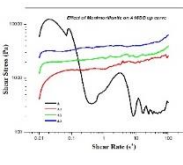
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In this study, two distinct-sized alumina suspensions were used to investigate the influence of particle size and clay addition on suspension behaviour. The first system employed finer alumina (A) with $D_{50} = 1\mu$, while the second system utilized coarser alumina (S) with $D_{50} = 5\mu$. To examine the effect of montmorillonite (Mt) clay on the rheological properties of alumina paste, layered silicate was systematically introduced into each alumina suspension at varying proportions. The total solid volume fraction ($\phi = 0.45$) of the aqueous suspension was maintained at a constant value to ascertain the effect of clay incorporation. This approach facilitates a comparative assessment of how montmorillonite incorporation affects the interparticle interactions, microstructural evolution, and flow behaviour in both fine and coarse alumina systems. Pure alumina suspensions (both A and S) exhibited shear thinning and periodic oscillation effects. Higher viscosities were observed for larger alumina particles. Upon incorporation of clay, sample A demonstrated the steepest decline in viscosity, indicating rapid network breakdown.

Incorporation of Mt ($\phi = 0.05, 0.1$ and 0.15 respectively for codes 1, 2 and 3) increased the initial viscosity ($A1 < A2 < A3 < A$), likely due to the formation of their plate-like structure and electrostatic and van der Waals interactions between clay and alumina particles. At higher shear rates, this network disintegrated, leading to a fully dispersed state, suggesting that the addition of Mt enhanced the microstructural interactions and flow resistance at low shear in fine alumina suspensions. The viscosity decreased with increasing shear rate for all samples (S, S1, S2, S3), confirming non-Newtonian pseudoplastic (shear-thinning) behaviour. At low shear rates, the viscosity followed the trend, $S1 < S2 < S3 < S$, owing to better particle alignment and agglomerate breakdown. At higher shear rates, S1 exhibited a sharper viscosity drop because Mt disrupted the internal network. For S2 and S3, a higher Mt content enhanced the interparticle interaction and viscoelastic structure, thereby increasing viscosity.

	
Effect of particle size of alumina on viscosity	Incorporation of Mt significantly alters the flow of alumina suspension depending on volume fraction of Mt

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CONTRIBUTORY SPEAKERS (POSTER)

Processed Raw Materials -Need Of Hour for Ceramic Manufacturing

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Ceramic whiteware and glass manufacturing is a highly resource-intensive process, demanding significant raw materials, energy, water and generating substantial waste. Processed raw materials play a crucial role in addressing these challenges, promoting sustainability, and enhancing manufacturing efficiency. Let's explore the importance, advantages and process of handling raw materials in ceramic manufacturing.

What Are Processed Raw Materials?

Processed raw materials are purified and enhanced versions of natural materials such as feldspar, quartz, clays and talc, tailored for ceramic manufacturing. These materials undergo rigorous refinement processes such as various stages of sorting, blending, wet grinding and magnetic separation to reduce foreign material and impurities and improve their properties, making them more suitable for efficient energy saving production. Key raw materials include:

- Clays (plastic, non-plastic, and semi-plastic) for structural enhancement
- Feldspar and Quartz, vital for forming the ceramic body.
- Talc and Zircon, used for glaze and astatic enhancements.

Why Are Processed Raw Materials Important?

Processed raw materials are pivotal in achieving the dual goals of **circular economics** and **sustainable ceramic manufacturing**. Their importance lies in:

- **Minimizing Waste:** Purified materials reduce material wastage during production. Average reduction 1-2%.
- **Enhanced Efficiency:** Improved properties allow for lower energy consumption and faster production cycles. Average saving 2-3%.
- **Environmental Sustainability:** Using cleaner raw materials reduces CO₂ emissions and dust pollution. Average reduction 1-2%.
- **Conservation of Resources:** Optimal use of lower-grade materials preserves high-quality reserves as well as balancing of mining operations. Average 10-20% more life of mine.

Advantages of Using Processed Raw Materials

- **Higher Quality Output:** Helps in achieving lower impurity levels of iron (from 2000 ppm to 100 ppm). Reduce defects by 0.5-1%.
- **Better Aesthetics:** Enhanced whiteness and reduced yellowing of ceramic bodies. Can fetch 2- 5% better price of finish product.
- **Cost Efficiency:** Reduced consumption of expensive glaze materials. Average saving 2-3%.

- **Thermal stable body:** Minimized wastage due to better thermal stability. Average reduction 1%.
- **Production Optimization:** Faster firing cycles due to purer raw material. Average increase production by 5%.
- **Energy Efficiency :** Lower firing temperatures helps in increased energy saving. Average energy saving 2-3%.
- **Environmental Benefits:** Reduced dust emissions at body preparation area/slip house. Average reduction 50%.

How Are Processed Raw Materials Prepared?

The refinement process for raw materials in ceramic manufacturing starts from mining operations & it includes:

- **Sorting at Mine front:** Initial sorting of Mineral at Mine front to ensure grading
- **Optical Sorting:** 2nd stage to use high efficient technology & use of optical sorter to remove different foreign material.
- **Wet Grinding:** Significantly reduces impurities, particularly iron content. Improves material homogeneity for better performance
- **Advanced Magnetic removing Techniques:** Removes iron & other impurities and optimizes material composition.
- **Technological Integration:** Real-time monitoring systems for consistent quality. Automated systems for precise material proportioning.

Advantage to the Natural Resource

- **Higher Yield:** In the mine ensures more usable material with close to zero wastage due to use of all quality mineral.
- **Mineral Conservation:** Efficient use of third- and fourth-grade materials ensures sustainable mining.
- **Balanced Mine Reserves:** Optimizing extraction helps maintain reserve longevity, reducing resource depletion.

Reduction in Dust Pollution and Energy Saving

Wet processing reduces dust emissions significantly at body preparation department and slip house. Wet grinding offers advantages in energy consumption and reduces it significantly.

Conclusion

Processed raw materials are at the heart of sustainable ceramic manufacturing, enabling improved efficiency, reduced environmental impact and cost savings. Leveraging innovative technologies, such as wet grinding and advanced sorting ensures the highest quality output while conserving resources. By embracing these methods, the ceramic industry can pave the way for a more sustainable and efficient future, aligning with the principles of circular economics.

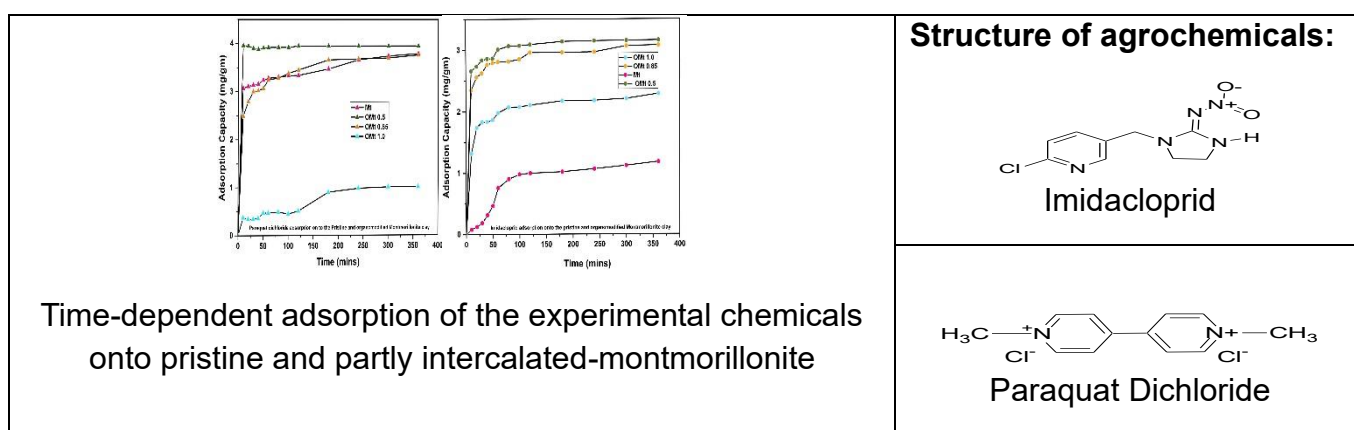
Efficient Removal of Harmful Organic Molecules by Partly-Intercalated Montmorillonite Clay

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The widespread use of agrochemicals in modern agriculture has raised serious environmental concerns due to their accumulation in soil and aquatic ecosystems. To address this issue, the present study focuses on enhancing adsorption performance towards hazardous agrochemicals by modifying purified Indian montmorillonite clay through intercalation with a long-chain quaternary ammonium surfactant, dimethyl dioctadecyl ammonium chloride (DDAC). Two representative compounds were selected: imidacloprid, a neutral neonicotinoid insecticide, and paraquat dichloride, a highly water-soluble and toxic di-cationic herbicide. Organo-montmorillonite adsorbents were prepared with varying DDAC loadings from sub-cation exchange capacity (CEC) to full CEC levels to examine the effect of intercalation degree on adsorption behaviour. Comprehensive characterization of pristine and modified clays was carried out using X-ray diffraction (XRD) to assess changes in interlayer spacing, thermogravimetric analysis (TGA) to evaluate thermal stability and organic content, and Fourier-transform infrared spectroscopy (FTIR) to confirm functional group interactions. Results demonstrate successful intercalation of DDAC into clay galleries, leading to a significant increase in basal spacing and alteration of surface chemistry. Adsorption studies reveal that adsorption performance correlates strongly with the degree of intercalation. Furthermore, the ionic nature of the pesticide molecules significantly influences adsorption affinity: paraquat, being di-cationic, exhibits strong electrostatic interactions with the negatively charged clay surface, while imidacloprid shows weaker adsorption, likely governed by van der Waals forces and hydrophobic interactions due to its neutral charge. A plausible adsorption mechanism is proposed, highlighting the interplay between adsorbate polarity, surface charge, and interlayer structure. This research contributes to the development of environmentally sustainable and cost-effective adsorbent materials for the removal of hazardous agricultural contaminants from water systems.



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Ceramics for Semiconductor Industry

INVITED SPEAKERS

CUMI's Advanced Ceramics: Enabling the Semiconductor Ecosystem

Prathap Kumar

Carborundum Universal Limited (CUMI)

The semiconductor industry demands materials that can withstand extreme thermal, chemical, and mechanical conditions while maintaining dimensional precision and purity. Advanced ceramics have emerged as indispensable enablers of this ecosystem, offering unmatched performance in wafer fabrication, packaging, and high-frequency applications. This talk will explore how Carborundum Universal Limited (CUMI) leverages its 30+ years of expertise in advanced materials to offer a comprehensive range of precision ceramic components for the semiconductors and electronics industry ranging from Wafer Fabrication Equipment to Power Semiconductor substrates and housings.

Ceramic Coatings for Chipmaking Equipment

Dr. Gayatri Natsu

Deputy Director of Process Engineering at Applied Materials India

After giving a brief overview of the semiconductor industry landscape, I will detail out the anatomy of a typical wafer fabrication equipment. I will then focus on the use cases of ceramic coatings that make advanced chipmaking possible. Finally, I will talk about the key gaps between technology development and product commercialization in the context of coatings.

Electroplated copper filled 3D Interconnects in Glass and Alumina

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Ceramic materials such as glass, alumina and aluminum nitride are emerging as alternative substrates in advanced electronic packaging. While glass is being explored in high-speed radio-frequency (RF) applications due to its superior electrical insulation, other materials like Alumina, AlN and SiC are preferred in high-power electronics where thermal conductivity is one of the critical parameters. In this presentation, the current status of Electroplated copper filled 3D Interconnects created in glass and alumina will be discussed. Vias in these ceramic materials are created by ultrasonic machining, and then thin-film metallization is performed by electroless plating. Via-filling and formation of embedded passive devices in glass/alumina will be presented.

CONTRIBUTORY SPEAKERS (ORAL)

Development of CVD-grown seamless monolayer 2D-MoS₂ for Electronics and Energy devices

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Two-dimensional (2D) Molybdenum disulfide (MoS₂), one of the transition metals dichalcogenides (TMDCs) has recently been found to be a promising alternative to graphene for applications in various semiconductor devices owing to its distinctive properties such as layered structure, tuneable electrical properties and bandgap. Of all the categories of MoS₂, monolayer MoS₂, features a direct bandgap, high surface area, and notable catalytic activity, making it highly desirable for advanced material applications. This study emphasizes on the fabrication of monolayer MoS₂ via chemical vapor deposition (CVD) offering various advantages such as high-quality, large-area films offering precise control over thickness. The monolayer MoS₂ synthesized in this work exhibits a triangular morphology with an overall growth area of $\sim 1000 \times 1000 \mu\text{m}^2$, as observed through a light microscope. Atomic force microscopy (AFM) confirmed the monolayer nature, with flake thickness ranging from 0.8-0.9 nm. Raman spectroscopy further validated the monolayer formation, depicting a peak separation (Δk) of less than 20 cm^{-1} between the A_{1g} and E'_{2g} modes. Furthermore, plasmonic polyhedral nanocrystals enhance phase transformation in MoS₂, improving electronic conductivity, and energy storage capabilities. This study further shows that the faceted silver-gold (AgAu) nanocrystals induce hot electron injection and phase transformation of CVD synthesized MoS₂ leading to a reduced overpotential and Tafel slope to 389 mV and 389 mV/dec under photoexcitation, when used as a catalyst for hydrogen evolution reaction (HER). These improvements are attributed to the increased active sites, light-induced phase transition, and enhanced charge separation.

Keywords: Molybdenum disulfide (MoS₂) Chemical Vapor Deposition (CVD), Hydrogen evolution reaction (HER), Faceted silver-gold nanocrystals (AgAu NCs).

High-Purity Alumina: Material Insights and Tailoring Properties

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High-Purity Alumina (HPA) is a material valued for its purity level, thermal stability, chemical inertness, and mechanical strength, making it highly reliable in a variety of applications. With purity levels ranging above 99.8%, HPA finds applications in areas such as semiconductor manufacturing, biomedical implants, and energy storage. While its low dielectric loss and good electrical insulation properties are beneficial for high-frequency electronics and communication technologies, HPA is also used for its wear resistance, corrosion resistance, and thermal performance in mechanical, chemical, and optical applications. Properties may be further influenced by controlled doping and understanding how they affect properties like densification, mechanical strength, and electrical performance facilitates selecting the right type of alumina for specific uses. Choosing the appropriate specialty alumina can improve device reliability and efficiency, while supporting more sustainable design approaches across different fields.

CONTRIBUTORY SPEAKERS (POSTER)

Designing VO₂ films with variable transition temperatures: effect of chemical strain

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The growing focus on energy conservation through sustainable methods has led to an increasing demand for energy-efficient smart building designs. One of the major constituents for heat exchange between buildings and surroundings are the windows. In this context, windows providing adequate visible transparency while modulating IR radiations based on the interior/exterior temperatures require smarter designs. Smart windows designs could incorporate thermochromic coatings which change their electrical and optical properties in response to external temperature. VO₂, a thermochromic material, displays an interesting reversible switching from the IR transmitting at room temperature to the IR reflecting state at higher temperatures with a phase transition temperature (T_c) of 340 K. However, T_c for the unstrained VO₂ is slightly on the higher side and needs to be brought down to near room temperature for its commercial applicability. Lattice strain engineering could be utilized as one of the strategies to reduce T_c . Unlike the thickness dependence in mechanical straining, the chemical straining could be applied to a film of any given thickness. In this work, the unstrained and chemically strained VO₂ thin films are deposited on the soda lime glass substrates using compound ceramic targets in an RF magnetron sputtering system. Here four dopants of varying size and concentration (W⁺⁶, Mo⁺⁶, Nb⁺⁵ and Ta⁺⁵) are used to alter the switching characteristics as well as T_c in VO₂ thin films. The chemically strained thin films have a T_c in the range 186 K to 334 K, with different doping elements and concentrations. Moreover, the chemically strained VO₂ shows switching characteristics with T_c of 310 ± 7 K, while also maintaining adequate luminous transmittance of 34.50% and a high infrared switching efficiency of 40.93% at $\lambda = 2500$ nm. The obtained experimental results could help establish VO₂ as a potential next-generation material for various energy-efficient device applications.

Tuning of Electrical properties of Barium titanate-based ceramics for the semiconductor industry

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Electroceramics research is driven by technology and device applications. This growing field includes a vast number of magnetic, dielectric, ionically conducting, semiconducting, and superconducting ceramics used in domains as diverse as transportation, industrial production, power engineering, medicine and health care, consumer electronics, and communication. Barium Titanate is one of the important and commercial ceramics used worldwide in the semiconductor industry for capacitors, thermistors, and sensor applications.

Ceramics rely on precise control of grain boundary barrier layers and electrode contact characteristics—factors that are critically important in semiconductor device reliability. In this work, the electrical behavior of Lanthanide-doped BaTiO₃-based ceramics with different electrodes, viz. Ni, Cu, Pt, Ag, and Au are investigated thoroughly through dielectric and resistivity analysis in the frequency domain.

Experimental results show that the contact resistance, and thus the total resistance of the ceramics increases with decreasing thickness and with decreasing area of the Ni layer, when the Ag top layer thickness is kept constant. This behavior is explained by an increase in the effective blocking contact area between the Ag layer and the ceramic. While Ni forms an ohmic contact with the semiconducting BaTiO₃, Ag exhibits a blocking (Schottky-type) contact. This difference is crucial in applications where stable low-resistance paths are required.

X-ray diffraction (XRD) and field emission electron microscopy (FE-SEM) analyses confirmed the interfacial microstructure and phase integrity of the electrode layers. Understanding these interface phenomena enables targeted optimization of electrode composition, thickness, and deposition methods—key factors in ensuring consistent performance of BaTiO₃-based devices in semiconductor-grade temperature compensation circuits, embedded safety components, and microelectronic assembly processes.

Using our electrode-interface model, the contribution of a very thin Ni layer can be linked to incomplete wetting of the ceramic surface during deposition, which leads to discontinuous metallic coverage. This incomplete coverage allows more of the Ag to directly contact the ceramic, thus increasing total resistance. Such insights are directly relevant to the semiconductor industry, where electrode engineering can significantly influence device performance, especially in multilayer ceramic devices and high-reliability components.

Prospects and challenges of Molecular Dynamic Simulations for Advanced Glass and Ceramic Materials

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Here we present a critical overview of one of the most emerging frontier research area, the computational Molecular Dynamic Simulation (MDS) of deformation and fracture in Advanced Glass, Glass-Ceramics, Ceramics and Ceramic Nanocomposites; all of which are characteristically brittle and hence characteristically very much prone to failure. The MDS is a very well known advanced computational tool which uses solution of equations of motions of individual atoms for a given potential distribution function; thereby revealing the atomic scale deformation scenario. For instance, the MDS results of Cu₆₄Zr₃₆ nanoglasses, showed that their deformation behavior is controlled by the defective short-range-order in the interfaces. In the case of Li₂O-2SiO₂ glass ceramics the MDS revealed that how dislocations, and shear flow at glass and crystal interfaces help to dissipate contact energy. Further, the MDS of nanoindentation of alumina shows exceptional consistency with the experimental nanoindentation data for transparent Alumina ceramics. Further, the MDS predicted a crossover from inter-granular continuous deformation of SiC to intra-grain discrete deformation at a critical indentation depth. In the case of NbC/Nb nanolaminate-nanocomposites the MDS predicted accurately the experimentally obtained results of the stress-strain behavior etc. Numerous such literature data are critically analyzed in this overview. Thus, the critical overview represents the state-of-the-art knowledge base, with the research gaps in MDS along with future research needs of the aforesaid materials. To the best of our knowledge this is the very first such attempt.

Hybrid and Nanostructured Materials for Chemical Mechanical Planarization

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Chemical Mechanical Planarization (CMP) is a key enabling step in semiconductor and advanced material fabrication, where tailored abrasives are critical for achieving nanometer-scale surface flatness. Alumina provides high hardness, robustness, and cost-effective removal rates, making it suitable for bulk material removal. [1] Silica, with its moderate hardness and chemical inertness, ensures smooth, low-defect finishes but generally exhibits slower removal. [2] Ceria offers strong chemical interactions with oxide films, delivering high selectivity and efficient planarization, though dispersion control is essential to minimize defects. [3] Hybrid core-shell abrasives, such as ceria-coated silica, integrate the stability and low abrasiveness of silica with the reactivity of ceria, achieving a balance of removal rate, planarity, and defect control. This work details the synthesis routes, surface modification strategies, and CMP performance of these abrasive systems, underscoring how hybrid and nanostructured materials can address evolving challenges in microelectronics manufacturing.

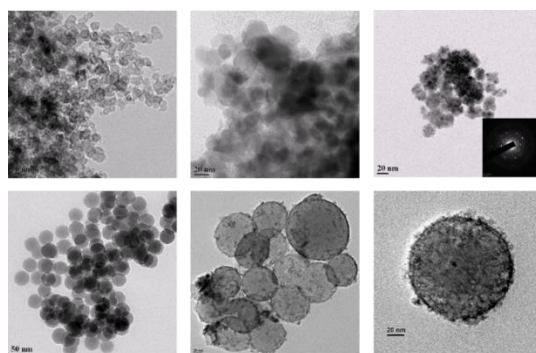


Fig. 1. Transmission electron microscopy (TEM) images of different CMP abrasives developed in this study.

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Ceramics for Advanced Batteries

INVITED SPEAKERS

PAPERATOR and PAPELYTE: Functionalized Cellulosic Separators Enabling Paper Cell Technology

Mononita Das, Kuntal Ghosh and Mir Wasim Raja*

Energy Materials & Devices Division, CSIR-Central Glass & Ceramic Research
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Battery separators must isolate electrodes while facilitating ion transport, with key requirements including porosity, wettability, mechanical and thermal stability, safety, and sustainability. Till now, polyolefin-based separators (PP, PE) are widely used in commercial Lithium batteries; however, they suffer from poor wettability, thermal instability, and environmental issues. As alternatives to address these, researchers have explored surface modifications of polyolefins and alternative synthetic polymers (e.g., PET, PAN, and PVDF). Increasing attention has turned to cellulose-based materials (e.g., bacterial cellulose, nanofibers), valued for their sustainability, abundance, lower cost, and favorable interactions with electrolytes due to their chemical structure. Here, an attempt has been made for the first time wherein cellulosic paper has been functionalized by impregnating ceramics into a separator membrane useful for lithium batteries and Supercapacitors. Pristine cellulose papers have limitations for use as a separator directly in the devices, due to their poor mechanical strength and uneven pores, which result in self-discharge and a safety threat; thus, functionalization is essential for their practical use in batteries (LIBs). The ceramic impregnated paper separator (named as PAPERATOR) demonstrated showed excellent electrolyte wettability (216-270%), quicker electrolyte saturation, increased mechanical strength (43.96-50.15 MPa), and zero-dimensional shrinkage up to 200 °C. The electrochemical cell comprising *Graphite|paperator|LiFePO₄* showed comparable electrochemical performances to that of commercial PP/PE separators in terms of capacity retention at different current densities (0.05-0.8 mA cm⁻²), long-term cycleability (300 cycles) and coulombic efficiency (>96%). In another effort, LLZO fast ion conducting ceramic loaded paper separator (named as PAPELYTE) also showed remarkable performance in terms of superior ionic conductivity (1.23 mS cm⁻¹), high Li-ion transport properties ($t_{Li^+} = 0.64$), wider electrochemical window (>5.5V). Such two breakthroughs now enabling us to envisage a new cell configuration called electroactive paper separator supported flexible paper cell. Such effort will pave the foundation for future electronics such as wearable devices, electronic foldable displays, smart textiles etc.

Keywords: Paper, Separator, LLZO, Flexi cell, Lithium batteries, Na-ion Batteries, Supercapacitors

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Li-Ion Dynamics in Halo-Spinel based Low Cost Solid Electrolyte

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Spinel-based halide solid electrolytes (HSEs) are gaining recent attention as they incorporate more affordable elements (Mn, Mg, and Fe) compared to conventional layered Li_3MCl_6 ($\text{M} = \text{Y}, \text{Sc}, \text{Er}, \text{In}, \text{Yb}$). However, the lithium occupancy is either fully saturated or exhibits limited disorder at elevated temperatures, resulting in lower ionic conductivity. To address these issues, we introduced aliovalent doping into some of existing spinel based Halide SEs, which creates both disorder and vacancies that improve conductivity by more than 2-3 orders of magnitude ($\sim 0.1 \text{ mS cm}^{-1}$ at 30°C). However, this is still not on par with the best-layered HSEs. This discrepancy is primarily due to the migration of a few ions from 16d to the new site 16c, which led to blocking effects for long-range Li^+ diffusion, confirmed through neutron diffraction, solid-state NMR, hopping frequency, and DFT analysis. Nonetheless, aliovalent doping provides valuable insights for the design of high-conductivity and cost-effective spinel halides for future solid-state battery applications.

References: *ACS Energy Letters* 10 (2025): 4703-4711. , *Energy & Environmental Science* 13, no. 7 (2020): 2056-2063.

Critical Material-Free Batteries – From Lab-Scale to Pilot-Scale and Beyond

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The battery manufacturing industry has a critical material problem! Over the recent years, rapid fluctuations in material prices have created a drastic supply chain constraint that threatens to derail the burgeoning projections for electric vehicles over the next few decades. Moreover, it is also important that any alternative battery material developed, should facilitate a seamless integration into existing global battery manufacturing infrastructures to avoid a complete overhaul. The search for viable alternatives that address these challenges simultaneously is a continuing quest in today's battery research and development sectors. Through this talk, I will highlight our paradigm shifting approaches in developing new classes of layered lithium-ion battery cathode materials with '0' cobalt in their compositions. These new class of battery cathodes, termed have the general formula, $\text{LiNi}_x\text{M}_1\text{yM}_2\text{zO}_2$ (where, $x + y + z = 1$ and $M = \text{Transition Metal Cations}$). These layered cobalt-free cathodes are analogous in crystal structure and material properties to mainstream cobalt containing cathodes such as NCMs and NCAs while delivering comparable and in some cases better electrochemical performance. Here, I will present our efforts in the systematic development of these novel cathodes starting from compositional landscape investigations and advanced in situ and operando characterizations in the lab-scale followed by scale-up efforts to upscale these cathodes to kg levels, using prevalent industrial processes such as co-precipitation in large continuous stirred tank reactors (CSTRs). Electrochemical performance assessments performed in both coin half-cell and pouch full-cell configurations will also be discussed. Overall, our research efforts in the development of this new class of critical material-free cathodes aims to mitigate the battery industry's cobalt problem paving a promising pathway towards the wide adoption of electric vehicles in the coming decades.

Advancements in Sodium-Ion Battery Technology: Novel Materials and Manufacturing Innovations

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Sodium-ion batteries (SIBs) have emerged as promising alternatives to lithium-ion batteries, offering potential advantages in resource abundance and cost-effectiveness. The pursuit of high-performance cathode and anode materials compatible with sodium-ion insertion/extraction processes has spurred innovation, showcasing notable potential in materials such as layered transition metal oxides, polyanionic compounds and hard carbons. This talk focus on the design and development of new cathode materials compositions and hard carbon production for sodium-ion battery demonstration. Further, ongoing developments in electrolytes, with a focus on enhancing sodium-ion transport and stability, coupled with novel cell configurations and sodium-ion full-cell systems, aim to overcome challenges associated with capacity and cycle life. Despite this progress, several challenges persist, including the quest for achieving high energy density, a comprehensive understanding of and effective mitigation strategies for electrode degradation mechanisms, and the optimization of large-scale manufacturing processes. This work emphasizes the ongoing efforts and potential breakthroughs in sodium-ion battery technology.

Keywords: Sodium-ion Batteries, Cathode materials, Anode, battery manufacturing, Electrochemical performance.

The Aditya Birla Group, a \$60 billion multinational conglomerate, is a global leader with diversified interests spanning metals, cement, textiles, carbon black, and financial services. Operating in over 36 countries, the group exemplifies excellence, innovation, and sustainability. Anchored by a forward-looking vision, mission, and core values, it continues to create long-term value for stakeholders while fostering inclusive growth. As a flagship company of the Aditya Birla Group, Hindalco Industries plays a pivotal role with its three primary business segments: Aluminum, Copper, and Specialty Alumina. Among these, the Specialty Alumina division stands out for its global impact, serving over 1,000 customers in 42 countries with a portfolio of more than 120 SKUs. Backed by over five decades of manufacturing expertise and strategically located global offices, Hindalco is a trusted supplier of versatile alumina products. We are proud to share our journey and advancements in specialty alumina tailored for electric vehicle (EV) and energy storage system (ESS) batteries. Our commitment to safety and performance has guided our innovations in response to pivotal industry moments, underscoring the critical importance of battery safety. As part of a diversified portfolio for lithium-ion batteries, Hindalco offers high-performance materials including aluminum and copper foils, and specialty alumina. Our focus is on how alumina plays a vital role in enhancing battery separator coatings and thermal management systems. We explore the distinctions between dry and wet separator technologies, noting the industry's shift toward wet separators to meet the demand for higher energy density. Our product evolution reflects our dedication to continuous improvement—from 3N to 4N alumina, and now toward boehmite, which delivers superior wettability, cost efficiency, and thermal stability. Our specialty alumina portfolio includes the SMA, HCA, IC, and UFB series, each engineered for specific applications in separator coatings and thermal interface materials. In addition, we are actively developing spherical alumina for next-generation thermal management solutions. Innovation at Hindalco is driven by strong R&D collaborations with leading educational institutions and our in-house Aditya Birla Science and Technology Company. We are also establishing a state-of-the-art battery lab to support advanced testing and product development. We invite industry partners to collaborate with us in shaping the future of battery technology through sustainable, high-performance materials.

Ceramics for Sustainability

INVITED SPEAKERS

Role and status on the advancement of Solid Oxide Cell Technology in India towards Atmanirbhar Bharat

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India has declared the goal to achieve Net Zero emissions by 2070. As India's growth story unfolds, its demand for energy and resources is set to rise. Energy use has doubled in the last 20 years and is likely to grow by at least another 25% by 2030. As per the report of National Green Hydrogen, published by Ministry of New and Renewable Energy (MNRE), India currently imports over 40% of its primary energy requirements, worth over USD 90 billion every year. Major sectors like mobility and industrial production are significantly dependent on imported fossil fuels. Blue Sky Projects having a long term (0-7 years in the first phase field trials and 8-12 years down the line for commercialization) horizon is planned with a focus on establishing global IP and competitive advantage for the Indian industry which will aim to develop capabilities of the Indian R&D sector within an array of subjects like 18 development of 3rd generation electrocatalysts, **Solid Oxide Fuel Cells (SOFCs), reversible Solid Oxide Electrolysers (SOECs) and,** seawater electrolysis, thermo-catalytic pyrolysis, plasma pyrolysis, salt cavern surveys, high entropy alloys for reversible hydrogen storage etc.

Solid oxide cell technology has the potential to deep decarbonize the eco-system by suitably converting the commercial grade H₂ for the usage along with methane, reformat gases, syn gases, bio gases including the flare gases from petroleum industries. CSIR CGCRI along with ARCI (International Advanced Research Centre for Powder Metallurgy and New Materials), HPCL (Hindustan Petroleum Corporation Limited) along CHT (Centre for High Technology) targets to develop pilot plant of SOFC technology. In this backdrop, the goal of the project is to scale up the existing CSIR-CGCRI's TRL-5 technology to a pilot plant to be established to a scale of 10 kW prototype with Hindustan Petroleum Corporation Limited as commercial deployer for this technology in due course of commercialization. The target is to establish a complete end-to-end process line for the production of 10 cm x 10 cm x 1.5 mm cells and stacks assemblies. The pilot plant capacity would be 10 kW is earmarked for scaling upto 10 kW to the future scale of economics of 200 kW – 500kW. Development and technology transfer of intermediate products such as electrode materials, single cells and stack components also will be addressed so as to accelerate commercialization by industries involved in SOFC technology.

Solid oxide cells (SOCs) play a major role in strategic visions to achieve decarbonization and climate-neutrality. With its multifuel capability, this technology has received rapidly growing amount of attention from researchers worldwide. Due to the great flexibility of SOC's with respect to the fuels that can be used, not only hydrogen, but also biogas, natural gas, diesel reformates and many other conventional and alternative fuels can be used. This makes it possible to couple SOC's with diverse sustainable fuel sources to generate electricity or to generate valuable fuels such as syngas when utilizing renewable electricity. The steel sector is one of the most carbon-intensive industries, and the sustainable strategies to reduce CO₂ emission on integrated mill plants are being discussed globally. The techno-economic analysis is suggestive to the maximum H₂ injection for the technical aspect and demonstration of the process economic viability considering the effects on the price of the SOEC system. It is further understood that

the net reduction of global warming potentials and carbon intensity shows that the coke replacement ratio ranges from 0.255 ~ 0.334 kg. Coke/ kgH₂ depending on injection conditions and that 25 kgH₂/ tHM was an acceptable maximum injection rate within the stable range of BF operating indexes. H₂ production cost to be US\$ 8.84 ~ 8.88 / kgH₂ in the present (2021-2022), but it is expected to be decreased to US\$ 1.41 ~ 4.04/ kgH₂ by 2050. Economic parity with the existing BF process will be reached between the years 2036 and 2045, depending on the maturity of the SOEC process. Injection of 25 kgH₂/ tHM can reduce CO₂ emission by 0.26 ~ 0.32 tCO₂-eq./ tHM. It is expected that this priming sustainable strategy to reduce CO₂ emission from integrated mill plants will widen applications of H₂ utilization in BFs if the economic efficiency of SOEC systems can be increased.

In this presentation, a short review of the existing knowledge about solid oxide fuel cell (SOFC) and solid oxide electrolysis (SOE) systems and how to safely operate them over the long-term, placing a special focus on real-world operating environments will be discussed in perspective of Indian Scenario and also to that of the role of the CSIR-CGCRI as a potential developer of this particular technology in Nation.

Enabling Sustainability Through Innovations in Diamond Tools

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Construction is one of the largest industries globally. It plays a central role in the world economy: it creates jobs for millions of people, provides housing to almost everyone living on our planet, and builds commercial, industrial and civil infrastructures that enable economic growth. The industry, however, faces significant challenges. It has not delivered productivity over the past decades. Historically, construction has been a traditional industry; workflows and processes have not fundamentally changed for generations. Skilled labor is in short supply and health and safety issues are abundant on jobsites. Carbon emissions are high and continue to rise. [1]

Innovations in diamond tool technology are playing a critical role in promoting sustainability in construction. Traditionally valued for their exceptional hardness and wear resistance, diamond tools are now being re-engineered through advancements in material science, precision manufacturing, and recycling technologies with an increasing focus on sustainability to minimize environmental impact throughout the product lifecycle while maximizing efficiency.

These innovations have led to extended tool life, reduced energy consumption as well as lower and healthier waste generation during operations. Furthermore, the integration of eco-friendly bonding agents is minimizing reliance on non-renewable resources and harmful chemicals. By enabling cleaner processes, improved resource efficiency, and decreased carbon footprints, modern diamond tools are transforming a traditionally resource-intensive industry into a more sustainable system. This is a big transformation, and it is not an easy one.

This paper highlights current developments, case studies, and future trends, emphasizing how innovation in diamond tooling serves as a catalyst for sustainable industrial transformation and how they become key enablers to support Hilti's purpose of "Making Construction Better" in terms of productivity, safety and sustainability.

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Tapping the cloud: Unlocking water and Energy from Ceramic Spray Dryer Exhaust

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Ceramic tile manufacturing is among the most water- and energy-intensive industries, with spray drying alone accounting for nearly 70 % of total water use and 30 % of process energy consumption. The humid exhaust from spray dryers—often vented to the atmosphere—contains over 95 % of the evaporated process water and significant recoverable heat. In the face of escalating water scarcity, energy costs, and climate-induced physical risks, this waste stream represents a major untapped resource.

This paper explores a circular-economy-driven recovery framework that transforms the spray-dryer exhaust into a dual source of reclaimed water and thermal energy. Through staged treatment—comprising pre-filtration (wet ESPs, scrubbers), condensation, and post-purification (RO/EDI)—the process yields high-purity water suitable for reuse in glazing and milling operations, while simultaneously capturing latent heat to reduce fuel demand. Various technological options, including direct- and indirect-contact condensation and sorption-based recovery, are evaluated for efficiency, corrosion resistance, and lifecycle cost.

The study emphasizes engineering resilience through material science, fouling control, and smart system integration, envisioning an industry shift from waste disposal to resource regeneration. By re-imagining water as an asset and aligning investments with ESG and carbon-pricing frameworks, ceramic manufacturers can future-proof operations against volatility in both energy and water supply.

“Water saved is progress made—जल है तो कल है.”

CONTRIBUTORY SPEAKERS (ORAL)

(Na_{1-x}K_x)_{0.5}Bi_{0.5}TiO₃ (NKBT) - Based Piezocatalysis: A Sustainable Solution for Wastewater Remediation

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Piezocatalysis, an eco-friendly technology that converts ambient mechanical energy (e.g., vibrations, noise) into chemical energy via piezoelectric materials, has emerged as a promising alternative to traditional catalysis for applications such as dye degradation, water splitting, medical therapy, and aquatic environment remediation. By generating highly reactive species for breaking down complex organic pollutants, piezocatalysts offer a sustainable, cost-effective solution to persistent contaminants like industrial dyes. The present work investigates (Na_{0.8}K_{0.2})_{0.5}Bi_{0.5}TiO₃ (NKBT) ceramic as a lead-free piezocatalyst for sustainable wastewater treatment. NKBT powders were synthesized via solid-state sintering (calcination at 800 °C for 6 h and sintering at 1150 °C for 3 h) and confirmed by X-ray diffraction to be a single-phase perovskite with coexisting rhombohedral(R) and tetragonal(T) distortions at the morphotropic phase boundary. The SAED pattern of NKBT indicated the coexistence of R and T phase nanodomains in the ceramics, which is consistent with the XRD data. Piezocatalytic activity was assessed by degrading a 5 mg L⁻¹ Rhodamine B solution using 100 mg of NKBT dispersed in 50 mL of dye solution. Ultrasonic treatment was conducted in a 53 kHz, 100 W bath with aliquots withdrawn every 15 min up to 90 min; dye concentrations were determined by UV–Vis spectroscopy at 554 nm. Under these conditions, NKBT achieved ~69 % decolorization within 90 min, following pseudo-first-order kinetics ($k \approx 0.013 \text{ min}^{-1}$). The performance was tempered by the use of micrometer-sized powders, partial depoling during pellet crushing, and the inability to remove catalyst particles after dye degradation before recording the UV spectra. Further, the work is focusing on nanoscale NKBT synthesis, gentle poling methods, and catalyst-separation techniques to fully realize its piezocatalytic potential. Piezocatalytic activity will also be evaluated using impact and attrition methods to enhance the understanding and significance of piezocatalysts in dye degradation processes. This study establishes NKBT as a promising candidate for mechanically driven advanced oxidation processes in real-world wastewater treatment.

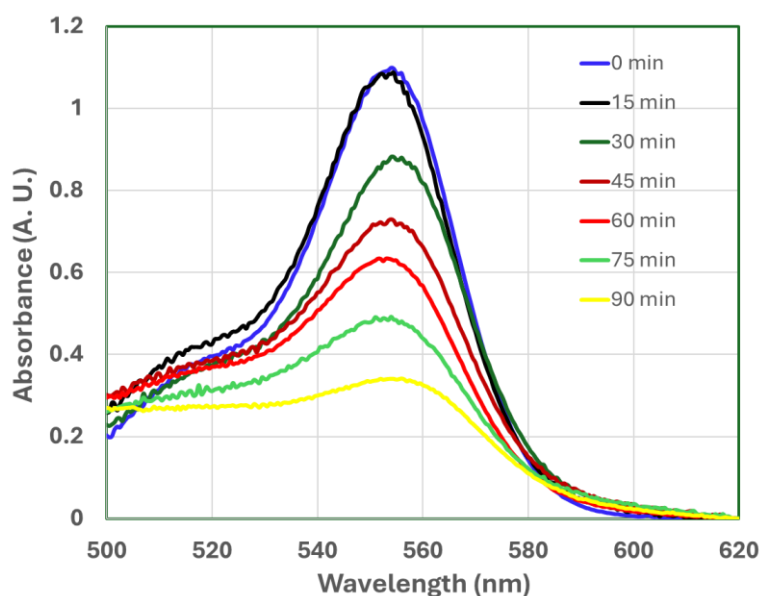


Fig. 1. UV-Vis spectra of RhB dye solution after sonication with NKBT piezocatalyst.

Table 1. Piezocatalytic performance of NKBT ceramic for degradation of RhB dye at different sonication time intervals.

Sonication time (min)	Max. Absorbance A (a.u.)	Concentration of solution after sonication C (mg/L)	Dye Degradation rate D (%)	Rate constant, k (min ⁻¹)
0	1.099	5.000	0.00	0
15	1.088	4.917	1.00	0.001
30	0.882	3.986	19.75	0.008
45	0.729	3.294	33.67	0.009
60	0.633	2.861	42.40	0.009
75	0.492	2.223	55.23	0.011
90	0.34	1.536	69.06	0.013

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CONTRIBUTORY SPEAKERS (POSTER)

Preparation and characterization of clay-based geopolymer for adsorptive dye removal

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The rapid rise in human population and their exploitation of natural resources, especially water, have severely deteriorated ground and surface water quality, posing serious environmental concerns. Clay-based adsorbents offer a promising solution for the remediation of such contamination in wastewater. This study investigates metakaolin-based geopolymer adsorbents for removing cationic dye from aqueous solutions. Geopolymer adsorbents were synthesized by varying the $\text{Na}_2\text{SiO}_3/\text{NaOH}$ content to achieve different $\text{SiO}_2/\text{Na}_2\text{O}$ ratios (1.3 to 1.5) in the activator and by adjusting the metakaolin-to-alkali-activator ratio to produce batches with distinct $\text{SiO}_2/\text{Al}_2\text{O}_3$ compositions. The impact of these variations on geopolymer phase formation and adsorption efficiency was studied. The raw clay and the alkali-activated reaction products were described using various techniques to determine their oxide composition, phase formation, surface area, and morphology. Batch adsorption experiments and UV–Visible spectroscopic study are carried out to evaluate the adsorbents' performance in removing methylene blue dye. The results revealed that the prepared adsorbents effectively treated the dye-contaminated water, with optimized batches achieving removal efficiencies greater than 80%. Electrostatic attraction facilitated the adsorption of cationic dye on the adsorbent surface, while chemisorption strengthened and stabilized the overall process; the combined effect of these two mechanisms enhanced the adsorption efficiency. The batch adsorption data followed the pseudo-second-order kinetic model and the Langmuir isotherm, indicating that dye uptake occurred via monolayer chemisorption. This work demonstrates that metakaolin-based geopolymers, with a tailored alkali activator and precursor ratios, can be effective, sustainable adsorbents for removing cationic dyes from contaminated water [1].

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Influence of Calcium Addition on the Stability, Structure and Photocatalytic Properties of (Mg, Co, Ni, Cu, Zn)O High Entropy Oxide

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The discovery of high entropy oxides (HEOs) has piqued the interest of researchers, extending the concept of phase stabilization through manipulating configurational entropy ($\geq 1.609R$ per mole) to ceramic materials, which typically stabilizes a single-phase solid solution. Multicomponent transition metal (TM) oxides have exhibited remarkable potential as catalysts mainly because of synergistic interactions among the active sites. We have synthesised (Co, Mg, Ni, Cu, Zn) $_{1-x}$ Ca $_x$ O ($x = 0.05, 0.1$) high entropy oxide (HEO) photocatalyst with single phase rocksalt structure (space group $Fm\bar{3}m$) using the solution combustion synthesis (SCS) method. The impact of strain, induced due to the addition of an isovalent larger cation Ca^{2+} ($\sim 1 \text{ \AA}$), on the stability landscape has been investigated. The variation in the crystal field splitting due to the elements with different electronegativities shows a reduced band gap compared to their individual oxides. The introduction of Ca^{2+} enhances covalency by increasing the exchange interaction between O 2p and TM 3d orbitals, further narrowing the band gap and boosting the photocatalytic activity in the visible spectrum. Ideally, in the rocksalt structure of (Co, Cu, Mg, Ni, Zn)O, each cation is symmetrically surrounded by anions; however, substituting Ca^{2+} , due to its larger ionic radius, introduces lattice distortions. These distortions can cause a deviation from the ideal rocksalt structure, leading to a distorted rocksalt phase. The extent of these distortions in Ca^{2+} -doped (Co, Cu, Mg, Ni, Zn)O are investigated using transmission electron microscopy.

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Paver block and composite cement development using CO₂ sequestered LD-slag through mineral carbonation

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Climate change due to global warming is a worldwide serious concern. The unprecedented rise of atmospheric level of carbon dioxide (CO₂), as a major greenhouse gas is responsible for global warming. The environmental CO₂ concentration rises from 390 ppm at the pre-industrial era to 422 ppm at present day is driven largely by fossil fuel combustion in power plants, steel and cement production and other man made activity which attracts global concern with pressing environmental challenge among the research fraternity. Kyoto Protocol, Copenhagen Accord, and International Energy Agency (IEA) also have urged concerns on mitigating greenhouse gas emission level by 5.2% with limitation of global temperature rise within $\pm 2^{\circ}\text{C}$ by 2100 and also suggested the contribution of CCUS technology up to 19% by 2050. In this work, mineral carbonation is performed using LD slag at room temperature and atmospheric pressure. Carbonated LD slag (CLS) is used in development of composite cement in comparison with OPC 53 grade through various property study and compressive strength test at CSIR-NML facility. The CLS is also used to produce M-35 to M-45 grade Paver block which can be used for light to medium traffic application. Optimization study with compositional variation and corresponding physical properties with compressive strength has performed. Techno-economic analysis has also performed to marketable this product with selective future modification.

Development of sustainable adsorbent for cationic dye removal: A fresh start for waste valorization

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Industrial wastewater treatment has been a serious global issue in recent decades, and waste management necessitates the invention of new, cost-effective, sustainable technologies. There is a massive demand for potential wastewater purification methods using eco-friendly, low-cost materials. Adsorption is the most affordable, reliable, and quickly operational wastewater treatment method [1]. In the 21st century, a rising demand for environmentally friendly porous geopolymer adsorbents may be produced from industrial waste via the circular economy concept. This work prepares a cost-effective, porous, shaped, fly-ash-based adsorbent to remove cationic dyes from wastewater efficiently. Various percentages of GGBS and clay are combined with fly ash to improve the removal efficiency of the synthesized adsorbent. Parent batches are activated using an activator solution of sodium silicate and sodium hydroxide to prepare the geopolymer slurry. To create a foamed slurry with good workability, sodium dodecyl sulfate was added as a foaming agent. Using the injection solidification process, the slurry was injected drop by drop into the PEG-600 medium using a syringe. The bead-shaped adsorbents are then cleaned and dried. Standard techniques (FTIR, XRF, XRD, and SEM-EDX) were used to characterize the adsorbents. Methylene blue (MB), a hazardous dye, was removed from water using batch mode to assess the adsorbents' adsorption capabilities. The ideal geopolymer-shaped adsorbent demonstrated a high % adsorption efficiency of 97% for 10 mg/L of MB dye solution at room temperature. The adsorption kinetics and isotherm were studied to explain the factors affecting the adsorption mechanism and how the geopolymer's unique ion exchange capabilities generally enabled it to adsorb MB. The study thoroughly examines the adsorbent's features, including the regeneration and desorption process.

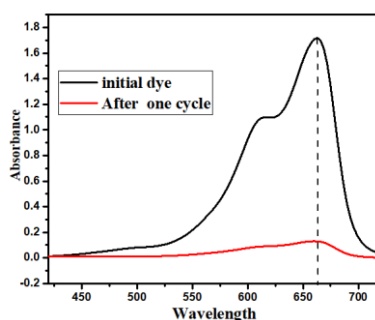


Fig. 1. Initial and final MB dye absorption spectra of shaped geopolymer

Keywords: Adsorbent; Geopolymer; Methylene blue; Porosity; Fly-ash; Dye removal.

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Ceramics for Nuclear Applications

INVITED SPEAKERS

Development of Lithium-based Ceramics for Fusion Reactor Application

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Nuclear fusion offers a promising pathway to abundant, clean, and low-cost energy. In the fusion process, light nuclei are forced to combine, releasing a substantial amount of energy that can be harnessed for electricity generation. The most widely studied fusion reaction involves two hydrogen isotopes—deuterium and tritium—producing a helium atom and a neutron. While deuterium is readily available from seawater, tritium is scarce in nature due to its short half-life and must therefore be bred *in situ* within the reactor using lithium through a transmutation reaction.

Lithium titanate (Li_2TiO_3) is a leading candidate for tritium breeding applications in nuclear fusion reactors owing to its favorable properties such as high lithium atom density, efficient tritium release at low temperatures, low activation characteristics, low thermal expansion coefficient, and high thermal conductivity. In fusion systems, the breeder material is typically employed in a pebble-bed configuration, which offers advantages such as ease of filling and optimization of packing density. However, this design also presents challenges, including pebble movement, fracture or fragmentation, sintering, and limited thermal contact at the breeder-wall interface.

To address these limitations, engineered porous breeder structures with interconnected porosity are being explored, offering improved temperature uniformity, enhanced tritium release, and greater mechanical stability. In this study, lithium titanate foams were synthesized for the first time at BARC using a sponge replication technique, yielding highly porous structures with interconnected pores. Furthermore, hyper-stoichiometric lithium titanate, containing an excess of lithium, was developed and characterized to assess its performance relative to the stoichiometric composition. The enhanced functional properties of the hyper-stoichiometric lithium titanate foam and its potential advantages for tritium breeding applications will be discussed in this presentation.

Silicon carbide and its Composite for Nuclear Applications – present status and developmental activities in BARC

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Silicon carbide (SiC) is a promising material for nuclear applications due to its exceptional thermal stability, radiation tolerance, mechanical properties and corrosion resistance. Its strong covalent bonding provides structural integrity under extreme irradiation and high temperature environment. SiC composites are being explored for fuel cladding, structural components, and accident-tolerant fuel systems in fission and fusion reactors. Moreover, its low neutron absorption cross-section and chemical inertness enhance safety and efficiency. It also serves as a crucial structural and barrier layer in TRISO (TRi-structural ISOtropic particle fuel) fuel particles, ensuring fission product retention and enhancing fuel safety. Low activation in the presence of neutron-producing fusion plasma is the major rationale for the use of silicon carbide in fusion reactors. The development of SiC-based fuel tubes poses a significant challenge owing to the material's low fracture toughness and inherent brittleness. This limitation can be addressed through the development of silicon carbide fiber–matrix composites. The recent status of SiC as a nuclear material and the developmental activity in Bhabha Atomic Research Centre which includes synthesis of SiC fibre, and densification and component development of monolith and composite ceramic will be highlighted in this presentation.

Challenges in processing of boron-containing ceramics for nuclear applications

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Boron containing ceramics are used as neutron absorber material in nuclear reactor because of high neutron absorption cross section of its isotope B^{10} which has its natural abundance of around 19.9%. The neutron absorber materials are required for making control rods, shut-off rods and neutron shielding applications. Potential boron ceramics include aluminum borate, boron carbide, various metal borides. Several challenges are encountered while processing boron containing ceramics. The most common problem is the loss of boron, primarily in the form of its oxide, during processing, be it high temperature synthesis or sintering. Understanding the mechanism of boron loss is important in order to overcome or minimising the problem. The other challenge is associated with sintering of boron containing non-oxide ceramics like boron carbide and metal borides because of their strong covalent bonding resulting in low self-diffusivity. The choice of sintering additives is limited in order to maintain high purity required for nuclear applications. The requirement of high sintering temperature causes significant grain growth which degrade the mechanical properties and resistance against irradiation swelling in many cases. Presence of surface oxide in the powder of these ceramics often impede densification. Advanced techniques like Spark Plasma Sintering (SPS) and Hot Pressing are useful to overcome the challenges in densification and microstructure control. In the presentation various powder metallurgical aspects and manufacturing challenges associated with these specialised materials will be covered.

CONTRIBUTORY SPEAKERS (ORAL)

Tuning Photoluminescence in ZnS:Ag,Cl Phosphors through Ag Ion Doping for Scintillation Applications

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Zinc sulfide (ZnS)-based phosphors doped with silver (Ag^+) and co-doped with chlorine (Cl^-) have emerged as promising materials for scintillation applications due to their efficient photoluminescence, fast response, and stability. In this study, the effect of Ag ion concentration on the photoluminescent properties of ZnS:Ag,Cl phosphors was systematically investigated to optimize luminescence performance for scintillator use. Phosphor samples were synthesized via a solid-state reaction method, incorporating varying concentrations of Ag^+ ions while maintaining constant Cl^- co-dopant levels to facilitate charge compensation and enhance luminescent efficiency.

In this work, X-Ray Diffraction (XRD) analysis of ZnS:Ag,Cl powder confirmed the formation of a pure cubic ZnS phase with no secondary phases, indicating successful doping without structural degradation. Photoluminescence (PL) measurements revealed that Ag^+ ions act as efficient luminescent centers, with emission intensities strongly dependent on the doping concentration. The characteristic blue emission peak around 450 nm, attributed to Ag^+ -related donor-acceptor pair recombination, showed a marked increase in intensity with increasing Ag content up to an optimal level. The presence of Cl^- ions was found to play a critical role in enhancing luminescence by aiding in charge balance and reducing defect states that typically act as non-radiative centers. The optimized ZnS:Ag,Cl composition demonstrated high luminescent efficiency, short decay time, and good spectral compatibility with photodetectors, making it a suitable candidate for scintillation-based radiation detection systems. Detailed results will be presented during the conference.

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Effect of Composition, Green Density and Temperature on Reaction Bonded -SiC prepared by Si infiltration

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Silicon carbide ceramics are attractive material for their use as structural application in nuclear industry, for equipment parts in semiconductor industry and optical mirror devices in space application [1]. The wide variety of SiC application is attributed to the combination its various properties such as low density, high stiffness, high hardness, high fracture toughness, high thermal and chemical stability, and good thermal and oxidation resistance [2]. However, the sintering of SiC powders for fabrication of high-density bulk SiC ceramics is difficult [3]. An alternate SiC synthesis method is reaction -bonded SiC where liquid Si is infiltrated in SiC-C preform. During the infiltration, carbon reacts with silicon to form additional SiC, bonding with pre-existing SiC particles. In the present study, we have studied the effect of preform's composition, green density and the reaction temperature on the final density, microstructure and mechanical properties of reaction bonded SiC. We have optimized the required green density of preform for maximum conversion of C into SiC. In an attempt to achieve this required density in pressed green preforms, different starting composition with varying SiC and C ratio and particle sizes have been prepared. The scanning electron microscope (SEM), Raman mapping and X-ray diffraction (XRD) are carried out on infiltrated samples. Infiltrated RBSiC sample with <95% of relative density and less than 5% residual Si has been achieved. This sample exhibited an average micro-hardness of approximately 24 GPa, comparable to conventionally sintered silicon carbide.

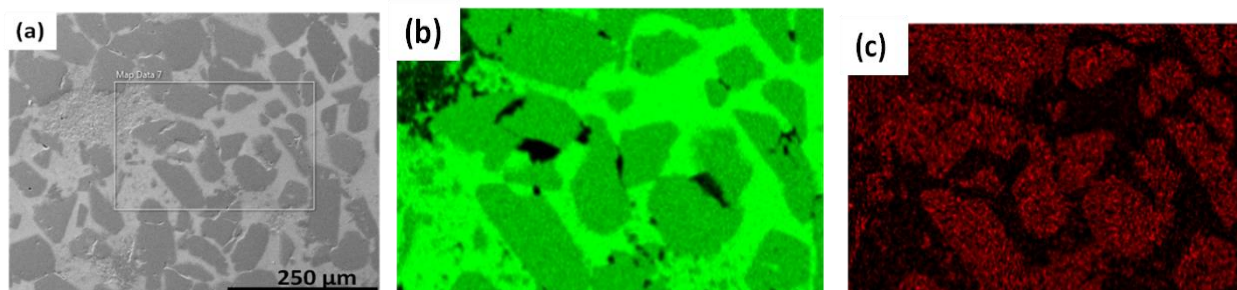


Fig. 1. SEM image of (a) infiltrated pellet and EDS maps of the corresponding area for (b) Silicon and (c) carbon.

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CONTRIBUTORY SPEAKERS (POSTER)

Synthesis, Densification, and Characterization of NbB₂ and TaB₂ for High-Temperature and Nuclear Applications

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High-purity niobium diboride (NbB₂) and tantalum diboride (TaB₂) are ultra-high-temperature ceramic materials with significant potential in demanding high temperature structural, nuclear, and aerospace applications. This study presents the carbothermic reduction for synthesizing phase-pure NbB₂ and TaB₂ powders, densification and characterisation. For NbB₂, reduction of Nb₂O₅ using B₄C and C was optimized under vacuum, enabling kilogram-scale production of single-phase NbB₂ powders. Mechanical milling yielded an average particle size of ~3.1 μm, with oxygen and carbon contents below 0.5 wt%. Hot pressing at 1800°C achieved 93 % of theoretical density. Nano-indentation of the hot-pressed NbB₂, obtained the hardness of 27.9 GPa and elastic modulus of 705 GPa; flexural strength value measured as 339 MPa in three-point bending tests. TaB₂ powders were also synthesized by carbothermic reduction of tantalum oxides with 25 % excess B₄C charge at 1800°C in high vacuum. The milled powders were consolidated using hot pressing (with and without sintering aids) and spark plasma sintering. This work provides a robust, efficient, and scalable pathway for producing and consolidating NbB₂ and TaB₂ ceramics, laying the foundation for their deployment in next-generation structural, nuclear, and aerospace applications.

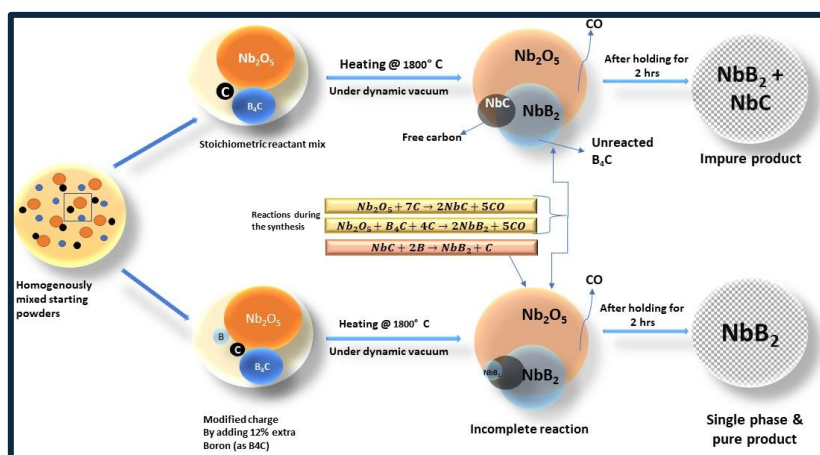


Fig. 1. Carbothermic reduction of Nb₂O₅ with stoichiometric and modified charge compositions

Reference: <https://doi.org/10.1016/j.ijrmhm.2023.106119>

Synthesis of Nanocrystalline γ -LiAlO₂ Powder: Enhanced Sinterability and Microstructure Control

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Gamma-lithium aluminate (γ -LiAlO₂) is a leading material for fabricating Tritium Producing Burnable Absorber Rods (TPBARs), which are used to breed tritium for strategic reserve and fusion reactors. However, a significant challenge in TPBAR fabrication is the high sintering temperature, which leads to Li-evaporation and a large grain size. This has a detrimental effect on tritium breeding performance. To mitigate these issues, a highly sinter-able nanocrystalline γ -LiAlO₂ powder (with an approximately 50 nm crystallite size) is synthesized by mixed-fuel (citric acid and glycine) solution combustion method, which exhibited a remarkably low sintering temperature. The phase-purity of synthesized powder was confirmed through Rietveld refinement of X-ray powder diffraction (XRD) pattern. Scanning Electron Microscope (SEM) images revealed a soft-agglomerated irregular flake-like morphology of the powder particles. Sintering of cylindrical pellets showed that a relative density of approximately 93% was achieved at a sintering temperature of 900°C. At 950°C, density increased significantly to 97-98% with a small grain size of 2-4 μ m. Further increasing the sintering temperature to 1000°C and 1050°C led to abnormal grain growth and the formation of numerous closed pores, without any significant improvement in pellet density. Interestingly, chemical analysis of the sintered pellets by Inductively Coupled Plasma Atomic Emission spectroscopy (ICP-AES) revealed that no Li evaporation occurred during sintering process. This finding is particularly significant as it demonstrates the effectiveness of the low-temperature sintering approach in preserving the critical Li-content.

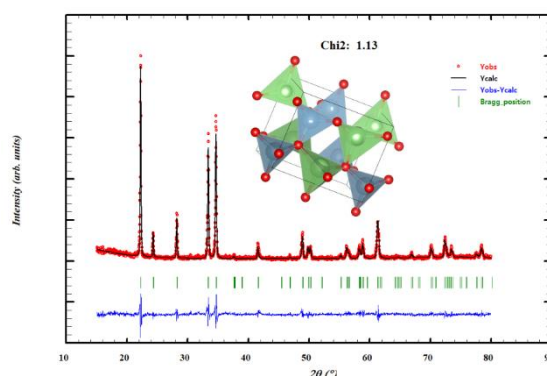


Fig. 1. Rietveld refinement of XRD pattern of γ -LiAlO₂.

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Thermal properties of aluminium borate whisker reinforced Alumina matrix composites

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The thermal properties of alumina-based composites with in-situ formed aluminum borate ceramic ($\text{Al}_{18}\text{B}_4\text{O}_{33}$) have been investigated. The initial constituents for the synthesis of the composites were alumina and boric acid. The boric acid was used as a source of B_2O_3 , where B_2O_3 reacted with Al_2O_3 to form aluminum borate. The Aluminum borate phase has been varied from 10wt% to 70 wt% and its effect on thermal conductivity was studied. The composite pellets were sintered in powder bed of aluminium borate powder @1650°C,4h to avoid boron loss. All the composite pellets sintered in powder bed had shown only ~1% boron loss from the system and 92-96% theoretical density have been achieved. SEM microstructure of the composites shows dense alumina microstructure but porosity was observed near aluminum borate phase hindering the densification process. In all the composites, the thermal conductivity is decreasing with increasing temperature but samples containing higher amount (more than 50%)of aluminum borate, the temperature dependence of thermal conductivity is less pronounced. The thermal conductivity of the composites is decreasing with increasing content of the aluminum borate.

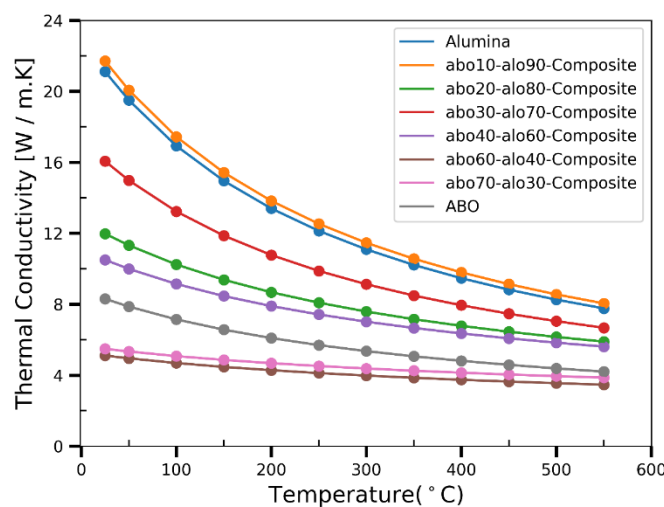


Fig. 1. Thermal conductivity variation in Alumina-Aluminum Borate composites with varying the aluminum borate weight percent.

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Refractories

INVITED SPEAKERS

Low carbon $\text{Al}_2\text{O}_3 - \text{C}$ refractories: a study on use of only nano-carbon

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The continuous casting process of steel requires various flow control refractory devices or functional refractories to perform certain specific targeted tasks related to molten steel flow. Primarily these refractories are of $\text{Al}_2\text{O}_3 - \text{C}$ compositions wherein residual carbon content goes even upto 25 – 30 wt%. Carbon, mostly used as graphite, imparts and enhances thermal shock resistance due to its low thermal expansion with high thermal conductivity and corrosion resistance due to its non-wetting character, especially against the silicate slags. But, presence of high carbon enhances the chances of carbon pick-up by molten steel (deteriorating steel properties), heat loss due to higher conductivity, formation of greater extent of CO_x gases on oxidation (causing environmental challenges), and formation of porous structure within the refractory on oxidation causing drastic deterioration in refractory properties, especially hot strength and corrosion resistance.

To counter these challenges, refractory researchers have worked with various carbon sources and come out with a new type of composition wherein a mix of graphite and nano-carbon is used as carbon source with a drastic reduction in total carbon content to below 5 wt%. In continuation to that trend, the present work describes a study where the graphite is completely replaced by nano-carbon and variation of nano-carbon content was done between 1 – 4 wt%. The refractories are prepared by conventional manufacturing technique and various physical, mechanical and thermo-mechanical properties are evaluated along with the study on phase formation, microstructural developments, oxidation resistance at different temperatures. All the properties are compared against the conventional $\text{Al}_2\text{O}_3 - \text{C}$ refractory containing 25 wt% graphite processed under exactly same processing conditions using the same raw materials. Nano-carbon, due to its higher reactivity, forms greater extent of in-situ ceramic phases, even at much lower temperatures, enhances strength and other properties. But, nano-carbon content above 2 wt% is found to be detrimental.

New Generation Ceramic Welding Powders for Hot Repairs in Glass Furnaces

K.G. Venkatesan (Fosbel India)

Glass melting furnaces need to produce high quality glass over a long period of time. Hot repair is indispensable for modern glass manufacturing, enabling continuous production while addressing maintenance needs. With advancements in materials and technology, the process is becoming more efficient and safer.

Ceramic Welding has proved to be a very efficient preventive maintenance hot repair technology for maximizing the furnace campaign life. In order to maximise the repair life and minimize contamination of glass during the ceramic welding process, Fosbel have developed a range of new generation ceramic welding powders known as **Nano-Tec™** materials which have helped the glass makers to meet the above objectives.

This paper explains the features of Nano-Tec™ range of Ceramic Welding powders developed by Fosbel and the techno-economic benefits that can be derived by use of these advanced materials.

ASSESSING THE EFFECT, A REFRACTORY INSULATION LINING HAS, ON EAF ENERGY CONSUMPTION

Mario Taddeo

Pyrotek®

Area MANAGER (ISOMAG®) ASIA & PACIFIC

Electric Arc Furnaces (EAF) are the single highest consumer of electricity within a mini mill steel plant. Their magnesia based refractory linings offer optimum performance at the expense of increased heat loss. The heat loss can be addressed by incorporating an insulating refractory board, without compromising vessel capacity. However, it is important to select an insulating material that has the necessary thermal structural integrity to provide optimum performance and lining security in this environment.

This paper determined the effect of incorporating Structural Insulation board in the refractory lining of the Electric Arc Furnace at an Australian Mini Steel Mill. This material was selected since it has excellent mechanical properties at elevated temperatures.

The outcomes of the comparative testing from the use of insulation are as follows:

- Average 70 deg-C shell temperature reduction.
- Average energy consumption reduced by 1.4%.
- Less energy losses for higher Tapping Temperatures and Tap to Tap Times.
- Theoretical return on investment (ROI) calculation with the use of insulation.
- Theoretical calculation in greenhouse gas emission reduction.

Key Words: EAF – Electric Arc Furnace; ISOMAG®70XCO – Backup Refractory Structural Insulation Board; Working Lining, Insulation Lining, Shell Temperature Measurement, GHG – Greenhouse Gas, Energy Consumption, Tap to Tap.

Improvement in corrosion and oxidation resistance with higher hot strength of Magnesia Carbon bricks for increasing the lining life of converters and steel teeming ladles in Indian steel plants

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Magnesia carbon (MgO-C) bricks are shaped refractory products made from dead burnt /sea water/ electro fused magnesia and graphite as carbon source. The bonding system is based on polymer binder and carbon additives including addition of antioxidants and the products are tempered for proper curing. Application under high temperature, the MgO-C bricks form carbon skeleton bonding which are very strong in nature. MgO and carbon do not have any mutual solid solution and hence the superior refractory properties of both the components are retained in the bricks. Moreover, carbon is not wetted by slag and as such good resistance to wear by slag.

In Champion Ceramics, Champa, MgO-C bricks for steel ladles and converters have been made since many years. Over this period various experiments have been carried out for improvement in quality of MgO-C bricks. This includes proper selection and use of Fused magnesia with higher B.D (3.40gms/cc) and crystal size (+500 micron) along with CaO/SiO₂ ratio more than 2.0 with less SiO₂ to obtain high temperature strength as some of the CaO enters into the solid solution in the MgO phase in order to achieve a refractory dicalcium silicate phase which has high melting point at the periclase crystalline boundaries.

Experiments carried out using 96-97% flake graphite and suitable binders having high fixed carbon (FC) and appropriate non- volatile matter (NVM) and viscosity along with appropriate combination of antioxidant and controlling granulometry which yielded reduction in coke porosity (8-10%) and apparent porosity (3-4%) and improvement in cold crushing strength(CCS) (450-500 kg/cm²) and coked strength (245--350 kg/cm²).

Further new studies have been conducted by addition of different antioxidant powders in MgO-C bricks for improvement of oxidation resistance and hot strength properties. It was followed by optimum addition of high temperature carbon into the resin bonding system having coking value 85% which resulted in increasing oxidation resistance, higher hot strength and higher mechanical flexibility due to formation of an anisotropic and graphitizable coke structure as compared to only glassy carbon like coke structure and thereby resulting better thermal shock stability. The special advantages of addition of high temperature carbon were its low micro porosity, structural flexibility and its non-brittle behavior.

The newly developed MgO-C bricks have been used as zonal lining in secondary steel ladle and converters in Indian Steel plants. The lining life of both steel teeming ladles and converter could be enhanced substantially including obtains highest lining life of 165 T converter in India (+ 13,800 heats) in IISCO , SAIL, Burnpur Plant and highest lining of 300 T steel ladle in Bokaro steel plant (+ 205 heats) incorporating the developed modifications.

In this paper a detailed description of development work done for improvement in MgO-C bricks quality vis-à-vis its performance improvement has been outlined.

Hydrogen Fuel and the Durability of Refractory Linings: Mechanisms, Risks, and Material Strategies

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The increased use of hydrogen as a combustion and process gas is transforming high-temperature industries, presenting distinct challenges for refractory linings. Unlike conventional carbon-based fuels, hydrogen generates a furnace atmosphere high in water vapor and with unique redox characteristics, accelerating chemical wear mechanisms in refractory materials. Silica-containing refractories are especially vulnerable: thermodynamic and laboratory studies confirm that SiO_2 phases react readily with hydrogen, forming volatile SiO that leads to extensive silica loss, particularly at high temperatures and low pressures. This process begins with the reduction of glassy phases, then proceeds to degrade mullite and, eventually, to substantial secondary alumina formation. In contrast, high-alumina and corundum-based refractories demonstrate superior corrosion resistance in hydrogen atmospheres, indicating their suitability for next-generation furnace linings. Recent industry corrosion studies highlight that oxide impurities can drastically affect performance compared to porosity. Notably, a shift to hydrogen use also increases corrosion rates for most materials between $1,250^\circ\text{C}$ and $1,400^\circ\text{C}$, meaning durability and material optimization must guide future refractory selection. The transition to hydrogen fueling, therefore, demands substantial adaptation of lining concepts and careful material engineering to maintain reliability and longevity in aggressive, hydrogen-rich environments.

Vesuvius's Advanced refractory Spinel base Solutions for Induction furnace

Shrijit Kulkarni*, Vijay Anand, Laurence Lamy

Induction furnace technology has become a preferred route for steelmaking, offering flexibility, energy efficiency, and suitability for small- to medium-scale operations with lower capital expenditure. Currently, around 50 million tons of steel are produced via induction furnaces, with coreless furnaces of increasingly larger capacities, up to 50 MT, being installed. The conventional choice for working lining in induction furnaces is silica ramming mass (acidic ramming mass). However, its use poses significant challenges, including premature refractory failure, cracking, metal penetration, and accelerated erosion from slag attack. Silica's sintering temperature ($\sim 1200^{\circ}\text{C}$) leads to full-depth sintering of the rammed lining, increasing safety risks in case of metal penetration, particularly in furnaces above 30 tons.

To address these challenges, Vesuvius has developed the Kellundite series—dry vibratable, spinel-forming alumina-based ramming masses with a three-layer sintering structure (powder back up to protect coil). The materials are designed for high rammed density and uniformity, with controlled in situ nano spinel formation ensuring predictable expansion and densification. Vesuvius have 300 kg lab-scale induction furnace which enables recipe optimization for different metal and slag chemistries. Variants of Kellundite developed specifically to give better performance for Stainless Steel, Medium Carbon Alloy Steel, High Mn steel and Ultra-low carbon steel chemistries. Recently Vesuvius has introduced Kellundite-MS800 for mild steel and Kellundite-85 for stainless steel (200/300/400 series). MS800 has demonstrated stable performance under aggressive millscale usage in Saudi Arabia and is expected to provide reliable, improved lining life in India for furnaces >30 tons, with capability to have more than 8 black patchings reducing specific refractory consumption. Kellundite-85 has achieved consistently at par performance in 25-ton stainless steel furnaces, with positive customer feedback. The Kellundite series offers enhanced campaign life, improved slag resistance, consistent quality, and safety against metal penetration. Kellundite is an ideal refractory solution to address the key limitations of conventional silica ramming masses in large induction furnaces.



Fig.1: Kellundite MS 800 After 40 heats with millscale | Fig.2: K85 after sintering heat

Keywords: Induction furnace, Spinel forming ramming mass, Safety, Mild steel

Interaction of MgO-C refractory with steel and slag and its effect on inclusion in low carbon Al-killed steel

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The demand for clean steel has increased significantly over the past two decades. Despite efforts to remove impurities, the heats were still rejected by customers mainly because of inclusions present in the steel. Controlling inclusions is essential for the steel-making industry to maintain the quality of steel. Inclusions during secondary refining can originate from slag or the ladle refractory. In low-carbon Al-killed steel, inclusions can change from alumina to MgO-containing spinel. This alumina-to-spinel transformation typically occurs in two steps: 1) reduction of MgO at the steel-refractory or steel-slag interface, and 2) reaction between dissolved magnesium in the steel and alumina inclusions.

Kumar[1] studied the transformation of alumina to spinel inclusions resulting from the reaction between steel and a MgO crucible. They found that impurities in the MgO crucible can lead to the formation of a liquid, slag-like layer at the steel-crucible interface. The presence of this slag-like layer can enhance the Mg transfer rate by about 20 times compared to the formation of a crusty spinel layer at the crucible surface. At an industrial scale, the presence of ladle glaze can significantly accelerate Mg transfer from refractory to steel. This work aims to understand that effect through laboratory-scale experiments. MgO-C refractory, both uncoated and slag-coated, was dipped in low-carbon Al-killed steel. Steel samples were collected every five minutes, and inclusion analysis was performed using manual and automated methods, including SEM-EDS. The steel-refractory interface was also examined via SEMEDS. It was observed that MgO-C refractory contributes to inclusions in two ways: a) converting existing alumina inclusions to spinel inclusions, and b) entrapment of MgO micro-fines from MgO-C refractory, which then transform into spinel inclusions. The glaze formation on MgO-C refractory was simulated by dipping it in molten slag. The glazed refractory showed an earlier formation of spinel than the uncoated refractory.

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Innovative Refractory Lining Solution: Minimizing Downtime During Shutdown Through Out of Box Approach

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We have a Combustion chamber in our Alkylolation unit at Jamnagar. This Chamber was designed with brick lining system. Since commissioning, we had hot spot & Refractory failure resultant into unplanned outage. This has ultimately warranted to have relining done for zone-1. Conventional in situ replacement was requiring 70 days. To address this challenge, an innovative approach was developed to replace the affected section with an upgraded refractory material capable of withstanding the corrosive environment & out of box replacement strategy. A standalone refractory-lined section for Zone-1 was prefabricated and installed during a planned shutdown, significantly reducing downtime. This strategic intervention enabled the complete replacement activity to be executed in just 20 days, compared to the conventional 70 days required for in-situ refractory lining. This paper presents the details of innovative approach to reduce downtime and minimise the business loss.



CONTRIBUTORY SPEAKERS (ORAL)

Enhancing Relining Efficiency and Durability in Reheating Furnace Skid and Post Beams: A Novel Plastic Refractory Solution

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The skid and post beam configuration in Reheating Furnaces plays a crucial role in maintaining operational efficiency and longevity. Traditionally, a steel pipe circulates cooling water while refractory material is applied to the outer surface to prevent steel deterioration. However, challenges arise from mechanical impacts, thermal shocks, and erosive damage, leading to frequent furnace stoppages and water leakages. This necessitates a refractory solution capable of withstanding thermo-mechanical loads and temperature fluctuations while facilitating faster repairs to avoid prolonged downtime and furnace damages.

In response, a joint solution with the newly developed Plastic Refractory was devised. This innovative material offers enhanced mechanical strength, erosion resistance, and thermal properties compared to traditional alternatives. Its application results in significant reductions in installation time, downtime during maintenance, and energy consumption. Trial applications of the plastic refractory in walking beams demonstrate an energy saving of over 25% compared to previously dense materials. The Plastic Refractory (80%) boasts superior Modulus of Rupture (MPa) and lower bulk density and thermal conductivity, minimizing heat loss from skid pipes. Compared to on-site castable installations, the plastic solution reduces installation time by approximately 75%, further enhancing productivity and operational efficiency.

This paper discusses the development, properties, and application of the Plastic Refractory in Reheating Furnace skid and post beams. Through its implementation, significant advancements in relining efficiency, durability, and energy savings are achieved, paving the way for enhanced furnace performance and reduced operational costs.

Keywords: Reheating Furnace, Skid and Post Beams, Plastic Refractory, Relining

Effect of in-situ formed MgAl_2O_4 matrix of MgO-C refractory in steel ladle lining performance

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Steel ladle is one of the major areas for consumption of refractory in steel plant. Reduction of specific refractory consumption in this area will have major impact on total specific refractory consumption. MgO-C refractory is a vastly used lining material for steel ladle lining. Works are being carried out for continuous improvement of MgO-C refractory by incorporation of different additives. The present work aims to synthesize different MgO-C composition with addition of micron size Al_2O_3 powder for strengthening of matrix of MgO-C bricks for better slag corrosion resistance. Effect of Al_2O_3 content on cold crushing strength, bulk density and porosity after curing at 200°C and coking at 1000°C were analyzed. Permanent linear change and oxidation index were measured after sintering at 1500°C . Phases were examined under X-ray diffraction of the sintered samples at 1500°C . Plant trial with the Al_2O_3 containing MgO-C refractory in slag zone and metal zone lining of steel ladles conducted in a steel plant.

The result shows that cold crushing strength of both green and coked samples were increased with the addition of Al_2O_3 powder. Bulk density and porosity for the samples with and without Al_2O_3 powder were in the same range. Permanent linear change of the sintered samples, up to 3.6 wt % of Al_2O_3 containing batch was same with the existing batch composition. Oxidation resistance was in increasing trend with the increase of Al_2O_3 content beyond 3.6%. Phase analysis confirmed that Al_2O_3 powder transformed into MgAl_2O_4 spinel in all the compositions. Performance of the trial ladle with reactive Al_2O_3 containing MgO-C bricks improved from 56 heats to 69 heats. In-situ formed MgAl_2O_4 spinel in the matrix of MgO-C refractory resulted better slag corrosion resistance.

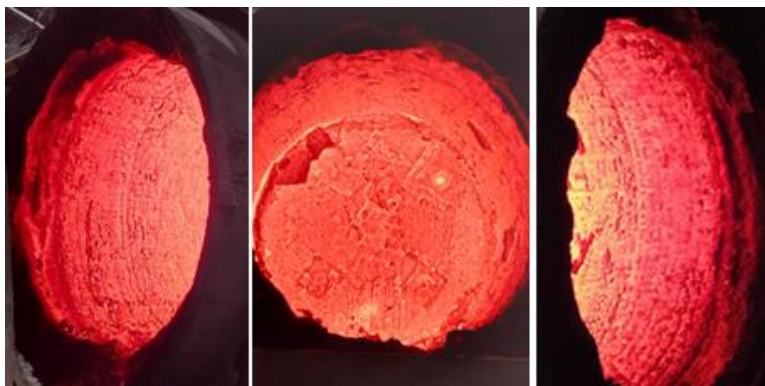


Fig. 1. Steel ladle lining appearance after trial

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Effect of Sintering Atmosphere on the Densification Kinetics of Calcined Magnesia

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Sintering kinetics of brucite-derived calcined magnesia synthesized from kimberlite tailings was studied. The non-isothermal sintering kinetics of the calcined MgO at two different sintering atmospheres was studied using dilatometric data obtained under controlled heating conditions with a Thermo-Mechanical Analyzer. Model free analysis like iso-conversional methods viz. Ozawa–Flynn–Wall and Friedman provided a basic understanding of activation energy (E_a) at different conversion points of the sintering reaction. The air atmosphere sintering reaction (CM-Air) comprised (E_a) in the range of 500–630 kJ·mol⁻¹ up to 80% densification and beyond that E_a increased steadily above approximately 1000 kJ·mol⁻¹, suggesting a shift in the dominant sintering mechanism. The activation energy values were even higher (E_a = 800-1000 kJ·mol⁻¹) during nitrogen atmosphere sintering (CM-N₂) up to 80% densification than air atmosphere and increased sharply above 95% conversion. Model based analysis viz. linear and non-linear regression analysis revealed that both the atmospheres sintering followed a single-step, n-dimensional Avrami–Erofeev model whereas the E_a and logA values were significantly higher in N₂ atmosphere sintering (E_a = 962.05 kJ·mol⁻¹ and logA= 31.16 s⁻¹) than air atmosphere sintering (E_a = 649.35 kJ·mol⁻¹ and logA=19.79 s⁻¹) with high coefficient of regression values. XRD analysis confirmed the presence of periclase as the major phase in all the reactions while energy-dispersive X-ray spectroscopy detected trace amounts of calcium silicate at the grain boundaries.

Fig.1 (a-d)

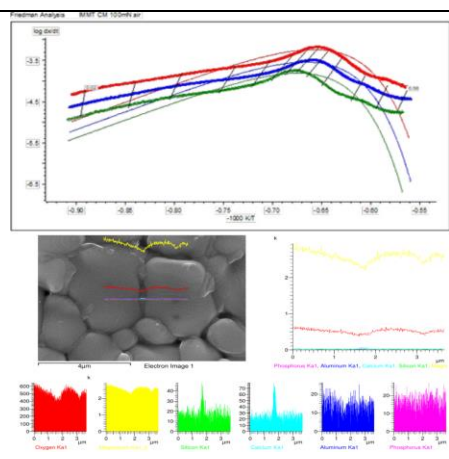
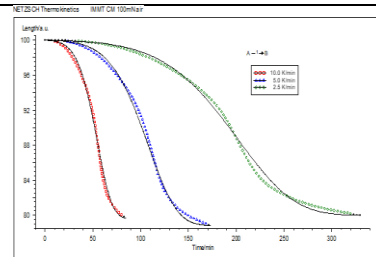


Table. 1

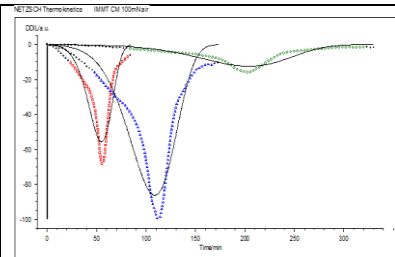
Sintering atmosphere	Model	Activation energy (kJ·mol ⁻¹)	logA (s ⁻¹)	Regression coefficient
N ₂ - 80% O ₂ - 20%	An n-dimensional Avrami–Erofeev	649.35	19.79	0.998270
N ₂ - 100%		962.05	31.16	0.998379

a) Friedman analysis of CM-air (top)

b) Microstructural analysis of CM -air after sintering at 1550°C (bottom)



c) Fitting of Shrinkage curve of CM-air



d) Fitting of rate of shrinkage curve of CM-air

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A Sustainable Strategy to maximize the Utilisation of Spent MgO-C Refractory

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With the global generation of spent refractory materials reaching approximately 28 million tons annually, the development of sustainable recycling methods has become crucial. This study proposes a strategic approach for the maximum utilization of waste MgO-C refractories into high-value refractory blocks promoting circularity in refractory applications. Spent MgO-C bricks were first characterized via chemical composition, XRD, CHNS analysis to understand phase distribution and elemental composition. Optical microscopy and XRD revealed that coarser aggregates (1–5 mm) predominantly consist of periclase, while finer fractions contain phases such as periclase, forsterite, monticellite, spinel, and quartz, along with increased carbon content. After size-based separation and recycling, recycled aggregates were incorporated into MgO-C block formulations by gradual replacement of fresh magnesia aggregates (0–50 wt%). For physiochemical and mechanical properties, apparent porosity, bulk density, cold compressive strength (CCS) have been evaluated of the recycled MgO-C blocks and results showed that 40% replacement gave the most favorable result compared to the reference sample. So, mechanical and thermal properties were further investigated for the 40% replacement batch. Although CMOR performance decreased slightly compared to the reference, HMOR performance improved. SEM analysis of CMOR-fractured samples revealed crack propagation along grain boundaries in the recycled sample. The 40% recycled blocks also retained comparable residual strength after five thermal shock cycles. Additionally, slag corrosion tests indicated slightly higher surface interaction for the recycled sample, but no severe degradation was observed.

This comprehensive study demonstrates that recycled MgO-C aggregates can be effectively reused upto 40% in refractory production without significant compromise in thermal and mechanical properties and without leaving any carbon footprint.

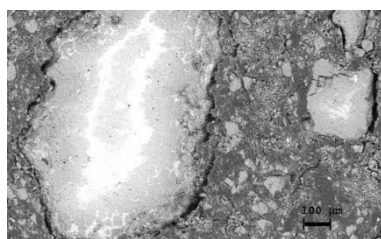


Fig. 1. Scanning Electron Microscopy of 40% recycled blocks

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Development of Porous YSZ using Foam Template for Thermal Insulation Applications

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Porous ceramics of yttria-stabilized zirconia (YSZ) are excellent candidates for high-temperature insulation due to their low thermal conductivity, high temperature strength, chemical inertness, and structural stability. In this study, we report a simple and scalable method to fabricate porous 8YSZ substrate using a polyurethane (PU) foam templating technique and a terpeneol-based slurry system without any additional dispersants, binders, or foaming agents.

The YSZ slurry was characterized for particle size distribution, zeta potential, and viscosity to ensure effective infiltration and uniform coating. PU templates were dip-coated in a 62 wt% solid loading slurry, dried, and sintered at 1450 °C to obtain open-cell porous structures. The sintered YSZ foams exhibit ~80% porosity, as determined by physical measurements, making them highly suitable for thermal insulation applications.

Characterization of sintered foam using XRD confirmed phase stability and crystallinity post-sintering. SEM imaging revealed a well-connected, homogeneous pore network while elemental analysis using EDS confirmed the presence of pure YSZ with no residual impurities from template material, solvent traces or secondary impurities. Mechanical performance was evaluated via three-point bending and compression tests, showing adequate strength for handling and integration. Thermal analysis confirmed low thermal conductivity consistent with high porosity of the foam and suitable for high temperature application.

The method presented here distinguishes itself by avoiding complex multicomponent formulations while achieving high porosity and desirable structural properties. These YSZ foams not only serve as effective thermal barrier materials but also show promise for multifunctional applications such as support scaffolds in solid oxide fuel cells or catalyst carriers in high-temperature systems.

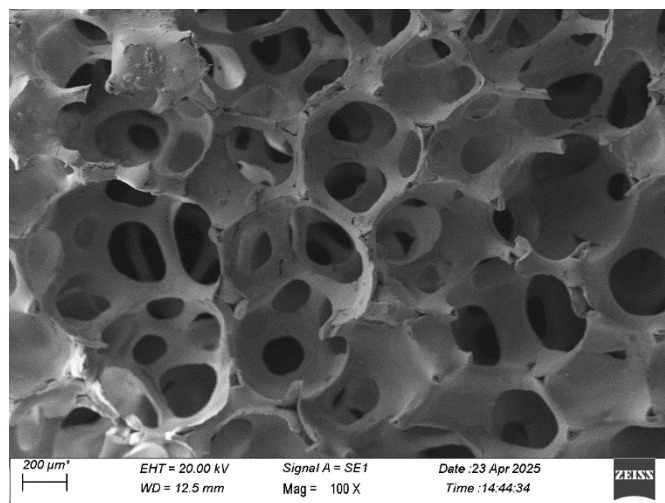


Fig. 1. SEM micrograph of sintered 8-YSZ Foam

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Grain Growth Control and Thermal Aging Behaviour in Zirconia-Toughened Alumina Fibers Synthesized by a Low-Temperature Route

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Ceramic fibers with micron- to nanometer-scale diameters are increasingly replacing conventional refractory bricks owing to their exceptional thermal insulation properties, including low thermal mass and low thermal conductivity. Among the various synthesis routes, low-temperature processes offer significant energy savings. In this study, alumina–3 mol% yttria-stabilized zirconia (3YSZ) fibers were synthesized via a sol–gel process combined with centrifugal spinning, with the objective of controlling grain growth during sintering. Monolithic alumina fibers exhibited an average grain size of $\sim 4\text{ }\mu\text{m}$, which is relatively coarse and detrimental to mechanical performance. To mitigate this, zirconia was incorporated as a grain growth inhibitor. The resulting fibers had diameters between 5–15 μm , with a fiber yield (post-90 μm sieve) of approximately 96%. SEM analysis confirmed the absence of abnormal grains in all the fibers (Fig. (a-e)). Zirconia-containing fibers revealed a homogeneous zirconia distribution throughout the fiber matrix (Fig. (a-e)). Average alumina grain size decreased from $\sim 4\text{ }\mu\text{m}$ (pure alumina) to 2.8 μm and 1.1 μm for 5 wt% and 20 wt% zirconia additions, respectively, with intermediate values for 10 wt% and 15 wt% zirconia. The observed grain refinement is attributed to triple-junction pinning by zirconia particles, consistent with the reported mechanisms. Increasing zirconia content enhanced the number of pinned grain boundary junctions, thereby further reducing boundary mobility. Thermal aging studies of alumina fibers heat treated at 1600°C for 24 and 100 hours exhibited abnormal grains with even single grain size varying from 30 μm to 140 μm (Fig. 2, 3 (a)). While alumina-3YSZ fibers did not exhibit any abnormal grain size. But the average size of alumina and zirconia grew (Fig. (2, 3 (b-e))). The presence of alkali impurities resulted in the exaggerated grain growth of alumina fibers which was confirmed by ICP-OES. XRD phase analysis confirmed that monolithic alumina fibers exhibited a corundum phase, whereas alumina–zirconia fibers contained corundum, monoclinic and tetragonal phases (Fig. 4).

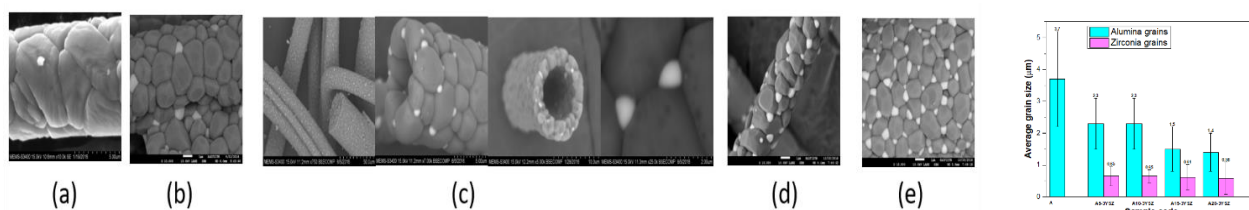


Fig. 1: SEM images of fibers sintered at 1600°C for 3 hours (a) Alumina (b) Alumina with 5 wt. % 3YSZ (c) Alumina with 10 wt. % 3YSZ (d) Alumina with 15 wt. % 3YSZ (e) Alumina with 20 wt. % 3YSZ.

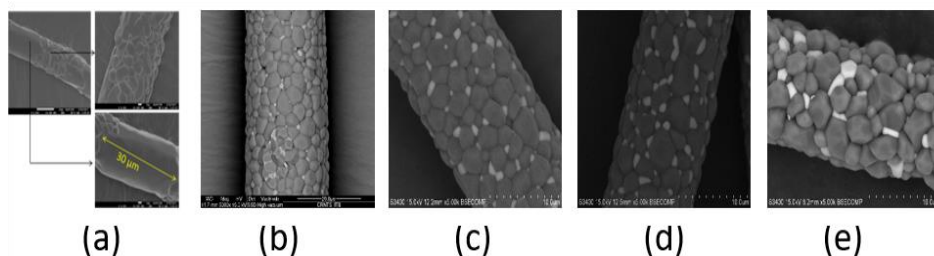


Fig. 2: SEM images of fibers thermally aged at 1600°C for 24 hours (a) Alumina (b) Alumina with 5 wt. % 3YSZ (c) Alumina with 10 wt. % 3YSZ (d) Alumina with 15 wt. % 3YSZ (e) Alumina with 20 wt. % 3YSZ.

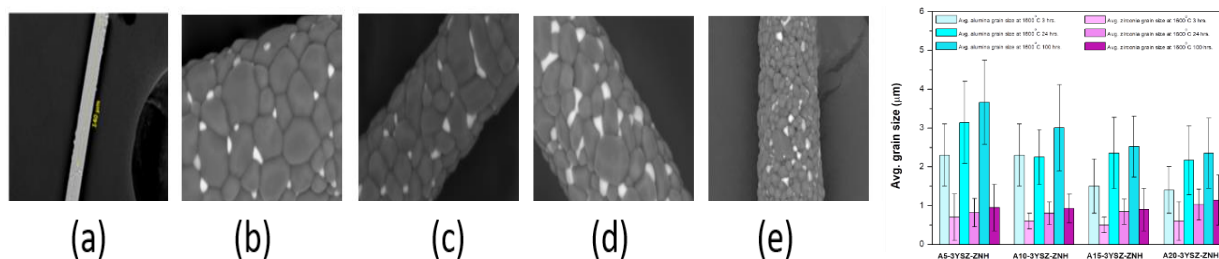


Fig. 3: SEM images of fibers thermally aged at 1600°C for 100 hours (a) Alumina (b) Alumina with 5 wt. % 3YSZ (c) Alumina with 10 wt. % 3YSZ (d) Alumina with 15 wt. % 3YSZ (e) Alumina with 20 wt. % 3YSZ.

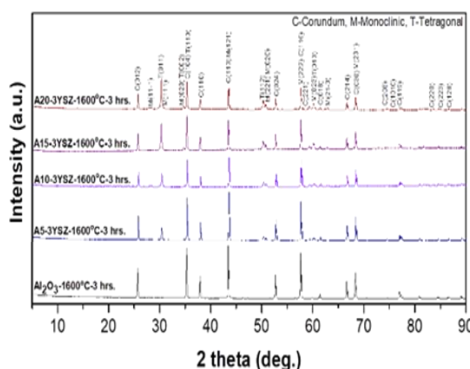


Fig. 4: XRD pattern of alumina, alumina-3YSZ fibers sintered at 1600°C for 3 hours (C-Corundum, M-monoclinic, T-Tetragonal).

Development of Composite Collector Nozzle (CNT) for 350 Ton Steel Ladle at JSW Dolvi SMS 2

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Collector Nozzle puncture during the casting at slab caster had been a long-standing problem especially for high Ca grade steels. During the casting CNT puncture mainly happens due to propagation of internal cracks, gauging & oxidation tendency. This leads to serious operational issues such as unplanned sequence break, blow hold in the BOF & also causes the metal penetration into the slide gate imported mechanism. In some cases, the casting is terminated if the CNT puncture takes place at the start or middle of the casting & the ladle returns with the remaining steel poured into the BOF/other ladles. To solve this problem, a dedicated team analysed the actual root cause & multiple trials were conducted to improve the product sustainability. As a trial outcome, a Composite CNT is developed over the conventional design to withstand the higher throughput & achieve target life in 350 Ton ladle. This paper explains the detailed roadmap of casted route CNT, pressed route CNT & Composite CNT developments to achieve 5 & more heats in 350 Ton capacity ladle without failures at JSW Dolvi SMS 2.



Fig. 1. Horizontal cracks & gauging in the conventional CNTs after 3 to 4 heats.

Table 1. Comparison of different types of trial CNT qualities at JSW Dolvi SMS 2.

Sr. No	Type of Product	Avg. Life (Heats)	Avg. Erosion Rate (mm/heat)	Puncture Incidents (Nos)
1	Casted CNT	2 to 3	2.8 to 3.7	3
2	Pressed CNT	2 to 3	2.8 to 3.7	2
3	Composite CNT	4 to 5	1.9 to 2.1	0

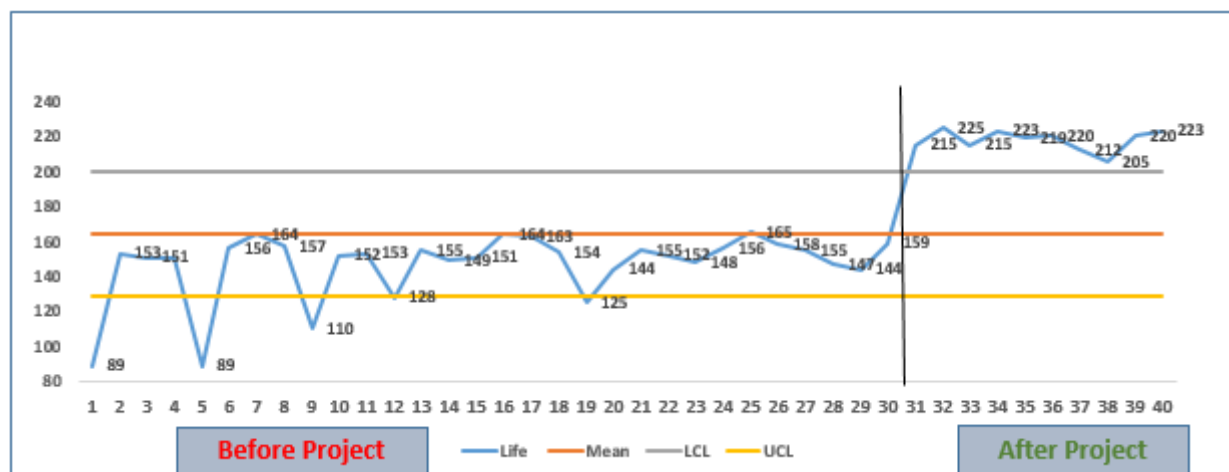
Innovative approach adopted for KR impeller refractory life improvement

Harsh Joshi, Balamurugan, Shivkumar, Rahul, Sagari, Bharath, Prabhanjan,
Harsh Joshi, Veeresh Bellatti, Ganapathi Prasad, VR Sekhar
At JSW Steel Ltd, VJNR works in Torangallu Ballary, India

Hot Metal Pre-treatment plays vital role in reducing sulphur level in the hot metal to improve steel quality and controlling temperature of hot metal by injection process and prepare the hot metal for better steelmaking performance and resulting in cleaner metal and better steel quality.

The KR impeller is critical in the KR desulfurization process because it: Mixes the molten iron and reagents uniformly, enhances sulphur mass transfer to the slag, maintains good chemical reaction conditions, keeps slag-metal interfaces active, helps maintain uniform temperature in the bath. All of these effects together boost the efficiency and speed of sulphur removal from hot metal during pre-treatment.

This paper presents the challenges faced in maintaining the availability of the KR impellers and the various steps taken like, Sol Gel based Refractory material selection and its behaviours during the operation, Slag coating during the Process, Controlled preheating, Behaviours of sol gel casatble with unique hot metal chemistry and sodium fluorspar to improve its refractory life. A unique and customized approach to material selection and operating practices led to significant improvements in both the desulfurization process and the refractory life of the KR impeller. These enhancements have helped ensure higher availability of the impeller for production while also reducing Specific Refractory Consumption by Increasing the Refractory life by 30% in Heats of operation



The Project results as shown in the graph

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Advancement in Total BOF-Converter Management / or Operational Strategies & Advance maintenance techniques for maximizing BOF campaign life: a case study in steel plant efficiency

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The 130-ton Basic Oxygen Furnace (BOF) converter in India, relined in May 2024, has achieved an unprecedented campaign life of 7,800 heats and is projected to cross 10,000 heats—setting a new benchmark in converter durability and operational excellence. This milestone is the result of a holistic approach to Total Converter Management, combining strategic refractory engineering, process optimization, and advanced repair technologies.

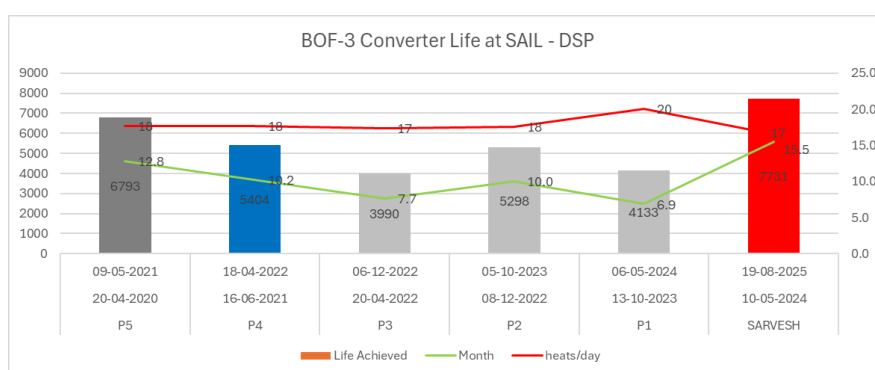
Key to this achievement was the meticulous selection of refractory bricks tailored to zonal lining requirements, ensuring superior slag adhesion and resistance to chemical erosion. Continuous monitoring of lining thickness across converter zones enabled timely interventions and minimized wear. Thermal shock prevention was prioritized by minimizing mechanical maintenance disruptions and addressing hood water leakages. Charge pad areas were cushioned with lime and dolomite to absorb scrap impact, while heavy scrap was excluded to prevent localized damage. During sequence breaks, slag holding and hot patching revitalized eroded zones.

A major innovation was the deployment of MiNTEQ's automated shooter gunning system, which enabled precise, consistent refractory application with minimal human intervention. This system reduced material waste by 15–25%, improved safety, and accelerated repair cycles. Minteq monolithics further enhanced lining integrity by sealing cracks and resisting slag attack.

Overall, this paper discusses about how integrated converter management—anchored in material science, process discipline, and automation—can dramatically extend BOF campaign life and set new standards for steelmaking efficiency.

Keywords: BOF Converter, Refractory lining optimization, Slag management technique, Advance repairing techniques

Fig. 1. Performance history of BOF-3 Converter at Indian Steel Plant



Vesuvius's Advanced Plastic Refractory Solutions Harsh Joshi, Shrijit Kulkarni*, Rajesh Patil, Sandeepan Ray, Asim Bera, Purushottam Bedare

Vesuvius Advanced Plastic Refractory Solutions India Ltd.

Single-component plastic refractories have emerged as a reliable alternative to conventional multi-component systems for high-temperature applications in iron, steel, non-ferrous, and cement industries. Unlike conventional multi-component systems that require separate binders, additives, and on-site mixing, single-component plastics are supplied in a ready-to-use form with all constituents pre-mixed under controlled conditions. Vesuvius has developed different grades of single component plastic refractory material which exhibit excellent workability and can be easily rammed for complex shapes and lined at constrained locations.

New grades of plastic refractories, namely Ramtite 60 and Blu Ram HS, have been developed for the Indian market. These products are based on high-alumina mullite compositions with a cement-free system, eliminating chemically bonded water and thereby removing the need for dry-out.

Ramtite 60 is rammable clay bonded plastic especially designed for reheating furnace. Once installed, the lining forms a similar to monolithic surface with near-zero permeability, ensuring superior integrity throughout the campaign. The materials exhibit enhanced thermal shock resistance for longer service life and lower thermal conductivity compared to cement base castables, to minimize heat transfer through the refractory.

Blu Ram HS, is phosphate bonded high strength single component plastic, has been designed for versatile and demanding applications. Blu ram has demonstrated reliable performance in critical zones such as the spout of induction furnaces, where direct contact with molten steel requires high resistance to steel penetration and slag-chemical attack.

These developments represent a significant advancement in refractory plastics, combining ease of installation with superior performance and durability in challenging operating conditions.



Fig.1: Reheat furnace entire wall with Ramtite | Fig.2: Spout and top area of Induction furnace

Keywords: Single-component plastic, Reheat furnace, Induction furnace, advanced plastics

Environment Friendly Snorkels for RH Degasser

Mr. Huang Xin / Mr Changsheng Qi / Mr Junling Xiao

Since a very long time Direct Bonded Mag Chrome Refractories has been used in RH Degasser units. The carcinogenic hexavalent chrome in the Direct Bonded Mag Chrome bricks has always been a health hazard not only to the workers who are producing the refractories but also to the soil and groundwater where the bricks are disposed off after use. PRCO has taken joint projects with many steel mills in China and outside China to develop Chrome free refractories for RH Snorkels. After several trials PRCO developed Magnesia Alumina Spinel bricks as a substitute for the carcinogenic Direct Bonded Mag Chrome refractories. Today many Steel Mills in China and outside China are showing preference to Chrome Free refractories in their RH Degasser units. Our presentation discusses the various advantages and disadvantages of Mag Alumina Spinel bricks over DBMC bricks and their comparative performance in few steel plants in China and outside China.

CONTRIBUTORY SPEAKERS (POSTER)

Effect of novel binder in dolomite-C refractory to improve the performance for clean stainless-steel production

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With the evolving demands for cleaner steel and reduced levels of carbon, phosphorus, sulfur, and metal oxides, the steel industry has increasingly adopted advanced metallurgical techniques. One such innovation is secondary steelmaking, which shifts critical refining processes from primary melting units to specialized secondary facilities. This approach is particularly prevalent in duplex processes, where a high-carbon melt is initially produced in an electric arc furnace (EAF) and subsequently refined in an argon–oxygen decarburization (AOD) converter to yield high-quality stainless steel.

To support these demanding metallurgical operations, the refractory lining of secondary steelmaking units must exhibit exceptional resistance to basic slag corrosion under extreme temperatures and pressures. Among the available materials, dolomite-C refractories have emerged as a preferred choice due to their superior techno-commercial properties, including cost-effectiveness and performance.

These refractories must possess robust thermo-mechanical and thermo-chemical characteristics to endure aggressive slag environments and facilitate efficient decarbonization and desulfurization during the AOD process route. However, the inherent hydrophilic nature of dolomite poses challenges related to hydration, which can compromise the material's integrity.

In the present study, dolomite-C bricks were developed using three distinct binder systems, aiming to optimize proper mixing with better costing of the grains to enhance the overall performance of the refractory. Three nos of batch are prepared keeping the same granulometry and raw material and mixed with 3 different binders with same percentage of addition. After brick pressing and tempering properties like physical, thermal and thermo mechanical are evaluated and compared. Hydration resistance of the samples were studied, and it was found that hydration resistance can be controlled by using suitable binder.

Keywords: Stainless Steel, Argon-Oxygen Decarburisation (AOD), Dolomite-C, Hydration, Grain Distribution, Secondary Steelmaking

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Redesigning of Burner Port by PCPF blocks in Sinter Plant

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Revamping burner ports is always a challenge with respect to their installation in confined space and hard to access area for 9 days yearly shutdown in sinter plant. Burner port revamping mainly governs the shutdown duration due to in-situ casting, heating, and involvement of a restricted number of people in a confined space. The existing burner ports were lined by in-situ casting of monolithic refractory which required air drying followed by 72 hours of heating. The existing castable which are more prone to cracks if not properly applied or cured. The existing burner port area used to fail within a year of operation at the Sinter Plant. Precast prefired (PCPF) burner are the ready to install blocks that do not require any heating. These PCPF blocks are specially with tongue and groove design. PCPF design for burner port to solve the perennial problem of sinter plant with challenge with respect to installation in shutdowns in confined space and hard to access area. PCPF burner blocks with tongue and groove design which provides the interlocking mechanism at the application area facilitates easier handling and installation on site. The PCPF block design provides a robust structural integrity at high temperature applications as compared to. The easier assembly process of PCPF blocks reduces the need for specialised labour in a confined space considering the need of safer working standards. This unique PCPF block design has been developed first time in India. It ensures ease-of-installation with a reduced number of people involved (50% reduction) and in less time (45% reduction). It also improves the reliability of the burner ports (by 50%).

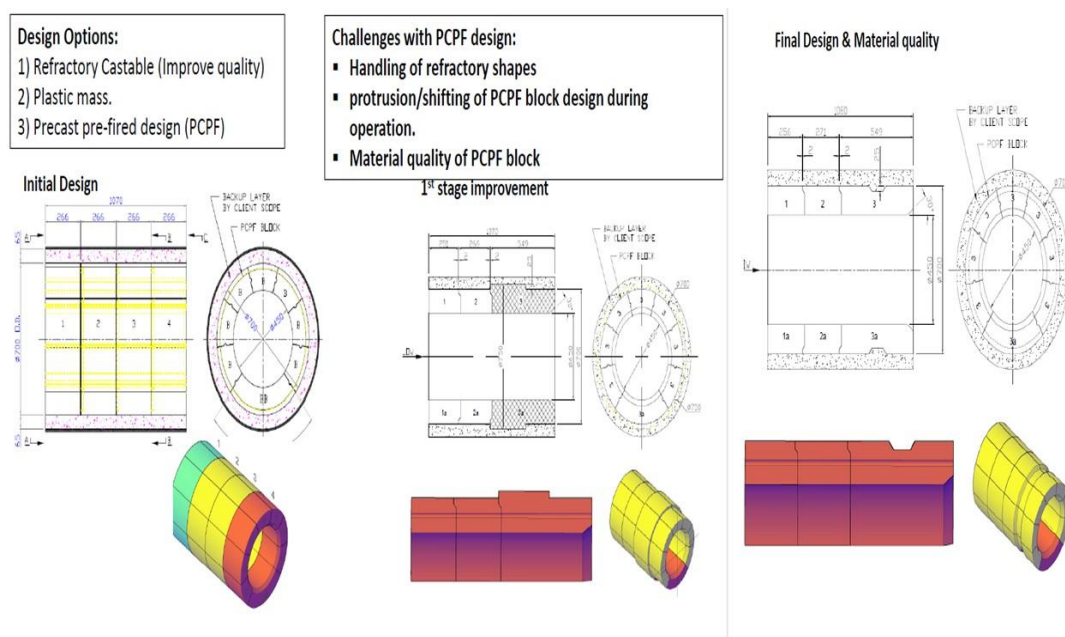


Fig. 1. Development stages of burner port PCPF blocks

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Microstructural and Tribological Behaviours of High Alumina Nano-Bonded Refractory Castable for Petrochemical Industry

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Fluid catalytic cracking (FCC) units in the petrochemical sector and refractory applications suffer substantial difficulties in procuring commercial materials with superior thermo-mechanical qualities for operation at temperatures under 1000°C. Several binding agents, such as colloidal silica, calcium aluminate cement, and zinc oxide nano-bonded refractories, generally undergo densification at temperatures around 1200°C. Therefore, the incorporation of sintering additives to improve and accelerate the densification process is an acceptable technical strategy. This study aims to assess the performance of high-alumina refractory castables that include a magnesium borate-based sintering additive and various binder sources. This study examines the impact of using magnesium borate as a boron source in high-alumina castables sintered at temperatures reaching 1200°C. The investigation includes evaluations of apparent porosity, wear resistance, and frictional characteristics of the developed castable compositions. Furthermore, X-ray diffraction (XRD) and scanning electron microscopy (SEM) investigations have been performed to investigate phase evolution and reactions that occur at high temperatures. Dry sliding wear experiments were performed utilizing a pin-on-disc tribometer under defined circumstances. The experiments were carried out with a load of 20 N at sliding velocities of 1 m/s and 2 m/s over a constant sliding distance of 2000m.

Keywords: Castable, Sintering additive, Nano bonded, Wear, Microstructure.

Effect of Alternate Fuel on Refractory Performance in Cement Rotary Kiln

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Cement is one of the leading industries in the world with India alone producing around 502 million tonnes per year. However, the manufacturing process is both energy intensive and environmentally taxing. Hence to reduce cost & improve sustainability, many cement producing plants have started using a blend of alternative fuels alongside conventional fossil fuels. Alkaline environment, high temperature and long processing time allow cement kilns to burn a wide range of alternative fuels including waste and hazardous materials.

In this regard, the use of waste lubricants, plastics, used tires, and sewage sludge has gained traction in the cement industry as alternate fuel materials. However, these alternate fuels often introduce several unwanted elements like Chlorine, Sulfur, Alkalis etc into the system which can have detrimental effect on the performance and longevity of the refractory linings. The Sulfur compounds (SO_x) released during combustion, react with free lime of the kiln feed and form spurrite ($2\text{CaO} \cdot \text{SiO}_2 \cdot \text{CaCO}_3$) rings. Simultaneously, the alkali compounds penetrate into the refractory pores and cause alkali bursting due to a significant mismatch in thermal expansion co-efficients.

This paper aims to evaluate the impact of using alternative fuel on the refractory performance. Simultaneously, it focuses on the zone-wise influence of these unwanted elements on both bricks and castable linings. In this regard, the paper also suggests the most effective refractory solutions for each zone tailored to achieve the targeted life of lining.

Record-Breaking Performance of ASC Refractory Lining in Torpedo Ladles (2335 Heats): A Comparative Study with High Alumina Refractory

Dillip Kumar Sahu*, Deepsikha Brahma, Goutam Ghosh, Tushar Agrawal,
Brijender Singh

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This study presents a comparative analysis of two torpedo ladles, one lined with ASC refractory material (torpedo numbered 37) and the other (torpedo numbered 18) with aluminosilicate (containing 85% high density alumina) refractory material as working lining, focusing on gunning consumption, erosion resistance, and the life of torpedo. The investigation revealed that the ASC refractory outperformed high alumina in all key metrics, demonstrating lower gunning consumption and superior erosion resistance, which contributed to enhanced operational efficiency. Notably, the ASC lining achieved the highest ever recorded straight life in torpedo ladle operations, underscoring its durability and cost-effectiveness. These findings advocate for the adoption of ASC refractory for improved ladle performance and extended service life.

Keywords: alumina, gunning, erosion, torpedo, refractory

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MgO-C Brick production by Single pressing

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This project focuses on the production and evaluation of magnesia-carbon (MgO–C) bricks using the single pressing technique. MgO–C bricks are essential in the steel industry due to their high thermal shock resistance, mechanical strength, and excellent resistance to slag and corrosion. The study examines the impact of raw material composition, mixing, ageing, and pressing parameters on the physical and chemical properties of the bricks.

Two different recipes (R-100 and R-101) were developed, with R-101 containing 5% fewer fines. Each recipe was tested under three different processing conditions, combining variations in ageing environment (room temperature vs. AC-controlled) and pressing parameters (normal vs. modified). Mixing was conducted using a Counter-Current Inclined Intensive Mixer (CCIM), and pressing was done using an electric screw press.

Key findings show that R-101, when processed under AC-controlled ageing and modified pressing conditions (Case 3), yielded superior results in terms of bulk density, apparent porosity, cold crushing strength, and chemical composition. Single pressing was found to be efficient for regular refractory production. The study also highlights critical quality control points and proposes future innovations like using nano carbon and carbon nanotubes (CNTs) to improve brick performance.

The results suggest that optimizing fines content and pressing parameters significantly enhances brick quality, offering a sustainable and cost-effective approach for refractory manufacturing in high-temperature applications.

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Import Substitution through in-house Development for Pilot Coke Oven of RDCIS

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Pilot scale coke ovens are widely used to produce coke samples for characterization and also to assess the coking behavior of coal blends and coke produced. Coke produced in these ovens is compared closely with coke produced in industrial coke oven for its process optimization.

At RDCIS, Ranchi there is one 250kg pilot coke oven which has been supplied by M/s Carbolite, UK in the year 1992. During 1997 intermediate repair of the furnace was taken. Since then furnace was running with the in-house maintenance facilities. However Refractory working lining was running with patch work and needed immediate replacement.

SAIL Refractory Unit, Bhandaridah produces castable for Blast Furnaces. A modified composition of this castable was made by addition of SiC grains to improve the thermal conductivity, erosion resistance, chemical stability etc of pilot coke oven refractory. With the use of 3-D printing technology thermoplastic moulds were manufactured for brick making. Full working lining bricks were made at RDCIS, Ranchi. Evaluation of these bricks were done and lined in the Pilot Coke Oven. Performance of these bricks was satisfactory and a lining life of more than 3 years was achieved.

This paper deals with the developmental work at RDCIS, Ranchi for an alternate material as import substitution for Pilot Coke Oven Refractories.

Keywords: Andalusite, Sinter Plant

Utilization of BOF Slag in the Synthesis of High-Temperature Refractory Materials

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This study investigates the stabilization of basic oxygen furnace (BOF) slag for refractory applications through the addition of silica and alumina additives. Physical examination of the refractory blocks after heat treatment revealed the presence of cracks, attributed to residual free lime content undergoing hydration and forming calcium hydroxide. XRD analysis confirmed a reduction in free lime content upon additive incorporation, leading to improved dimensional stability. The formation of gehlenite contributed to enhanced abrasiveness and stabilized the melting behaviour of the refractory materials. Thermal analysis (DSC/TGA) further demonstrated that alumina-doped samples exhibited improved thermal stability, indicated by higher decomposition temperatures and reduced mass loss. In contrast, silica-doped samples displayed less favourable thermal performance due to phase transformations of quartz under heat exposure. These findings suggest that alumina is more effective than silica in stabilizing BOF slag for refractory applications.

Keywords: BOF slag, additive, refractory, lime, gehlenite, calcination.

Preparation and Characterization of Alumina fiber

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Alumina fibers are employed in a diverse array of applications, such as aerospace, high-temperature insulation, gas filtration, electronic devices, sensors, and catalysis. Various methods, such as solution blowing, sol gel method, melt extraction, melt spinning, slurry spinning, centrifugal spinning, and electrospinning, are employed to synthesize them. Among their noteworthy attributes are mechanical strength, chemical inertness, electrical insulation, thermal stability, low thermal conductivity, high surface area, mechanical strength, and high-temperature stability. Its robustness, resilience, and chemical stability augment its adaptability across diverse applications. The market for alumina fiber is anticipated to increase owing to its lightweight, corrosion-resistant, and electrically insulating characteristics, propelled by industries pursuing materials that offer improved performance, corrosion resistance, and electrical insulation. Aluminium chloride hexahydrate, aluminium powder, colloidal silica sol, polyvinyl alcohol (PVA), and polyvinylpyrrolidone (PVP) were employed to make a solution, which was subsequently stirred and refluxed at 80°C. The resultant solution underwent processing using the electrospinning technique to yield nonwoven alumina fiber mats. The mats were further dried and calcined at temperatures ranging from 800°C to 1100°C to produce the final alumina fibers. The sol was evaluated based on its viscosity and pH levels. The produced alumina fiber underwent additional characterization by X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR). Thermal analysis was conducted using TG-DTA across a spectrum of temperatures to evaluate the thermal behaviour and heat response of alumina. A flame test was performed, indicating that the fibers possess superior flame resistance.

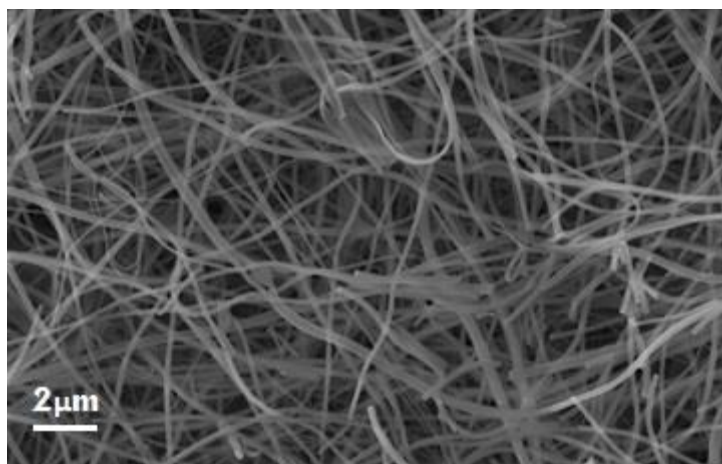


Fig. 1. FESEM of calcined Alumina fiber

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Utilization of aluminium dross to prepare dense mullite aggregates for refractory applications

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This study investigates the feasibility of utilizing aluminium dross- a prevalent industrial by-product, as a sustainable precursor for mullite synthesis, specifically targeting mullite-60 and mullite-70 compositions. Leveraging the intrinsic alumina (Al_2O_3) content in dross and related industrial wastes offers a low-cost alternative to pure oxide precursors, with potential raw material cost reductions of 30–50%. For instance, it could partly substitute for expensive commercial Al_2O_3 in mullite ceramics. The repurposing of dross can also address the environmental pressures associated with hazardous waste disposal, with some processing pathways offsetting waste management expenses. In this study, aluminium dross collected from different sources was initially analyzed for its chemical composition, after which mullite formulations were synthesized through conventional sintering. The resulting materials were then evaluated for their mineralogical, physico-chemical and thermo-mechanical properties, with the objective of establishing a foundation for scalable and environmentally sustainable production of mullite aggregates.

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Recovery of Magnesia from Waste MgO-C Refractory Fines via Chemical Treatment

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Magnesite is a crucial raw material in the manufacture of refractory materials due to its high resistance to heat, chemical corrosion, and alkali effects. Despite having substantial magnesite reserves, India continues to rely heavily on imports of high-grade magnesia, primarily because a significant portion of its domestic supply is available in impure form. With rising demand in steel and allied industries and shrinking global availability, the recovery and reuse of magnesia from industrial waste offer a sustainable and economically valuable alternative.

This study explores the recovery of magnesia from waste MgO-C refractory fines, which are typically discarded during recycling processes. While coarse refractory are often reused, the fine powder fraction despite its high magnesia content is commonly overlooked. Our research demonstrates that up to 86% of magnesia can be effectively recovered from these fines using chemical treatment, evaluated through two distinct processing routes.

Comprehensive characterization techniques, including X-ray fluorescence (XRF), X-ray diffraction (XRD), Thermogravimetric and Differential thermal analysis (TGA-DTA), and manual analysis, confirm that the recovered material contains more than 90% periclase (MgO) in both processing routes. Microstructural analysis reveals that Route 2 yields a finer grain size compared to Route 1, indicating potential advantages in specific application. Our hope is to form spinel by using this highly pure recovered magnesia for high end application in refractory industry. This approach presents a practical and environmentally responsible solution to address raw material scarcity while enhancing the circular economy in refractory and metallurgical industries.

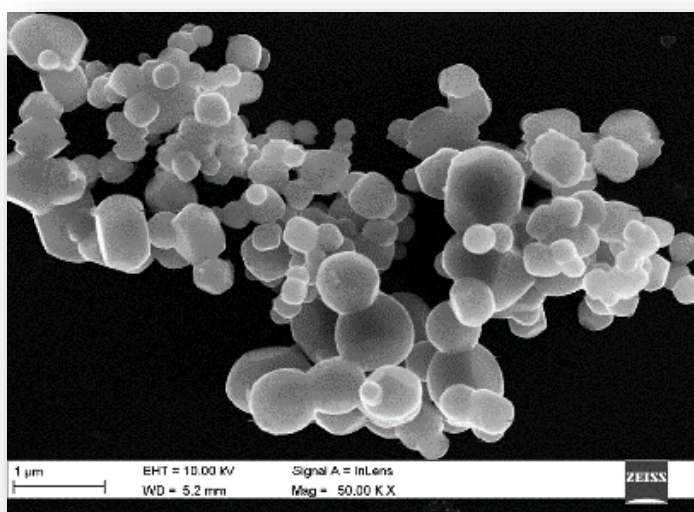


Fig. 1. Microstructure of recovered MgO by Route1.

Interaction of Hydrogen with Refractory Materials at High Temperatures

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The use of hydrogen for the reduction of iron ore has gained significant global attention in the steel industry, primarily due to its potential to drastically reduce CO₂ emissions associated with conventional reduction processes. Hydrogen gas serves as a carbon-neutral alternative fuel and reducing agent. Gases can affect refractory materials through chemical reactions, thermal stress, and corrosion, making it crucial to understand these interactions. Identifying the interaction mechanisms of these materials with hydrogen is essential for improving the durability and performance of refractory linings in gaseous-rich, high-temperature environments. Limited studies in this area has been reported in the literature. Our study investigates the interaction of refractory materials such as alumina, stoichiometric spinel (Magnesia Aluminate Spinel), alumina-rich spinel, and mullite with hydrogen: argon mixtures. The effect of interaction of refractory with 5% H₂ in Argon atmosphere over a 8-hour period with controlled gas flow rates at different temperatures was studied with respect to apparent porosity, bulk density, mechanical properties (modulus of elasticity and modulus of rupture). Results showed that the MOE of stoichiometric spinel increased following treatment with nitrogen gas, while alumina exhibited no significant change. XRD analysis were conducted to confirm the formation of new phases resulting from gas interactions. Additionally, the microstructures were examined using SEM-EDX for elemental mapping to assess the extent and nature of gas-material interaction at the microscopic level.

Keywords: Thermal Stress, Refractory, Refractory oxide-gas interaction

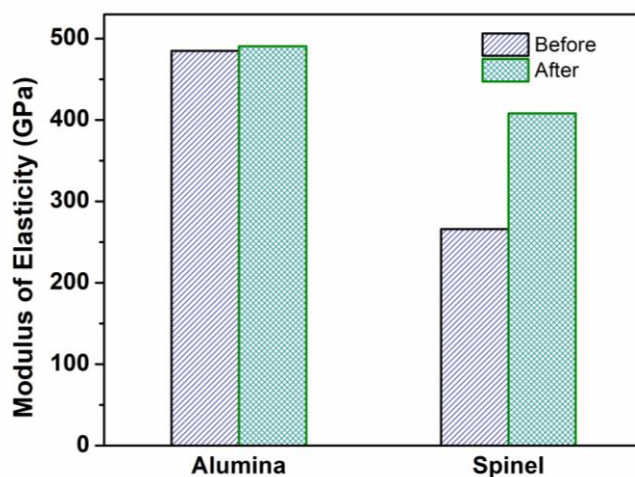


Fig: 1. Modulus of Elasticity before and after the gaseous interaction

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Interaction of MgO-C refractory with steel and slag and its effect on inclusion in low-carbon Al-killed steel

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The demand for clean steel has increased significantly over the past two decades. Despite efforts to remove impurities, the heats were still rejected by customers mainly because of inclusions present in the steel. Controlling inclusions is essential for the steel-making industry to maintain the quality of steel. Inclusions during secondary refining can originate from slag or the ladle refractory. In low-carbon Al-killed steel, inclusions can change from alumina to MgO-containing spinel. This alumina-to-spinel transformation typically occurs in two steps: 1) reduction of MgO at the steel-refractory or steel-slag interface, and 2) reaction between dissolved magnesium in the steel and alumina inclusions.

Kumar^[1] studied the transformation of alumina to spinel inclusions resulting from the reaction between steel and a MgO crucible. They found that impurities in the MgO crucible can lead to the formation of a liquid, slag-like layer at the steel-crucible interface. The presence of this slag-like layer can enhance the Mg transfer rate by about 20 times compared to the formation of a crusty spinel layer at the crucible surface. At an industrial scale, the presence of ladle glaze can significantly accelerate Mg transfer from refractory to steel. This work aims to understand that effect through laboratory-scale experiments. MgO-C refractory, both uncoated and slag-coated, was dipped in low-carbon Al-killed steel. Steel samples were collected every five minutes, and inclusion analysis was performed using manual and automated methods, including SEM-EDS. The steel-refractory interface was also examined via SEM-EDS. It was observed that MgO-C refractory contributes to inclusions in two ways: a) converting existing alumina inclusions to spinel inclusions, and b) entrapment of MgO micro-fines from MgO-C refractory, which then transform into spinel inclusions. The glaze formation on MgO-C refractory was simulated by dipping it in molten slag. The glazed refractory showed an earlier formation of spinel than the uncoated refractory.

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Refractory Selection Consideration for Aluminium Melting & Holding Furnace

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Refractory lining of an aluminum melting and holding furnace are engineered with a primary design objective to keep the furnace condition stable throughout the life of the furnace. Service environment, service temperature, mechanical degradation and the ability to install or repair of the refractory materials in a cost effective manner are the major factors which limit the uses of refractory. Energy efficiency of the processes, as degradation of refractory reduces the thickness of walls, cause heat loss through the walls and increases exponentially are directly related to the said limitation. This condition requires cooling of the furnaces for maintenance and again reheating for further uses which causes huge loss of energy and production time. Refractories for aluminum melting and holding furnaces must withstand mechanical abuse from charging, from thermal shock due to cyclic heating and from complex forces on the refractories when molten metal penetrates their surface. Penetration can destroy the furnace. In metal melting furnaces, wear of the refractory lining is not uniform in nature; it is severe in specific areas where most corrosive condition exists. In melting furnaces the most severe condition occurs at the metal lines where solid refractory comes in contact with liquid metal and gaseous environment above the liquid metals. This paper discusses the proper selection criteria and best suitable solution of refractory materials for aluminium Melting & Holding furnace which can contribute potential productivity.

Vesuvius's Fused Silica based Concept for Aluminum launders

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The transport of molten aluminum through conventional cement-based launder systems presents persistent challenges, including chemical reactivity with bauxite-based refractories and significant temperature losses during metal flow. To address these issues, Vesuvius has developed Sigma 2SL, an advanced fused silica-based refractory system engineered for direct contact with molten aluminum and aluminum alloys.

The Sigma 2SL precast launder solution offers lower thermal conductivity to minimize heat loss and helps maintain molten aluminum temperature during transfer. It exhibits thermal shock resistance, negligible thermal expansion for campaign stability. The fused silica surface exhibits non-wettability against molten aluminum alloys, thereby reducing the likelihood of chemical reaction, minimizing possibility of contamination from the refractory. Its reduced density decreases material consumption, while the precast design simplifies installation and handling. Specialized surface coatings further enhance resistance and durability.

Following successful indigenization, "Sigma 2SL-Precast Launder system" has been introduced in India and has demonstrated more than one year of continuous operation with stable performance without any repairs.

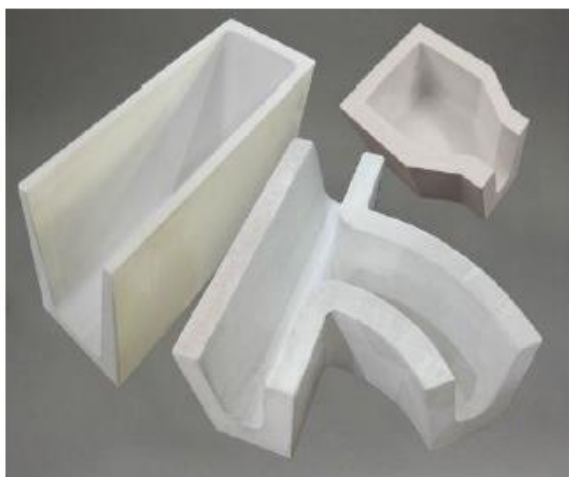


Fig. 1: Fused silica launder | Fig. 2: no sticking and no penetration of molten aluminum

Keywords: Fused Silica, Molten aluminum, Precast Launderers, non-wettability

Microstructural and mechanical properties of MgAl_2O_4 spinel ceramics prepared from commercial grade oxides

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Magnesium aluminate (MgAl_2O_4) spinel refractory is getting attention as a superior refractory material in steel and cement industry due to its unique chemical and physical properties suitable as a lining material. Pre-formed spinel due to its double stage sintering is not cost-effective as refractory material in the industrial application. Present investigation focuses on the fabrication of different MgAl_2O_4 spinel including stoichiometric, alumina excess and magnesia excess from commercial grade sintered MgO and calcined Al_2O_3 powders by conventional single-stage sintering process from 1550°C to 1650°C and study on microstructural and mechanical properties. Different compositions of the sintered magnesia and Al_2O_3 powder were mixed with binder, compacted at 150 MPa pressure and sintered at 1550°C , 1600°C and 1650°C temperature. Mineralogical phases and microstructures of the sintered samples were examined under X-ray diffraction and FESEM. Mechanical properties like flexural strength, Young's Modulus, Hardness and Fracture toughness were determined and correlated. The result shows that densification increased with the increase of MgO content in the composition. XRD patterns confirmed that Al_2O_3 and MgO powders transformed into MgAl_2O_4 spinel. Plate like grains with more pores for ASP, compact bimodal grains with less pores for SSP and round shapes grains for MSP samples were observed in the microstructure. Improved mechanical properties were found in stoichiometric and MgO excess composition.

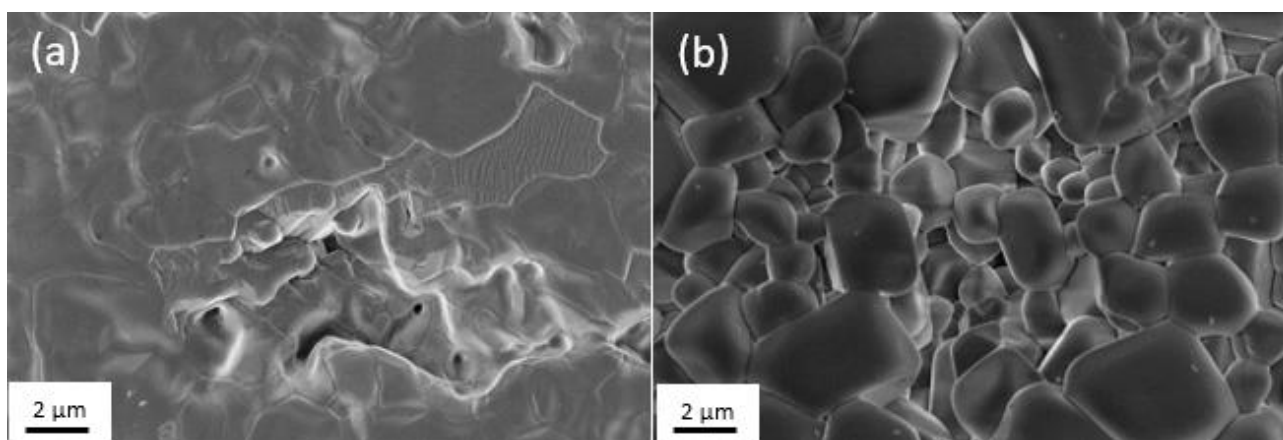


Fig. 1. FESEM micrograph of (a) stoichiometric and (b) MgO excess spinel sample

Development of graphite-silica based anti-stick coating for LD slag pot

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LD slag pots undergo huge thermal shock due to the number of heats running due to slag loading and unloading at slag pit area [1]. Slag pots, made up of cast iron, catch up cooled down slag on the pot surface which is removed by pounding them. This slag build-up reduces the working tenure of the slag pots reducing the number of heats on service. To avoid such scenarios, some development on anti-stick coating was done with silica [2] or alumina based material [3]. The developed graphite-silica based anti-stick coating was targeted to reduce the slag build-up on the pot surface. The coating was a dispersed aqueous solution of the components of the coating. The dispersion was made by adding various surfactants and dispersants which made the complete solution stable for a certain period. In lab scale studies, this coating was applied on small pieces of cast iron, heated at a temperature of 200°C on which molten slag is poured at 1400°C. The coated slabs were then turned upside down to determine the anti-sticking property. It was observed that two compositions of the coatings became non adherent to the semi molten slag. This easy-to-use solution was found to improve the number of heats by two times compared to the uncoated cast iron slab. The coating solutions were taken for plant scale trial with a 1000 litre quantity and applied through a spray system at 200°C as shown in fig. 1. The coated slag pot sustained for 8 heats without any slag adhesion on the surface. The coating performed better with a life enhancement of four times than bare pots. The coated pot was found very stable in presence of slag due to its anti-sticking nature which in turn improved the life of the pot with superior life.



Fig. 1. Slag pot coating by graphite-silica solution

Keywords: Anti-stick coating; LD slag pot; spray technology; sustainable coating

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Glass & Glass-Ceramics

INVITED SPEAKERS

High-Performance Glass and Glass-Ceramic Materials for Mission Critical Space Applications - Progress report by ISRO

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Glass & Glass-ceramics are an inevitable material element in demanding space applications. This presentation shall provide a brief overview of the gamut of R&D activities in ISRO in the field of glass & glass-ceramic, and discuss the following specific development efforts in detail, namely (i) Processing low thermal expansion glass-ceramic (LEGC), (ii) Development of glass sealing for glass-to-metal seals (GTMS), and (iii) Development of glass for low-temperature co-fired ceramic (LTCC). The material with dimensional and thermal stability manifests its importance in widespread technical applications, namely, satellite-based surveillance mirrors, Ring Laser Gyroscope (RLG), or an astronomical telescope, lithography platforms, etc. Low thermal expansion glass-ceramic processed through the controlled crystallisation of lithium aluminosilicate (LAS) glass is the primary choice for the said applications. This talk shall summarise the lab-scale development work to identify an optimum crystallisation heat treatment schedule to attain the desired crystal size, volume fraction and CTE. The crystallisation behaviour of the glass between 780 and 900 °C and its influence on microstructure and thermal dilation will be presented. Transparent glass-ceramics with 80% crystallinity from nanocrystals (24-40 nm) of $(\text{Li, Mn, Zn})_{1.7}\text{Al}_2\text{Si}_6\text{O}_{16}$ phase demonstrated CTE less than $<0.1 \times 10^{-6} \text{ K}^{-1}$. Challenges faced in facility establishment, scale-up trials and process optimisation shall be discussed. Glass sealing is inevitable for realising the hermetic assemblies required for electronic, automobile, industrial, and aerospace applications. Towards the development of compressive sealing assembly for surface discharge spark plug (SDSP) and pyro ordnance devices, an alkali barium borosilicate glass family was identified with suitable coefficients of thermal expansion (CTE). This presentation shall detail the lab-scale development and functional test results of the glass-sealed SDSP assembly. This work attempted to develop a glass sealant for a surface discharge spark plug whose configuration involves a metallic casing, central electrode, ceramic insulator, and spark-augmenting semiconductor. Alkali barium aluminosilicate glass compositions was explored for realising compressive glass sealing. As CTE of the glass plays a major role in achieving compressive stress in a sealed assembly, a range of compositions was explored for thermal expansion in the range of 7 and 12.5 ppm/K. The effect of composition and its influence on CTE shall be presented in detail. The dielectric breakdown of the glass was found to be close to 33 kV/mm. It will present the stress distribution in the assembly through finite element modelling. Optimised sealing could withstand hydrostatic pressure up to 740 bar and could initiate sparking at 2kV input voltage. The effect of configuration changes will be discussed in brief. This talk shall cover the results of functional performance during the torch ignitor test. Glass-based low-temperature cofired ceramic (LTCC) is a matured technology that finds application in wireless communication systems. Low relative permittivity (4-9) and low dissipation factor ($< 2 \times 10^{-3}$) are key requirements for selecting material for LTCC application. The development and processing of novel $\text{ZnO-B}_2\text{O}_3\text{-SiO}_2$ (ZBS) glass-ceramic towards its application as an LTCC substrate shall be presented. ZBS glass with a hexagonal willemite structure as a significant phase and the tetragonal willemite as a minor phase were processed with additives like Al_2O_3 and TiO_2 . The successful sintering was achieved on the sample heat-treated at 750°C-875°C, which resulted in densification $>98.5\%$. The dielectric constant of 5.2 to 6.2 and $\tan\delta = 1.12 \times 10^{-3}$ to 1.90×10^{-3} , CTE of $5.8\text{-}7.9 \times 10^{-6} \text{ K}^{-1}$ and $\tau_f = -61$, making them a promising candidate for LTCC applications.

Glass-supported hybrid gold nanoislands for multi-functional applications

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Metal nanoparticles (MNPs) can be synthesized on a variety of substrates using different fabrication techniques, with the substrate type playing a crucial role in determining their physicochemical properties. However, achieving long-term stability of MNPs remains a major challenge due to their typically weak adhesion to conventional substrates. In this context, we demonstrate that a newly developed H-glass substrate can simultaneously stabilize plasmonic gold nanoislands (GNIs) and enable multifunctional applications. The GNIs are formed on H-glass through a simple yet robust thermal dewetting process. Remarkably, H-glass-supported GNIs (HGNIs) exhibit significant photocatalytic activity in solar-to-hydrogen (STH) conversion via water dissociation, achieving an impressive 0.6% STH efficiency without the use of sacrificial agents. Furthermore, a novel photocatalytic platform based on gold nanoparticles (GNPs) immobilized on a glass-derived porous scaffold attains an enhanced STH efficiency of 2.2% under simulated solar irradiation. This study elucidates the critical role of H-glass-supported HGNIs in promoting light-driven chemical transformations and provides new insights for designing high-performance catalysts for diverse chemical conversion reactions. Additionally, the H-glass embedded with GNIs functions as a room-temperature chemiresistive gas sensor, demonstrating a 70% response toward NO₂ gas. The GNIs serve as catalytic nucleation centers, enhancing crystallinity and facilitating the vertical alignment of interconnected Cs₃Bi₂I₉ petal-like thin films.

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Quasi-high-entropy alumina-based amorphous oxides in 3-D forms with enhanced stability

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Alumina-based non-crystalline oxides possess high hardness, refractive index, and exhibit interesting phenomena such as large-scale plasticity [1] and poly-amorphism. Alumina alone cannot be obtained as a bulk non-crystalline form, although it can act as a network former in silicate glasses [2]. Alumina-based non-crystalline oxides are not yet deployed in applications because of inadequate thermal stability, high melting points, and high cooling rates required to retain the non-crystalline structure, leading to difficulty in producing 3-D shapes. It is desirable to obtain bulk alumina-based amorphous oxides to exploit their unique properties. However, the sintering of these materials typically required extremely high pressures (~1 GPa), limiting the achievable size of the dense forms. It is important to achieve sintering without applied pressure by designing new compositions with enhanced thermal stability. In the present work, a quasi-high-entropy strategy [3] was implemented in the design and synthesis of Al₂O₃ based-amorphous oxides with different stabilizers such as TiO₂, Y₂O₃, Yb₂O₃, and ZrO₂ for enhancing the ease of amorphization. Amorphous powders were obtained by solution combustion synthesis. The thermal stability was successfully improved up to 950 °C in some of the compositions. These were selected for densification (sintering) by pressureless sintering, vacuum sintering, and hot-pressing. We report for the first time, extensive time-dependent viscous sintering in such materials. Mechanical, functional and thermal properties were measured on the bulk sample, made possible by the ability to produce 3D shapes. Structural analysis of amorphous network was carried out using the combined techniques of ²⁷Al MAS NMR and X-ray absorption spectroscopy (XAS), and Raman spectroscopy. Pressureless and pressure crystallization were performed on dense pellets produced a range of ultrafine microstructures. This study opens up the possibility of obtaining alumina-based nanocrystalline ceramics, apart from dense bulk amorphous oxides.

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Influence of phase separation and melt size on property variation in GeSe₂-As₂Se₃-PbSe glasses for infrared gradient refractive index (GRIN) applications

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Chalcogenide glasses are of significant interest for infrared photonics and optoelectronic applications owing to their excellent infrared transparency, compositional flexibility, and tunable structural and thermal properties. Understanding how compositional modifications and phase separation phenomena influence their structure–property relationships is essential for optimizing their performance in practical devices. In this work, the physical, thermal, and optical properties of (GeSe₂-3As₂Se₃)_{1-x}PbSe_x chalcogenide glasses were systematically investigated as a function of PbSe content and glass morphology. Measurements of density, microhardness, thermal behavior (glass transition, stability, and conductivity), and infrared transmission spectra reveal strong correlations with Pb concentration, emphasizing the role of liquid–liquid phase separation (LLPS) in governing the properties of this multi-component system. Structural interpretation suggests that Pb acts both as a network modifier and as a partial network participant, driving the observed variation in physical and optical characteristics. Raman spectroscopy and transmission electron microscopy (TEM) confirm the structural origins of these changes, illustrating distinct phase-separation morphologies and their influence on property evolution. Additionally, the influence of melting conditions was examined by scaling from laboratory-scale melts (40 g) to larger, commercially relevant batches (1.325 kg), enabling a quantitative understanding of how thermal history affects structure and property development in these glasses.

Innovating Opal Glass for Sustainable and Long-Life Furnaces

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The development of a non-conventional opal glass system represents a major step toward achieving environmentally sustainable manufacturing and extending the operational life of opal glass melting furnaces. Conventional opal glasses rely on traditional opacifiers that generate corrosive and environmentally harmful species during melting, leading to refractory degradation, shorter furnace campaigns, and increased emissions. The non-conventional formulation eliminates these issues by employing an alternative opacification mechanism governed by controlled phase separation and crystallite formation, offering a cleaner and more durable melting process. The objective of this work is to design and assess a non-conventional opal glass composition suitable for industrial-scale trials in existing continuous furnaces. Although full-scale implementation is yet to be undertaken, laboratory-scale studies have demonstrated excellent melt stability, opacity development, and compositional compatibility. During simulated transition from conventional to non-conventional batch compositions, the opacity was observed to decrease progressively up to about 50% conversion, resulting in a temporary semi-transparent appearance, and then increase again as the conversion approached completion. This reversible trend arises from the dilution of opacifiers in the intermediate region, where neither mechanism predominates sufficiently to produce effective scattering centers. A similar transient effect has been observed in solar glass production during the melt refining process, when glass containing type-1 refining agents is replaced by glass containing type-2 refining agents, causing a temporary reduction in refining efficiency. Overall, the non-conventional opal glass system shows strong potential for greener production, longer furnace life, and a deeper understanding of compositional transition effects in industrial glass melting operations.

CONTRIBUTORY SPEAKERS (ORAL)

Sintering and Thermal Characteristics of BaO-CaO-Al₂O₃-SiO₂ Based Glass System

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The BaO-CaO-Al₂O₃-SiO₂ glass system is highly demanding material for many applications particularly as a sealant in planar type anode-supported solid oxide fuel cell (SOFC) or solid oxide electrolyzer (SOEC) cell because of its unique combination of compatible thermal expansion, rigid hermetic sealing ability to other fuel cell components like anode and interconnect [1]. It is to be noted that although presence of B₂O₃ in glass improve the workability and surface wettability to the substrates; but, it imparts significant weight losses due to its evaporation at high application temperature (800-850°C) [2]. Therefore, presence of B₂O₃ is detrimental for sealant application. Our composition is completely boron free which is the novelty of this material. In the present study, BaO-CaO-Al₂O₃-SiO₂ based glass is prepared with a minor addition of second phase through melt-quench route for making into frits. Thereafter, the frits are pulverized into powder having mean particle size < 45µm, with the help of planetary ball mill. The powders are made into pellets and sintered at different temperatures to achieve maximum density (to avoid the presence of pores) which is essential for sealant applications to inhibit leakage of process gases. The bulk densities and CTE of sintered glass are close to that of fuel cell components like anode, interconnect, as depicted in Table 1. The densification of glass is improved through viscous flow mechanism during sintering, usually observed for non-crystalline material. The sintering kinetics has been determined for such material with the help of shrinkage profile recorded using high temperature heating stage optical microscope (HSM). The in-line real time images of important thermal events such sintering (close to ≈ 15% shrinkage), sphere, half-sphere, and onset of melting of glass are also recorded using HSM, which is illustrated in Fig.1. Such results assisted to achieve the semi-viscous regime of glass through tuning of composition for suiting to application temperature.

Table 1 : Bulk density vs. sintering temp

Sintering parameters	Bulk density (g/cm ³)
	Commercially available
Starting particle size (µm)	< 45
850°C-5°C/min-2h	3.21
875°C-5°C/min-2h	3.41
900°C-5°C/min-2h	3.38
925°C-5°C/min-2h	3.38
CTE (×10 ⁻⁶ /°C, 80-750°C)	10.5
CTE (80-750°C)	11 (YSZ), 11.5 (Ni-ZrO ₂)

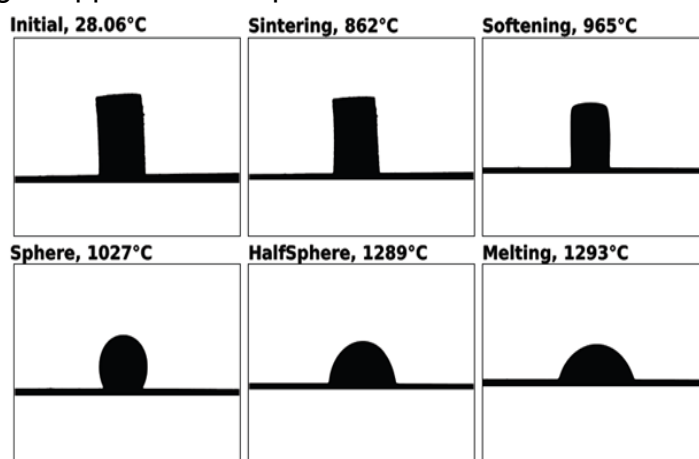


Fig. 1. Important thermal events of BaO-CaO-Al₂O₃-SiO₂ glass

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Studies on the Electrical and Mechanical Properties of LTCC Tapes with changes in the Dielectric and Organic Constituents

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In the era of high-performance electronics and miniaturization, the demand for robust, thermally stable, and process-friendly ceramic tapes is increasing. By allowing the combination of low-temperature sintering and multilayer circuitry, “Low Temperature Co-fired Ceramics (LTCC)” tapes offer a flexible solution. In the present work, high-quality tapes are made by doctor blade method using carefully regulated organic formulations and variety of glass-to-ceramic ratios (from 50:50 to 70:30). The mechanical, thermal, and microstructural characteristics of LTCC green and sintered tapes are examined in this study in relation to changes in the inorganic phase (glass and cordierite) and organic system (binder, plasticizer, and dispersant) [1-2]. Densification trends with compositional shifts are revealed by studying the sintering behaviour of ceramic stacks made from these tapes, and the optimal composition for dense, faultless stacks is determined by monitoring shrinkage and microstructural consolidation [1, 3]. It is noted that the green tape's flexibility, tensile strength, and surface integrity are all greatly impacted by the composition and proportion of plasticizers and binders [2]. A systematic analysis of dimensional stability, processability, and mechanical strength in both green and sintered states reveals that a higher glass content improves densification and flow characteristics during processing, whereas a higher ceramic content increases structural rigidity. Furthermore, the powders are characterized for XRD, SEM, and particle size analysis. The mechanical and dielectric properties as well as thermal properties are also evaluated and the results are correlated to slurry formulation. Finding the ideal balance between processing simplicity and functional performance is made easier with the help of this integrated approach. Our study has given a lead into formulation of LTCCs that are more reliable in terms of mechanical and thermal performance for use in embedded electronics, high-density interconnects, RF packaging, and advanced thermal management systems [1, 3].

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Structural, Thermal, Photoluminescence, and Electrical Studies of CoO-Doped Lithium Zinc Phosphate Glasses

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Lithium zinc phosphate glasses with the composition $45\text{P}_2\text{O}_5 - 25\text{ZnO} - (30 - x)\text{Li}_2\text{O} - x\text{Co}_3\text{O}_4$ ($x = 0-6$ mol%) were synthesized via the conventional melt-quenching method as shown in figure 1. X-ray diffraction (XRD) confirmed the amorphous nature of all samples. Density and molar volume varied systematically with increasing CoO content, indicating structural rearrangements within the phosphate network. Thermal analysis revealed improved thermal stability with cobalt incorporation, suggesting the strengthening of the glass matrix. The electrical behavior was examined over a wide frequency and different temperature range, showing typical thermally activated conduction. The calculated activation energy in the range of 0.12 to 1.24 eV, depending on composition. The AC conductivity followed Jonscher's universal power law as shown in Figure 2, expressed as $\sigma_{ac}(\omega) = \sigma_0 + A\omega^s$, [1] with the frequency exponent s less than 1, indicating a correlated barrier hopping mechanism. Dielectric analysis (ϵ' , ϵ''), electric modulus (M' , M''), and impedance spectra (Z' , Z'') provided further insights into relaxation dynamics and ion transport behavior. Photoluminescence (PL) studies revealed that visible emissions attributable to cobalt ion transitions, highlighting that these materials are potentially suitable for photonic and optoelectronic device applications.

Key Words: Phosphate glass; Cobalt ions; Thermal Stability; AC conductivity; Dielectric Properties.

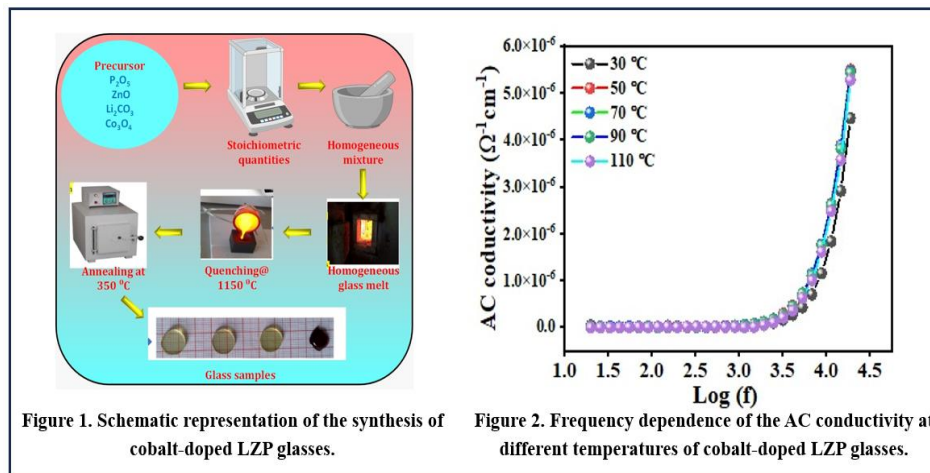


Figure 1. Schematic representation of the synthesis of cobalt-doped L郑 glasses.

Figure 2. Frequency dependence of the AC conductivity at different temperatures of cobalt-doped L郑 glasses.

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Improvements of Mechanical and Functional Properties of Aluminosilicate Glass/ Glass-ceramics Composites

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Aluminosilicate glass and its composites are extensively used in structural applications due to their durability, thermal shock resistance, and mechanical strength. This investigation explores the development of aluminosilicate-based glass composites reinforced with advanced ceramic particulates to enhance their structural integrity and mechanical performance. Aluminosilicate base glass was synthesized using the conventional melt-quenching method. Using Differential Scanning Calorimetry (DSC) certain thermal parameters, including the glass transition temperature (T_g), crystallization temperature (T_c), and melting point (T_m) were measured. The developed glass powder was then employed to fabricate composites by incorporating ceramic particulates in varying proportions. These composites were sintered at optimized temperatures to achieve maximum bulk density. A Comprehensive characterization was carried out using techniques such as Differential scanning calorimeter (DSC), X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Transmission electron microscope (TEM) for microstructural evaluation and Universal Testing Machine (UTM) as well as Nano-indentation used to examined mechanical behavior of composites. Mechanical properties improved with increasing ceramic content up to a certain level, after which a decline was noted. SEM analysis revealed that the unreinforced base glass had a smooth surface, whereas the reinforced composites displayed distinct grains and grain boundaries, indicating microstructural changes due to particulate incorporation.

Synthesis of Glass-Foam from End-of-Life Photovoltaic Materials

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End-of-life (EoL) photovoltaic (PV) materials primarily consist of silicon (Si), aluminum (Al), glass, and various metals like copper (Cu), silver (Ag), and others. These materials, found in solar panels and their components, pose both environmental and economic concerns at the end of the PV system's lifespan. Effective recycling strategies are crucial to recover valuable materials and minimize the environmental impact of PV waste. In the present work an effort has been taken in order to recycle the EoL PV glass into a foam glass, a lightweight material with high compressive strength to use it as a thermally insulating material. Cylindrical glass pellets (10 mm in diameter and 5–10 mm in height) were fabricated by mixing milled PV glass powder with different concentrations of polyvinylpyrrolidone, followed by firing at 800 °C and subsequent furnace cooling. The densities of the sintered pellets varied in the range 0.53 g/cc and 1.99 g/cc (Fig. 1). SEM image showed the pores and their size varied from 1.50 μm till 3.8 μm (Fig. 1). Xrd of the sintered pellets confirmed the amorphous pattern of glass. The compression strengths of the pellets were in the range of 1000 N to 2713 N.

Table 1. Hardness of pellets as per Mohs Scale.

Pellet no.	PVP%	Mohs Hardness	
		Sintered	Unsintered
0	0	6 to 7	0
1	5	3 to 4	2 to 3
2	7	3 to 4	2 to 3
3	10	3 to 4	2 to 3
4	12.5	3 to 4	3 to 4
5	15	4	3 to 4
6	17.5	4 to 5	3 to 4
7	20	4 to 5	3 to 4
8	25	4 to 5	3 to 4
9	30	4 to 5	3 to 4

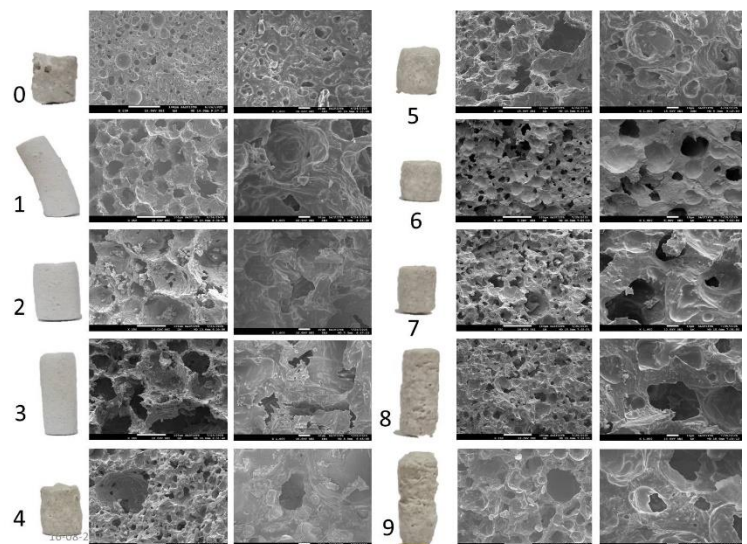


Fig. 1. SEM images of Pellets (PVP mixed with glass powder). Different concentrations of PVP mixed with glass powder labelled as 0 to 9 as in table 1.

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Challenges in usage of high cullet in float glass production

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Incorporating high percentages of cullet into float glass production presents clear advantages—such as accelerated melting rates, notable energy savings, reduced reliance on virgin raw materials, and enhanced sustainability through circular economy practices. However, achieving these benefits involves navigating significant operational challenges.

A primary concern is contamination: cullet may harbour metal fragments, heavy minerals, ceramics, sticker residues, or incompatible glass types (e.g., borosilicate, lead glass), leading to melting inconsistencies and quality defects. Even trace amounts of impurities can cause bubbles, cracks, or shifts in tint—making compatibility with SG float glass quality especially critical.

From a regulatory and logistical standpoint, the fragility of cullet supply chains demands meticulous sorting, storage, and segregation, especially when sourcing from diverse post-consumer or post-industrial streams.

Collectively, the challenges of high cullet usage span contamination control, composition consistency, regional compliance, logistics, and furnace operation dynamics. Overcoming these hurdles necessitates advanced sorting and monitoring technologies, standardized supply chains, and precise composition management to unlock the full potential of cullet in cost-effective, sustainable float glass production.

CONTRIBUTORY SPEAKERS (POSTER)

APPLICATION OF POTASSIUM CRYOLITE (PAF) IN ALUMINUM, CERAMICS AND GLASS INDUSTRIES

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Potassium Cryolite, PAF is a commercial fused inorganic salt. It has useful properties and is found in several industrial applications such as a filler in the manufacture of abrasives, as a damaging Flux, as a brazing flux for Aluminium, as a salt flux to maximize metal recovery in secondary aluminium smelting and as a non-hygroscopic flux in Metal Tablet to accelerate dispersion after addition. PAF is a Low cost & low melting Fluorine based flux. It is mainly used in resin bonded, more specifically in phenolic resin bonded, grinding products. Here the binder consists of a combination of the binding substance – the resin - plus several filler materials such as Cryolite, PAF and Pyrite. The filler gives the binder “substance” and adds several desired properties. Phenolic resin bonded tools such as cut-off and deburring discs are designed to operate at high rotating speeds that may cause very high temperatures locally. Cryolite and PAF keep the grinding surface cool and protect it from oxidation.

PAF has an application as a Opacifier in glass and enamel. Potassium cryolite is used to make glass and enamel opaque by causing light scattering in the material. It helps control refractive index and improves the aesthetic appearance of ceramic glazes and porcelain enamels.

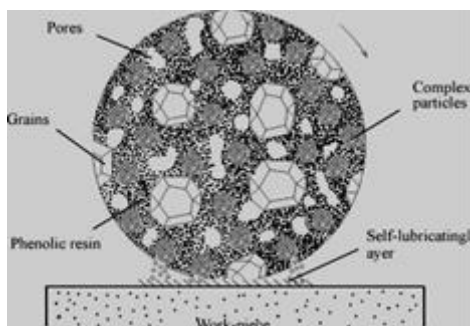


Fig. 1. Potassium Cryolite (PAF) as a lubricant in phenolic grinding wheels

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Nd³⁺-Doped Phosphate Glasses Derived from Bio-Waste for Photonic and Optoelectronic Applications

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In the pursuit of sustainable material development, calcium oxide derived from biowaste eggshells was utilized as an eco-friendly precursor in the synthesis of Nd₂O₃-doped aluminum sodium calcium phosphate glasses. The glasses were fabricated using the melt-quenching method at approximately 1060°C temperature. X-ray diffraction (XRD) analysis confirmed the amorphous nature of the prepared samples. Scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDX) verified the elemental composition of both the raw eggshell and glass composition, confirming the presence and successful incorporation of calcium. Optical properties were thoroughly investigated using UV–Visible spectroscopy, allowing the determination of the optical band gap and corresponding optical conductivity values. The refractive indices of the glass samples were also evaluated, reflecting compositional dependence on rare-earth doping. Furthermore, Raman spectroscopic studies provided insights into the structural units and phosphate network modifications induced by Nd₂O₃ incorporation. The incorporation of eggshell-derived CaO not only promotes circular economy practices but also tailors the glass network for enhanced optical features. These glasses show promising potential for photonic applications, such as in solid-state lasers [1], optical amplifiers, and protective coatings for optoelectronic devices, demonstrating both functional performance and environmental consciousness.

Key Words: Phosphate glasses; Eggshells; Optical conductivity; Bio-glasses

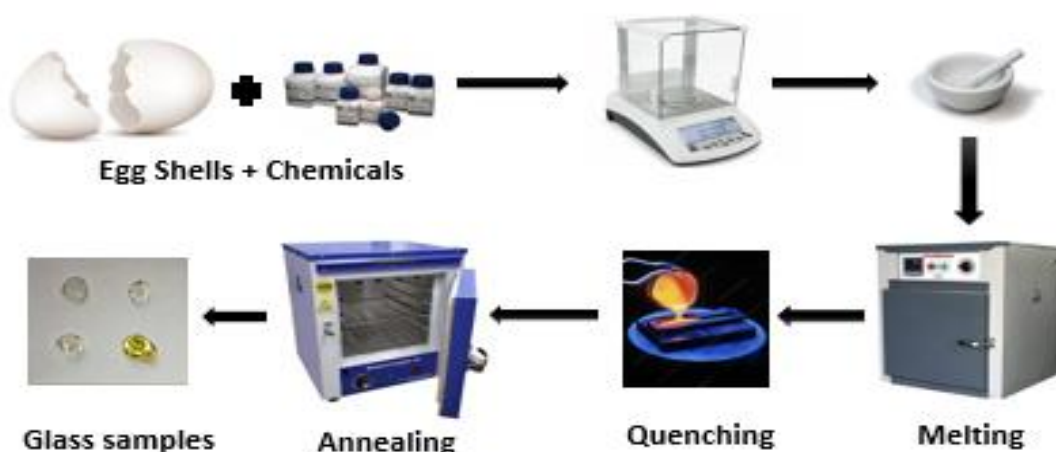


Fig.1- Synthesis of glass material

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Isa, N. Y. M., Sazali, E. S., Hisam, R., Ghoshal, S. K., Zain, S. K. M., Juma'in, N. H., Yaacob, S. N. S., Mahraz, Z. a. S., Harun, A. N., Noor, F. M., Sahar, M. R., Samah, K. A., Aziz, M. S., Salim, A. A., & Awang, A. (2021). *Physical, structural, and raman spectroscopic traits of Neodymium-Doped lead oxyfluoride zinc phosphate glass*. Journal of Physics Conference Series, 1892(1), 012027.

Study of Electrical Properties of Silver Oxide and gadolinium (III) Oxide doped Borate Glasses

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A series of glass samples with compositions $60\text{B}_2\text{O}_3-(38-x)\text{ZnO}-x\text{Ag}_2\text{O}$ ($x = 0, 0.5, 1, 1.5, 2.0, 2.5$ mol%) and $60\text{B}_2\text{O}_3-(38-x)\text{ZnO}-2\text{Ag}_2\text{O}-x\text{Gd}_2\text{O}_3$ ($x = 0, 1, 2, 3, 4, 5$ mol%) were synthesized using the conventional melt-quenching technique. Following synthesis, the glasses were annealed for 1 hour to relieve internal stresses and subjected to structural characterization through X-ray diffraction (XRD). Dielectric measurements—including capacitance, dielectric constant (ϵ'), dielectric loss (ϵ''), electrical conductivity, and modulus analysis—were performed over a frequency range of 30 Hz to 30 kHz and at temperatures ranging from ambient to 110 °C. The incorporation of Ag_2O and Gd_2O_3 was found to enhance the dielectric constant across the measured frequency range. The frequency-dependent electrical conductivity was analyzed using Jonscher's universal power law to distinguish between AC and DC contributions. Cole–Cole plots indicated non-Debye-type relaxation behavior. Moreover, the conduction mechanism was consistent with the Correlated Barrier Hopping (CBH) model, as evidenced by the observed decline in the frequency exponent (s) with increasing temperature.

Keywords: Silver oxide; Borate glass; Density; gadolinium trioxide; Energy band gap.

Study of electrical properties of Erbium doped Boro-Tellurite glasses

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Erbium trioxide mixed with boro-tellurite glasses with the composition $60\text{B}_2\text{O}_3-(30-x)\text{TeO}_2-10\text{Na}_2\text{O}-x\text{Er}_2\text{O}_3$ (where $x=0.0, 0.1, 0.2, 0.3, 0.4$ & 0.5 mol%) were prepared using the traditional melt-quenching process. The nature of the prepared glass samples was verified using X-ray diffraction. The electrical conductivity measurements was recorded in the frequency range of 10 kHz to 30 MHz at room temperature (300 K) using an impedance spectrometer. It was found that the impedance Cole-Cole plots of all glass samples exhibits good single well shaped semi circles. The conductivity increases with increasing frequency at room temperature. Dielectric constant (ϵ') decreases and dielectric loss (ϵ'') was increased with frequency. The variation electric modulus for both real (M') and imaginary parts (M'') with frequency were discussed.

Keywords: Cole-Cole plots; Dielectric constant and loss: Conductivity.

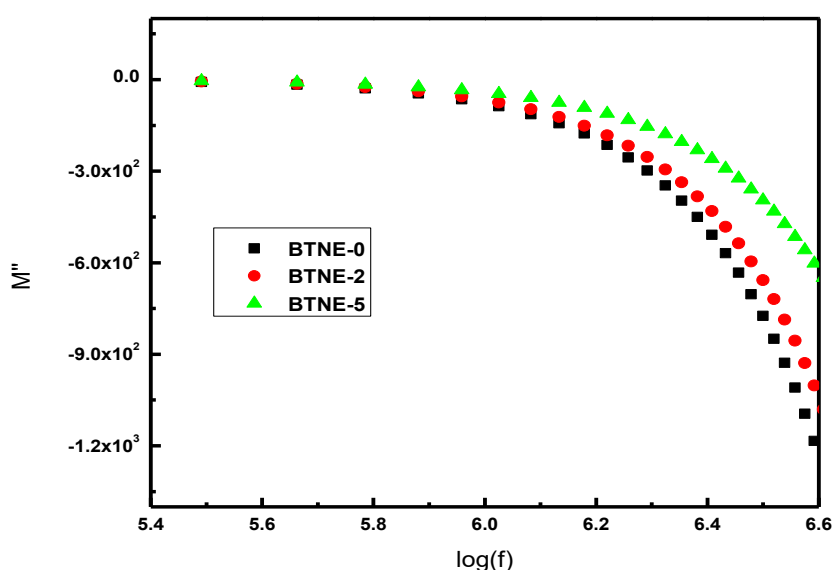


Fig. 1. Variation of imaginary part of electric modulus with frequency

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Optical properties of Zinc Borate Glasses in the presence of Gallium and Gadolinium oxide

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Zinc borate glasses are highly versatile and most extensively used materials. The variation in their composition and inclusion of other modifiers can bring a large change in their physical and optical properties. In the present work, we have prepared the glasses with chemical composition $(70-x)\text{B}_2\text{O}_3-x\text{ZnO}-3\text{Ga}_2\text{O}_3-0.5\text{Gd}_2\text{O}_3$ where $x = 26.5, 31.5, 36.5, 41.5, 46.5$. using melt quench method. The XRD pattern of these materials confirms the amorphous nature as shown in figure 1. The prepared materials were characterized using uv-visible spectrometer and photoluminescence spectrometer. The obtained optical parameters like energy bandgap, refractive index, colour coordinate, chromaticity and emission properties were analysed with respect to zinc and borate composition.

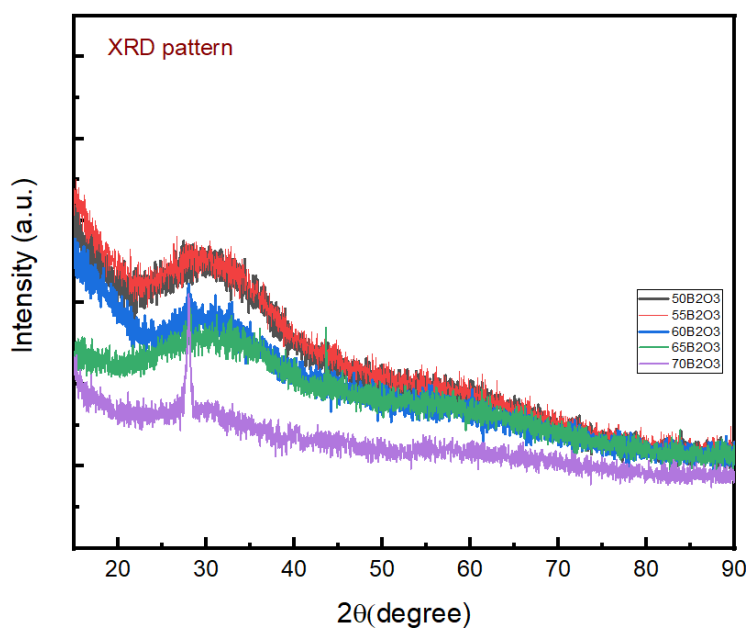


Fig. 1. XRD spectra of Zinc borate glasses with Gallium and Gadolinium oxides.

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Effect of ytterbium ions on optical and transport attributes of lithium aluminium borate glasses

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The comprehensive analysis of optical, structural, and electrical properties of lithium aluminum borate glasses doped with Yb_2O_3 was carried out in this investigation. Using the melt quenching method, glass samples were prepared with varying Yb_2O_3 concentrations. X-ray diffraction (XRD) was used to confirm that the prepared samples are amorphous in nature. The energy band gap (E_g) is determined using UV-Visible spectra. Dielectric properties such as dielectric constant, dielectric loss, elastic modulus, and ac conductivity were analyzed across a broad frequency range and at temperatures from 30°C to 110°C using an impedance analyzer. The complex modulus analysis indicates a relaxation process and transition from long-range to short-range ion mobility with increasing frequency. The results obtained demonstrated that Ytterbium-doped lithium aluminum borate glasses exhibit enhanced conductivity and dielectric properties, suggesting their suitability for advanced optoelectronic and solid-state battery applications.

Keywords: Borate glass; Impedance spectroscopy; Electrical conductivity; Ion transport; Dielectric behavior.

Glass & Glass-Ceramic based Radomes: A Critical Review

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Being environmentally resistant, Radome serves as a crucial part in avionics, military aircrafts, telecommunication, missiles, weather monitoring, space and maritime applications. Radomes are made from materials providing excellent weather resistance and transparency to radio waves, such as glass, glass-ceramics, glass-composites, fibre glass, PTFE-coated fabric, or other specialized composites etc. To function at Mach speed 4 or more, along with allowing the radio magnetic waves to pass through, the flexural and mechanical properties along with dielectric properties of the material are of utmost importance when considering a radome material. High dielectric constant (ϵ) and loss tangent ($\tan\delta$) restrict the usage of a Radome. Unfortunately, low ϵ and high mechanical strength are often mutually exclusive characteristics, requiring the designer to settle for a compromising solution. Radome should also possess high rain erosion resistance and low porosity. Properties of high abrasion resistance, high chemical inertness, high thermal shock resistance are also crucial. Radome should have low thermal expansion coefficient and low $\tan\delta$. Since the service temperature for an airborne radome can be 1400 °C, the preferred range for dielectric constant is < 9.0, allowing a temperature variation of less than 7% up to 1260 °C. $\tan\delta$ can also be compromised but not more than 0.1 up to 1260 °C. Thus, Radomes should have 'maximum transmission' and 'minimum reflection' of electromagnetic signals. As radome technology advances rapidly across the globe, India faces significant challenges such as reliance on discarded technologies, limited raw materials supply, harsh weather conditions and e-waste burdens. Incorporation of state-of-art indigenous product is the need of hour as this paper aims to compile properties of glasses, glass-ceramics and glass composites which have been successfully deployed for radome enthusiasts across the globe.

Optical Characteristics of Silica-Based Glasses Synthesized from Rice Husk Ash (RHA) via a Sustainable Route

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High-purity, high-surface-area amorphous silica (SiO_2) was extracted from rice husk ash (RHA), an abundant agricultural waste, via acid–base precipitation using 2N HCl, followed by calcination at 600 °C for three hours. The silica was incorporated into a glass composition $x\text{SiO}_2\text{--B}_2\text{O}_3\text{--alkali ion}$ system ($x = 0\text{--}20$ mol%, in 10 mol% increments) and processed into glassy materials via melt quenching. X-ray diffraction confirmed the non-crystalline nature of the products. Increasing silica content, the density (2.67 to 2.76 g cm³) increased, but decreased the molecular volume, and raised the refractive index (2.02 to 2.26). FTIR and Raman spectroscopy revealed the characteristic Si–O–Si bonding and borate network vibrations. UV–Vis spectroscopy showed that the glasses are wide band gap semiconductors (direct and indirect), activated in the UV region while transparent in the visible range. Photoluminescence (PL) measurements supported the optical findings. This work presents a sustainable route to producing silica-based glasses with tuneable optical properties.

Fabrication of Rice-Husk Silica Mediated Bioactive Glass for Antibacterial and Wound Healing Applications

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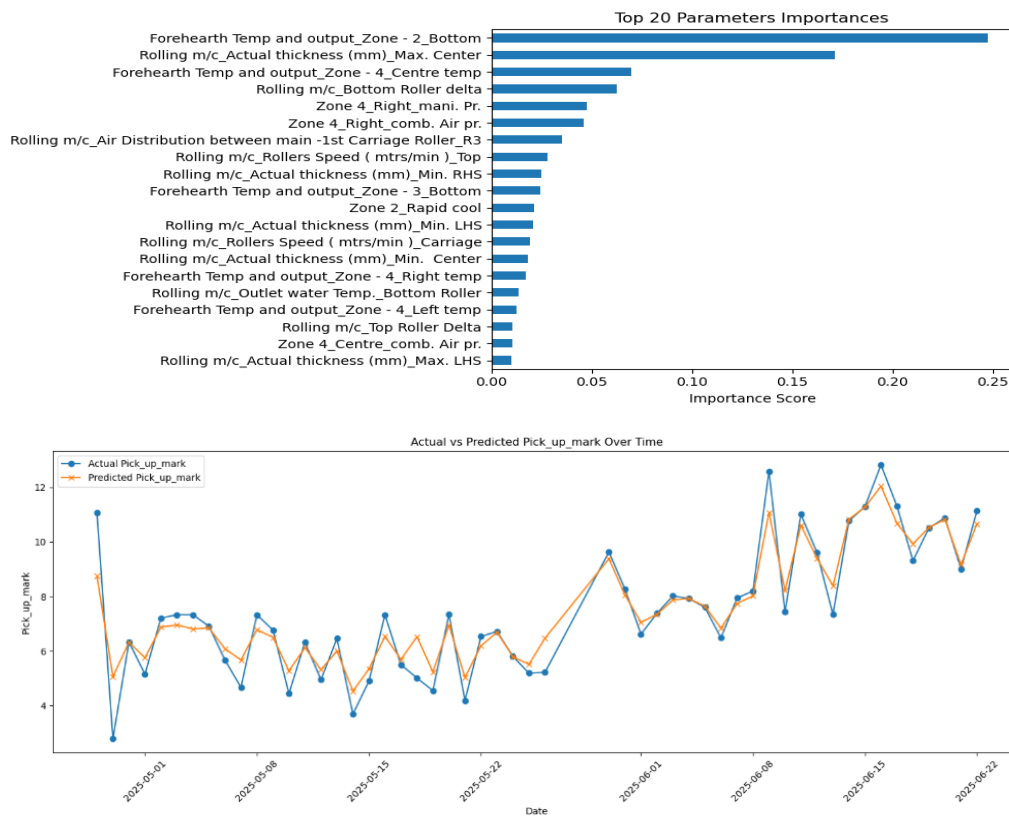
Bioactive glass is a promising material for biomedical applications due to the presence of biologically active ions. In this paper, we explored sustainable and cost-effective substitutes for pure quartz glass by utilizing rice-husk extracted silica for antibacterial and wound healing applications. Two new bio glasses - rice-husk silica glass (RSG) and quartz silica glass (QSG) - were synthesized by using rice-husk extracted silica and pure quartz silica, respectively, and their physiochemical and biological properties were compared with the conventional 45S5 bio glass. Different biological assays like zone of inhibition, colony counting and morphology analysis by electron microscopy confirmed the potent antibacterial activities of the newly developed bio glasses. Antioxidant assay and cytotoxicity assays proved that these bio glasses are biocompatible and promote normal cell proliferation. Finally, in vivo wound healing studies carried out in the rat model demonstrated rapid wound healing properties of the RSG bio glass. This study elaborates the sustainable approaches of utilizing biomass derived silica for synthesizing bioactive glasses for biomedical applications.

Keywords: Rice-husk; Bioglass; Bioactivity; Wound healing; Sustainability

AI-Deployed Glass Production: Defect Analysis and Process Parameter Optimization

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In a glass manufacturing process various surface and bulk defects can be present in the manufactured products. Glass manufacturing lines are equipped with IoT sensors that collect hundreds of process parameters, which are typically stored in a centralized DCS server. This study focuses on deploying Artificial Intelligence (AI) tools to develop predictive models capable of identifying and forecasting defects by analyzing the influence of the glass manufacturing process parameters on the defects. These process parameters are collected from the DCS system and interfaced with the AI tools for analyses. Using a combination of machine learning and statistical techniques, AI-driven recommendations were generated to identify and optimize key process influencing parameters, resulting in a reduction of defect occurrences. These initiatives significantly enhanced the accuracy of defect prediction and provided robust analytical tools that support continuous process improvement in glass production.



Investigation of creep and recovery in Zr-based Bulk Metallic Glasses using constitutive creep models

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Bulk metallic glasses (BMGs) represent a newer class of material that due to their unique amorphous structure have potentially promising applications. In practice, however, applications are often limited by insufficient plasticity, with the mechanisms of plastic deformation still under investigation. Creep, which describes the plastic deformation that occurs in a material at a constant stress, is useful in characterizing the fundamental plastic deformation mechanisms of amorphous materials. Previous creep experiments mostly performed in compression at room temperature using a nanoindenter, have suggested behaviours to validate the shear transformation zone and Kelvin models for BMGs. Understanding the creep response of BMGs at temperatures approaching their glass transition temperatures (T_g) is critical to determine the service temperatures for various applications. In this research, we use tensile creep experiments on different compositions of zirconium-based BMGs at temperatures up to T_g to validate the plastic deformation models proposed for BMGs.

3 different Zr-based BMGs – $\text{Zr}_{46.5}\text{Cu}_{46.5}\text{Al}_7$, $\text{Zr}_{22}\text{Cu}_{54}\text{Ti}_{18}\text{Ni}_6$ and $\text{Zr}_{57}\text{Nb}_5\text{Al}_{10}\text{Cu}_{15.4}\text{Ni}_{12.6}$ were subjected to tensile creep experiments at various stress levels ranging from 10% to 20% of yield stress and at temperatures of $0.82 T_g$ and $0.88 T_g$. The stress was applied for one hour following which, the BMG was allowed to recover for one hour. It was found that the primary creep region for the BMGs lies in the order of 800-1200 seconds following which the strain rate becomes roughly constant. This steady state strain rate closely follows Argon's equations [1] for creep in BMGs. Using these equations, the activation energy for creep at the atomic level was computed and was found to lie in the order of 0.5 – 1.5 eV.

The analysis of the recovery data of the BMGs and correlations of material properties with obtained creep behaviour is currently under investigation.

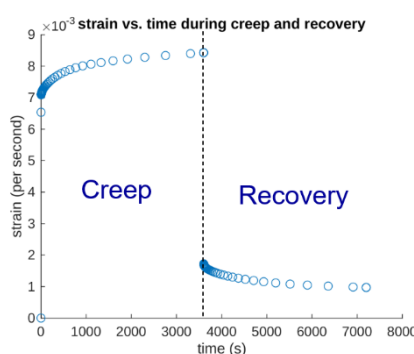


Fig. 1. Creep vs time for a BMG at $0.82 T_g$ and 10% Yield stress

Functional Ceramics

INVITED SPEAKERS

Large electrostrain in polycrystalline piezoceramics: A critical analysis

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Ferroelectric oxide-based piezoceramics exhibit a large electromechanical response and are utilized in high-performance transducers and actuators. Due to the mutual mechanical clamping of grains and their random orientations, the maximum electric-field-driven strain achievable in polycrystalline piezoceramics has been limited to $\sim 0.3\%$. In contrast, a series of recent reports has appeared, claiming electrostrain of $\sim 1\%$ and higher in specially designed compositions of certain Pb-free perovskite materials. Such large electrostrains in piezoelectrics were thought possible only in good-quality single crystals. Our group has rigorously investigated these unusual observations and found interesting facts like (i) the large electrostrain measured is not a composition effect but seen only when the thickness of the piezoceramic is reduced to below 300 microns. Our detailed investigation revealed that most Pb-free piezoceramics, when thinned to below 300 microns, exhibit a strong propensity for bending. We found that this bending propensity is caused by the asymmetric switching of ferroelectric domains in the grains near the positive and negative electrodes, which, in turn, is attributed to defects such as oxygen vacancies present in the ceramic bodies.

Satoshi Uchida

Plasmon-Driven Phase Transformation in MoS₂ by AgAu Nanocrystals for Enhanced Hydrogen Evolution and Sensing

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Plasmonic polyhedral nanocrystals (PPNCs) can drive phase transformations in two-dimensional (2D) MoS₂, thereby unlocking new opportunities in energy harvesting and storage through enhanced electronic conductivity, improved catalytic activity, reduced Gibbs free energy for adsorption/desorption, and accelerated charge-transfer kinetics. Here, we report the synthesis of faceted polygonal Silver–Gold alloy (AgAu) (FNCs) nanocrystals that enable efficient plasmon-induced hot-electron injection and light-driven phase transformation of CVD-grown MoS₂ from the semiconducting 2H phase to the metallic 1T phase. The as-synthesized AgAu FNCs, enriched with facets, corners, and edges, exhibited strong multimodal plasmonic resonances under the visible spectrum. Upon photoexcitation, the AgAu/MoS₂ hybrid catalyst displayed a significant reduction in hydrogen evolution reaction (HER) overpotential (~45%, to 330 mV) and a markedly lower Tafel slope (~61%, to 61 mV dec⁻¹). These improvements are attributed to the light-induced 2H→1T phase transition, enhanced active-site density, lower Gibbs free energy for hydrogen adsorption, efficient charge separation, modified surface potential, and improved film conductivity. Consequently, the photocurrent density increased by ~2.8-fold under illumination compared to dark conditions. Beyond catalysis, the AgAu FNCs exhibited broad plasmonic absorption and extended photoluminescence lifetimes (1.26 ns), surpassing conventional metallic nanostructures. Surface-enhanced Raman scattering (SERS) studies confirmed strong signal enhancement, enabling reliable detection of analytes at concentrations as low as 100 ppm. Computational analyses corroborated the experimental findings, highlighting robust charge-transfer interactions between the hybrid substrate and target molecules.

Density Functional Theory (DFT) calculations further revealed pronounced modifications in the electronic structure of the AgAu/MoS₂ hybrid (including work function, chemical potential, and density of states), arising from plasmonic and exchange interactions at the AgAu–MoS₂ interface, which synergistically promote phase transition and catalytic activity. Altogether, this work demonstrates the dual utility of AgAu–MoS₂ hybrids as both high-performance HER electrocatalysts and versatile sensing platforms, offering promising pathways for food safety monitoring, biomedical diagnostics, and the rational design of next-generation alloy-based multipolar plasmonic nanocrystals for advanced energy and sensing applications.

Keywords: Two-dimensional nanostructures, functional nanostructures, nano-heterostructure, nano-scale engineering, Electronics, Energy applications

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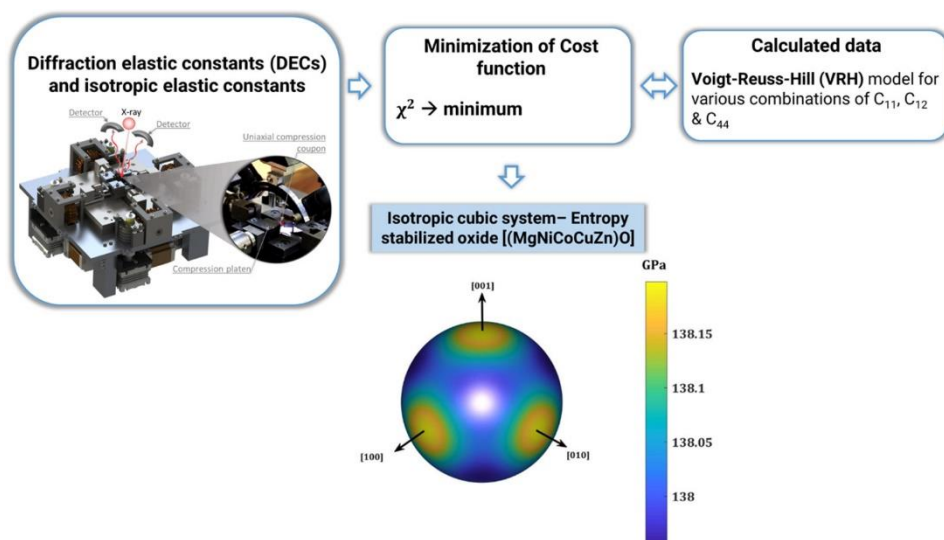
Single crystal elastic constants from polycrystalline ceramics

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Single crystal Elastic Constants (SECs) are fundamental to the understanding of the deformation behavior of materials and are most often used for the validation of interatomic potentials. Estimation of SECs is particularly important as single crystals find applications in semiconductor to aerospace industries. Also, SECs are vital for micromechanical modelling of various properties and for residual stress measurements using diffraction techniques. Standard methodologies for the estimation are complex and the most common techniques used to measure SECs are resonant acoustic spectroscopy (RAS) and the Brillouin scattering and in both these techniques sufficiently large single crystals are required. However, it is not easy to grow a single crystal of sufficiently large length for all materials and also of the same composition as its polycrystalline counterpart. Computational techniques, in particular first principle density functional theory (DFT) simulations are successful in estimating SECs for several inorganic compounds, but without experimental validation calculated values from DFT may be questionable.

One alternate approach to estimate SECs is by *in situ* loading of polycrystalline samples in a diffractometer. Such experiments are usually carried out using synchrotron and neutron diffraction facilities which can be time consuming. Therefore in this work, we have attempted to develop an elegant methodology wherein SECs could be determined from polycrystalline samples using a commercial laboratory X-ray diffractometer. For this purpose, a universal miniature multiaxial loading fixture was custom-built that is capable of performing *in situ* experiments by integrating it with a commercial laboratory X-ray diffractometer. Proof-of-concept experiments have been carried out for various materials. In this talk, the methodology that was developed to estimate SECs from a polycrystalline entropy stabilized oxide of composition (MgCuNiZnCo)O will be discussed.

Keywords: Single crystal elastic constants (SECs), Entropy stabilised oxides, X-ray diffraction



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Self-Assembly Kaolin Platelets and Processing of Mullite Ceramic Micro/Macro Spherical Granules

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Assemblage of 2D nanomaterials via chemical interaction possibly produce attractive shapes like cages and spheres, and till date, such studies have not been attempted on the assembly of 2D kaolin platelets. In this invited talk, the self-assembly of kaolin clay platelets in various polar/non-polar solvent media is discussed. CSIR NIIT developed a facile self-assembly technique under a mechanical rotation (*mechanical vortex*) carried out at varying RPM in order to make highly uniform micro/macro spherical granules. The spherical kaolin assembly was subsequently transformed into mullite ceramic spheres upon heat treatment.

The effect of kaolin feed to solvent ratio, mechanical rotation, effect of RPM, transformation of kaolin to mullite, variation of diameter of the kaolin spheres, effect temperature on kaolin to mullite transformation, bulk density, and porosity features were systematically studied. Mullite ceramic spheres thus obtained was further explored for fabricating epoxy-polymer composites. The thermal conductivity, dielectric property and mechanical strength have been studied and the results are presented. A facile technique is demonstrated for the first time to obtain self-assembled kaolin platelets into ceramic spheres, and validated its' application potential to manufacture epoxy-polymer composites as future dielectrics.

Key words: Kaolin platelets; Mechanical Vortex; Non-polar Solvent; Self-organized assembly; Spherical Mullite ceramic, Polymer-Ceramic Composite Dielectrics

Preparation of Ceramic Metal Matrix composites to enhance its wear Resistance Properties for ZTA reinforced High Chromium Cast Iron

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This study investigates the hardness, fracture toughness, and wear resistance of Metal Matrix Composites (MMCs) reinforced with Zirconia Toughened Alumina (ZTA) particles at varying contents. A key challenge was the poor wettability between ZTA ceramics and the iron matrix during casting. To address this, ZTA particles were surface-modified by coating them with metal layers, such as nickel (Ni), to improve compatibility with the metal matrix.

High Chromium Cast Iron (HCCI), known for its excellent wear resistance, was selected as the matrix material. The ceramic reinforcements were designed with 25% and 40% zirconia content to optimize mechanical and tribological properties. The MMCs were fabricated via a two-step process: first, ceramic preforms were made from coated ZTA grains with controlled porosity; second, these preforms were infiltrated with molten HCCI during casting, allowing precise control over microstructure.

Mechanical properties were characterized through hardness and fracture toughness testing, focusing on the influence of porosity and chemical composition. Scanning Electron Microscopy (SEM) verified the uniformity and thickness of metal coatings on ZTA particles before preform fabrication, ensuring effective surface treatment.

Wear behaviour was evaluated using three-body abrasive wear tests. Analysis showed that porosity within ceramic grains strongly affected hardness, while improved wettability between coated grains and the metal matrix reduced volumetric material loss during wear. Additionally, higher zirconia content correlated with increased fracture toughness, enhancing resistance to crack propagation.

In summary, ceramic grains with higher zirconia content, lower porosity, and improved wettability exhibited superior wear resistance, demonstrated by reduced volumetric loss and longer wear life. This research underscores the importance of microstructural control and surface engineering in developing MMCs with enhanced mechanical and tribological performance for demanding industrial applications.

CONTRIBUTORY SPEAKERS (ORAL)

ThermaFill – Almatiss' alumina solutions for superior thermal management

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Alumina (Al_2O_3) is a versatile ceramic material valued for its combination of thermal stability, electrical insulation and mechanical strength, enabling its use across a wide range of industrial applications. The unique combination of high thermal conductivity, electrical insulation, chemical inertness and dielectric strength makes it an ideal functional filler in thermal interface materials (TIMs) used in electronic and energy storage applications for optimal heat dissipation and thermal management. These materials, such as gap fillers, potting compounds, thermal pads and tapes, are typically based on polymer matrices like epoxy, polyurethane or silicone. Effective integration of alumina into these systems requires careful control of particle morphology and size distribution to maximize thermal conductivity without compromising flow behavior or processability. Almatiss has developed a range of engineered alumina fillers under the ThermaFill brand, optimized for use in high-performance TIMs. These grades feature controlled particle size distributions and tailored surface properties to improve particle packing. By enabling higher filler loadings while maintaining manageable viscosity, ThermaFill aluminas support the design of advanced TIM formulations used in battery packs, semiconductor devices and other heat-sensitive components, ensuring safety, reliability and longevity of these devices.

Influence of lanthanide metal doping on the properties of Ba₅Y_{2-x}Gd_xAl₂SnO₁₃ (x=0,0.2,0.4,0.6) electrolytes for proton-conducting solid oxide fuel cells

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The complex perovskite type proton-conducting system of material with formulation Ba₅Y_{2-x}Gd_xAl₂SnO₁₃ (x=0,0.2,0.4,0.6) were fabricated through solid-state synthesis route. Structural characterization of all the samples was performed through X-ray diffraction analysis (XRD). The microstructure was assessed by scanning electron microscopy (SEM). The electrochemical properties were evaluated using alternating current impedance spectroscopy (EIS). The XRD patterns confirmed the successful synthesis of single-phase structures. Microstructural analysis through SEM revealed dense morphology with thin grain boundaries and well-connected network of grains with an average grain size of 4 micron. Impedance measurement was carried out on all the compositions from 800°C to 300°C with a step of 25°C. Nyquist graphs were plotted and protonic conductivities were evaluated. Among the series, the composition with x = 0.4 exhibited the highest conductivity, reaching $\sim 10^{-2} \text{ S cm}^{-1}$ at 500°C. Grain and grain boundary characteristics were estimated using distribution of relaxation process and fitted the curves through equivalent circuit using Z-view software that resulted into R and CPE in parallel indicating the deviation in the ideal behaviour. Activation energies calculated for the all the composition are in the range of 0.5-0.8eV. The results will be discussed during presentation.

Unveiling the role of ceramic based perovskite $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ at graphene interface for enhanced photocatalytic water splitting

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The supply of clean and sustainable energy for the development of carbon-neutral society, is regarded as one of the most important scientific and technological challenges in the 21st century.¹ Solar energy harvesting via photocatalytic water splitting ensures a desirable approach for realizing sustainable future energy supply under minimal environmental impact.² Fabrication of multidimensional heterogeneous photocatalysts combining ABO_3 type ceramic based perovskite with graphene nanosheets is crucial for efficient solar energy conversion at the 3D/2D interface. Herein, a direct Z-scheme heterostructure with 3D/2D interface has been developed by modification of the wide bandgap ceramic based perovskite sodium bismuth titanate ($\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$, NBT) with graphene nanosheets *via* facile hydrothermal method.³ The as-synthesized nanocomposites exhibit 14-fold augmentation in photocatalytic H_2 generation ($\sim 100 \text{ mmol h}^{-1} \text{ g}^{-1}$) with an apparent quantum yield of 6.3% compared to pure NBT ($\sim 7 \text{ mmol h}^{-1} \text{ g}^{-1}$). The photoelectrochemical (PEC) measurements reveal that the NBT/Reduced Graphene oxide exhibits ~ 32 times enhancement in photocurrent density due to a significant increase in the charge-carrier concentration ($1.8 \times 10^{17} \text{ cm}^{-3}$) of the heterostructure as compared to bare NBT ($3.4 \times 10^{16} \text{ cm}^{-3}$). This enhancement of photocatalytic and photoelectrochemical performance occurs due to the formation of direct Z-scheme heterojunction at the interface of graphene and NBT which facilitates the vectorial transfer of the photogenerated charge carriers and improves H_2 generation rate without using noble metal-based cocatalysts. The 3D/2D interface increases the specific surface area and hinders electron-hole recombination. Moreover, graphene oxide synthesized from graphite powder reclaimed from spent Li-ion batteries has also been used to synthesize waste-derived NBT/Reduced Graphene oxide nanocomposites (NBT/WrGO) which shows excellent photocatalytic and photoelectrochemical performance comparable to the natural resource graphene oxides. This paves the path for the development of highly efficient photocatalysts from natural as well as waste-derived carbon sources for solar fuel generation.

Keywords: Reduced Graphene Oxide, Sodium Bismuth Titanate, Direct Z-scheme, Visible light-driven Photocatalytic water splitting

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Alumina Entrenched Polymer Composite Material for the Applications in Thermally Conductive Interface Materials (TIMs): *Correlation between Thermal, Mechanical, and Morphological Properties*

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Thermally Conductive Interface Materials (TIMs) are essential for controlling heat in power and electronic devices because they bridge the tiny gaps between heat sinks and heat-generating parts. The common materials used for the preparation of TIMs are basically a polymeric matrix e.g. silicone, epoxy, polyimide etc. whereas, the thermally conductive fillers used are primarily ceramic, carbon and metallic based filler in addition to other important additives such as plasticizers, thickeners, adhesion promoter, flame retardant materials depending on their end- use applications. Among the various fillers used, alumina is one of the most widely used fillers in TIMs due to its good thermal, mechanical, chemical properties, electrical insulation characteristics, electrical insulation features along with cost effectiveness and easy processability.

In our present investigation, the impact of alumina on polymer matrix in terms of its grain size, crystal structure, and porosity has been explored and afterwards a correlation between mechanical, and thermal behaviour of the alumina embedded matrix with morphological analysis has been tried to establish. Several instrumental tools including thermal conductivity, differential scanning calorimetry-thermogravimetric analysis (DSC-TGA), universal testing machine (UTM), Scanning electron microscopy (SEM) etc. are being employed to characterize the materials. One of the most popular ingredients in TIM formulation is alumina, which balances thermal performance. Alumina's abundance, non-toxicity, and capacity to prolong product life make it a sustainable material for TIMs, despite ongoing difficulties in the production and recycling procedures. It was found that silicone containing alumina had a little higher in-plane thermal conductivity ($\sim 1\text{-}1.2\text{ W/m}\cdot\text{K}$) than through-plane conductivity ($0.94\text{ to }0.98\text{ W/m}\cdot\text{K}$). The sustainability profile as whole can be raised by innovation in environmentally friendly alumina refining and composite recycling.

Keywords: Thermally Conductive Interface Materials (TIMs), Thermal and Mechanical Properties, Morphology, Sustainability

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High entropy oxide-based flexible ceramic tribopositive electrodes for micromechanical energy harvesting

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The development of high-performance triboelectric nanogenerators (TENGs) is often hampered by the inherent limitations of polymers, limited surface charge creation and low dielectric constants, which lowers electrostatic induction efficiency. While ceramic materials like oxides exhibit superior tribopositive properties, their intrinsic brittleness and rigidity have prevented their use in TENGs for energy harvesting. This work introduces a novel approach to overcome this critical challenge by fabricating a flexible, ceramic-rich tribopositive electrode. A composite with high loading (80 wt%) of tribopositive oxide particles embedded within a polymer-derived amorphous silicon oxycarbide (SiOC) matrix. The SiOC matrix provides exceptional flexibility, structural stability, and adhesion to the substrate. While the work is focused on exploring high entropy oxides with various crystal structures, preliminary investigation utilizes titanium dioxide (TiO_2) as proof-concept. Structural and morphological characterization (XRD, Raman, SEM, AFM) confirmed the homogeneous distribution of TiO_2 particles and their phase stability within the SiOC matrix after pyrolysis. The flexible ceramic also demonstrated excellent mechanical resilience and adhesion to the substrate in cylindrical mandrel and cyclic bending tests. When paired against Polydimethylsiloxane (PDMS) in a vertical contact-separation mode, the resulting TENG yielded an outstanding peak open-circuit voltage of 290 V, a short-circuit current of 9.26 μA , and a maximum power density of 13.72 W/m^2 . By developing a method to incorporate high-performance ceramics into flexible systems, this work utilizes ceramic oxides as superior tribopositive electrodes to create the next generation of mechanically durable TENGs.

Reflectivity and emissivity properties of ZnO–silicone composite coatings for passive daytime radiative cooling application

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In recent years, the demand for cooling has significantly increased for buildings, industrial processes, food preservation, and medical supplies due to the escalating global warming and related extreme heatwaves. It is estimated that cooling accounts for 15% of global electricity consumption and contributes to 10% of greenhouse gas emissions. In response to this challenge, significant research initiatives and support have been dedicated to the development of clean, sustainable, energy-efficient, maintenance-free, cost-effective, and environmentally friendly cooling technologies. In light of this, passive daytime radiative cooling (PDRC) technology has emerged as an alternative solution to address the current demand, and this innovative technology is implemented in the form of a coating. In this technology, a cost-effective, easily scalable, and environmentally friendly coating will exhibit high solar reflectivity within the solar spectrum range of 0.25 to 2.5 μm and high emissivity in the atmospheric transmission window (ATW) of 8 to 13 μm . This coating will possess a high solar refractive index (SRI) of > 100 . In the present work, ZnO–silicone based polymeric composite coatings on aluminium substrate have been prepared by spray coating method. ZnO powder and coatings have been characterized by XRD, FESEM, FTIR, XPS, and UV-visible techniques. Silicone has been used as resin matrix. Thicknesses of the coatings are around 200 μm . Reflectivity, emissivity, and SRI values of the coatings have been evaluated. Coatings show high emissivity values of $>90\%$ in the ATW region and SRI values of >100 . Reflectivity and emissivity plots of ZnO–silicone PDRC coating with respect to wavelength are shown in **Fig. 1**.

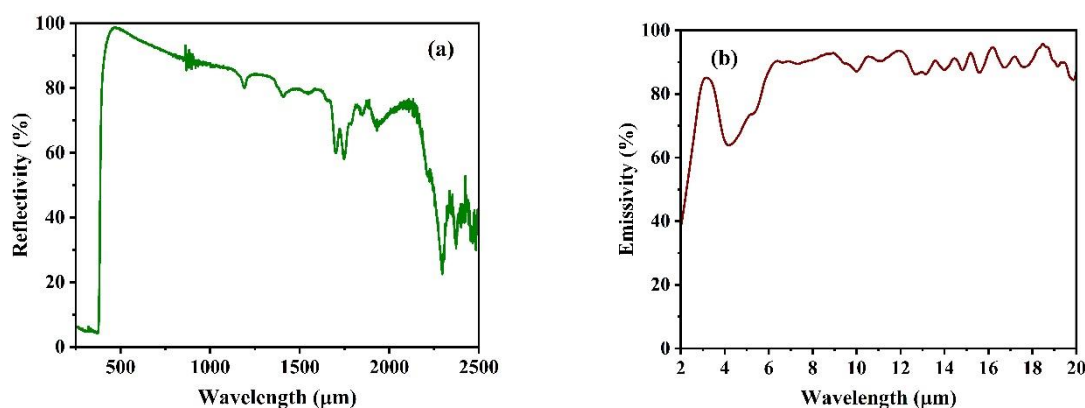


Fig. 1 Reflectivity (a) and emissivity (b) plots of ZnO–silicone PDRC coating with respect to wavelength.

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CONTRIBUTORY SPEAKERS (POSTER)

Alternative B-site-doped $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.2}\text{Fe}_{0.8-x}\text{Ni}_x\text{O}_{3-\delta}$ & $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.8}\text{Fe}_{0.2-x}\text{Ni}_x\text{O}_{3-\delta}$ ($x=0, 0.1$) as a novel cathode materials for IT-SOFC

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In this study, the perovskite $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.2/0.8}\text{Fe}_{0.8/0.2}\text{O}_{3-\delta}$ (LSCF) is modified by doping B-site cation (Ni) as a cathode materials for intermediate-temperature solid oxide fuel cells (IT-SOFCs). The characterization results indicate that $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.2}\text{Fe}_{0.7}\text{Ni}_{0.1}\text{O}_{3-\delta}$ & $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.8}\text{Fe}_{0.1}\text{Ni}_{0.1}\text{O}_{3-\delta}$ oxides are successfully synthesized using combustion route, and the as-prepared samples manifest superior electrochemical performances in contrast to the parent compound (LSCF). XRD results reveals single phase in the pure and also in composition with the dopant. SEM results have shown porous microstructure with uniform distribution of pores. These powders were made into pastes and fabricated symmetric cells with GDC electrolyte material for electrochemical performance. The EIS studies were carried out from 300-800°C in the frequency range from 10MHz to 1Hz with 10mV AC voltage. The polarization resistance (R_p) of the doped compositions are compared with those of undoped LSCF compositions. This performance improvement can be largely attributed to the increased oxygen vacancy concentration caused by Ni^{+2} doping, leading to the acceleration of oxygen transport rate, which may provide more active sites for oxygen adsorption and enhance cathode oxygen reduction reaction (ORR) activity as desired, suggesting that Ni doping can be a promising modification strategy for LSCF cathode materials in IT-SOFC.

Tuning Electronic Structure of LaFeO_3 for Efficient Oxygen Evolution Reaction

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Fuel cells and batteries are future energy conversion technologies that meet future energy requirements. These high energy density technologies depend on electrochemical reactions. Currently, perovskites are introduced in place of conventionally used materials to conduct electrocatalysis due to their cost effectiveness, chemical stability. The present work investigates the Oxygen Evolution Reaction (OER) of the Sr, Cu doped LaFeO_3 Perovskite. The EDTA-citrate-assisted solution combustion technique was adopted to synthesize the powder. The physio-chemical characteristics of the prepared powder samples were studied using XRD, FESEM, BET and XPS techniques. The Phase analysis indicates the synthesis of phase pure perovskite in the studied composition range. The morphological study indicated the spherical nanoparticles in the agglomerated form. The surface area of all sample is correlated to inter and intra-agglomerate porosity in the samples. OER activity of synthesized samples was investigated using linear sweep and cyclic voltammetry study in an alkaline medium. The Sr, Cu -substitution at the lanthanum site will lead to a decrease in the cationic charge of the ferrite, which will be compensated by the creation of oxygen deficiency and an increase in the oxidation state of B-site iron. The variation in OER activity of synthesized oxides is correlated to the defects in the oxides. Sr, Cu doped LaFeO_3 showed the better catalytic activity than LaFeO_3 .

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Effect of Calcination Temperature on Structural, Morphological, and Electrocatalytic Properties of Sol-Gel Derived LaCoO_3

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The surging global energy requirement and the ensuing crisis led to the need for sustainable energy options. Energy-efficient devices such as fuel cells and metal-air batteries, relying on OER/ORR, offer high energy density. LaCoO_3 -based perovskite oxides are utilized as electrocatalysts for OER/ORR catalysis. The calcination temperature plays an important role in their performance by affecting crystallinity, surface area, and oxygen vacancies. In this study, LaCoO_3 was made using the Sol-Gel method and calcined at temperatures between 400 °C and 800 °C. The X-ray diffraction technique was utilized to examine the crystal structure and phase purity of the synthesized powders. Metal-oxygen bonding and the presence of any organic residual precursor were tested by FT-IR spectroscopy. The FE-SEM technique was employed to examine the morphologies of the synthesized powders at different calcination temperatures. The powder's surface area and pore structure were analyzed using the BET measurement. Electrocatalytic performance towards OER/ORR was examined in alkaline media by conducting Cyclic voltammetry and Linear cyclic voltammetry. The lowest calcination temperature yields a cubic crystal structure, followed by a hexagonal structure at 500 °C. Above this calcination temperature, all the powders exhibit a monoclinic structure, and all the samples were found to be pure from Rietveld analysis. FTIR spectra show organic residue at lower calcination temperatures and diminish at higher temperatures due to complete decomposition. FESEM micrographs showed agglomerated porous particles, and the mean particle size was found to increase with higher calcination temperatures, which led to a decrease in surface area, as concluded from BET analysis. Electrochemical tests demonstrated optimal OER/ORR activity by perovskite calcined at a moderate temperature, ascribed to balanced conductivity, active surface area, and structural integrity.

Keywords: OER, ORR, Calcination temperature LaCoO_3

Processing and Characterization of Ceria-Zirconia Structured Catalyst for Sustainable Hydrogen and CO Generation

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Thermo-chemical splitting reactions are vital in sustainable energy, enabling the conversion of carbon dioxide (CO_2) and water (H_2O) into valuable fuels such as hydrogen (H_2) and carbon monoxide (CO), respectively. This study focuses on the development of structured catalysts based on ceria-zirconia coated open-cell alumina foams, for high-temperature redox cycles. Ceria-zirconia was chosen due to its high oxygen storage capacity, superior thermal stability, and resistance to sintering, making it an ideal candidate for thermo-chemical cycling.

A slurry was prepared using cerium and zirconium precursors using ethylene glycol and anhydrous glycerol as the dispersion medium. The slurry was coated directly onto the alumina foam support using the dip-coating technique. The process parameters such as dipping velocity, immersion time, and withdrawal speed were optimized to obtain the coating deposition. The as-coated samples were then calcined at 700°C in ambient air.

The as-coated samples were subjected to characterization techniques such as X-ray diffraction (XRD), energy-dispersive X-ray spectroscopy (EDS) and field emission scanning electron microscopy (FESEM) for phase analysis, elemental composition, and surface morphology, respectively. Temperature programmed reduction and Brunauer–Emmett–Teller (BET) was utilized for reducibility and surface area measurements. The results demonstrated that the ceria-zirconia coated foams retained catalytic activity and structural integrity across multiple redox cycles, with minimal degradation. These findings confirm that the as-prepared structured catalysts are promising for efficient and sustainable thermochemical splitting of CO_2 and H_2O , contributing to clean fuel production and greenhouse gas reduction.

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Large-scale Processing of High-Entropy (MgCoNiCuZn)O Ceramics for Catalytic Applications

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The pursuit of affordable and durable catalysts has driven growing interest in the development of novel high-entropy oxides (HEOs). These materials are distinguished by their configurational entropy-driven stability, abundance of diverse multi-cation active sites, and exceptional structural stability under complex environments. In recent times, spinel-HEOs have been used as an electrocatalyst, which showed impressive oxygen as well as hydrogen evolution reactions (OER and HER) for water electrocatalysis applications.

Herein, we investigate (MgCoNiCuZn)O, a rock-salt HEO, as a catalyst for photo and photo-electrocatalytic applications. High entropy (MgCoNiCuZn)O ceramic were synthesized using the solid-state route and subsequently thermally treated to obtain single-phase material. Structural and chemical characterization techniques such as XRD, SEM, TEM and BET analysis confirmed the formation of single-phase rock-salt structure with fine-morphology and high surface area, respectively. Raman studies revealed the presence of vacancies and catalytically active sites. UV-vis spectroscopy was carried out to obtain the band gap of the as-synthesized samples, which indicated the feasibility of employing these materials as photo or photo-electrocatalysts. Furthermore, XPS studies were carried out to understand the variable oxidation states. Finally, the as-synthesized samples were investigated to assess the performance in both photocatalytic and photo-electrocatalytic water-splitting applications.

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One pot Solvothermal Synthesis of Phase-Controlled and Defect-Rich α -NiS and Evaluation of their Supercapacitors, Electrocatalysis, and Sensing Properties

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Defect Engineering and phase purity significantly influence in electrochemical behaviour of Metal sulphide in various application. In this study, we present role of solvent assay in the phase and morphology control of α -NiS at low temperature. The presence of in-situ defects in metal sulphide was confirmed through XRD, FTIR, Raman, EPR and TEM. SEM verifies the morphology and particle size. The defect rich α -NiS enhance the electrochemical behaviour in both energy storage and conversion. The specific capacitance of 1351 F/g at 1 A g⁻¹ was recorded for defect rich NiS three electrode system measurement. While an asymmetric supercapacitor (ASC) with activated carbon in solid-state electrolyte achieves 245 F/g at 2 A g⁻¹ - 27% increase in the capacitance of NiS. The device maintained 97.2% retention of capacitance after 5000 cycles due to structure imbalance. The electrocatalyst study, of defect-rich NiS shows on excel hydrogen evolution reactions (HER), it exhibits a Tafel slope of 64 mv/dec at 197 mv overpotential in 0.5M aqueous H₂SO₄. For its Oxygen Evaluation Reaction (OER), the Tafel slope is 81 mv/dec at 741 mv overpotential in 3M aqueous KOH. Additionally, non-enzymatic sensing behaviour of pure NiS has a detection limit of 0.8 μ l of 30% H₂O₂. Defect-rich NiS is more active in sensing oxygen molecules of H₂O₂, with a lower limit of detection of 0.5 μ l. Overall, it is demonstrated that the defect NiS has an outstanding electrochemical behaviour in energy storage, energy generation and sensing.

Keyword: Defect engineering, Supercapacitor, Nickel Sulphide, Asymmetric

High Entropy Spinel Oxides as potential Co-free electrodes for Li-ion batteries

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High entropy oxides (HEOs) are single phase solid solutions consisting of multiple metal cations in near-equiatomic ratios occupying a given cation sub-lattice.^[1] One of the primary advantages HEOs is their ability to maintain phase-purity despite the high chemical complexity.^[2] Their exceptional structural robustness along with synergistic properties stemming from the presence of multiple cations make them attractive candidates for advanced energy applications. Earlier studies have showcased different HEO compositions (both as cathode and anode) exhibiting superior capacity retention capability when used as electrodes in Li-ion batteries (LIBs).^[3] One of the pressing issues in LIBs is the use of Co in commercial cathodes, due to its supply chain issues. The tunable compositions of HEOs can be particularly advantageous for Co-free electrode research. In this work, S-HEOs, both with and without Li, have been synthesized by Pechini-based sol-gel method using citric acid as chelating agent and ethylene glycol as crosslinking agent followed by calcination to obtain single-phase spinel structure. The powders were characterized by X-ray Diffraction (XRD) with Rietveld refinement, Raman spectroscopy, and elemental mapping via Scanning Electron Microscopy (SEM), confirming their phase purity and compositional uniformity. HR-TEM research work is planned for ruling out any local scale secondary phase or chemical inhomogeneity. The electrochemical performance of the synthesized HEO powders are being tested for LIBs using galvanostatic charge–discharge cycling, and cyclic voltammetry. Systems containing Li are being tested for their potential applications as cathodes, while those without Li are being evaluated as anodes. Key electrochemical metrics, including specific capacity, capacity retention, and Coulombic efficiency, will be systematically investigated to evaluate their performance as next generation Co-free LIB electrodes

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Design and optimization of AlN/Al/AlN multilayer coatings for low-Emissivity energy saving window applications

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Low emissivity (Low-E) multilayer coatings play a vital role in reducing the heat transfer through windows while maintaining visible light transmittance (T_{vis}). Conventional low-E coatings typically consist of silver (Ag) as a metallic layer which is sandwiched between multiple dielectric layers [1]. However, such configurations often suffer from high material cost and stability issues due to the metal degradation [1,2]. In this work, a novel multilayer configuration consisting of aluminium nitride/aluminium /aluminium nitride (AlN/Al/AlN) is designed on the glass substrate using RF magnetron sputtering. Al is selected for being low cost, neutral appearance and self-passivating alumina layer, while AlN serves as an antireflective coating as well as protective layer for Al from external degradation. Experimental results demonstrate an AlN/Al/AlN stack with ~12nm Al realizing T_{vis} , infrared transmittance (T_{IR}) and infrared reflectance (R_{IR}) of 23.66%, 16.81% and 60% respectively. Increasing the Al layer thickness to ~16 nm resulted in an enhancement of R_{IR} of 90% but reduced visible and IR transmittance of 16.58% and 9.68% respectively. Further, varying AlN thickness is found to shift the position of the visible transmittance maxima due to the interference effects, governed by the constructive and destructive interference of the electromagnetic radiation [3]. These results show tunability in the optical performance through thickness control and demonstrates the potential of Al as a cost effective, durable alternative to conventional Ag based low-E coating for energy saving window application.

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Two-Step Sintering of Lead-Free ferroelectric ceramics for Solid-State and Pyroelectric Energy Harvesting Applications

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Lead-free KNLNT+BNZ ferroelectric ceramics were synthesized via a two-step sintering method, involving heating to 900 °C at 5 °C/min, then to 1000 °C at 10 °C/min (hold: 30 min), followed by cooling to 900 °C (hold: 3 h), and final slow cooling to room temperature. X-ray diffraction with Rietveld refinement confirmed a tetragonal phase boundary with minor secondary phases. 3D electron density mapping revealed a central high-density peak with symmetric side lobes, evolving with BNZ content, reflecting changes in electron distribution and microstructure. FESEM analysis showed mixed grain morphologies, with smaller grains filling voids between larger ones. EDAX confirmed compositional accuracy without foreign elements. Ferroelectric loops were rectangular for all compositions, but samples with $x = 0.4\text{--}0.5$ exhibited rounded loops, likely due to oxygen vacancies and defect-induced domain wall pinning. The dielectric constant and Curie temperature decreased with BNZ content, and modified Curie–Weiss fitting indicated diffuse phase transition behavior typical of relaxors. A.C. conductivity increased with frequency and temperature. The electrocaloric effect peaked at $x = 0.5$, with an adiabatic temperature change $\Delta T = 0.39\text{ K}$ and electrocaloric strength $\Delta T/\Delta E = 1.30 \times 10^{-7}\text{ K}\cdot\text{m/V}$ at 30 kV/cm. Pyroelectric energy harvesting figures of merit were also highest at $x = 0.5$, with $F_i = 344.5\text{ pm/V}$, $F_v = 0.128\text{ m}^2/\text{C}$, $F_d = 1.05 \times 10^{-5}\text{ Pa}^{0.5}$, $F_e = 367.08\text{ J}\cdot\text{m}^{-3}\cdot\text{K}^{-2}$, and $F_e^* = 4.40 \times 10^{-12}\text{ m}^3/\text{J}$, surpassing other reported ceramics. These results demonstrate the potential of two-step sintered KNLNT+BNZ ceramics for advanced ferroelectric, electrocaloric, and pyroelectric applications.

Keywords: KNN, Two-Step, sintering, Electrocaloric, Pyroelectric, Energy Harvesting.

Role of Boron nitride nano sheet-metal oxide interface in photo-electro chemical water splitting

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Two-dimensional hexagonal boron nitride (2D-hBN), a structural analogue of graphene with a comparable layered configuration, is distinguished by its exceptional opto-electrical properties, along with outstanding mechanical strength, thermal stability, and chemical inertness. Researchers have shown growing interest in the eco-friendly and efficient exfoliation of hexagonal boron nitride to directly produce high-yield functionalized boron nitride nanosheets (f-BNNSs) [1-2]. Inorganic semiconductors, such as typical metal oxides, are widely employed as effective photocatalysts [3]. Our work offers essential guidance for selecting green and efficient solvents for the exfoliation of h-BN powder through a high-power sonication-assisted liquid phase exfoliation technique for bulk-scale nanosheet production. To explore the BNNS-metal oxide interphase, in-situ deposition of Bi_2WO_6 , and sensitisation have been done by using TiO_2 and Fe_2O_3 . According to the optical microscope and FESEM images observation, the exfoliation process has been optimized at pH=7 and 500 W sonication power conditions. The FESEM image shows that h-BN has obvious vertical stratification, indicating that h-BN raw powder is peeled into h-BN 2D sheets. BNNS/ Bi_2WO_6 heterostructure shows a higher current density, 2.5 times that of BNNS. From transient photocurrent measurements, we observe that BNNS/ Bi_2WO_6 shows much better photo-response among all the materials and improved charge transfer as reflected in impedance spectra. The current density of the as-synthesized nanocomposites remains stable for a long duration, which indicates that they are durable against photo corrosion. This novel metal oxide interphase with the BNNS highlights a good strategy for photo-electrochemical water splitting.

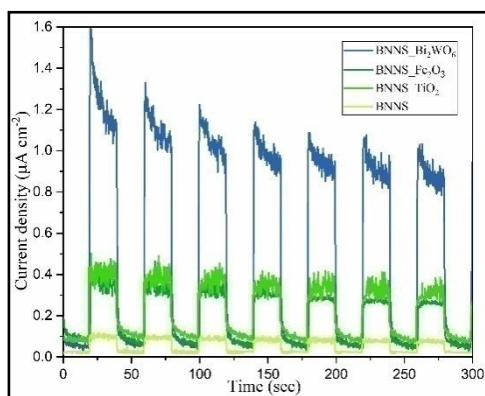


Fig. 1a. Transient chrono amperometry spectra shows that BNNS- Bi_2WO_6 , BNNS- Fe_2O_3 and BNNS- TiO_2 metal oxide interphase shows much better response than BNNS

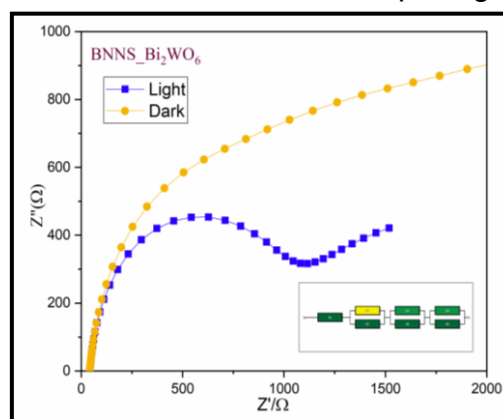


Fig.1b. Nyquist plots of BNNS- Bi_2WO_6 .

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Optimizing Electrostatic Energy Storage in BiFeO_3 through Nd/Nb Co-Doping

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With rising concerns about energy security and climate change, renewable technologies such as solar, wind, geothermal, and ocean energy are progressing rapidly. However, their effectiveness relies on efficient energy storage. While high-energy-density batteries serve well in long-duration applications, they lack the power density required for high-power devices such as Pulse Power Devices (PPDs). In contrast, electrostatic capacitors offer rapid charge-discharge cycles (within microseconds) and extremely high-power densities, making them ideal for applications in defense, electric vehicles, power grids, and medical equipment. Bismuth ferrite (BiFeO_3 or BFO) has emerged as a promising lead-free material for such capacitor applications due to its high spontaneous polarization, Curie temperature ($\sim 830^\circ\text{C}$), and ferroelectric properties. However, its practical use is limited by high leakage current, low resistivity, poor sinterability, and secondary phase formation. These drawbacks can be mitigated through appropriate changes in the chemical composition and crystal chemistry.

This study focuses on enhancing BFO's performance via Nd and Nb co-substitution. $\text{Bi}_{0.8}\text{Nd}_{0.2}\text{FeO}_3$ (BNFO) and $\text{Bi}_{0.8}\text{Nd}_{0.2}\text{Fe}_{0.99}\text{Nb}_{0.01}\text{O}_3$ ceramics were synthesized using conventional solid-state methods. XRD analysis revealed that co-doping induced a structural transition from a pure rhombohedral phase (R3c) to a mixed R3c + orthorhombic (Pnma) phase. Grain size was significantly refined—from $\sim 4\ \mu\text{m}$ to $\sim 0.6\ \mu\text{m}$ —indicating improved microstructure. XPS analysis showed a reduction in Fe^{2+} content, suggesting decreased oxygen vacancies and enhanced insulating behaviour. Notably, the co-doped ceramic demonstrated an impressive energy storage efficiency of $\sim 80\%$ under an applied electric field of $85\ \text{kV/cm}$. These results highlight that Nd/Nb co-doping is an effective strategy to overcome the intrinsic limitations of BFO and significantly improve its structural, dielectric, and energy storage properties, making it a strong candidate for high-power electrostatic capacitor applications.

Keywords: Lead-free ceramics, Bismuth ferrite, Nd/Nb Co-doping, Electrostatic energy storage

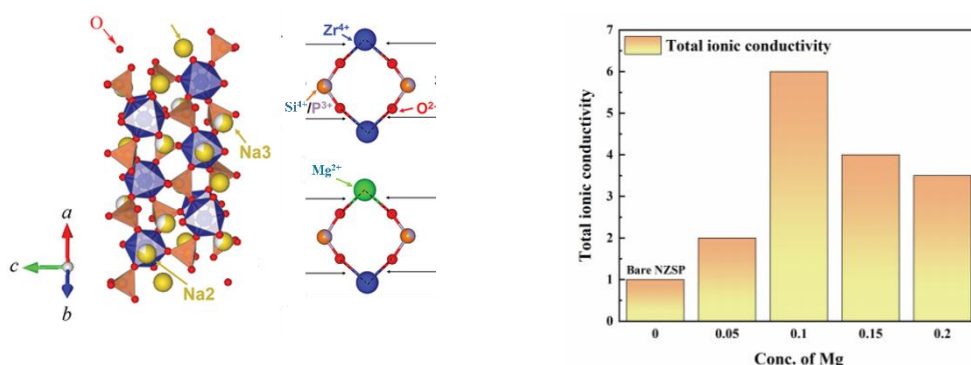
Enhanced phase stability and ionic conductivity of Mg Doped - $\text{Na}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$ Solid Electrolyte - Synthesized via Solution Combustion Method

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Sodium-ion batteries (SIBs) are promising alternative to lithium-ion batteries due to sodium's abundance, low cost, and favourable electrochemical properties. However, the use of liquid electrolytes poses challenges such as leakage, flammability, and low electrochemical stability. As a solution, the NASICON-type solid-state electrolyte, $\text{Na}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$ (NZSP), emerges as a potential candidate for all-solid-state Na batteries, aiming to replace traditional liquid electrolytes used in Na-ion batteries, offering a safer and more stable alternative. However, conventional solid-state synthesis routes often suffer from high sintering temperatures, formation of insulating secondary phases, and poor ionic conductivity. In this study, magnesium (Mg^{2+}) was doped at the Zr^{4+} site of NZSP and synthesized via solution combustion method to enhance phase stability, reduce secondary phase formation, and improve densification and conductivity. The rationale behind choosing Mg doping in NZSP will be discussed in detail in the present paper.

NZSP powders were doped with Mg at varying concentrations (0.05, 0.1, 0.15, and 0.2 wt.%) and sintered at temperatures between 1150°C and 1200°C . The 0.1 wt % Mg-doped sample sintered at 1175°C achieved optimal performance, exhibiting a relative density of 96% and the highest total ionic conductivity of $6.77 \times 10^{-4} \text{ S cm}^{-1}$ at room temperature. Phase analysis confirmed minimal ZrO_2 and Na_3PO_4 impurity formation at this concentration. DC polarization measurements further confirmed the dominant ionic conduction behaviour, with negligible electronic contribution. Also, the optimized sample exhibited low activation energy, indicating efficient sodium-ion transport through the NZSP lattice. However, doping beyond 0.15 wt.% resulted in increased formation of insulating ZrO_2 and Na_3PO_4 phases, which negatively impacted conductivity. This study establishes that Mg doping serves as an effective sintering aid and structural stabilizer in NZSP, enabling the fabrication of dense, phase-pure ceramics with enhanced ionic conductivity.



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Microstructural design of silicon-carbon nanostructures for LIB anodes

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Preceramic polymers with their unique nanostructure and phase composition have aided myriads of structural and functional applications of materials. One such important application is their usage as anodes in lithium ion batteries. In the next generation anodes, silicon is widely regarded as a leading anode material candidate for next-generation lithium-ion batteries due to its high theoretical capacity. However, its practical use is hindered by significant volume expansion (over 300%) during lithiation, leading to mechanical degradation. In this work, we propose nanostructured silicon–carbon (Si–C) hybrids synthesized from a carbon-rich preceramic polymer and high-energy mechanically milled (HEMM) silicon particles as a strategy to overcome these limitations.

The study investigates the phase composition, microstructure, and electrochemical performance of Si–C hybrids synthesized by varying Si:C ratios, pyrolysis temperatures, and etching conditions. A polymer-derived SiCO ceramic is used as the carbon source, offering tunable pore architecture and surface chemistry. A key innovation lies in introducing controlled porosity into the SiCO matrix by tailoring its microstructure, thereby enhancing its functionality as an anode material.

Three synthesis routes are explored. In the first, HEMM-prepared nanocrystalline Si is combined with SiCO-derived carbon synthesized at 1000 °C and 1200 °C, followed by HF etching to introduce porosity. The second route incorporates amorphous SiO₂ fillers as sacrificial pore-forming agents, which are later removed via HF etching. The third approach enhances interfacial bonding between Si and the carbon matrix through the addition of a non-ionic surfactant that facilitates uniform dispersion of Si particles within the amorphous SiCO matrix.

All synthesized Si–C hybrids exhibit outstanding electrochemical performance, with the surfactant-assisted hybrids showing the most significant improvement. The SiCO-derived carbon matrix acts as a mechanically resilient and conductive framework, accommodating the volume changes of Si during cycling and promoting efficient electron transport. High mesoporosity and ordered carbon structures further contribute to the superior electrochemical behaviour. These results underscore the potential of SiCO-based Si–C hybrids and suggest the feasibility of extending this strategy to other polymer precursors for advanced lithium-ion battery anodes.

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Dielectric and Optical Properties of a new class of ‘High Entropy’ Perovskite Oxides

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Owing to their high degree of configurational tunability, high-entropy perovskite oxides (HEPOs) are considered as excellent candidates for various applications where the functional properties can be fine-tuned by optimising the composition and structure. In this regard, 8- component and 6- component- equimolar high-entropy perovskite oxides systems based on $(\text{Ba}, \text{La}, \text{Sr}, \text{Na})(\text{Ti}, \text{Yb}, \text{Sn}, \text{Nb})\text{O}_3$ have been prepared via a hybrid synthesis method. Their crystal structure, dielectric, light absorption properties have been investigated to evaluate their potential for various applications. Rietveld refinement and microstructural analysis confirmed the presence of double phase (tetragonal phase and cubic phase) in the ceramics which plays an important role in the variation of the functional properties of these HEPOs. The optical band gap has been calculated experimentally by using Tauc plot method and lowest optical band gap was found to be nearly 1.934 eV for $(\text{Sr}_{0.33}\text{La}_{0.33}\text{Na}_{0.33})(\text{Ti}_{0.33}\text{Yb}_{0.33}\text{Nb}_{0.33})\text{O}_3$. Frequency dispersion behaviour of dielectric constant has been observed from room temperature dielectric constant measurement as a function of frequency. Also, the presence of relaxor behaviour in some compositions was confirmed from the temperature-dependent dielectric constant measurements. In addition, the microscopic polarization state and domain alignment have been verified from Piezo response force microscope (PFM) measurement. The highest converse piezoelectric coefficient (d_{33}) is found to be 99.5 pm/V for $(\text{Ba}_{0.25}\text{La}_{0.25}\text{Sr}_{0.25}\text{Na}_{0.25})(\text{Ti}_{0.25}\text{Sn}_{0.25}\text{Nb}_{0.25}\text{Yb}_{0.25})\text{O}_3$. Overall, this study provides a novel approach for the design and optimization of the ‘high-entropy’ perovskite oxide systems as well as deepens the understanding and correlation between crystal structure and various functional properties of HEPOs suitable for wide range of technological applications specifically in optoelectronic devices.

Nanostructured Si/C composite as an advanced anode material for Li-Ion Batteries

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This study presents the development of a novel silicon–carbon (Si/C) hybrid composite as a negative electrode material for lithium-ion batteries, along with a cost-effective and scalable synthesis route. The composite is synthesized through high-energy mechanical milling of silicon nanoparticles with amorphous silica to form a Si/SiO₂ intermediate, which is subsequently coated with a preceramic polymer and pyrolyzed to yield a Si/SiO₂/SiOC composite. In an alternative method, a carbon-rich phenolic resin is employed in place of the polymer-derived ceramic precursor, resulting in a Si/SiO₂/C composite. In both synthesis pathways, selective removal of the SiO₂ phase using hydrofluoric acid produces a porous Si/C hybrid architecture. The resulting material effectively mitigates the volumetric expansion of silicon during electrochemical cycling, leading to significantly improved capacity retention and cycling stability compared to conventional graphite anodes. Moreover, the strategy minimizes side reactions, enhances battery lifespan, and offers a simplified, energy-efficient fabrication process with higher material yield, thereby demonstrating strong potential as a next-generation anode material for advanced lithium-ion battery systems. The optimum composites delivered 722 mAh g⁻¹ after 100 charge-discharge cycles at a current density of 0.1 A g⁻¹, thereby rendering it a suitable anode material for lithium-ion battery applications.

Keywords: Lithium Ion Batteries, Anode, Silicon, Carbon

Synthesis and Characterization of $\text{Na}_x\text{Fe}[\text{Fe}(\text{CN})_6]\cdot n\text{H}_2\text{O}$, a Prussian Blue Analogue, as a Cathode materials for Sodium-Ion Batteries

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$\text{Na}_x\text{Fe}[\text{Fe}(\text{CN})_6]\cdot n\text{H}_2\text{O}$ is a promising Prussian Blue Analogue (PBA) type cathode material for sodium ion batteries due to its open framework and rapid Na^+ diffusion kinetics. However, its long-term electrochemical stability remains a significant challenge, primarily due to structural vacancies and the loss of sodium ions during cycling. These issues can lead to framework collapse and capacity fading over time.

In this work, $\text{Na}_x\text{Fe}[\text{Fe}(\text{CN})_6]\cdot n\text{H}_2\text{O}$ is synthesized via a coprecipitation method to achieve high-purity crystalline material with reduced defect density. Post-synthetic modifications such as surface sodiation and basic surface treatments are explored to improve performance further, suppress structural degradation, and reduce Na^+ depletion. In structural characterizations, XRD demonstrated the pure phase $\text{Na}_x\text{Fe}[\text{Fe}(\text{CN})_6]\cdot n\text{H}_2\text{O}$ with a crystallite size of 199.68 nm. These phase-formed powders were then coated on the aluminum current collector and assembled into a half-cell configuration in an Ar-filled glove box. Electrochemical studies were performed on these half-cells using CV, GCD, and EIS. The results demonstrate that combining coprecipitation synthesis and material modification improves electrochemical stability. This study presents a scalable approach for developing durable $\text{Na}_x\text{Fe}[\text{Fe}(\text{CN})_6]\cdot n\text{H}_2\text{O}$ -based cathodes through accessible synthesis and post-synthetic modification strategies.

High Entropy Oxides: A Journey from Fundamental Understanding to Future Possibilities

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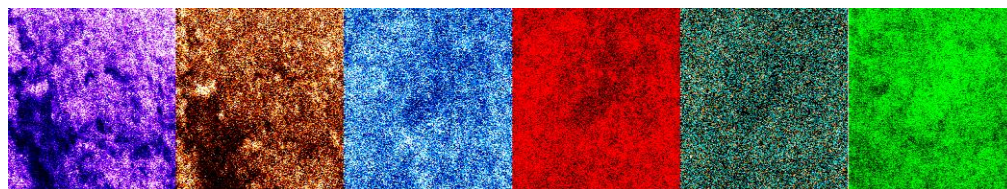
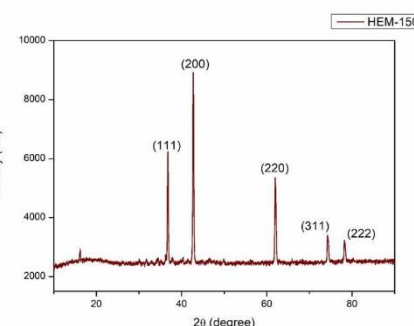
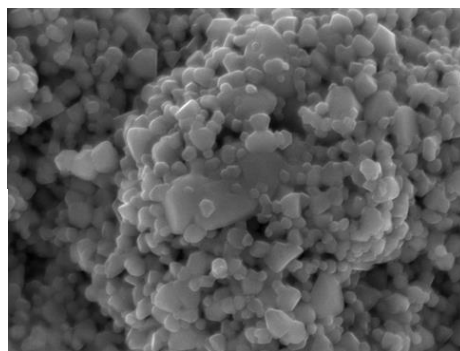
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High Entropy Oxides (HEOs) represent a novel class of materials that have emerged at the intersection of complexity and stability, driven by the concept of configurational entropy. Unlike conventional binary or ternary oxides, HEOs consist of five or more metal cations distributed in a single-phase crystalline lattice, typically adopting rock-salt, spinel, perovskite, or fluorite structures. This unique compositional complexity imparts exceptional thermal stability, mechanical strength, defect tolerance, and tunable functional properties such as ionic conductivity, catalytic activity, and magnetism.

This study focuses on the synthesis, detailed characterization, and catalytic performance evaluation of selected high entropy oxides. HEOs of rock salt based (Mg, Co, Ni, Cu, Zn)O were synthesized using a sol-gel and hydrothermal method to ensure homogeneous elemental distribution and phase purity. Comprehensive structural and morphological characterization was performed using X-ray diffraction (XRD), scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS), inductively coupled plasma atomic emission spectrometry (ICP-AES) confirming the formation of single-phase rock-salt type structures with uniformly dispersed multivalent cations. Despite different ionic radii and electronic configurations of the 5 cations, the high configurational entropy stabilizes the solid solution into a single-phase rock-salt structure has been formed. The surface area and porosity were evaluated using BET analysis, highlighting the suitability of these materials for catalytic surface reactions. This study demonstrates the synthesis of HEOs in wet chemical route and characterisation.

Keywords: High entropy oxides, sol-gel synthesis, catalytic activity, multifunctional materials.

**Scanning Electron
Microscopy (SEM) of HEO
X-ray diffraction (XRD)
of synthesized HEO**



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Comparative Study of Al and Mg Doping in ZnO: Effects on Grain Boundary Segregation and Thermoelectric Performance

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Zinc oxide (ZnO) is a promising oxide thermoelectric material due to its thermal stability, abundance, and environmental compatibility; however, its performance is limited by high thermal conductivity and moderate electrical conductivity. Tailoring grain boundary chemistry offers a pathway to enhance phonon scattering while controlling carrier transport, making the study of grain boundary segregation essential for thermoelectric optimization. In this work, ZnO ceramics doped with aluminum (Al) and magnesium (Mg) were synthesized via spark plasma sintering under identical conditions to elucidate the influence of dopant chemistry on microstructural and thermoelectric behavior. Al was selected for its potential to increase electrical conductivity by introducing additional charge carriers, whereas Mg was chosen for its ability to enhance the Seebeck coefficient by modifying carrier concentration and scattering mechanisms. Our results reveal pronounced grain boundary segregation in Al-doped ZnO, while Mg-doped ZnO exhibits a uniform dopant distribution without significant segregation. Thermoelectric measurements demonstrate that Al doping improves electrical conductivity, whereas Mg doping increases the absolute value of the Seebeck coefficient. This study provides clear experimental evidence that dopant-induced grain boundary segregation can significantly influence the balance between electrical and thermal transport in ZnO, offering a targeted approach for designing high-performance oxide thermoelectrics for sustainable energy conversion applications.

Exploring the structural, ion transport, water stability properties upon aliovalent Boron substitution in the NASICON-structured $\text{Na}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$ -based solid electrolyte

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NASICON-structured $\text{Na}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$ (NZSP) solid electrolyte offers excellent electrochemical, thermal, and chemical stability. However, its practical application is hindered by insufficient ionic conductivity in grains and grain boundaries, as well as interfacial challenges. In this work, aliovalent boron is optimally substituted at the less explored tetrahedral Si site in the NZSP structure, forming a phase-pure, Na-rich solid electrolyte which shows a 143% enhancement in total ionic conductivity, reaching ~ 0.5 mS/cm (compared to 0.2 mS/cm for unmodified NZSP), attributed to increased grain size and reduced grain boundary resistance, along with unit cell volume shrinkage making the modified NZSP “water stable”. The sintered density improves significantly from 93.2% to 98.4%, and enhancement of mechanical properties is observed, including increased indentation toughness, which is critical for suppressing Na dendrite growth. These improvements result in a $\sim 58\%$ reduction in charge transfer resistance ($\sim 194 \Omega \text{ cm}^2$) in all solid-state Na-doped-NZSP-Na symmetric cells. This work reveals that adopting an integrated strategy concerning lattice substitution can improve the electrolyte properties, which are significant for the development of the next-generation solid-state sodium batteries.

Keywords: NASICON, Structure, Ion conduction, Solid Electrolyte, All-Solid-State Battery

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Analysis of electrochemical characteristics of cost-effective $\text{CaCu}_3\text{Ti}_{4-x}\text{Zr}_x\text{O}_{12}$ /rice husk activated carbon composite for supercapacitor electrode application

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In this study high dielectric constant material, $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$ doped with Zr and activated carbon out of waste material rice husk was used as resource material to fabricate low cost supercapacitor electrode material. Various compositions of $\text{CaCu}_3\text{Ti}_{4-x}\text{Zr}_x\text{O}_{12}$ ($x=0.001, 0.005, 0.05, 0.1$, and 0.2)/rice husk composites were synthesised using the solid-state ceramic technique to investigate its feasibility as supercapacitor electrode material. The effect of heat treatment on crystal structure, microstructures, ionic distribution, and oxidation states were studied by XRD, SEM, EDS, and XPS in the first part of the investigation. XRD showed the formation of a single phase along with few impurity phases. Using cyclic voltammetry (CV), galvanostatic charge/discharge (GCD), and electrochemical impedance spectroscopy (EIS) techniques, the electrochemical performance of as-synthesized materials has been examined in detail. The dielectric and resistive properties of $\text{CaCu}_3\text{Ti}_{4-x}\text{Zr}_x\text{O}_{12}$ ($x=0.001, 0.005, 0.05, 0.1$ and 0.2) sintered at 1100°C for 12 h with the help of impedance and modulus spectroscopy were also reported.

Synergistic effect and defect engineering in (Fe,Co,Ni,Cu,Zn)O High Entropy Oxides for Oxygen Evolution Reaction

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High-entropy materials have emerged as a promising class of electrocatalysts owing to their inherent compositional tunability and the coexistence of multiple potential active sites, offering pathways toward earth-abundant and energy-efficient electrochemical energy storage technologies. In this work, we report that incorporating alkali metals into transition metal oxides offers an attractive route toward cost-effective, high-performance electrocatalysts for energy conversion technologies. Here, we unveil the stability activity relationship in rocksalt high-entropy oxides (HEOs) (FeCoNiCuZn)O, (LiFeCoNiCuZn)O, and (NaFeCoNiCuZn)O synthesized via the solution combustion method and evaluated for the oxygen evolution reaction (OER). The introduction of Li^+ or Na^+ markedly enhances the stability of the rocksalt solid solution at lower synthesis temperatures. This stabilization arises from increased configurational entropy due to cation-vacancy formation, coupled with oxidation of transition-metal cations, particularly Co and Ni, from +2 to +3. Surface-sensitive analysis reveals the emergence of intermediate-spin Co^{3+} ($t_{2g}^5e_g^1$) species, which, along with electron deficiency in the transition-metal-oxygen network, tunes the adsorption energetics of O^* and OH^* toward optimal values for OER catalysis. Among the compositions studied, (Li,Fe,Co,Ni,Cu,Zn)O exhibits exceptional electrocatalytic performance, delivering an overpotential of 322 mV to achieve 10 mA cm^{-2} with a Tafel slope of 63 mV dec^{-1} , while retaining its activity over 30 h of continuous operation in alkaline electrolyte. The demonstrated OER performance surpasses that of most previously reported rocksalt-based electrocatalysts.

Keywords: High entropy oxides; Multicomponent oxides; Aliovalent substitution; Oxygen evolution reaction; EXAFS, XANES.

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Nd_{1-x}Ba_xCo_{1-y}(Fe, Ti)_yO_{3-δ} material for cathode application in Solid Oxide Fuel Cell (SOFC)

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Solid oxide fuel cell (SOFC) is a promising technology owing to its high efficiency, ability to use wide variety of fuels, electricity production with zero emission to the environment and reversible operational flexibility. However, as the operating temperature can be very high higher temperature (> 850°C) leads to limited choice of materials for cell components. The lowering of operating temperature to intermediate (650-850 °C) and low (400- 650 °C) is a major objective for researchers, scientists and entrepreneurs in order to expand the materials choice as well as commercialization of SOFCs. Here in this work the perovskite oxide powders of Nd_{1-x}Ba_xCo_{1-y}(Fe, Ti)_yO_{3-δ} (0 ≤ x ≤ 0.3, y = 0, 0.2) were synthesized by combustion technique and investigated as cathode materials for SOFCs application. The Rietveld refinement of the XRD data confirms the formation of single-phase orthorhombic perovskite structure of Pnma space group within the compositions (0 ≤ x ≤ 0.1, y = 0, 0.2). The X-ray photoelectron spectroscopy (XPS) analysis confirms the presence of mixed valence states of Co³⁺/Co²⁺, Fe³⁺/Fe²⁺, Ti⁴⁺/Ti³⁺ and O-Lattice/O-Chemisorbed/O-physisorbed species. The measured average CTE values are varies from 18 - 25 x 10⁻⁶ K⁻¹ in the temperature range 200-900 °C for all the synthesized samples. The measured electrical conductivity values are found to be 252 Scm⁻¹, 308 Scm⁻¹, 157 Scm⁻¹ at 700 °C for the compositions Nd_{0.9}Ba_{0.1}CoO_{3-δ} (NBCO.1), Nd_{0.9}Ba_{0.1}Co_{0.8}Fe_{0.2}O_{3-δ} (NBCFO), Nd_{0.9}Ba_{0.1}Co_{0.8}Ti_{0.2}O_{3-δ} (NBCTO) respectively. XRD analysis reveals no chemical reactivity for the compositions NBCFO, NBCTO with 20 mol% gadolinium doped ceria oxide (Ce_{0.8}Gd_{0.2}O_{2-δ}) electrolyte material after firing at 1200 °C for 8hr. The area specific resistances (ASR) were calculated for the symmetrical cells and are found to be 0.67 Ω cm², 1.07 Ω cm² at 850 °C for the NBCFO, NBCTO compositions respectively. The particular composition is Nd_{0.9}Ba_{0.1}Co_{0.8}Fe_{0.2}O_{3-δ} showed highest total electrical conductivity ~ 308 Scm⁻¹ and lowest ASR value ~ 0.67 Ωcm² as compared to all other compositions. Therefore, the synthesized Nd_{0.9}Ba_{0.1}Co_{0.8}Fe_{0.2}O_{3-δ} composition could be a promising cathode material for SOFC application.

Techno-Economic Assessment of Concentrated Solar Power Systems: A Review of Simulation Tools and DOE-Based Optimization Methods

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Concentrated Solar Power (CSP) technologies have emerged as a promising solution for sustainable electricity generation, particularly in regions with high solar irradiance and growing energy demands. This review provides a comprehensive examination of recent advancements in techno-economic analyses of CSP systems, with a focus on the integration of simulation tools and Design of Experiments (DOE) methodologies. Various simulation platforms including Greenius, System Advisor Model (SAM), HOMER Pro, and TRNSYS are critically evaluated in terms of their capabilities for modeling thermal performance, system integration, storage, and cost analysis. The review also explores the application of statistical DOE techniques such as Taguchi, Response Surface Methodology (RSM), Grey Relational Analysis (GRA), and ANOVA for optimizing system parameters and improving decision-making under uncertainty. Key performance indicators like Levelized Cost of Electricity (LCOE), net power output, and capacity factor are analyzed across different CSP configurations, including parabolic trough, power tower, and hybrid systems. By synthesizing findings from diverse case studies and methodologies, this review highlights best practices, identifies research gaps, and outlines future directions for the effective deployment and optimization of CSP technologies in water-constrained and economically sensitive environments.

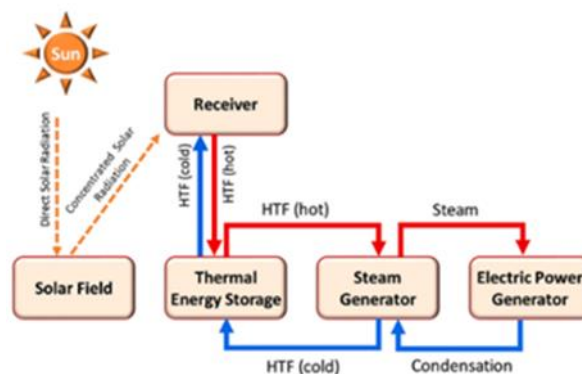


Figure 1 Basics concerning solar heat energy production

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Optimization of device parameters in Thermoelectric Generator for Enhanced Waste Heat Recovery in Industrial Systems

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Thermoelectric generators (TEGs) have emerged as a promising technology for sustainable energy conversion, particularly in harnessing waste heat. However, their deployment in commercial settings is hindered by inherent performance limitations, largely due to energy losses. This study presents a finite element modelling (FEM) analysis of a SiGe-based TEG performance under realistic operational conditions, accounting for heat and parasitic contact losses. The investigation demonstrates that the geometric configuration of thermoelectric elements is crucial for optimizing heat flow and reducing the thermal resistance of device. Adjustments to fin designs were made to enhance convective heat transfer, resulting in a 116% increase in power output from a single TEG module. We achieved maximum energy conversion efficiency of 8.5% under practical conditions. Additionally, to enable more efficient TEG optimization, we modified the internal parameter fill fraction (FF) in terms of system-level parameters. To bridge the gap between theoretical models and practical applications, we simulated the heat transfer processes in a thermal power plant boiler, with an emphasis on radiative heat loss from the boiler's surface to the ambient environment. Considering the high operating temperatures (1600K–2000K) of industrial boilers, the strategic placement of TEGs on the boiler's exterior surface can enable the conversion of waste heat into electrical power. The findings demonstrate the potential of the optimized TEG designs to significantly enhance energy conversion efficiency, thereby supporting their integration into commercial waste heat recovery systems.

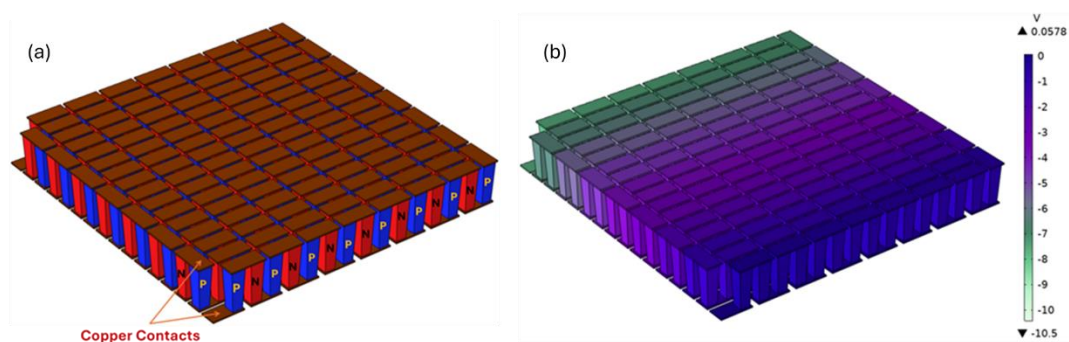


Fig. 1. (a)Schematics of a TEG device with p and n legs (b) Potential difference variation within the TEG device

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Ceramics for Health Care and Dental Applications

INVITED SPEAKERS

BIOCERMIC MATERIAL DEVELOPMENT FOR SPECIFIC CLINICAL NEEDS

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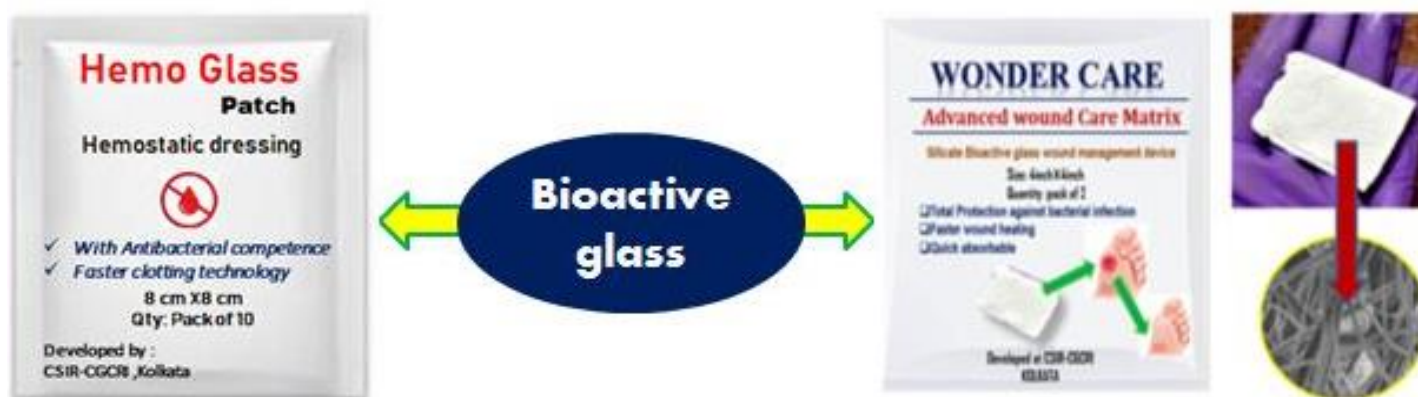
A variety of synthetic calcium phosphates and calcium–phospho-silicate compounds have been used as bone grafts over the last three decades. While autogenic bone is the gold standard, their limited availability and donor site morbidity lead to the search for alternate sources such as allografts and synthetic biomaterials. Synthetic biomaterials, mainly, bioactive ceramics are widely tried as bone substitutes owing to their biocompatibility. They elicit very little inflammation and has the ability to integrate with the surrounding bone. In clinical point of view the ideal ceramic bone graft substitute should be the one that rapidly integrates with the host bone, attains optimum mechanical stability very quickly and disappears rapidly after its function has been achieved with minimum toxic byproducts, allowing replacement by host bone. Bioactive ceramics, glasses and cements have already made their mark in bone graft substitution. The Bioceramics Laboratory at SCTIMST had been working on these materials over the last decade dealing from the synthesis to clinical applications. Various technologies for manufacturing calcium phosphates based ceramics (dense and porous), bioactive ceramic composites (calcium-phosphate-silica systems) and calcium phosphate cements have been developed. The efficacy of these bioactive materials is now being explored in various cases of skeletal and dental repair, where synthetic bone substitutes are not conventionally used. Such tailor-made ceramic implants were realized through the teaming up of material scientists, biologists and clinicians

Bioactive Glass in Chronic Wound Healing and Rapid Coagulation of Profuse Bleeding: Breakthrough in Healthcare at Affordable Cost

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Bioactive glass (BG) originally developed for bone regeneration, has emerged as a powerful biomaterial in the management of chronic wounds and emergent hemostasis. Its unique network structure, upon contact with biological fluids, stimulates a cascade of cellular responses that promote angiogenesis, antibacterial activity, and rapid tissue regeneration. The present abstract consist of novel bioactive glass based woundcare matrix in three-dimensional architectures, e.g., micro-nanofibres for healing of non healing diabetic ulcer, while the mesoporous glass is being used for prompt hemostatic action in the profusely bleeding combat wounds of soldiers. In both the cases, therapeutic efficacy of the formulations/compositions are expected to establish their superiority over the respective market brands with the surge of 'Swasth Bharat', Atmanirbhar Bharat and 'Make in India' mission.



Development and therapeutic use of [⁹⁰Y]Y-glass microsphere ('BhabhaSphere') for affordable treatment of liver cancer

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Selective Internal Radiation Therapy (SIRT) using a β -emitting radionuclide is an established treatment modality for managing inoperable liver malignancies. Among the available options, [⁹⁰Y]Y-labeled glass microspheres are widely regarded as the preferred agent [1]. Upon intra-arterial administration via the hepatic artery, these microspheres become selectively lodged in the tumor vasculature, delivering a targeted cytotoxic dose of ionizing radiation from ⁹⁰Y [$T_{1/2}=64.1$ h, $E_{\beta(\max)} = 2.28$ MeV] to malignant liver cells. TheraSphere®, a commercially available [⁹⁰Y]Y-glass microsphere product, is approved by the US FDA for this application. However, its high cost poses a significant barrier to accessibility, particularly in resource-limited settings. Yttrium aluminosilicate (YAS) glass with a composition of 40 wt.% Y₂O₃, 20 wt.% Al₂O₃, and 40 wt.% SiO₂ was synthesized using the melt-quenching method. The resulting glass was converted into microspheres with >95% sphericity through flame spheroidization. Particles in the size range of 20-35 μ m were isolated by sieving. Intrinsically ⁹⁰Y-labeled YAS glass microspheres were then produced via neutron irradiation of the non-radioactive (cold) glass microspheres at a thermal flux of 1.4×10^{14} n.cm⁻².s⁻¹ for 3 days in Dhruva research reactor. The irradiated [⁹⁰Y]YAS microspheres were suspended in 0.6 mL of sterile physiological saline. [⁹⁰Y]YAS glass microspheres ('BhabhaSphere') were produced with specific activity of 150 ± 12 MBq/mg and radionuclide purity of $99.94 \pm 0.02\%$. [⁹⁰Y]Y-glass microspheres formulation presented excellent *in-vitro* stability at room temperature in physiological saline and human blood serum. Leaching of ⁹⁰Y activity from the labeled microspheres was found to be insignificant (<0.2%) even after 15 days. Intra-arterial administration of the [⁹⁰Y]YAS microspheres into the liver lobe, followed by biodistribution studies in normal Wistar rats, demonstrated that over 97% of the injected ⁹⁰Y radioactivity was retained in the liver for up to 7 days post-administration. In human patients, the administered formulation remained localized and was retained at the site of administration within the liver malignancy [2]. The indigenously developed [⁹⁰Y]YAS glass microspheres are comparable to the commercially available TheraSphere® in terms of safety and efficacy for the treatment of hepatocellular carcinoma. To date, 36 ready-to-use doses of [⁹⁰Y]YAS microspheres have been supplied to multiple hospitals across the country and have been successfully used in the treatment of patients with unresectable hepatocellular carcinoma. The presentation will detail the indigenous development, quality control, preclinical evaluation and clinical utilization of [⁹⁰Y]Y-glass microspheres ('BhabhaSphere'), a biosimilar to TheraSphere®, aimed at providing an affordable and effective treatment option for liver cancer patients in India.

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An Indigenous Innovation Journey of CSIR-CGCRI towards Strategic Self-Reliance in Advanced Multifunctional Biomaterials: *Harnessing Ceramic-Glass-Polymer Synergy and Sustainable Healthcare with Biogenic Ceramics*

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Achieving self-reliant, high-performance biomaterials for healthcare implants is critical to Atmanirbhar Bharat and sustainable healthcare innovation. Current orthopedic and dental implants rely heavily on PEEK and titanium, which, despite mechanical reliability, suffer from bioinertness, poor osseointegration, and lack intrinsic antibacterial properties, limiting long-term clinical outcomes. Addressing these challenges, we at CSIR-CGCRI has developed multimaterial-reinforced, bioactive, and multifunctional PEKK composites integrating hydroxyapatite (HAp), bioactive glass (BAG), tricalcium phosphate TCP), and antibacterial agents (CuO/ZnO). These composites demonstrate superior cytocompatibility, osteogenic differentiation (5–6 fold increase in alkaline phosphatase activity, 2–3 fold increase in mineral deposition and collagen), and strong antibacterial efficacy (2–3 fold reduction in *E. coli* adhesion) compared to pure PEKK and commercial benchmarks. Mechanically, composites exhibit enhanced hardness (3.2–3.7 GPa), compressive strength (225–234 MPa), and elastic modulus (4–4.9 GPa), combining load-bearing capability with radiolucency for imaging compatibility.

Complementing this, we explored derivation of bioceramics from biogenic sources such as bovine, caprine, and fish scale HAp as a proof-of-concept for sustainable healthcare materials. These naturally derived CaP materials exhibit calcium-deficient compositions (Ca/P 1.55–1.59), crystallite sizes of 36–55 nm, and enriched trace elements (Sr, Mg, Zn, Cu) that enhance osteogenesis and antibacterial activity with fish scale-derived scaffolds promoting up to 36% higher new bone formation than synthetic HAp. This work demonstrates that integrating indigenous PEKK composites with biogenic ceramics not only advances multifunctional implant technologies but also contributes toward a circular, sustainable healthcare paradigm.

Our research represents a first-in-class platform for self-reliant India, combining high-performance bioactive composites with environmentally conscious biomaterials, enabling next-generation orthopedic and dental solutions.

CERAMICS IN DENTAL PRACTICE: EFFICIENCIES, DEFICIENCIES AND PATHWAYS TO PROFICIENCIES

Dr Mohit Kheur

Glass ceramics, Leucite reinforced ceramics, lithium disilicate ceramics, crystalline ceramics and ceramic-polymer combinations have been the mainstays of dental ceramics applications over the past few decades.

The oral cavity presents unique challenges and has over time exposed lots of deficiencies in all ceramics that have been developed for dental applications.

Some of these challenges are related to bonding to the tooth, inherent flexural and strength limitations and esthetic limitations.

Dental materials scientists have tried to develop strategies to overcome these shortcomings.

This presentation describes the various beneficial applications of different types of ceramics for different patient conditions, highlights some of their deficiencies, points out areas where there is scope for improvement and dwells upon areas of current research on dental ceramics.

Dental Prosthetics by Machining of Ceramic Dough Shaped Green body - Improved Strength and Aging Resistance

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Zirconia, alumina and their composites are being extensively used in dental and orthopaedic industries. Machining of ceramics with superior surface finish is energy intensive due to high hardness and low fracture toughness. The customized implant especially dental and orthopedic market is dominated by CAD-CAM technology through pre-sintered state machining. However, tailoring geometry with compositional variation along the surface contour is relatively difficult to achieve by this approach. Binder assisted coagulation processing and green shaping could be a cost-effective alternative. A novel ceramic dough forming technique is explored inspired by food technology where powder blend with homogeneous dough is achieved by a kneading process. The pressure-less sintered strength of ATZ composite was comparable to traditional cold isostatic pressed components. Dental prosthesis like threaded root form implants, were successfully green machined on dried blanks.

Although partially stabilized zirconia composites are extensively used in prosthetics, their life time is widely debated due to hydrothermal phase transformation associated ageing under *in vivo* environment. A facile dip-coating on green ceramics with functionally graded composition was formed on ATZ. Coated samples had greater Weibull modulus of ~ 19 and scale parameter of 1053 MPa compared to the uncoated samples that had $m = 10.5$ and $\sigma = 722.0$ MPa corresponding to an increase of $\sim 83\%$ in Weibull modulus and $\sim 45\%$ in scale parameter. Accelerated aging test resulted in profound phase preservation even after 72 h under autoclaving in coated samples compared to uncoated ones, with significant difference in XRD, Raman and electron microscopy investigations. Trabecular porous surface on dense zirconia was also achieved by this method to minimize stress shielding. The porous section had a compressive strength of 20 MPa with $\sim 85\%$ vol % porosity. Further a bioactive coating made of Hap–Zirconia composite was explored successfully for bone ingrowth and ongrowth simultaneously towards Osseo-incorporation, without compromising interfacial failure.

CONTRIBUTORY SPEAKERS (ORAL)

Enhancing Ti-6Al-4V biomedical implant performance through TiO_x , Ta_yO_z , and hybrid $\text{TiO}_x\text{-Ta}_y\text{O}_z$ coatings: Evaluation of wear, corrosion resistance, and biocompatibility

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Biomedical implants are susceptible to corrosion and performance deterioration due to the hostile conditions within the human body. To mitigate these challenges, this study develops non-stoichiometric oxide-based TiO_x , Ta_yO_z and hybrid $\text{TiO}_x\text{-Ta}_y\text{O}_z$ thin film coatings via co-sputtering to enhance both the mechanical durability and biocompatibility of titanium-based implants. By combining the biocompatibility of TiO_2 with the chemical stability and bioactivity of Ta_2O_5 , the $\text{TiO}_x\text{-Ta}_y\text{O}_z$ hybrid films aim to synergistically improve implant performance.[1, 2] Moreover, the effectiveness of $\text{TiO}_x\text{-Ta}_y\text{O}_z$ films is compared with TiO_x and Ta_2O_5 coatings on Ti-6Al-4V alloy through a comprehensive evaluation of their corrosion behavior in various environments designed to mimic physiological and extreme conditions such that NaCl solution (replicating saline environment), Hank's solution (mimicking regular body fluids) and Hank's solution with added H_2O_2 (replicating the inflammatory conditions in the body).[3] Furthermore, the films are characterized for their microstructure and compositional make-up via an array of experimental techniques, whereas their mechanical durability and adhesion to the substrate are evaluated through adhesion tests. Furthermore, MTT as well as live/dead staining assays are conducted employing MG63 (human osteosarcoma cells) and mouse fibroblast cells for 24 and 72 hr to assess cell viability, attachment and proliferation. The synthesized TiO_x , Ta_yO_z and $\text{TiO}_x\text{-Ta}_y\text{O}_z$ thin films exhibit up to two orders of magnitude higher corrosion resistance as compared to the bare alloy implant. These films also display superior cell attachment and growth over 72 hr indicating the excellent biomedical potential of the newly developed films for implant applications even under inflammatory conditions.

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The Evolving Landscape of Oral Care: Applications and Commercial Trajectory of Nano-Hydroxyapatite

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Nano-hydroxyapatite (nHAp) has emerged as a transformative biomimetic material in modern oral care, offering a multifaceted approach to dental health. This paper details its scientific applications, including superior enamel remineralization, effective dentin hypersensitivity relief, contributions to oral biofilm management, and aesthetic enhancement through tooth whitening. The material's unique nanoscale properties and biocompatibility position it as a compelling alternative to conventional ingredients like fluoride. Commercially, the nHAp oral care market is experiencing robust growth, driven by increasing consumer demand for natural and fluoride-free solutions, alongside its expanding utility in professional dental treatments. This growth reflects a strategic market positioning, where nHAp is not merely a scientifically promising material but a response to evolving public sentiment and a desire for biomimetic approaches. While its market presence continues to expand, particularly in regions like Asia-Pacific and North America, ongoing discussions regarding long-term safety data and regulatory harmonization remain central to its broader adoption and future trajectory.

Endothelial Cell Responses and Molecular Mechanisms Induced by TiN-Coating on L605 Cardiac Implants

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Despite the advances in coronary stent processes, there are still complications like endothelial damage, thrombosis, neointimal hyperplasia and finally in-stent restenosis. These adverse outcomes are usually linked to stent material properties, choice of design, and host tissue response. While drug-eluting and bioresorbable stents have improved outcomes, their long-term effects are poorly investigated (1).

The high corrosion resistance and low radial recoil make the alloy L605 an ideal material for the stent. The hard, low-friction ceramic coating of Titanium nitride (TiN) on top of the L605 stent further increases its chemical stability and biocompatibility. Our prior in vivo studies demonstrated that TiN-coated L605 stents significantly reduced restenosis compared to uncoated counterparts. Fast reendothelialization is proven to be important for overcoming the adverse effect associated with stenting (2). Moreover, TiN film has shown to enhance the attachment and proliferation of endothelial cells (3). However, the underlying cellular and molecular mechanisms behind the reduced restenosis of TiN coated L605 stents remain poorly understood. We hypothesize that the differences in the gene expression of the endothelial cells play a major role which remains under explored.

Here we aim to systematically evaluate the biological response of human endothelial cells (ECs) to TiN-coated versus bare L605 alloy surfaces. We will investigate cellular features such as proliferation, migration, apoptosis, morphological changes, cytoskeletal organisation and adhesion patterns. To uncover molecular mechanisms, label-free quantitative proteomics (LC-MS/MS) will be performed, followed by bioinformatics analysis and validation using Western blotting and RT-PCR.

Findings from the gene expression studies can be used to guide future coronary stent development aimed at minimizing endothelial damage, reducing neointimal hyperplasia, and enhancing vascular healing.

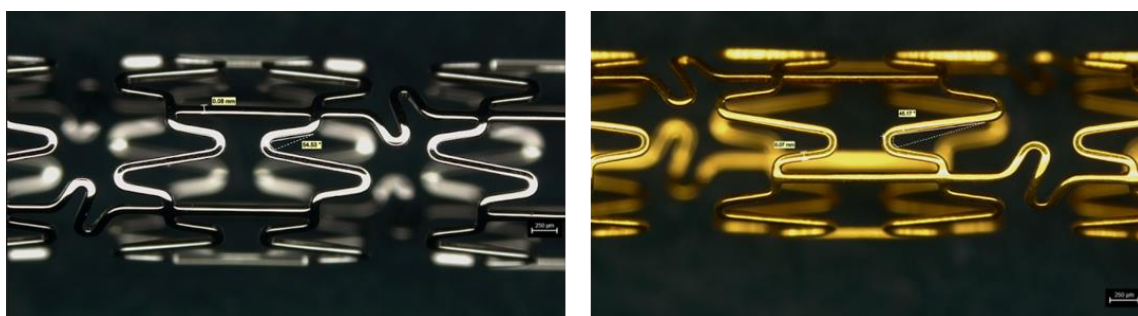


Fig. 1. L605 stents before (left) and after TiN coating (right), showing identical structural design with modified surface characteristics

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Spray Drying for High-Quality Hydroxyapatite Powder: Production Challenges and Strategies

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Hydroxyapatite (HAp), a vital biomaterial for bone tissue engineering and implant coatings, is widely produced as a powder. Among various synthesis and processing techniques, spray drying offers significant advantages for generating spherical, free-flowing HAp granules with controlled particle size and morphology, crucial for downstream applications like plasma spraying and additive manufacturing. However, achieving consistent high-quality HAp powder via spray drying presents several inherent challenges that require careful consideration and optimization.

This article addresses key difficulties encountered during the spray drying of hydroxyapatite. These include maintaining desired particle size distribution and preventing the formation of undesired morphologies such as hollow or fractured particles, which are often influenced by feed slurry properties (viscosity, solids content etc.) and spray drying parameters (inlet/outlet temperatures, atomization pressure, flow rate, draft etc.). Furthermore, challenges related to agglomeration, wall deposition, and ensuring phase purity and crystallinity of the resulting HAp powder will be discussed. The degradation of HAp's structural integrity or phase transformation (e.g., to tricalcium phosphate) due to high processing temperatures is another critical concern, particularly for biomedical applications where specific crystallographic phases are paramount. This work will highlight the interdependencies of various process parameters and material properties on the final HAp powder characteristics, proposing potential strategies to mitigate these challenges through precise control over slurry preparation, judicious selection of spray drying conditions, and innovative atomizer designs. By understanding and overcoming these obstacles, the efficacy of spray drying for advanced HAp powder production can be significantly enhanced, paving the way for improved biomedical devices and applications.

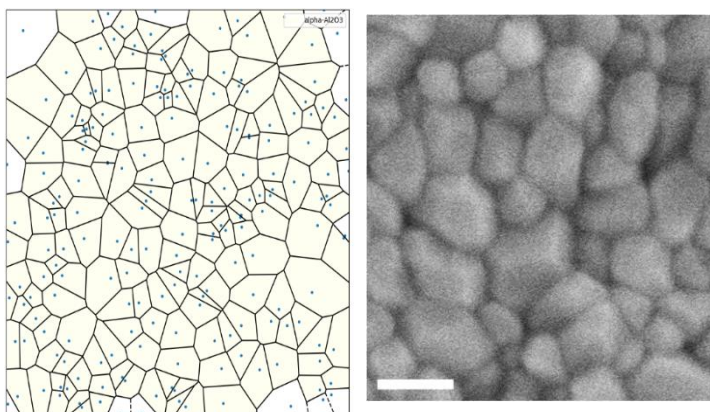
Quantitative Structure-Property Analysis of Polycrystalline Alumina: A Virtual-Based Modeling Approach

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Alpha-alumina (α -Al₂O₃) is extensively used in biomedical implants owing to its outstanding wear resistance and bio-inert behavior. The mechanical reliability of these implants is largely influenced by microstructural characteristics, particularly grain size. This study introduces a comprehensive computational methodology combining synthetic generation of X-ray diffraction (XRD) patterns, stochastic microstructure modeling via Voronoi tessellation, and statistical correlation techniques to analyze the impact of grain-scale features on the mechanical properties of α -Al₂O₃ ceramics. Synthetic polycrystalline microstructures were developed from 25 crystallographic datasets obtained from the American Mineralogist Crystal Structure Database (AMCSD), with simulated XRD patterns used for phase validation. Grain sizes extracted from the model were correlated with yield strength values through the Hall-Petch relationship. Statistical analysis revealed strong relationships between microstructural parameters and mechanical behavior. Specifically, reducing grain size from 5.62 μ m to 4.28 μ m resulted in an increase in predicted yield strength from 365 MPa to 408 MPa, illustrating the strengthening effect of grain refinement. Additionally, this approach underscores the possibility of optimizing microstructural features to enhance implant performance without relying solely on time-consuming experimental procedures. The integrated framework offers a rapid virtual platform for screening and improving alumina-based biomaterials, facilitating a deeper understanding of how microstructure governs mechanical outcomes in biomedical applications. Ultimately, these computational tools can speed up the advancement of durable, high-performance ceramics suitable for long-term physiological use. Future work may include extending this methodology to account for other influential factors such as porosity, grain boundary character, and the presence of secondary phases, thereby providing a more holistic insight into the material behavior. Enhanced predictive capabilities from such studies can drive the design of customized implants tailored to specific biomedical requirements.

Fig. 1. Comparison of synthetic (left) and actual (right) [3] α -Al₂O₃ microstructures.



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Gastrointestinal And Renal Health Monitoring Using High Entropy Oxide-Based Gas Sensors By Ammonia Detection

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In this work, we report a comprehensive study of room-temperature gas-sensing characteristics of high-entropy perovskite oxide (HEPO) based $\text{La}(\text{Fe Co Ni Cr Mn})\text{O}_3$ screen-printed gas-sensor synthesized via solution combustion synthesis using fuel as urea. The structural and morphological analyses were performed using XRD and SEM, respectively, whereas DSC and EDS were used to confirm phase transformation and elemental uniformity. The vibration mode of bonds was determined by the Raman scattering spectrum. The gas sensing behaviour was tested by exposing the sensor to different concentrations NH_3 under controlled conditions. The results showed high sensitivity, fast response and recovery times, and good selectivity at room temperatures. This sensor demonstrates strong potential for integration into portable breath analysis systems aimed at medical diagnostics. It is aiming to detect breath ammonia with high accuracy, supports its application in real-time, point-of-care health monitoring, offering a promising tool for early detection and continuous assessment of renal and gastrointestinal disorders.

Keywords: High entropy oxide, Perovskite, Solution combustion synthesis, ammonia, gas sensor

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Solution Combustion Processed Screen Printed $(\text{MoZnCoCrMn})_3\text{O}_4$ High Entropy Spinel Oxide for ammonia gas sensing applications in the fertilizer industry

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The development of high-entropy oxide (HEO)-based gas sensors aims to ensure reliable detection of toxic ammonia emissions from fertilizer plants, thereby protecting the health of industrial workers. In this study, the room-temperature gas-sensing performance of $(\text{Mo}_{0.2}\text{Zn}_{0.2}\text{Co}_{0.2}\text{Cr}_{0.2}\text{Mn}_{0.2})_3\text{O}_4$ high-entropy spinel oxide sensors synthesized via facile solution combustion synthesis (SCS) from a mixture of corresponding metal precursors using urea as fuel has been demonstrated. The obtained as-combusted powders were calcined at various temperatures (from 500 °C to 1000 °C) to optimize high-entropy spinel oxide (HESO) without any secondary phases, which was then screen printed to fabricate gas sensors. The Thermogravimetric Analysis and Differential Scanning Calorimetry thermograms of the precursor gel depict the thermal changes undergone before and after combustion in the HEO powders with respect to temperature. The morphology of HEO powders was confirmed from FESEM micrographs, along with its spinel crystal structure, X-ray diffraction patterns. Equimolar elemental compositions of calcined HEO powders were identified by Energy Dispersive X-ray Spectroscopy. The vibrational characteristics of the metal-oxide bond were confirmed using Raman and Fourier Transform Infrared Spectroscopy. Screen-printed HESO sensors processed at their phase stabilization temperature depicted high crystallinity with remarkable performance in the gas response towards ammonia (NH_3) in comparison with methanol, ethanol, formaldehyde, and n-butanol. As the permissible ammonia gas exposure limit for humans is strictly capped at 50 ppm, the HEO-based ammonia gas sensor, with a detection range up to 1 ppm, ensures reliable monitoring of ambient ammonia levels in fertilizer manufacturing environments.

Keywords: High entropy spinel-oxide, Spinel, Solution Combustion Synthesis, Phase stabilization, NH_3 , Gas Sensing.

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CONTRIBUTORY SPEAKERS (POSTER)

Cost-effective technique of fabricating porous TiO_2 , Ta_2O_5 , and $\text{TiO}_2\text{-Ta}_2\text{O}_5$ composite films and comparative evaluation for use in biomedical applications

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Titanium metal and its alloys like Ti-6Al-4V are widely used for fabricating biomedical implants due to their excellent mechanical and antibacterial properties. But these require surface modifications to overcome the compromised corrosion resistance and biocompatibility. In this regard, porous coatings play a key role in encouraging osteoblast and tissue ingrowth, enhancing implant fixation and minimizing the risk of loosening. This study focuses on modifying Ti-6Al-4V surfaces via a cost-effective bottom-up sol-gel method to prepare TiO_2 , Ta_2O_5 , and $\text{TiO}_2\text{-Ta}_2\text{O}_5$ nanocomposites (in 1:2, 1:1, 2:1 ratios). Spin coating technique with optimized rotational speed and deposition time is used here to deposit films on the Ti-6Al-4V substrate. Microstructural characterization of the prepared films reveal the porous structure with varying pore sizes, uniform thickness and stoichiometric formation of the desired metal oxides and composites. A detailed corrosion study in Hank's and SBF (simulated body fluid) solutions is performed on these deposited films. Tafel plot and Electrochemical Impedance Spectroscopy (EIS) show high corrosion resistance with I_{corr} values in the order of 10^{-8} A/cm² for the coated samples. Pull-off adhesion testing confirms excellent film-to-substrate adhesion, effectively addressing one of the most common limitations of the sol-gel-derived coatings. The prepared porous films exhibit superior cell viability and attachment relative to the bare Ti-6Al-4V in both the MG-63 (cancerous osteoblast) and NIH3T3 (fibroblast) cell lines across 1, 3, and 7 days. Thus, the study throws light on the efficacy of the cost-effective coating technique as well as the behaviour of TiO_2 , Ta_2O_5 and $\text{TiO}_2\text{-Ta}_2\text{O}_5$ composite films, thereby showcasing their superior surface properties over bare Ti-6Al-4V implant.

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Engineered Calcium Phosphate Bioceramics for Orthopedic applications: ISO-Compliant development, scale-up and clinical validation

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Hydroxyapatite (HA) and β -tricalcium phosphate (β -TCP) are two prominent commercial bioceramics of the calcium phosphate (CaP) family. While both materials have been extensively studied at the laboratory scale, the current work focuses on their scalable production from scratch under tightly regulated synthesis and processing conditions to meet global medical device standards (ISO-13485).

Hydroxyapatite (HA) developed at Ceramat (ISO 13485-certified) is engineered for orthopedic implant coatings via atmospheric plasma spray (APS) deposition, conforming to ISO 13779 standards. These standards require stringent control over phase composition such as limited secondary phases [$\text{CaO} < 1\%$; (β -TCP+TTCP+ α -TCP) $< 5\%$] and a strict Ca/P atomic ratio range within 1.66–1.71. Additionally, heavy metals and trace elements are regulated per medical device safety norms. Industrial-scale production poses challenges in achieving chemical homogeneity, thermal stability, and controlled morphology. Ceramat addresses these through a precisely tailored wet chemical precipitation route, followed by granulation/spray drying and high-temperature sintering. The resulting HA powder demonstrates consistent flowability, phase purity, and thermal stability, ensuring reliable coating performance. This scalable, ISO-compliant manufacturing approach enables its successful deployment in commercial APS deposition processes on orthopedic implants for load-bearing applications.

Ceramat also manufactures β -tricalcium phosphate (β -TCP) at industrial scale using a modified wet chemical precipitation process, maintaining a precise Ca/P molar ratio of 1.50 in accordance with ASTM F1088-23. Key synthesis parameters including pH, precursor concentration, and ripening time are tightly controlled to achieve high phase purity (β -TCP $\geq 95\%$) suitable for biomedical use. The powder is converted into near-spherical granules via a proprietary granulation technique, enabling control over porosity and particle/granule size distribution. These granules have been clinically deployed in orthopedic and spinal surgeries for bone defect repair and infection control. Post-operative evaluations demonstrated effective bone regeneration without signs of inflammation or infection, even in the absence of antibiotic loading, highlighting the material's biocompatibility and osteoinductive potential. This work establishes a robust path for translating CaP bioceramics into scalable, regulatory-compliant, and clinically effective orthopedic solutions.

Keywords: Calcium phosphate, bioceramics, hydroxyapatite, β -tricalcium phosphate

Design, Synthesis, and Evaluation of pH-Responsive Calcium Carbonate Nanocarriers for Targeted Drug Delivery Applications

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Calcium carbonate (CaCO_3) nanoparticles are emerging as effective carriers for targeted drug delivery owing to their biocompatibility, biodegradability, and pH-responsive characteristics. This study examines the synthesis and characterization of CaCO_3 nanoparticles by both green (natural) and chemical co-precipitation approaches, aiming to establish an effective platform for cancer drug delivery. In the eco-friendly process, Gum Arabic served as a natural stabilizer, whereas the chemical approach utilized traditional precursors, calcium chloride and sodium carbonate. The co-precipitation procedure was refined to enhance the synthesis of vaterite and calcite polymorphs under mild circumstances. FESEM examination indicated that the green synthesis resulted in uniformly dispersed CaCO_3 particles with mean diameter (D_{50}) $\sim 199 \pm 6$ nm, whereas the chemical technique produced smaller particles averaging $D_{50} \sim 40 \pm 4$ nm. This size variation is crucial for regulating drug loading and release kinetics. The XRD patterns validated the samples' high crystallinity, as seen by sharp peaks that signify well-ordered structures. BET surface area analysis indicated both nanoparticle having substantial porosity and surface area, hence augmenting their drug delivery capacity. The nanoscale dimensions, elevated surface area, and pH-responsive disintegration of these CaCO_3 particles render them optimal for the targeted delivery of anticancer drugs to tumor locations, where the acidic medium triggers drug release. The study indicates that both synthesis processes are effective, with the green pathway providing an environmentally sustainable alternative. These findings provide a robust basis for subsequent *in-vitro* and *in-vivo* assessments of CaCO_3 based carriers in cancer treatment.

Keywords: CaCO_3 , Drug delivery, pH-responsive, Biocompatibility

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A comprehensive study of molecular docking with TYLC Gemini-Virus coat protein

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The Tomato yellow leaf curl virus (TYLCV) is a significant disease in tomato cultivation, resulting in considerable output reductions worldwide. The coat protein (CP) is an essential structural and functional element in viral replication, host contact, and immune evasion, rendering it a viable target for antiviral strategies. This research utilized an in silico method to evaluate phytochemicals as prospective inhibitors of TYLCV-CP. The three-dimensional structure of TYLCV-CP was predicted utilizing AlphaFold2, due to the lack of resolved crystal structures. A curated library of antiviral phytochemicals was docked to the expected CP model via AutoDock, with the most promising candidates demonstrating binding affinities between -10.2 and -8.1 kcal/mol. These interactions focused on conserved active areas critical for coat protein functionality. Desmond molecular dynamics (MD) simulations were conducted for 100 ns to validate the docking results and evaluate the stability of the protein-ligand complexes. The highest-ranked phytochemicals exhibited stable binding, demonstrating consistent interactions and negligible changes throughout the simulation, indicating favorable compatibility and binding stability. This comprehensive method underscores the promise of phytochemicals as environmentally sustainable antiviral medicines against TYLCV. The integration of AlphaFold2 structure prediction, AutoDock docking, and Desmond MD simulation establishes a dependable framework for the identification and validation of natural inhibitors. These results promote further experimental research for the development of plant-based antiviral formulations aimed at suppressing TYLCV infections and boosting sustainable crop protection.

Keywords: In-silico, Binding affinity, TYLCV-CP, Antiviral

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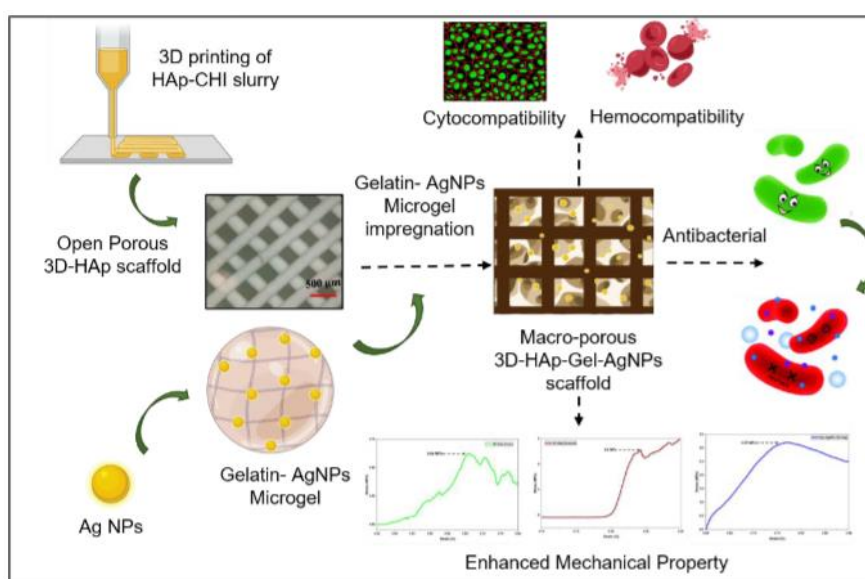
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3D printed Hydroxyapatite Scaffold impregnated with Gelatin-AgNPs Microgel as Potential Skeletal ECM Analogue

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Bone tissue engineering holds immense promise in regenerative medicine, aiming to develop scaffolds that mimic the natural extracellular matrix to support cell growth and tissue regeneration. In this study, we present a novel approach utilizing 3D printing technology to fabricate porous hydroxyapatite (HAp) scaffold towards bone tissue engineering and further silver nanoparticle crosslinked gelatin was impregnated into the porous scaffold to incorporate antibacterial efficacy and mechanical stability. Open porous hydroxyapatite scaffold is 3D printed by optimizing chitosan-hydroxyapatite slurry extrusion and pH induced precipitation followed by sintering at 900 °C of the dried green body. To improve mechanical and antibacterial property, 30% (w/v) gelatin solution was cross-linked using Ag-NPs while infiltrated into the porous 3D printed HAp Scaffold. Characterization techniques such as scanning electron microscopy (SEM), energy dispersive X-ray (EDX) spectroscopy, X-ray diffraction (XRD), X-ray Photoelectron spectroscopy (XPS) and Fourier-transform infrared spectroscopy (FTIR) were employed to assess the scaffold's morphology, crystal structure, and chemical composition. Mechanical testing of 3D-HAp post Gel-Ag impregnation demonstrates substantial increase in the scaffold's strength and suitability for load-bearing applications in bone tissue engineering. Furthermore, in-vitro biocompatibility [cytocompatibility (82 ± 2.35 %) in L929 and haemolysis (3.8 ± 0.17 %) in human RBC] of 3D-HAp-Gel-Ag is found to be within the standard range to be utilised as a bone scaffold. The presence of silver nanoparticles within the scaffold exhibited potent antibacterial activity against *Escherichia coli* (63.5 ± 6.12 %) and *Staphylococcus Aureus* (70.1 ± 5.89 %). Overall, the 3D-HAp-Gel-Ag scaffold demonstrates significant potential in bone tissue engineering, offering both structural support with antimicrobial properties.



Ceramics For Defense and Aerospace

INVITED SPEAKERS

Performance of zirconia based thermal barrier coatings at temperatures above 1200°C

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Thermal barrier coatings (TBCs) are needed in modern gas turbines to allow the use of operation temperatures above 1500°C without excessive cooling. In literature often a maximum operation temperature of 1200°C is given for the standard TBC material yttria partially stabilized zirconia (YSZ). However, our adopted burner rig tests on atmospherically sprayed (APS) TBCs clearly indicate that much higher surface temperatures above 1500°C can be tolerated without early spallations. This is related to a modification of the transient phases of the burner rig tests, i. e. the heating and cooling rates were slowed down considerably to about 10K/s. Adjusting these cooling rates during the major part of the thermal cycle dramatically reduces the thermal stress in the coatings during the start of the transient phases. As a result, the driving force for spallation is significantly reduced.

Also, the detrimental phase transformation in YSZ after heating to elevated temperatures and then cooling down to room temperature can generate stresses in the TBCs. It could be demonstrated that moderate cooling rates down to low temperatures can avoid this transformation. However, it was also found recently that during storage at room temperature phase transformation can be initiated. More details on this desk top degradation process will be shown.

Key Words: Thermal Barrier Coatings, Thermal Cycling, Burner Rig Testing

Significance of Ceramic Raw Materials and Consumables for Investment Casting process

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Metal or alloy being cast through the investment casting process requires various major raw materials such as pattern wax, sprue wax, ceramic core, refractory fillers, inorganic binder, and stucco. Other minor consumables, such as die cleaning solutions, pattern cleaning agents, slurry additives, shell additives, and ceramic blankets, are also required. The Ceramic core needs to have adequate strength, thermal stability, and thermal expansion behavior to survive all the operations from wax injection to casting. Pattern wax must have excellent dimensional stability, a fine surface finish, and low ash content. An optimal combination of inject-ability and thermal expansion properties is vital. Sprue waxes should have desired properties such as low melting point, softness and sufficient fluidity. Different types of wax systems are developed by blending various synthetic waxes and polymer fillers with base paraffin wax. The ceramic shell moulding is the backbone of the investment casting process. For shell-making, a slurry is prepared by adding refractory fillers to the colloidal binder. After dipping the pattern in the slurry, a layer of slurry is formed over the pattern, and stucco is sprinkled over the slurry-coated part. A shell coat is composed of three components: refractory fillers, binder, and stucco. The proper ceramic raw materials for slurry compositions determine shell properties such as thermal properties, high-temperature strength, and chemical inertness for casting high-temperature materials. This paper describes a technical assessment of ceramic raw material and consumables used in the Investment Casting process to achieve optimal shell properties to cast Gas turbine components using Ni-based Superalloy.

Key words: Inorganic; wax; Binder; Refractory; Superalloy

Neeraj

AC Electric field assisted sintering of gadolinium doped ceria

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Sintering of gadolinium doped ceria (GDC) ceramics was done in an alternating current (AC). Electric field ranging from 10 V/cm to 40 V/cm and a current density of 200 mA/mm² were used to investigate densification process. A wide spectrum of frequencies ranging from 0.1 to 1000 Hz were compared to DC field densification. The onset temperature for densification with DC and AC (various frequencies) electric field are correlated to the electro-chemical reduction of ceria. Microstructural analysis of the GDC ceramics sintered under different frequencies indicates towards different internal redox reactions which maybe different for GDC sintered under different frequencies. The grain size trend of ceramics sintered at 20 V/cm is increasing with increasing frequency whereas the reverse trend is true for samples sintered under 40 V/cm. This is speculated in terms of redox reactions at the grain boundary during the incubation period in the presence of electric field resulting in complete or partial percolation of reduction front.

Keywords: Flash sintering, frequency effect, gadolinium doped ceria

High-Temperature Materials for Propulsion, Re-entry, Hypersonic and Stealth Systems: Challenges, Strategies, and Future Directions

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The growing demands of advanced propulsion, re-entry, and hypersonic defence platforms have introduced unprecedented thermal, mechanical, and electromagnetic challenges to material design. Components operating beyond 2000 °C in oxidative, erosive, and plasma-rich environments require materials that combine ultra-high-temperature capability, structural integrity, environmental resilience, and stealth functionality.

This paper will provide a comprehensive overview of recent advances in high-temperature material systems—from oxide and non-oxide ceramic composites to ultra-high-temperature ceramics (UHTCs) and ceramic-matrix composites (CMCs)—engineered for thermal protection systems (TPS), hot structures, nozzle throats, and high-temperature stealth applications. Emphasis is placed on thermo-structural performance, erosion and oxidation resistance, and the integration of thermal and electromagnetic design for next-generation aerospace defence systems.

Recent progress in zirconia-based fibres, C/C–UHTC hybrid composites, and BN-based electromagnetic-transparent ceramics will be discussed, along with advances in high-temperature radar-absorbing ceramics and multifunctional materials that couple thermal protection with electromagnetic stealth. Finally, strategic opportunities for indigenous material development, a roadmap for collaborative research, and scaling challenges in flight-qualified hardware will be outlined in the context of India's evolving aerospace-defence ecosystem.

Keywords: missile propulsion, thermal protection systems, high-temperature materials, ceramic materials, carbon and silicon carbide based materials, material characterization, and aerospace engineering.

CONTRIBUTORY SPEAKERS (ORAL)

Dynamic behaviour and deformation micromechanisms of engineered ceramics for Armor applications

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The high strain rate (HSR) impact studies on engineered ceramics are of immense importance in defense and aerospace industries particularly for strategic applications. The studies performed in the strain rate ($\dot{\epsilon}$) regime 10^2 to 10^4 s^{-1} employing maraging steel split Hopkinson pressure bar (SHPB). Concomitant utilization of high-speed videography was exploited to study in-situ details of dynamic deformation process. The dynamic maximum compressive stress (σ_c) in textured and Zirconia-toughened alumina (ZTA) ceramics has been found as 3 and 3.2 GPa at ($\dot{\epsilon}$) $\sim 1 \times 10^3 \text{ s}^{-1}$ where dynamic equilibrium was established; however, their load carrying duration (t) varied $\sim 80 \mu\text{s}$ favourably from textured to ZTA alumina. During propagation of stress wave, it could be speculated that grain orientation played an important role in local redistribution of the total global impact stress in both the cases.

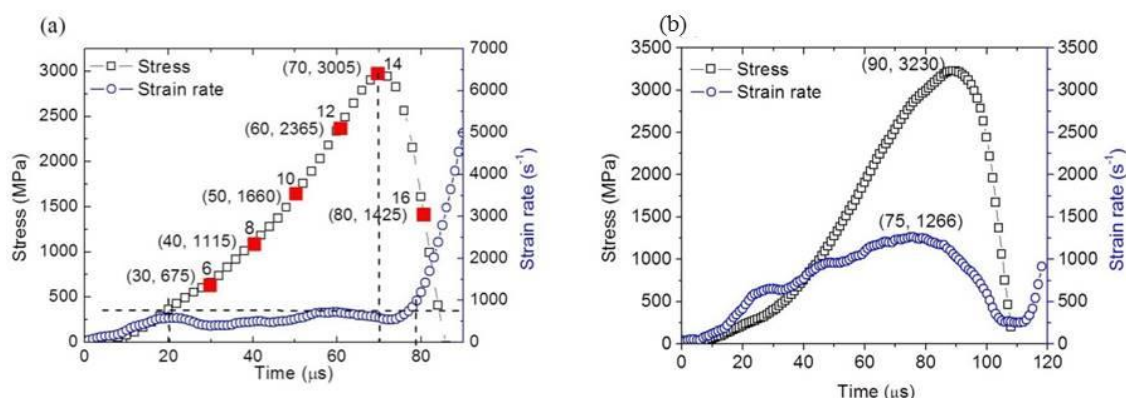


Fig. 1. A typical plot of loading history of stress and strain rates as a function of time in the present SHPB experiment: (a) textured Al_2O_3 and (b) Zirconia-toughened Al_2O_3 .

In Fig. 1(a) at $\sim 20 \mu\text{s}$ the specimen reached to 400 MPa and the strain rate achieved e.g., $\sim 950 \text{ s}^{-1}$ which remained fairly constant from 20 to 70 μs till the specimen reached to its peak strength i.e., 3005 MPa at $\sim 70 \mu\text{s}$. Therefore, dynamic equilibrium was achieved during high strain rate loading [1]. The red points e.g., 6 to 16 as indicated on the stress-time curve in Fig. 1(a) corresponded to the real time deformation images. Similar analysis could be done in ZTA. Further research is necessary to finally come to the conclusion; however, the very preliminary experimental observations are quite encouraging for structural application.

Acknowledgement:

The help of Mr. M.K. Gautam, IIT Kanpur under the supervision of Prof. P. Venkitanarayanan is greatly acknowledged.

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Electrical, Thermal, and Ablative Properties of Spark Plasma Sintered ZrB_2 -SiC- LaB_6 Composites

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Zirconium diboride (ZrB_2) is widely recognized as an ultra-high temperature ceramic (UHTC) due to its exceptional combination of properties, including a high melting point, excellent hardness, low theoretical density, and moderate resistance to oxidation and ablation. In the present study, the influence of lanthanum hexaboride (LaB_6) additions (7, 10, and 14 vol%) on the electrical resistivity, thermal conductivity, thermal shock resistance, and ablation resistance of ZrB_2 -SiC composites was systematically investigated. Nearly full densification was achieved using B_4C and carbon as sintering aids. Among the compositions, the composite with 10 vol% LaB_6 exhibited the lowest electrical resistivity, attributed to enhanced grain growth. Thermal conductivity showed a positive correlation with LaB_6 content, increasing as more LaB_6 was added. Conversely, thermal shock resistance deteriorated with increasing LaB_6 due to thermal mismatch effects. Notably, the composite with 14 vol% LaB_6 demonstrated superior ablation resistance when exposed to temperatures up to 2200 °C. This improvement is attributed to the formation of a dense and stable oxide layer composed of ZrO_2 , along with $\text{La}_2\text{Si}_2\text{O}_7$ phases formed at the grain boundaries, effectively shielding the underlying material from further degradation. These findings highlight the potential of LaB_6 -modified ZrB_2 -SiC composites for extreme thermal environments.

Structure–Property Correlation of ZrB₂–SiC Composites Fabricated by Pressureless Sintering of Green Bodies

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The ZrB₂-20 vol.% SiC based composites have been processed by pressure-less sintering of gel-cast green bodies at 2000°C for 2 h in inert atmosphere with intermediate holding at 1250 and 1600°C. The effect of pH, zeta potential, dispersant and binder content of slurries on their rheological behaviour has been examined to optimize the slurry compositions for preparing apparently defect-free green bodies. A novel approach has been developed by involving the use of egg-white (ovalbumin protein) as an environment-friendly natural binder with sucrose as an additive to reduce viscosity. A slurry comprising 35 vol.% solid loading, 0.3 wt.% PAA, 22 vol.% egg-white, and 8 vol.% sucrose containing 0.3 wt.% polyacrylic acid (PAA) as dispersant, and exhibiting the lowest zeta potential value at pH~09, has been found to have the most desirable rheological properties for gel-casting. From such slurries, the samples with a maximum relative green density $\approx 50\%$ with 5.07 ± 0.7 MPa crushing strength and sintered density $\approx 98\%$ has been successfully prepared with low drying ($\sim 6.9\%$) and sintering volume shrinkage ($\sim 52\%$). The average grain sizes of ZrB₂ and SiC are found to be respectively, 7.1 ± 0.83 and 4.71 ± 0.49 μm . Elastic constant, hardness and indentation fracture toughness of the ZrB₂-SiC composites processed using the optimized slurry have been found as 492 GPa, 17.3 GPa, and 4.7 MPa $\sqrt{\text{m}}$, respectively. While these properties are marginally worsened after thermal shock test by quenching from 1100 °C, a much sharper deterioration is observed on quenching from 1300 and 1600 °C. The optimized slurry composition and process parameters optimised through this study are suitable for processing much sub-scale sizes (100mm*100mm tile) for use in high temperature structural applications.

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Spectroscopic Mapping of Residual Stress in Thermal Barrier Coatings for Aero Propulsion Applications

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Thermal barrier coatings (TBCs) are indispensable in gas turbine engines for aerospace and defence applications, enabling higher operating temperatures and enhancing component longevity. A typical TBC system comprises a nickel-based superalloy substrate, a metallic bond coat (often NiCrAlY or NiCoCrAlY) that forms a protective aluminium-rich oxide layer (TGO), and a ceramic topcoat, usually 6–8 wt% yttria-stabilized zirconia (YSZ). Residual stresses, induced by thermal cycling, oxidation-driven thermally grown oxide (TGO) formation, and sintering, are key contributors to coating degradation and failure. Raman and photoluminescence spectroscopy offer high-resolution, non-contact stress measurements but lack widespread adoption due to limited performance validation. This work evaluates their accuracy, precision, and repeatability, enhancing confidence in their application for TBC systems. This study presents residual stress measurement in air plasma sprayed (APS) ceramic coatings, focusing on YSZ topcoat deposited on NiCoCrAlY bond-coated Nimonic C263 substrates. Raman stress-free reference peak positions for YSZ coatings were established by powdering freestanding topcoats and calibrating their Raman peak shifts against thermal exposure, to account for diverse ageing conditions. Raman stress measurements aligned with XRD-derived stresses using similar corrections for stress-free reference positions and elastic modulus, validated the methodology. Novel PL-based techniques employing rare-earth-doped YSZ enabled subsurface stress probing within the YSZ topcoat. Additionally, Cr³⁺ PL emission from the alumina TGO, captured via confocal focusing near the interface, facilitated simultaneous, co-located residual stress mapping in both, the topcoat and TGO. Stress measurement uncertainties were evaluated based on various parameters such as spectrometer configuration, and repeatability tests confirmed the robustness of the methodology. The findings contribute to more reliable TBC lifetime prediction and failure analysis using Raman and PL spectroscopy.

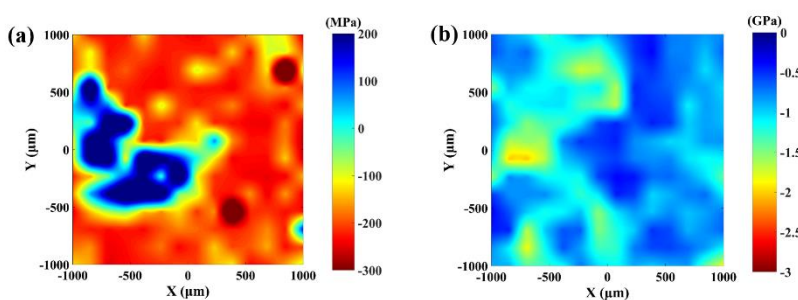


Fig. 1. Co-located in-plane residual stress maps for (a) topcoat and (b) TGO for APS YSZ specimen exposed at 1050 °C for time 1250 h obtained from simultaneously acquired PL spectra.

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Insights into Hypersonic Structural Properties of 2D-BN Ceramics

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Boron nitride (BN) is the preferred material for several high temperature aerospace, defense, and energy sectors due to its extremely high melting temperatures and excellent oxidation resistance under challenging circumstances [1-2]. The combination of 2D materials in h-BN system creates synergistic effects, unlocking new opportunities for structural hypersonic systems and also enhancing the limited amount of dielectric data across a high-frequency band range. Our work offers essential guidance for selecting 2D materials as second phase in particulate BN system. In this present work, we have chosen graphene nanoplatelets (GNP) and indigenously prepared boron nitride nano (BNN) as 2D materials and studied the effect of 2D incorporation for high Mach electromagnetic (X-band) and structural applications. A uniform dispersion of 2D materials was achieved by sonicating in isopropyl alcohol (IPA) medium. Sonicated 2D materials were incorporated into a precursor BN powder composition, followed by densification using spark plasma sintering (SPS) in the range of 1400-1600°C temperature. It is understood that polarizability of 2D materials based on their electron bandgap is a fundamental factor in determining the dielectric properties. The morphological, thermal, mechanical and EM properties of 2D-BN composites were elucidated (Fig 1(a)). BNN incorporation reduces the dielectric property of BN composite below 5, whereas conducting GNP addition increases the dielectric property of BN composite (> 5 , Fig. 1(b)) at 8-12 GHz ranges which means BNN addition improve the EM transparent property of the BN composites. The fracture toughness and flexural strength were increased after addition of 2D materials and achieved its optimum value in the range of 76-87 MPa (flexural strength).

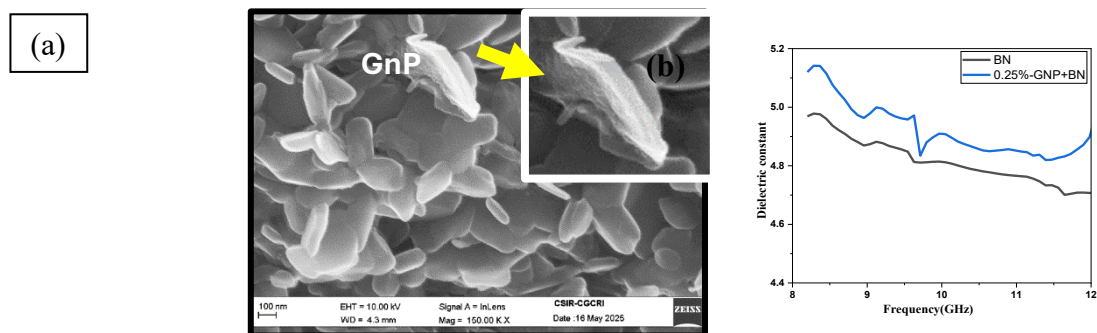


Fig. 1: (a) Fracture surface and (b) Dielectric constant of BN and BN-GNP composite.

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Effect of rapid thermal cyclic loading on TBC-bond coat system deposited on Hastelloy-X superalloys

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Components in the hottest sections of gas turbines in aero engines are typically made of superalloys coated with a bond coat and a thermal barrier coating (TBC). These components are subjected to variable thermal cyclic loading during operation. The adhesion and integrity of the TBC with the underlying substrate are critical for extending the service life of the blades. To be able to improve this integrity, it is essential to investigate the root causes of TBC delamination, under conditions of rapid thermal cycling. An in-house rapid heating laser system has been developed and integrated with a high-speed ultra-violet digital image correlation (UV-DIC) along with a high-speed IR camera to investigate the delamination behavior of a TBC–bond coat system under rapid thermal cycling. The substrate, a Hastelloy-X superalloy specimen measuring 10 × 10 mm with a thickness of 4 mm, was first coated with a 200 µm NiCoCrAlY bond coat using the vacuum plasma spray process. This was followed by the deposition of a 450 µm thick 7 wt.% yttria-stabilized zirconia TBC layer using the air plasma spray technique. Rapid thermal cycling tests are conducted on TBC coated samples under varying conditions to correlate the effects of heating rate, peak temperature, hold time, and cooling rate with the number of cycles to TBC delamination. Microstructural analysis reveals that failure initiates at the thermally grown oxide (TGO) interface. The mismatch in the coefficient of thermal expansion (CTE) between the TBC and TGO leads to the accumulation of thermal strain/stress over successive cycles, ultimately resulting in coating failure.

Vacuum Brazing of Zirconia and Titanium along with Micro-structural evaluation of joint interface

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The increasing usage of advanced technologies demand for hybrid products wherein an optimized combination of properties can be realized in single assembly along with taking care of limitations of individual materials. To suffice this, advanced ceramics like alumina, zirconia and metallic alloys like titanium, superalloys, high alloy steels, etc. are being continuously researched upon to obtain dissimilar joints. Vacuum brazing is an effective and proven technique for obtaining dissimilar and incompatible joints. In the present paper, partially stabilized zirconia (PSZ) and commercially pure Titanium (Grade2) samples were assembled in controlled environment of clean room followed by brazing using Palcusil (silver based alloy) under high vacuum of about 10^{-5} mbar. The obtained brazed joints interface was examined for microstructural characteristics through scanning electron microscopy (SEM) in which the brazed joint was found to be uniform, continuous, homogeneous and free from micro-cracks. Probable phases such as Ti_2Cu , $TiCu$, $TiCu_xO_y$, Cu (solid solution), Ag (solid solution) etc. were identified using energy dispersive spectroscopy (EDS), based on chemical composition analysis, that were further confirmed using X-ray Diffraction (XRD). Dot mapping and Line Scans have been used to reveal the distribution of various elements across the brazed joint. Micro-hardness measurements were also done across the brazed joint and correlated with the formed phases. It was found that the micro-hardness value was lowest for filler region than parent materials indicating its ability to accommodate the residual stresses generated on account of difference in coefficient of thermal expansion (CTE) and thermo-mechanical properties between the different class of parent materials viz, ceramic and metal. Helium leak testing was further carried out to determine leak tightness of the obtained joint which was found to be better than 10^{-9} mbar. litre/second. The obtained joint quality was thus found to be satisfactory and shall be a good choice for applications such as implants, light weight automobile components, electronic packaging etc.

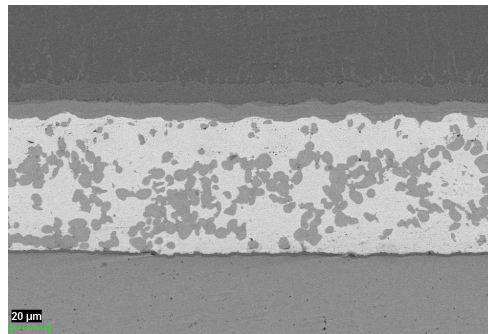


Fig.1. SEM (BSE) image of PSZ/Cu-Ag-Pd/Ti (Grade2) brazed joint

Keywords: Vacuum brazing, SEM, Dot mapping, Line scan, Micro-hardness, Helium leak testing

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Joining of TaC-SiC ceramics without filler by spark plasma sintering

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The use of ultra-high-temperature ceramics necessitates efficient joining methods to address the challenges related to the manufacturing of intricately formed components. This work examines a novel approach for efficiently bonding identical pre-sintered dense TaC-SiC ceramics composites with (0 & 35 vol% SiC) without any filler material by spark plasma sintering. Strong-bonded interface obtained without any evident cracks or porosity near the joint. The composite with 35vol% SiC exhibits higher shear-strength of joints of 120 MPa owing to the formation of *in-situ* intermetallic compound tantalum silicide (Ta_3Si). Further, heating the joints at 800°C revealed that mass gain is higher for monolithic TaC, while protective passive oxide layer of SiO_2 on the composite reduces further oxidation resulting lower mass gain and insignificant cracking/spalling. This study demonstrates the potential of spark plasma sintering to join TaC-SiC composites without filler, and the beneficial effect of SiC addition to obtain strong and oxidation-resistant joints for thermal protection system applications.

KEYWORDS: Ceramic joining, TaC, SiC, Spark plasma sintering

CONTRIBUTORY SPEAKERS (POSTER)

Synthesis of Rare Earth High Entropy Oxides Using Reactive Decomposition Method for High Temperature Applications

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High-entropy ceramics are known for their exceptional functional and thermal properties. For instance, rare-earth containing high entropy oxides (RE-HEO) have very low thermal conductivity and a comparable coefficient of thermal expansion with regards to nickel-base super alloys. Due to these excellent thermal properties, RE-HEO is a potential candidate as a top-coat material for thermal barrier coating applications. However, current processing methodologies such as solid-state reaction, sol-gel method, hydrothermal and co-precipitation techniques using oxides or nitrate precursors, is a challenge for large-scale commercial production. The utilization of expensive chemicals and longer processing hours is uneconomical and environmentally unviable.

This work primarily focuses on the development of an alternate methodology to synthesise high entropy ceramics using pristine carbonate and oxalate precursors of rare earth materials. A novel (La, Ce, Nd_xPr_{1-x}, Sm)O has been synthesised and subsequently characterised using X-ray diffraction, scanning electron microscopy, and energy dispersive spectroscopy, respectively. The as-synthesised RE-HEO displayed single-phase, cubic fluorite structure. In addition, thermal properties of as-synthesised materials were explored using thermogravimetry, differential scanning calorimetry and light-flash technique, respectively.

Keywords: Rare earth Ceramics, Light-flash, High entropy oxide

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First-Principles Investigation of Mechanical Strength and Thermodynamic Stability in High-Entropy (Hf, Zr, Ta, Ti, Mo)B₂ for Extreme Environments

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Extreme environment application requires materials that must sustain at ultra-high temperatures and maintain their structural integrity. These materials are selected based on their robust mechanical properties and thermodynamic stability. The combination of these exceptional properties is found in high-entropy boride (HEB). These HEBs have emerged as a novel class of materials for ultra-high temperature ceramics (UHTCs). In these materials, entropy plays a critical role in the stability of the final HEB. To explore the properties of the material, density function theory (DFT) is employed to explore the capabilities of HEB (Hf, Zr, Ta, Ti, Mo)B₂. The quantitative and qualitative analysis carried out through DFT calculations has revealed that these materials have huge untapped potential. The results through thermodynamic calculations establish the stability of HEB. The mechanical properties calculated through the stress-strain method have confirmed that the HEB exhibited a higher Vickers hardness of 40.4 GPa and a bulk modulus of 343.5 GPa. Furthermore, the electronic density of states (DOS) analysis confirmed hybridization between transition metal d-orbitals and boron p-orbitals, indicating strong covalent bonding. The finite density of states at the Fermi level confirms the metallic nature of the material, making it a promising candidate for high-temperature and extreme environment applications.

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Synthesis of mixed non-oxide UHTCs of ZrC, ZrB₂ and SiC by PDC route and fabrication of Ceramic Matrix Composites

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Ultra-high temperature ceramics are the materials of choice for sharp aerofoil structures and control surfaces of hypersonic and re-usable launch vehicles, where the application temperatures are expected to go beyond 2000°C. Fabrication of such large hot structures is not preferred using conventional ceramic fabrications processes due to fabrication limitations and brittle nature of the materials. Continuous fiber reinforced Ultra-high temperature ceramic matrix composites such as C/ZrC or C/ZrC-SiC have a role to play where near net shaping is possible at the same time brittle nature of UHTCs is eliminated with the introduction of reinforcing fiber. A novel fabrication methodology for fabrication of C/ZrC-ZrB₂-SiC composites is evolved through polymer derived ceramic approach. The present study describes a synthetic route for mixed non-oxide ceramics of ZrC, ZrB₂ and SiC in a single system with a formation temperature as low as 1500°C in inert atmosphere. The as-synthesized preceramic oligomer gave mixed oxide ceramics of ZrO₂ and ZrSiO₄. These were further converted to mixed non-oxide ceramics of ZrC, ZrB₂ and SiC by carbothermal reaction. Heat treatment temperatures and heating rates were varied to study the effect on the phases formed. The so obtained ceramics were evaluated for phases formed by XRD, morphology and composition by SEM-EDS. Fabrication of UHTCMC was also explored and flexural strength was evaluated by three-point bending test at room temperature and up to 1650°C. Flexural strength of 27±2 MPa was achieved at room temperature and the strength was observed to be increased to 40±6 MPa at 1500°C and retained up to 1650°C. Composition of the CMC and distribution of the elements was analysed using elemental mapping by SEM-EDS.

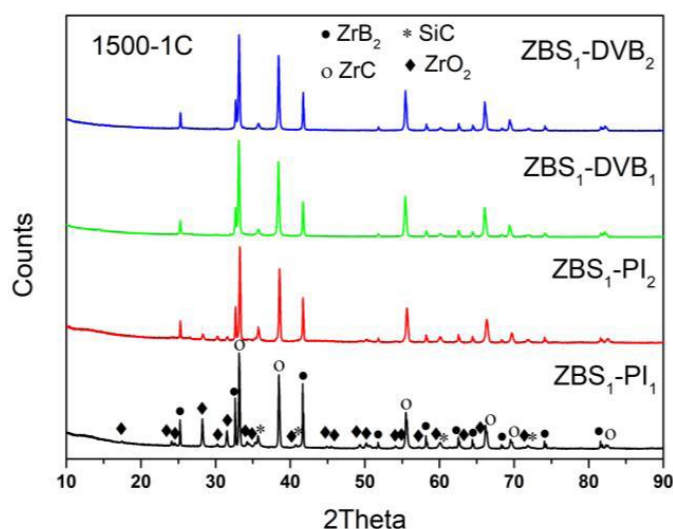


Fig. 1. XRD of zirconoborosiloxane up on carbothermal reaction with polyimide and divinylbenzene heated at 1500°C in argon

Influence of Sintering Temperature on Hierarchical Structure and Mechanical Properties of Bio-inspired Alumina-PMMA Composite

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Natural nacre consists of a hierarchical *brick-and-mortar* microstructure that imparts superior fracture toughness, damage resistance, high specific strength and toughness, which mark it an inspiring model for aerospace-grade composite materials operating in harsh and tough environments. The challenge of fabricating bulk materials with such intricate microstructure in a cost-effective and energy efficient way has persisted since long time. In the present investigation, a scalable, bottom-up fabrication route was implemented to produce *bulk* nacre-like alumina-based composites using anisotropic α -alumina platelets (brick phase) with a compliant mortar phase of poly-methylmethacrylate (PMMA). The platelets were directionally aligned via vacuum-assisted gravity sedimentation process to emulate the nacre-like lamellar architecture. To densify the ceramic preforms, 4 wt% TiO_2 was used as sintering aid, and the ceramic preforms were heat-treated at 1200, 1350, and 1500 °C for 4 h. The ceramic fraction improved with increasing temperature, and attaining a maximum of 81% (when sintered at 1500 °C). The partially dense ceramic preforms were then impregnated with PMMA via in-situ polymerization using 1 wt% Azobisisobutyronitrile (AIBN). The large scale aligned *brick-and-mortar* microstructure, akin to natural nacre, was obtained at all the sintering temperature investigated. The strength (bending) and single-edged notched beam (SENB) test revealed significant enhancement in mechanical performance of our biomimetic composite with increase in the sintering temperature. An optimum strength (bending) of 230 ± 31 MPa and fracture toughness of 7.7 ± 1.4 MPa $\sqrt{\text{m}}$ was achieved after sintering at 1350 °C/4 h. The combination of alignment of ceramic anisotropic particles, interfacial energy dissipation, and hierarchical toughening mechanisms makes our bioinspired nacre-like hybrid composite considerably suitable for high to moderate strain rate applications like aerospace, defense, and other strategic fields.

Keywords: alumina platelets, TiO_2 , brick-and-mortar, strength, fracture toughness.

Low Temperature Processing of Si_3N_4 - SrTiO_3 ceramics

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Silicon nitride (Si_3N_4) has emerged as a promising structural and functional ceramic material owing to its excellent mechanical strength, thermal stability, and favourable electrical properties. Conventionally, the processing of Si_3N_4 to achieve superior densification and performance requires high-temperature sintering, typically around 1800 °C, under controlled atmospheric conditions. Such extreme processing parameters, however, are energy-intensive and limit large-scale applications. To address these challenges, the present work explores the cold sintering process (CSP) as an alternative low-temperature technique for fabricating dense Si_3N_4 -based composites. CSP, carried out at ~300 °C with applied uniaxial pressure, offers the potential to drastically reduce processing temperatures while maintaining desirable material properties. Strontium titanate (SrTiO_3) is well recognized for its excellent dielectric tunability and ferroelectric properties. Thus, combining SrTiO_3 with Si_3N_4 is expected to yield composites that synergistically integrate the mechanical robustness of Si_3N_4 with the functional electrical properties of SrTiO_3 . In this study, Si_3N_4 - SrTiO_3 composites were synthesized with varying SrTiO_3 concentrations. Homogeneous mixing of powders was achieved through high-energy ball milling, followed by CSP to consolidate the samples. The sintered composites attained a relative density of approximately 90 % which is higher than the ceramics sintered in the normal atmosphere at 1000 °C. A slight decline in density was observed with increasing SrTiO_3 content; however, no impurity phases were detected, indicating successful incorporation of SrTiO_3 into the Si_3N_4 matrix. The results demonstrate that optimized CSP conditions can yield densification and microstructural features comparable to those obtained through conventional high-temperature sintering, while enabling a unique combination of mechanical and functional electrical properties. This study highlights the viability of CSP as a sustainable processing route for advanced Si_3N_4 - SrTiO_3 composites. Ongoing investigations will focus on comprehensive microstructural, dielectric, and mechanical characterizations to further evaluate the potential of these materials for structural and multifunctional applications.

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Fabrication and Property Evaluation of β -SiAlONs with Z value variation

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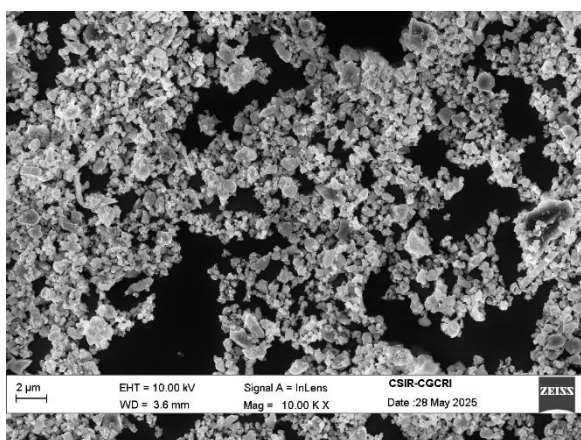
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Different β -SiAlONs compositions ($\text{Si}_{6-Z}\text{Al}_Z\text{O}_z\text{N}_{8-Z}$ with $Z = 0.5, 1.0, 1.5$, and 2.0) were formulated for property evaluation via controlled mixing of phase pure α - Si_3N_4 , AlN, and Al_2O_3 powders, followed by pressure assisted densification. In this $\text{Si}_{6-Z}\text{Al}_Z\text{O}_z\text{N}_{8-Z}$ formula, Z denotes the number of Si-N bonds replaced by Al-O bonds and this replacement effects on the material's mechanical strength, thermal and EM properties of β -SiAlON.¹⁻³ Powder compositions were prepared by homogeneously mixing of α - Si_3N_4 , AlN, Al_2O_3 in their respective weight ratios, followed by spark plasma sintering under nitrogen atmosphere in the range of 1800-1850 °C. The sintered specimens were characterized by measurement of density, percent apparent porosity, phases by XRD, microstructure by field-emission scanning electron microscopy (FE-SEM), energy dispersive x-ray analysis (EDX) for elemental composition and chemical analysis, Vicker's hardness (H_v) and fracture toughness (K_{IC}), Raman spectroscopy and high temperature DTA and TGA for thermal stability. It is observed that with increase of Al_2O_3 content in SiAlON composition, apparent porosity increased while hardness remain same or slightly increase whereas fracture toughness decreased from 2.73 to 1.49 $\text{MPa}\cdot\text{m}^{1/2}$. TGA result showed that the material is very much stable upto 1550°C in argon atmosphere.

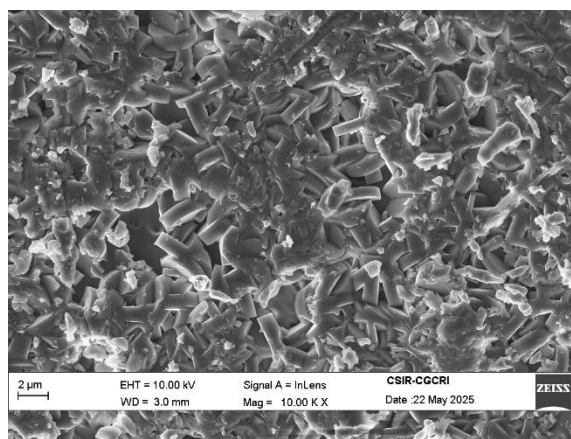
Keywords: β -SiAlON; $\text{Si}_{6-Z}\text{Al}_Z\text{O}_z\text{N}_{8-Z}$; Z-Value; Spark plasma sintering

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FESEM image of α - Si_3N_4 powder



FESEM image of β -SiAlON (Z=2)

Synthesis of Rare Earth Phosphates for High Temperature Protective Coatings

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The demand for high-performance materials in aerospace, gas turbines, and next-generation energy systems has driven the development of thermal barrier coatings (TBCs) and environmental barrier coatings (EBCs). These coatings protect structural components from extreme heat, oxidation, and corrosive environments, extending their operational lifespan. Till date, RE silicates are being used as the most advantageous EBCs. These materials have issues of water vapor corrosion owing to the formation of volatile $\text{Si}(\text{OH})_4$. Recently, Rare earth phosphates (REPO_4) have emerged as a promising class of materials for advanced high temperature coatings due to their exceptional thermal and chemical stability, among other desirable characteristics. These materials primarily exist in two crystal structures: monazite and xenotime both of which exhibit superior resistance to phase transformations and environmental degradation.

In the present work an effort has been taken to synthesize mixed rare earth (La, Gd) based phosphates by co-precipitation, followed by compaction and sintering. The sintered samples exhibited a monazite-type phase, as confirmed by XRD (Fig. 1(a)). The average grain size, estimated from SEM micrographs, was in the range of 1.2–1.5 μm (Fig. 1(b)). SEM–EDS analysis revealed a homogeneous elemental distribution, with no evidence of agglomerates (Fig. 1(c)). The TG–DTA thermogram of the as-synthesized LaGdPO_4 indicated no significant weight loss beyond 200 $^\circ\text{C}$, suggesting the absence of volatile species and confirming the thermal stability of the compound. Future work will focus on the design and synthesis of multicomponent equimolar rare earth phosphates, evaluation of thermal properties and resistance to CMAS attack/water vapour.

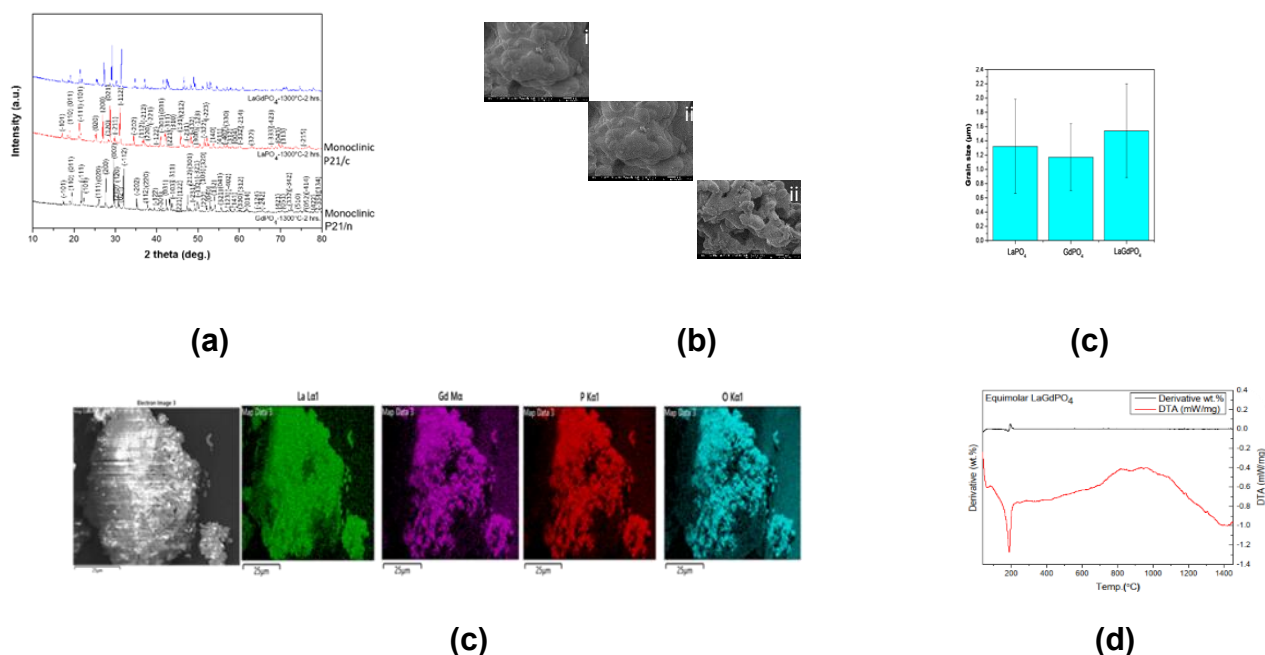


Fig. 1. LaPO_4 , GdPO_4 , LaGdPO_4 powders calcined at 1300 $^\circ\text{C}$ (a) XRD pattern (b) SEM images (c) Histogram of grain size measurements (d) TG-DTA thermogram of as synthesized LaGdPO_4 powder.

Effect of Y_2O_3 and Gr additives on thermal shock resistance and mechanical properties of B_4C reinforced Al_2O_3 composite for cutting tool applications

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Alumina (Al_2O_3) ceramics and their composites are widely used in the cutting tool industries due to their superior mechanical properties. This study presents a comprehensive investigation of the influence of B_4C content and particle size on the sinterability, microstructure, and mechanical properties of Al_2O_3 - B_4C composites fabricated using Spark Plasma Sintering (SPS). The relative density of the composites increased and residual porosity decreased as the B_4C particle size in the powder blends decreased. The addition of B_4C particles improved the mechanical properties of monolithic Al_2O_3 and the highest property enhancements were obtained for the composite with 30 vol% of the finest B_4C particles. For this composition, with respect to monolithic Al_2O_3 , the density was reduced by 11% and hardness, Young's modulus, indentation fracture toughness, and flexural strength increased by 24%, 8%, 51%, and 88%, respectively. The effect of the B_4C particle size on the Young's modulus in relation to existing micromechanical models reveals that the composites with a fine B_4C particles fit the Reuss model. Tribology of the composites of the composites was carried out and detailed explanation of wear behaviour is discussed. The thermal cycle shock of composites was studied through Non-destructive testing technique. The 830°C yielded the drastic changes in the properties.

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Engineering Phonon Scattering: Multicomponent Oxides with Low Thermal Conductivity as Thermal Barrier Coatings

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Multicomponent oxides (MEOs) represent a unique class of materials comprising multiple cations, combined in either equimolar or non-equimolar ratios [1]. This compositional complexity often gives rise to physical and chemical properties that are markedly distinct from those of the individual oxides. Recent studies have shown that such multicomponent oxide systems can be stabilised into single-phase structures [2]. In this work, we explore the incorporation of the multicomponent oxide concept to develop new materials with inherently low thermal conductivity (κ) for thermal barrier coating (TBC) applications. By strategically modulating cation size and mass, we introduce localised strain due to the size mismatch between adjacent cations. This localised strain enhances phonon scattering, thereby reducing the thermal conductivity of the material. Materials exhibiting low thermal conductivity are particularly desirable for TBCs applications. Gaining a comprehensive understanding of the thermal stability and properties of these materials—and correlating these properties with specific design parameters—lays the foundation for broader material design strategies. Multicomponent stabilised zirconia, in particular, emerges as a promising platform for the development of novel low thermal conductivity materials. Leveraging these design principles, we have synthesised materials exhibiting a thermal conductivity less than ~ 1 W/m·K, demonstrating their potential for deploying in service.

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Hierarchically Structured Biomimetic Alumina/Epoxy Composite with Enhanced Strength and Toughness

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Abalone nacre, also known as mother-of-pearl, is a natural composite known for its exceptional combination of strength, toughness, and resistance to impact. This remarkable performance is attributed to its hierarchical 'brick-and-mortar' architecture, consisting of hard aragonite (CaCO_3) platelets embedded in a thin biopolymer matrix. Drawing inspiration from this structural motif, the present study focuses on the fabrication and mechanical property evaluation of nacre-mimetic alumina/epoxy composites; which were produced by adopting 3-step processing approach comprising freeze-casting, uniaxial pressing and vacuum-assisted epoxy infiltration. Initially porous lamellar ceramic scaffolds were produced by freeze casting of aqueous suspensions containing 15 vol% α -alumina platelets and silica-calcia liquid phase sintering aid (0 to 7.5 wt% of alumina platelets). Level-1 hierarchy, representing large-scale alignment of the platelets, was achieved by uniaxial pressing of porous alumina scaffolds orthogonal to the freezing direction, followed by sintering at 1500 °C/4 h. To introduce level-2 hierarchy analogous to nacre's biopolymer mortar, the sintered structures of aligned brick layers (i.e., alumina platelets) were infiltrated with epoxy resin under high vacuum conditions. Mechanical characterizations through 3-point bending and single-edge notched beam (SENB) tests revealed significant improvements in structural performance. The composite with 7.5 wt.% sintering additive achieved flexural strength of 450 ± 14 MPa and fracture toughness of 7.7 ± 0.2 MPa $\sqrt{\text{m}}$, exceeding both natural nacre and many conventional engineering materials. Ashby plot of strength vs toughness further underscore the superior position of our biomimetic hybrid composites with amalgamation of both high strength and toughness. This work demonstrates the potential of bioinspired hierarchical design in engineering high-performance ceramic-polymer composites, thereby opening avenues for their application in aerospace, protective systems and structural domains where simultaneous strength and damage tolerance are critical.

Keywords: Biomimetic composites, alumina, epoxy, microstructure, fracture toughness

A- and B- site co-doped Modified PZT pyroelectric ceramics for IR detector application

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Pyroelectric lead zirconate titanate (PZT) ceramics have attracted considerable interest for infrared (IR) detection in both defence and civilian applications due to their stable performance in a wide temperature range. PZT ceramic compositions (Zr ~58at%) co-doped at both A- and B-sites with Sm and Mn were synthesized using the conventional solid-state reaction route. Stoichiometrically weighed ingredients for each composition were homogenized, calcined at ~ 900 °C, re-milled, granulated, pressed in the form of cylindrical discs, and sintered in lead-rich atmosphere at 1200 °C/2hrs. Thin slices were cut from each sintered disc using a low-speed precision cutter, lapped, polished to a thickness ~ 0.5 mm, and electroded using fired- on silver paste. The electroded discs were poled near to 100 °C with applied dc field ~ 3kV/mm in silicone oil. A phase pure rhombohedral crystal structure with space group $R3m$ was confirmed from the Rietveld refinement of the XRD data of sintered ceramics. The room temperature piezoelectric charge constant (d_{33}) and the planar electromechanical coupling coefficient (k_p) increase with Mn doping (0, 0.005, 0.01, and 0.02) from 50 to 80 pC/N and 0.10 to 0.13, respectively. The measurement of dielectric constant at 10kHz with varying temperature was done using a lock-in-amplifier, and the pyroelectric coefficient was determined under controlled thermal conditions following the Byer-Roundy method. The minimum of dielectric constant ~450, loss factor ~0.007, and maximum of pyroelectric coefficient ~ 500 $\mu\text{C}/\text{m}^2\text{K}$ were observed for Mn doping content~0.01 at room temperature. Low values of piezoelectric and dielectric parameters, large pyroelectric coefficient, a high value of figure of merit (FoM) corresponding to current responsivity $F_r \sim 125\text{pm}/\text{V}$, voltage responsivity $F_v \sim 31.4 \times 10^{-3} \text{ m}^2/\text{C}$, detectivity $F_D \sim 23.7 \mu\text{Pa}^{-1/2}$, thermal energy harvesting FoM $F_e \sim 62.8 \text{ Jm}^{-3}\text{K}^{-2}$, $F_e^* \sim 3.9\text{pJ}^{-1}\text{m}^3$, and transition temperature $T_c \sim 200 \text{ }^\circ\text{C}$ make this composition promising for IR detector applications.

OVERVIEW- INVESTMENT CASTING OF NICKEL-BASED SUPERALLOY COMPONENTS

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Hot gas path (HGP) components of Gas Turbine are produced through Investment Casting (IC) process using Nickel-based Superalloy. The IC process overcomes the challenges presented due to their complex geometry incorporating intricate hollow cooling passage. The positive replica of the component is created by injecting the suitable type of wax, enclosing the core for making hollow parts into the pattern dies using the Wax Injection Machine, wherein the temperature, injection pressure, and dwell time are controlled in order to produce near-net shape patterns. Several injected wax patterns are then attached to a central sprue system, referred to as a 'cluster', or 'pattern-tree' to optimise productivity. Subsequently, the wax cluster is dipped into the colloidal slurry, stuccoed with coarse sand, and dried for a few hours in controlled atmosphere. This process is repeated several times to achieve adequate shell strength. Drying of the shell mould is performed in controlled room temperature (RT) and relative humidity (RH). The shell mould is subsequently de-waxed using a steam autoclave. After dewaxing, shell firing is executed to get proper hot strength for the casting operation. Single Crystal (SX) blades and vanes are cast using a Vacuum Induction Melting (VIM) furnace using the Bridgman method. Subsequently after the casting of the component, the shell is knocked off, and the component is separated from the sprue system. Post casting components are inspected for quality assurance. This paper describes operations involved in Investment Casting process of Ni-based Superalloy.

Key words: Investment Casting, Wax, Shell, Superalloy, Single Crystal

Sustainable Chemistry of MXenes: Fluoride-Free Synthesis and Characterization of $\text{Ti}_3\text{C}_2\text{T}_x$

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MXenes, an innovative category of two-dimensional transition metal carbides and nitrides, have emerged as highly promising materials for applications in energy storage devices, electromagnetic shielding and electrochemical reaction [1]. They are typically synthesized by selectively etching the A element from MAX phases ($\text{M}_{n+1}\text{AX}_n$, where M = early transition metal, A = group 13–16 element, and X = carbon and/or nitrogen). Despite their potential, most conventional synthesis methods rely on hazardous fluoride-containing etchants, which pose limitations for scalability and environmental safety. One such alternate route to synthesis MXene is using alkali etching at elevated temperature [2, 3]. In this study, $\text{Ti}_3\text{C}_2\text{T}_x$ MXene was synthesized from Ti_3AlC_2 through selective etching of [Al] layers using a minimally hazardous fluoride-free alkaline solution under controlled heating. The etched powder was repeatedly washed to achieve neutral pH, subsequently intercalation and deintercalation were carried out by prolonged stirring with dimethyl sulfoxide followed by ultrasonication and centrifugation. The structural evolution during etching and delamination was characterized by X-ray diffraction (XRD) analysis, which confirmed the reduction of the intensity ratio of the characteristic (104) peak and a pronounced shift of the (002) peak when compared with XRD of Ti_3AlC_2 , indicating aluminium extraction and enlarged interlayer spacing. This study also focused on the field emission scanning electron microscopy (FESEM) to reveal the evolution of a layered, accordion-like morphology and confirmation of surface functional groups by X-ray photoelectron spectroscopy (XPS). The study highlights that the developed non-hazardous, fluoride-free synthesis approach not only ensures reduced environmental risks but also offers a scalable and sustainable pathway for the production of MXenes, paving the way for their integration into next-generation energy storage and electronic systems.

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Modelling and Optimization of Laser-Assisted Turning Operations on Fused Silica-based Ceramic Composites

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This experimental investigation employs laser-assisted turning (LAT) to thermally soften fused silica-based ceramic composites and reduce cutting forces. This experimental study employs a central composite design to develop response surface models correlating input parameters—correlating laser power (W), cutting speed (m/min), feed rate (mm/rev), and depth of cut (mm)—with output responses: cutting force (N), surface roughness (Ra), and cutting tool temperature (Ct). Assumptions include homogeneous material properties, steady-state laser irradiation, and isotropic thermal conductivity. Multi-objective optimization via desirability functions identified parameter combinations that achieved reductions of 35 % in cutting force, 20 % in surface roughness, and 15 % in tool temperature relative to conventional turning benchmarks. Validation experiments confirmed performance improvements within 10 % of predicted values for all metrics. The resulting optimization framework facilitates the selection of LAT parameters to enhance the machinability of fused silica ceramic composites.

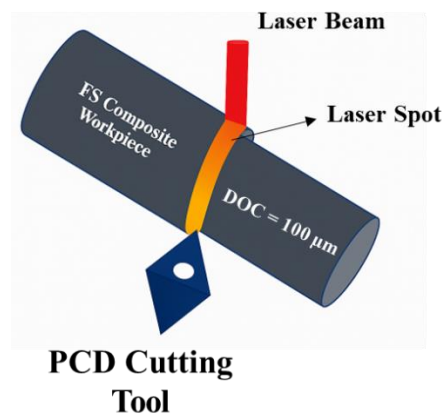


Fig. 1. Schematic showing Laser Assisted turning of fused silica-based ceramic composites.

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Understanding the Temperature-Driven Transition in Erosive Wear Mechanism of Hot-Pressed SiC-35 vol%hBN Composites

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The present study examines the solid particle erosive wear characteristics of hot-pressed SiC-35 vol% hBN composite using SiC erodent under varying impact angles: 30°, 60° and 90° and temperatures: ambient condition and 800°C. The incorporation of 35 vol% hBN in SiC ceramics exhibited a significant reduction in density, flexural strength and hardness, while an enhancement in the fracture toughness was observed in comparison to the previously reported monolithic SiC ceramics [1][2]. Although, the composites displayed lower mechanical properties, a distinct temperature-dependent erosive wear response was observed. At ambient conditions, the composite exhibited severe material removal in comparison to monolithic SiC ceramics, irrespective of impingement. However, at 800°C, the erosion rate of the composites significantly decreased attributing to the formation of a borosilicate phase, which acted as a protective layer, thus resisting surface degradation and minimizing material loss. These findings suggest that thermally induced glass-phase formation can effectively counteract the influence of inferior mechanical strength, thereby enhancing the high-temperature erosion resistance of SiC-based composites. These findings strongly demonstrate that thermally induced borosilicate phase formation for SiC-35vol% hBN composite can effectively compensate its inherent mechanical limitations, rendering them promising candidates for erosion-prone high-temperature environments such as turbine components, heat exchangers, and thermal protection systems.

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Shape Forming of Ceramics

INVITED SPEAKERS

Effect of Porosity on Microstructure and Mechanical Properties of SiC Foams by Aqueous Gelcasting

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Extensive theoretical and experimental studies have been reported on mechanical properties of ceramic foams as the presence of pores lead to unique combination of properties that differ significantly from dense ceramics. Since the pioneering work of Ashby in the 1970s [1], there has been considerable interest in predicting the properties of cellular solids (pore volume > 70 %) including cellular ceramics. The Ashby model is based on deformation mechanisms (e.g., bending, stretching etc.) of minimum solid contact area in the foam structure. This model is useful to explain how the factors like overall porosity and pore interconnectivity can influence the final mechanical properties. The literature reports indicate that the Ashby model fails due to the stress concentrations near pores, particularly in the lower porosity regime. These studies consider the stress concentration resulting from pore anisotropy, pore overlap and pore size distribution. Improvement of foam properties is also reported through the tailoring of struts (the solid regions) during their processing, e.g., the use of reinforcements and multimodal particle size distributions [2].

The models mentioned earlier for predicting porosity-dependent properties assume that the microstructure of the struts remains consistent in the entire porosity range. However, current investigation indicates that the strut microstructure in sintered SiC foams changes significantly due to the surface effects at higher porosity. SiC foams with different relative densities (RD, 0.44-0.11) were processed through aqueous gelcasting followed by sintering. Analysis of the mechanical properties showed that the elastic modulus of SiC foams aligned well with the Ashby's model, compared to the results for compressive strength. Sprigg's model was used for fitting of compressive strength results in two different regime and correlated with the variation of microstructure with porosity.

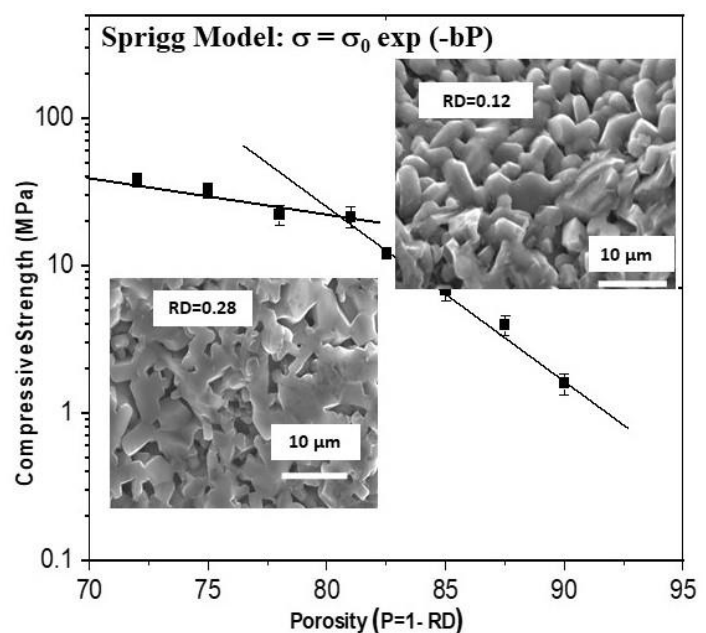


Fig. 1. Variation of compressive strength with porosity % of gelcast and sintered SiC foams

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SiC-*in situ* Zr₂CN composites: Tribology in different wear regimes under extreme conditions

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Hot-pressed SiC-*in situ* Zr₂CN composites with varying initial (0, 4 and 10 vol%) ZrN were systematically investigated under different tribological regimes of scratch, sliding and erosive conditions. The composites were subjected to extreme tribological condition of load, humidity, impact angle and temperature. Monolithic SiC ceramics endured maximum wear attributing to extensive fracture and grain pull-out, while the presence of Zr₂CN, substantially lowered the wear rate across all tribological regimes, irrespective of test condition. Tribo-oxidation and surface deformation during sliding and erosion conditions, along with additional ridge formation during scratch were identified as the dominant material removal mechanism in composites with Zr₂CN content. Results from the study recommend SiC-4vol % initial ZrN composites for applications where material removal via particle impact is of major concern and SiC-10 vol% initial ZrN composites for applications where material in sliding contacts experiences extreme conditions of humidity and temperature.

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Alumina Ceramic Shape Forming using Natural Rubber Latex as a Sustainable Binder

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Ceramic forming, ranging from the powder pressing to the additive manufacturing, uses a polymeric binder to aid shape forming and to provide strength to the green ceramics. The synthetic polymeric binders such as PVA, PEG, PMMA, acrylic emulsions, cellulose derivatives etc. are widely used for this purpose. Sustainable development demands the use of natural renewable materials as feedstock and processing additives for advanced materials. Naturally renewable molecules such as agar, agarose, gelatin, pectin, alginic acid, carrageenan, starch and sucrose are studied as binders in various ceramic shape forming processes. Natural rubber latex, an emulsion of poly (isoprene) taped from the bark of rubber trees, is a sustainable resource. We explored the potential of natural rubber latex as a binder in ceramic shape forming for the first time. The negative surface charge on natural rubber latex particles enables its co-dispersion with alumina powder in aqueous medium using ammonium poly(acrylate) dispersant to prepare highly concentrated slurries for shape forming by slip casting, gel casting, tape casting and powder pressing. The slip-casting of alumina powder- natural rubber latex co-dispersions enabled the rapid preparation of thin walled alumina shapes. The gelation by freezing of highly concentrated alumina powder suspension containing natural rubber latex in a mould coagulate the latex particles that retains the shape while thawing. The green tapes prepared from aqueous alumina powder-natural rubber latex co-dispersions shows sufficient strength and flexibility due to the low glass transition temperature of natural rubber. The granulated feed stock prepared by coagulation of the aqueous alumina powder-natural rubber latex co-dispersions by spraying in formic acid medium is used for powder pressing. The green bodies produced from the alumina powder-natural rubber latex co-dispersions achieve high strength on annealing at 120 °C due to the cross-linking of natural rubber through the double bonds, aided by the Lewis acid character of the alumina particles. The green shapes produced were binder removed at temperature < 600 °C and sintered to near theoretical density.

Net Shape Forming of Advanced Ceramics by Colloidal Processing

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Slurry stability has profound impact on achieving homogeneous green density and quality of microstructure of sintered body. The problem of density gradient due to sedimentation can be avoided by replacing the long-range repulsive potential in dispersed systems with short-range repulsive potential to develop a weakly attractive particle network or weakly flocculated system. In such weakly flocculated slurries, long-range repulsive potential is screened by reduced effective charge on the powder surface. Approach of powder particles is prevented by electrostatic forces that exist over a thin region around the powder particles. When such particles are forced together during compaction, short-range repulsive forces prevent particle segregation and the particles slide over each other to produce homogeneous packing of the particles. Furthermore, the weakly flocculated slurries exhibit clay like plastic behavior and can be reshaped after consolidation. The attractive inter-particle force provides the mechanical strength needed to hold the body until sintering. Herein, particle surface charge, effective zeta-potential value and method of measurements are the key to understand the above phenomena. Notably, slurry stability has direct impact on success of different advanced manufacturing techniques especially colloidal processing, gelcasting, different coagulation casting and plastic dough processing. The presentation will highlight merits and demerits of different conventional and advanced colloidal processing of ceramics. Microfabrication and green machining approaches would be discussed as well.

Additive Manufacturing of Ceramics

INVITED SPEAKERS

Advancing Ceramics through 3D Printing: Technologies, Applications, and Case Studies with a Focus on DLP-based Mass Production

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Advanced ceramics are essential in industries such as semiconductors, healthcare, automotive, and energy, yet conventional processes—including machining, pressing & sintering, and ceramic injection molding (CIM)—face inherent limitations: costly molds, design inflexibility, long lead times, and material waste.

Ceramic additive manufacturing has emerged as a transformative alternative. Among its methods, Digital Light Processing (DLP) enables high precision, fast throughput, and geometric freedom without the need for molds. In this study, we present TD6 Plus, a DLP-based ceramic 3D printing system by 3D Controls (Korea), designed to bridge prototyping and industrial mass production. The system achieves >98% yield rate in zirconia and alumina while reducing resin waste and ensuring cost-effectiveness. Comparative results indicate that while CIM remains advantageous for extremely high-volume standardized parts, DLP provides superior economics up to 10,000 units and unmatched flexibility for complex, customized designs.

Case studies demonstrate applications across various industrial sectors: battery, automotive, consumer electronics and high-end fine jewelry. Finally, integration of AI in design optimization, automated cleaning, intelligent sintering, and defect inspection introduces a scalable “smartfactory” model.

This work highlights how DLP ceramic printing complements and, in many cases, surpasses traditional processes in precision, efficiency, and industrial applicability, underscoring its role in the future of advanced ceramics.

Development of sustainable functional ceramic using additive manufacturing

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Porous materials (ceramic or ceramic-hybrid coatings/functionalizations) are used in space, wastewater treatment, and energy harvesting. The controlled porous architecture with high toughness is the one the major requirement for such scalable applications. In this talk, we will discuss some of our recent work on direct ink writing of ceramics with enhanced structural properties. Also, the current method allows for making/mixing different materials during the printing process, which can provide various functionalities in the printed architecture. Direct-ink writing can be utilized to print complex architectures using waste materials, which helps in reducing the environmental impact of the manufacturing process. The controlled topology with high damage-tolerant 3D printed architectures can also utilize such printing methods to make unique ceramic-based composites for energy, environmental, and water-treatment applications.

CONTRIBUTORY SPEAKERS (ORAL)

Direct ink writing of silicon nitride: from a novel ink formulation to liquid phase sintering for bioimplant applications

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Silicon nitride (Si_3N_4) exhibits exceptional physical, mechanical, and biological properties, making it a promising material for orthopedic implants. However, conventional manufacturing methods struggle to fabricate intricate porous structures essential for bone ingrowth and implant integration. Direct ink writing (DIW) enables layer-by-layer fabrication of intricate Si_3N_4 scaffolds, overcoming the limitations of conventional methods. Although achieving high solid loadings remains challenging due to particle agglomeration and the ink's shear-thickening tendency. This study focuses on developing a highly loaded novel colloidal ink containing 89.3 mol % Si_3N_4 , 8.2 mol % Y_2O_3 , and 2.5 mol % Al_2O_3 in double distilled water by incorporating 2-5 wt.% polyethyleneimine (binder-dispersant), 0-2 wt.% polyethylene glycol (plasticizer), and 0.5 wt.% hydroxypropyl methylcellulose (viscosifier). The work involves two major steps: firstly, ink was optimized for stable dispersion and desired rheology by homogeneous mixing and carefully balancing zeta potential and electro-steric interactions. The optimized ink exhibited shear-thinning behavior (flow index, $n \approx 0.75$), a low yield stress ($\tau_0 \approx 1.13$ Pa), and solid loading of ~ 48 vol.%. Secondly, printing parameters such as printing speed, nozzle diameter, layer height, extrusion width, pulse, and prime rate were optimized to print solid and porous architectures. The printed green components were further analyzed to assess layer flaws based on various nozzle diameters (0.4-0.8 mm), pore size distribution (300-500 μm), and the influence of air entrapment. Finally, the porous and solid parts achieved relative densities of $\sim 60.2\%$ and $\sim 96\%$, respectively, with $\sim 17\%$ volumetric shrinkage after debinding and pressureless sintering in nitrogen. Subsequently, the samples were characterized for dimensional accuracy, microstructure, mechanical, and biological properties. This study also includes a comprehensive comparison with previous research findings and highlights recent advancements in the additive manufacturing of Si_3N_4 .

Keywords: Additive manufacturing, Colloids, Direct ink writing, Rheology, Silicon nitride.

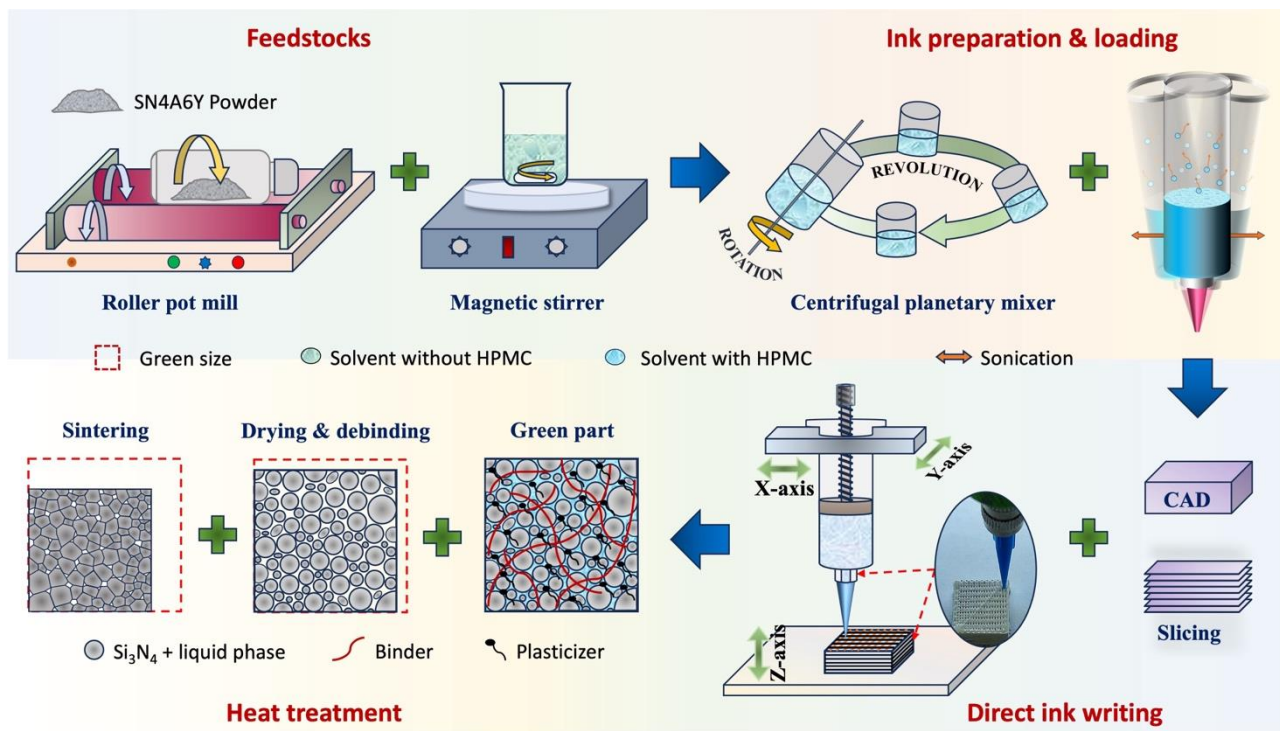


Fig. 1. Schematic diagram illustrating the materials and methods employed for DIW of Si_3N_4 .

Table 1. Printing parameters optimized for the fabrication of SN4E2G0.5H paste using the Hydra 16-AS printer.

Parameters	Corresponding values
Nozzle size	0.4–0.8 mm
Extrusion width	110%
Layer height	90%
Printing speed	7 mm/s
Pulse rate	150 pulse/ μl
Unprime and prime rate	1500/3000 step/s

Structural, Microstructural & Magnetic Properties of 3D Printed La-Co Co-doped Strontium Hexaferrite for Permanent Magnet Applications

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Permanent magnets are indispensable in various energy applications including electric vehicles, generators, and motors. Rare-earth magnets, known for their superior performance, are extensively used; nevertheless, interest in alternative solutions is growing amidst geopolitical and economic challenges associated with rare-earth elements. M-type hexaferrites have gained significant research attention in past few years due to their chemical stability, high Curie temperature, magnetic properties, availability of raw materials, and corrosion resistance. To improve the magnetic properties of $\text{SrFe}_{12}\text{O}_{19}$ co-doping with La-Co at strontium and iron sites has been explored. This approach is expected to increase magneto-crystalline anisotropy, coercivity, and thermal stability. M-type ferrites have a better potential when fabricated with optimal geometry and shape. Additive manufacturing has drawn considerable research attention for creating three-dimensional objects with complex geometries. . In this work, La-Co co-doped $\text{SrFe}_{12}\text{O}_9$ (SF) ($\text{Sr}_{1-x}\text{La}_x\text{Fe}_{12-x}\text{Co}_x\text{O}_{19}$, $x = 0, 0.2 \text{ \& } 0.3$) powder has been synthesized by conventional solid-state reaction method by mixing SrCO_3 , La_2O_3 , Fe_2O_3 & Co_3O_4 in the stoichiometric ratio followed by calcination at 1050°C for 4h. Subsequently, the calcined powders have been subjected to milling for 6 hours to reduce particle size and to improve the flowability of the printing paste. The paste suitable for 3D printing is prepared by adding suitable binder, plasticizer, dispersant, and DI water (combined 25wt%) with La-Co co-doped SF powder (solid loading 75wt%). The rheological properties were optimized by altering the ratios of powder to additives to achieve the paste with suitable consistency for printing. The paste is extruded through a plastic syringe using a customized 3D printer (MANPROTTO) equipped with a universal extruder. A significant feature of this work is applying the magnetic field during the 3D printing process. After printing, the samples were air-dried and sintered at various temperatures from 1050°C to 1300°C to achieve densification and improved magnetic performance. This paper will discuss the effects of La-Co co-doping with $\text{SrFe}_{12}\text{O}_{19}$ on the structural, microstructural, and magnetic properties of the printed samples. It also discusses the field-assisted printing on the texture development and its correlation with enhanced magnetic properties.

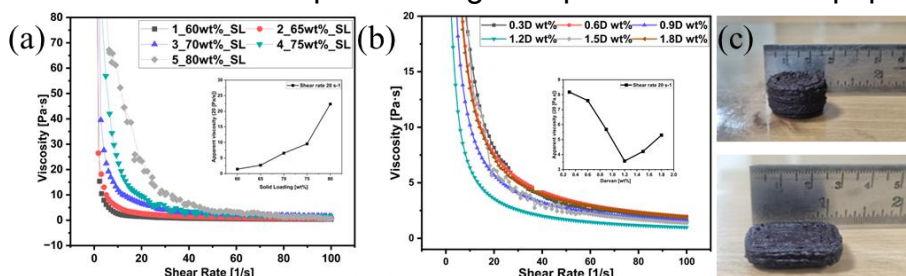


Fig (a): Viscosity vs Shear rate for varying solid loading from 60wt% to 80wt%, (b) Viscosity vs Shear rate for solid loading & excess Dispersant for the required material, (c) After Printing (Green Pellet)

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Simulation of Pyrolysis-Induced Shrinkage and Stress in 3D-Printed SiCN Ceramics

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Silicon carbonitride (SiCN) polymer-derived ceramics (PDCs) offer exceptional thermal stability and mechanical performance, making them attractive for high-temperature applications. During pyrolysis, however, the polymer-to-ceramic transformation produces significant shrinkage and residual stresses, which can cause warping or cracking in complex geometries. In this work, a finite element model of a 3D-printed SiCN lattice was developed to simulate the thermo-mechanical response during the actual multi-stage heating, holding, and cooling cycle used in processing. The model integrates temperature-dependent material properties obtained from experimental characterization and includes shrinkage strains calibrated from thermogravimetric data. Coupled temperature–displacement analysis provided predictions of displacement, shrinkage distribution, and von Mises stress evolution. The results reveal localized high-stress regions that correlate with potential crack initiation sites. This simulation framework offers a predictive tool to optimize design, printing parameters, and pyrolysis schedules, improving the quality and reliability of additively manufactured PDC components.

Keywords: Pyrolysis, shrinkage, polymer-derived ceramics, numerical simulation, displacement analysis

Process Optimization and Defect Evolution in 3-YSZ Components Fabricated via DLP-Based Additive Manufacturing

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Digital Light Processing (DLP), combined with pressureless sintering, has gained attention as a promising technique for manufacturing complex-shaped yttria-stabilized zirconia (3-YSZ) components. This process enables high precision and customization but often faces challenges related to defect formation during printing and thermal post-processing[1]. These defects, such as porosity and surface irregularities, can significantly affect the microstructure and mechanical performance of the final parts. This study investigates the influence of key DLP printing parameters, including layer thickness, part orientation, and light intensity, on green part density and surface quality. A central composite experimental design was used to evaluate individual and interaction effects. Results indicate that increasing layer thickness reduces green part density, while increasing light intensity and build orientation improves it. Surface roughness turned out to be more sensitive to changes in layer thickness and orientation than to light intensity variations.

Further, to understand the origin and progression of defects, a detailed analysis was carried out across the printing, debinding, and sintering stages. Techniques such as scanning electron microscopy (SEM) and micro-X-ray computed tomography (μ -XCT) were used to study internal voids and porosity distribution. Due to the difficulty in distinguishing polymer binder and ceramic particles in XCT scans[2], a Random Forest-based machine learning approach was applied for accurate image segmentation. A 3D profilometer was used to monitor surface roughness evolution throughout the process.

Consequently, multi-objective optimization was performed using regression models to identify parameter combinations that yield high green part density and low surface roughness. Components fabricated using these optimized settings showed improved densification and surface finish compared to those produced with arbitrary parameters. This comprehensive study offers valuable insights into process–structure relationships and provides guidelines for producing high-quality zirconia parts using DLP-based additive manufacturing. Building upon the optimized processing conditions, graded Triply Periodic Minimal Surface (TPMS) structures were subsequently designed and fabricated. These architected geometries offer spatially varying porosity and mechanical properties[3]. The successful fabrication of graded TPMS zirconia components highlights the potential of DLP-based additive manufacturing for producing functionally graded, high-performance ceramic structures.

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CONTRIBUTORY SPEAKERS (POSTER)

Microstructural evolution and phase analysis of SS410-Al₂O₃-SiC multilayered functionally graded composite fabricated through laser cladding

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In the present study, a functionally graded metal-ceramic composite structure comprising SS410, Al₂O₃, and SiC particles with varying composition, structure and properties in a single deposit was successfully fabricated using direct energy deposition (DED). The composition varied from 90% SS410 with 10% (xAl₂O₃ + ySiC) to 10% SS410 with 90% (xAl₂O₃ + ySiC), where x=70% and y=30% in a five-layered FGM design. The microstructure, phase evolution and mechanical properties of the components with different composition gradients were characterized by microscopy, energy dispersive spectroscopy, wavelength dispersive spectroscopy, X-ray diffraction and micro hardness. The investigation revealed that complex phases such as C_{0.12}Fe_{0.79}Si_{0.09}, M₇C₃, Fe₃C, and Fe₃Si formed as a result of the interaction between SiC and SS410 during the cladding process. Microstructural analysis showed a transition from columnar dendrites at the bottom zone of the cladding to a typical cellular structure and carbide particle agglomerates in the middle zone, with finer grains at the top zone. This gradation in microstructure correlated with an increase in microhardness ranging from 299 HV at the bottom to 966 HV at the top. This enhancement in hardness is primarily attributed to solid solution strengthening from C and Si originating from the decomposition of SiC and the precipitation of intermetallic phases.

Keywords: armour material, functionally graded materials, direct energy deposition, C_{0.12}Fe_{0.79}Si_{0.09}, graphite.

Induction Plasma-based Synthesis of Nanoscale and Spheroidized Ceramics for Additive Manufacturing Applications

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In today's world, advanced ceramics are widely used in diverse applications including fabrication of electronic components using next-generation additive manufacturing (AM). The crucial condition for achieving full potential relies on precise control over component dimensions. These precisely engineered microstructures depend on powder properties, viz packing density, purity, flowability, and particle size distribution, to achieve defect-free 3D printed parts. Thus, powder preparation plays a cornerstone role in this direction. For 3D printing of ceramics, spherical micro-powders and nano-powders are preferred, especially when using powder spreading methods such as binder jetting or ink-based methods like direct-ink writing and ink-jet printing. The technique which can provide a solution over such a vast particle morphology range is thermal plasma, especially induction thermal plasma. Insights from the latest experimental findings and computational modeling clarify the complex relationships between the final powder properties and plasma process parameters, as well as the characteristics of the plasma jet. This review critically examines recent advancements in Induction Plasma (IP) technology, with transformative impact on material processing and potential as a foundational technology for AM. The ultra-high temperatures (up to 10,000K) and exceptionally high rapid quenching rates (10^5 - 10^6 K/s) inherent to the IP system enable unique capabilities. These processes are the direct, high-purity synthesis of diverse ceramic nanoparticles from various raw materials and effective transformation of irregular powders into dense, highly flowable spheroidized powders. Studies on plasma spheroidization assist in consistent powder bed packing, minimizes defects, and facilitates the fabrication of complex, high-density ceramic components through powder bed AM techniques, are also provided. The challenges and opportunities for the materials community to explore vast potential of IP for commercialization and novel material design, with strong emphasis on AM advancements, are also discussed. Finally, future scope of IP based ceramics in expanding the horizons of AM technology are presented.

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Rheological Behaviour of TiO₂-MgO Composite Inks for Direct Ink Writing

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The comprehensive rheological behaviour of Titanium Dioxide (TiO₂)-Magnesium Oxide (MgO) composite inks has been investigated across different dispersions and composite systems for extrusion based additive manufacturing process. The study focused on the evaluation of the flow behaviour, printability and microstructural properties which is suitable for direct ink writing and additive manufacturing applications. TiO₂-MgO composite ink were prepared with 1 wt% and 3 wt% carboxy methyl cellulose. MgO used as sintering aids for TiO₂ and for other ceramics which enhance densification modifying grain growth and reducing the sintering temperature and also provide stability of inks. At different composition and at different solid loading of TiO₂-MgO inks were investigated. Rheological behaviour of titania and magnesia composite inks were characterised before printing using rheometer. The remarkable effect of solid loading of TiO₂-MgO was observed in the viscosity of inks. Viscosity of ink decreased with increasing solid loading. Also, it was observed that on decreasing the viscosity, shear rate of composite inks increases which shows the shear thinning behaviour of inks which indicates the suitability of ink for direct ink writing. Yield stress of composite inks was found to increase with increasing solid content of TiO₂-MgO. De-binding and sintering of TiO₂-MgO composite was carried out at 800°C for 60 minutes and 1400°C for 180 minutes respectively.

Keywords- TiO₂, MgO, Direct ink writing, Rheology.

Electronic & Magnetic Ceramics

INVITED SPEAKERS

Studying the Electronic Structure of Semiconductors from Charge Transport Measurements

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The electronic structure of semiconductors which can be broadly classified as consisting of the electronic band structure (EBS) and the charge carrier scattering mechanisms plays a vital role in determining charge transport properties. Sophisticated experiments and theoretical calculations are required to obtain these information and represents a bottleneck in studying the vast and increasing number of semiconducting compounds. In this presentation, some recently discovered techniques which can provide electronic structure information from routine charge transport measurements will be discussed. This will be followed by examples wherein the applicability of these techniques in both semiconductor materials and devices are demonstrated.

Influence of Entropy Engineering on the Energy Storage Properties of Novel Lead-free Ferroelectric Ceramics

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Among various energy storage devices, viz., dielectric capacitors, electrochemical capacitors, batteries and solid oxide fuel cells (SOFC), dielectric capacitors are devices of choice in high temperature energy storage applications. Electrostatic ceramic capacitors, because of their high-power density, faster charging-discharging characteristics, excellent fatigue endurance and high-temperature stability, are becoming extremely popular in highly integrated, compact, and miniaturized electronics and electrical power systems including solid state pulse power systems, advanced power electronics, electric vehicles (EVs), and aerospace power systems. In this talk, design principles and synthesis of novel lead-free ferroelectric ceramics with varying configurational entropy and their influence on structural, dielectric, and ferroelectric properties for energy storage application will be discussed.

Elimination of Dimensional defect phenomena of EP21 in T38 through TPM QM pillar 10 steps: A structured Problem-Solving approach

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One of the major key performance indicators for any manufacturing set up is reduction of defect phenomena. There are many ways to follow the defect identification, root cause analysis and corrective action implementation. Under **Total Productive Maintenance (TPM)** – a tool for operational excellence approach, **Quality Management (QM)** pillar, mainly dealing with these problem-solving techniques. We had used this QM pillar 10 step methodology to eliminate the dimensional defect for a product EP21 in T38 material in two stages. EP21 is a Manganese Zinc Ferrite core made with High permeability material (MnZn Ferrite), T38 used for broadband small-signal transmission (xDSL). Initial dimensional defect rate for EP21-T38 was hovering around 8.50% which was taken as base level called benchmark and using initial 4 steps out of 10 steps, this defect level dropped to nearly 1.0%. Here main activity involves surveying the basic 4MTE (Material, Machine, Method, Man, Tools and Environment) condition compliance with defined standard. After that, to eliminate the dimensional issue for EP21-T38 completely further QM pillar steps were explored which include the Phenomena Mechanism analysis. This involves deep diving into the defect generation process and helping to achieve finally 0 (Zero) dimensional defect for EP21. The QM pillar steps also support to sustain the obtained result through standardization.

CONTRIBUTORY SPEAKERS (ORAL)

Tailoring FMR Linewidth and Magnetic Properties in Nd-doped Yttrium Iron Garnet ($\text{Y}_3\text{Fe}_5\text{O}_{12}$) for Circulator Application

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Yttrium iron garnet ($\text{Y}_3\text{Fe}_5\text{O}_{12}$, YIG) is a versatile material that has attracted significant attention since its discovery because of its broad use in microwave technology. Its exceptional properties, including low cost, chemical stability, high electrical resistivity, and favourable dielectric behaviour, make it suitable for many consumer and industrial devices. This study investigates the effect of Nd^{3+} substitution ($\text{Y}_{3-x}\text{Nd}_x\text{Fe}_5\text{O}_{12}$, $x = 0.01-0.05$, $\Delta x = 0.02$) on the structural, morphological, and magnetic properties of YIG, focusing on the ferromagnetic resonance (FMR) linewidth (ΔH), a key parameter governing circulator performance. Ferrites were synthesized via a solid-state route: mixed powders were calcined at 1250°C for 8 hours, yielding phase-pure material with no detectable impurities. The X-ray diffraction peaks of sintered $\text{Y}_3\text{Fe}_5\text{O}_{12}$ match the cubic $1a\bar{3}d$ structure (JCPDS card No. 01-070-0953). Nd^{3+} substitution shifts the (420) peak reflection toward lower 2θ angles, indicating increased lattice parameters. SEM images show that Nd-doped samples have larger grains than undoped YIG. VSM measurements reveal that increasing the Nd^{3+} content from $x = 0.01$ to 0.05 raises the saturation magnetization (M_s) from 26.85 emu g^{-1} to 35.45 emu g^{-1} , compared with 25.89 emu g^{-1} for pure YIG. FMR analysis shows a progressive narrowing of ΔH at low Nd concentrations, attributable to reduced magnetic damping and inhomogeneities. This improvement benefits circulator applications because a narrower ΔH lowers insertion loss and enhances non-reciprocal performance. These findings demonstrate that precise control of Nd doping is crucial for optimizing YIG magnetic and FMR properties and designing efficient, low-loss microwave circulator components.

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Design, synthesis and functional properties of spinel multicomponent equimolar oxides (MEOs)

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Multicomponent equimolar oxides (MEOs) are a class of “high entropy” materials consisting of multiple metal oxide components in equal molar ratios. These oxide compositions are equivalent to mixing distinct metal oxides in nearly equimolar proportions on cation basis, ideally yielding a single crystalline phase.¹ The diverse interactions among the metal ions within the lattice often produce unique physical properties, which are distinct from those observed in the individual component oxides.² The present study investigates the physical properties of single-phase spinel MEOs composed of six distinct transition metal cations from the 3d transition metal series. The synthesis process used for preparing bulk samples was powder production by the solution combustion method (SCS) followed by compaction and sintering. XRD was used to determine the crystalline phase(s) present and to confirm the formation of single-phase solid solutions, while SEM was used to obtain information on the surface morphology and microstructural features, enabling evaluation of grain size, and shape. Additionally, energy-dispersive X-ray spectroscopy (EDS), coupled with SEM, was utilized to perform elemental mapping and confirm the uniform distribution of constituent elements within the samples. Raman spectroscopy enabled the identification of characteristic vibrational modes associated with specific crystal phases, allowing for the detection of phase purity, and possible secondary phases. Optical bandgap values were calculated from UV-visible spectroscopy. Significantly lower bandgap values were observed for MEOs as compared to binary oxides.³ Dielectric constant, carrier concentration and mobility of charge carriers were also measured. These lower bandgap values enhance the materials' suitability for energy conversion applications.

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CONTRIBUTORY SPEAKERS (POSTER)

High entropy approach for tuning structure and magnetic properties of B-site disordered perovskite oxides

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High entropy (HE) approach involves substituting an equimolar combination of five or more cations at the cation-sublattice of a metal oxide.^[1] This results in a high configurational entropy (S_{config}) that is believed to favour the formation of single-phase solid solutions, despite the high compositional complexity. Such oxides, with $S_{config} \geq 1.5$ R/formula unit are often classified as high entropy oxides (HEOs).^[1] HEOs due to their unique combination of multiple cations often show cases magnetic properties that are substantial different or enhanced compared to conventional oxides. For instance, perovskite HEOs with either five equiatomic rare-earth (RE) cations on the A-site or five equiatomic transition metal (TM) cations on the B-site exhibit properties such as intrinsic exchange bias or enhanced colossal magnetoresistance, compared to conventional RE–TM perovskite oxides.^[2,3] Their exciting magnetic properties stem from the competing magnetic exchange interactions arising from the presence of multiple TM–O–TM pairs. The system of focus in this study is $\text{La}(\text{Co}_{0.2}\text{Cr}_{0.2}\text{Fe}_{0.2}\text{Mn}_{0.2}\text{Ni}_{0.2})\text{O}_3$, referred to as P-HEO. In this work, we explore the non-equiatomic variants of this P-HEO. The samples were synthesized via citrate based Pechini sol-gel technique followed by calcination leading to the formation of three systems. Each system's stoichiometry is calculated by incrementally increasing Cr, Ni, Fe respectively from their equimolar concentrations. The resulting powders were characterized using various techniques, including x-ray diffraction coupled with Rietveld refinement, and elemental maps from scanning electron microscopy, which indicated the phase purity and chemical homogeneity of the samples. Interesting changes in the other rhombic distortion has been observed as a function of B-site compositions. Magnetic investigation using SQUID are underway to examine the effect of composition on intrinsic exchange bias. Overall, the work explores the structural evolution along with the resulting changes in the magnetic properties in non-equiatomic variant so P-HEOs.

Keywords: High entropy, perovskite, Pechini sol-gel, magnetic properties, Jahn-Teller effect

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Fabricating Niobium Nitride Thin Films with High Superconducting Transition Temperature

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Niobium Nitride (NbN) has been known for its relatively high superconducting transition temperature ($T_c \sim 17$ K), mechanical robustness, and low resistivity in the world of superconducting electronics. Josephson Junctions fabricated with NbN thin films shows high gap voltage which supports operation in the terahertz (THz) frequency range making it suitable for applications in quantum computing and SIS (Superconductor-Insulator-Superconductor) devices^[1,2]. However, fabricating stacked high T_c NbN thin films often poses a challenge: high-temperature deposition techniques can induce atomic diffusion and interfacial degradation and hence such techniques are unsuitable. Few studies show high- T_c NbN thin films on lattice-matched substrate in an ultra-high vacuum environment, but such processes are complex and increase the cost of the system^[3]. For these reasons, it is desirable to develop a low-temperature process with a high vacuum chamber on native-oxide covered single crystal Silicon (100) substrates that still yield high- T_c NbN films. In this work, NbN thin films are deposited at ambient temperature using reactive RF magnetron sputtering on native-oxide-covered silicon (SiO_2/Si) substrates. This study explores the relationship between deposition rate, oxygen incorporation, and superconducting properties by varying RF power and the nitrogen-to-argon gas ratio. Depth Profile X-ray photoelectron spectroscopy (XPS) reveals a correlation between increased deposition rate and reduced oxygen content in the films. Grazing incidence X-ray diffraction (GI-XRD) confirms the formation of δ -NbN phase with a rock-salt cubic (FCC) structure, where high- T_c films exhibit a dominant (111) orientation. Film thicknesses are measured using Cross-Sectional scanning electron microscopy (SEM). The highest T_c achieved is 13.4 K, verified through Cryogen-Free Measurement System (CFMS) analysis. These findings demonstrate the potential of this low-temperature, high vacuum chamber method for scalable superconducting device fabrication.

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Phase-field modelling of domain evolution in BZCT using CUDA

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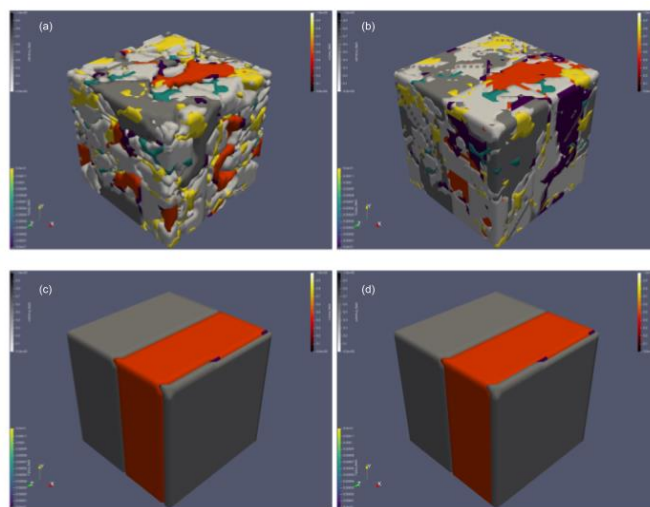
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Magnetoelectric materials are a subset of multiferroics which show coupling between magnetic and electric order parameters. Obtaining such coupling at room temperature has been a challenge with naturally occurring single phase magnetoelectrics. Heterostructured nanocomposites are suitable alternatives where ferromagnetic and ferroelectric phases are physically distinct but elastically coupled at interfaces. Phase-field modelling is a relevant tool to study the relation between strain, magnetic and electric fields in such systems through microstructural evolution of polarization magnetization and strain. Thermodynamics is incorporated by adding elastic, electric and magnetic contributions from the system along with gradient energy density and Landau theory based bulk energy density in the free energy functional of the system ([1], [2]). Kinetics is defined by the Ginzburg-Landau equation which is solved using a semi-implicit Fourier spectral method. The model was implemented in C and parallelized using CUDA (Compute Unified Device Architecture) for GPU acceleration. In this presentation, we present some preliminary results on the domain stability, evolution and polarization switching for the ferroelastic system of equimolar BZCT ($\text{BaZr}_{0.2}\text{Ti}_{0.8}\text{O}_3 - 0.5\text{Ba}_{0.7}\text{Ca}_{0.3}\text{TiO}_3$) which is a prospective replacement for lead based ferroelectrics.

Fig. 1. Ferroelectric domain evolution at non dimensional time, (a) $t = 1000$, (b) $t = 10000$, (c) $t = 20000$ and (d) $t = 300000$.



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Correlating Statistical Nature of Activation Energy of Sintering to Underlying Mechanisms

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Master sintering curve (MSC) theory proposed by Su and Johnson has been considered as one of the reliable tools to estimate the densification of ceramics as a function of time and temperature [1]. The MSC theory assumes that the densification trajectory is independent of heating rates and proposes convergence of multiple densification trajectories into a single one provided the apparent activation energy of is estimated correctly using mean residual square method. Critics of MSC theory have always emphasized that the apparent activation energy of sintering is a mere fitting parameter and no physical significance is attached to it. However, in the present study involving densification of $\text{La}_2\text{Ti}_2\text{O}_7$ piezoceramics with heating rates from 3 to 15 °C/min, it was found out that there was variation in magnitude more than 3 times in the activation energy of sintering for different combinations of heating rates. While this observation correctly points out to statistical nature of apparent activation energy of sintering, the present study also highlights the appropriate activation energy of sintering along with underlying sintering mechanisms (surface diffusion vs. lattice diffusion). Moreover, the appropriate activation energy determined in this work using MSC theory was compared to that determined using Wang and Raj method and it was validated that the statistical nature of the activation energy cannot be denied but considering it as a mere fitting parameter is not appropriate [2]. As a result, relation between activation energy of sintering and underlying mechanisms in light of various time-temperature excursions is established.

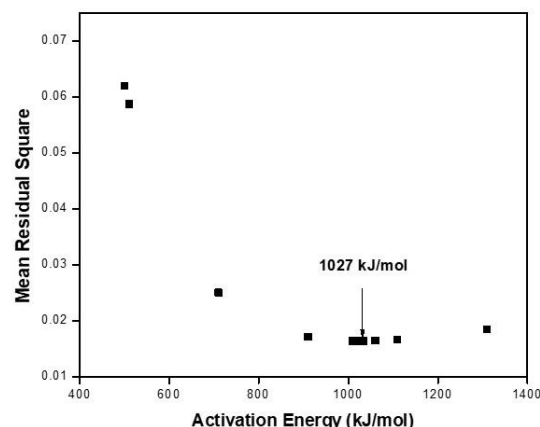


Fig.1 Variation of Mean Residual Square vs. Activation Energy

Table 1. Apparent activation energy of sintering determined for various combinations of heating rates

Heating Rates (°C/min)	Apparent activation energy of sintering (kJ/mol)
3,5 and 7	3873.8
5,10 and 15	1024.4
3,5,7,10 and 15	1027

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Glucose-derived carbon-coated nickel oxide (GDCC-NiO) as an efficient electrode material for supercapacitor applications

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Glucose derived carbon coated nickel oxide (GDCC–NiO) composite was synthesized through a colloidal route using nickel oxide and glucose as precursors. In this process, glucose acted as a soluble carbon source, generating a uniform carbon coating over NiO nanoparticles. The structural and morphological features of the material were systematically examined using XRD for phase identification, BET surface area analysis, Raman spectroscopy for carbon structure, and SEM/TEM for microstructural evaluation. Electrochemical performance was assessed in 1 M KOH electrolyte, where the composite exhibited an impressive specific capacitance of 404.5 F/g at a scan rate of 5 mV/s. The enhanced energy storage capability is attributed to the synergistic contribution of the conductive carbon layer, which improves electrical conductivity, and nickel oxide, which provides increasing total resistance. Such insights are directly relevant to the semiconductor industry, where electrode engineering can significantly influence device performance, especially in multilayer ceramic devices and high-reliability components.

Optimization of KNN-based piezoelectric ceramics for actuator application

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The performance of piezoelectric ceramics strongly depends on the delicate balance between processing conditions, microstructural evolution, and their resulting electrical responses. In this work, potassium sodium niobate (KNN) ceramics were synthesised with varied sintering conditions to explore the effect of grain growth on their functional properties. This may lead to changes in grain growth, which can in turn affect the piezoelectric responses. Accordingly, the piezoelectric charge coefficient (d_{33}) was observed to vary with processing conditions, underlining the sensitivity of electromechanical behaviour to microstructural refinement. The synthesized specimen was further tested under cyclic load to examine the stability of the fabricated device. These findings highlight not only the potential of KNN as a sustainable alternative to lead-based ceramics but also the importance of processing parameter tuning for designing actuators applications.

Advanced Ceramics

INVITED SPEAKERS

Design of preceramic polymer derived nanostructured anodes for lithium ion batteries

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Preceramic polymers with their unique nanostructure and phase composition have aided myriads of structural and functional applications of materials. One such important application is their usage as anodes in lithium ion batteries. In the next generation anodes, Si is widely regarded as a leading material due to its high theoretical capacity. However, its practical use is hindered by significant volume expansion (over 300%) during lithiation, leading to mechanical degradation. In this work, we propose the design of a nanostructured silicon–carbon (Si–C) hybrid anode synthesized from Si nanoparticles and a carbon-rich preceramic polymer.

The study investigates the phase composition, microstructure, and electrochemical performance of Si–C hybrids synthesized by varying Si:C ratios, pyrolysis temperatures, and etching conditions. A polymer-derived SiOC ceramic is used as the carbon source, offering tunable pore architecture and surface chemistry. A key innovation lies in introducing controlled porosity into the SiOC matrix by tailoring its microstructure, thereby enhancing its functionality as an anode material.

Three synthesis routes are explored. In the first, nanocrystalline Si is combined with SiOC-derived carbon synthesized at 1000 °C and 1200 °C, followed by HF etching to introduce porosity. The second route incorporates amorphous SiO₂ fillers as sacrificial pore-forming agents, which are later removed via HF etching. The third approach enhances interfacial bonding between Si and the carbon matrix through the addition of a non-ionic surfactant that facilitates uniform dispersion of Si particles within the amorphous SiCO matrix.

All synthesized Si–C hybrids exhibit outstanding electrochemical performance, with the surfactant-assisted hybrids showing the most significant improvement. The SiCO-derived carbon matrix acts as a mechanically resilient and conductive framework, accommodating the volume changes of Si during cycling and promoting efficient electron transport. High mesoporosity and ordered carbon structures further contribute to the superior electrochemical behaviour. These results underscore the potential of SiCO-based Si–C hybrids and suggest the feasibility of extending this strategy to other polymer precursors for advanced lithium-ion battery anodes.

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Multifunctional Nanocomposite Sensors: A New Frontier

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The increasing demand for self-powered electronics in wireless technology, low power devices and sensors have caused an extensive amount of research into power harvesting devices over the last decades. Harvesting clean and renewable energy holds great promises for powering small electronics and achieving self-powered electronics devices. Energy harvesters employ one of the technologies that are developed to harvest mechanical energy with different frequency and amplitude in our environment by way of piezoelectric effect. The next generation application such as wearable energy harvesting system may require the piezoelectric materials to be flexible and lightweight. But the main drawbacks of these polymers are that the piezoelectric coefficient (d_{33}) which is responsible for energy conversion is very low. Composites can be considered as a potential candidate especially due to the possible tailoring of its properties by a judicious/logical selection of constituent components and their volume ratio.

Piezoelectric ceramic-polymer composites are promising materials for energy harvesting because of their excellent properties. These composites combine superior properties of both polymer and ceramic phases, which offers many advantages over those of the constituent materials. In our group we have made and attempt to fabricate polymer-ceramic piezocomposites using different ceramic particles both Lead and Non-Lead based and piezopolymer Polyvinylidene Fluoride (PVDF). The incompatibility between the ceramic and polymer phase may lead to degradation of the electrical properties of the fabricated composites. Hence, surface modification or addition of fillers has been introduced to enhance the compatibility.

The composites were fabricated by tape casting followed by hot press technique. The structural, microstructural and detailed electrical characterization of the developed composites was studied. The energy storage density of the composites was also evaluated. Finally, the piezo response was studied by making EPE (Electrode-Polymer-Electrode) stacks and the output power was measured. The generated power was also used for different applications like lighting LEDs, flank array sensors, human motion sensors.

Scalable synthesis of ultra-thin α -MoO₃ films for energy-efficient devices

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α -MoO₃, a layered oxide, offers intriguing electronic properties such as tunable band gaps², high-charge carrier mobility³, high work function⁴, and facile stoichiometric modulation⁵. α -MoO₃ nanostructures have been extensively used for catalysis, electrochromism, and battery electrodes. Coalesced ultra-thin films of these materials can also be promising for low-power UV photodetectors and field-effect transistors, which are comparatively unexplored. Optoelectronic applications necessitate large-scale synthesis of coalesced films, which need control over the precursor on the substrate and a conversion regimen. We utilized spin coating of liquid soluble precursors due to the benefits of low deposition temperature, ease of use, and uniform coating to synthesize α -MoO₃. We spin-coat and pre-bake an ammonium molybdate tetrahydrate/ethylene glycol solution on a Si/SiO₂ substrate. The prebaked film is converted into coalesced α -MoO₃ films through thermal exposure at 400°C- 3 min or 550 °C- 30 s. These time-temperature conversions are necessary to ensure phase formation while maintaining a coalesced morphology.

In addition, variation in spin speed and precursor concentration is utilized to control film thickness and investigate layer-dependent optoelectronic properties. Spin speed and concentration affect surface roughness, layer thickness, and optical and electrical properties. For instance, when spin speed is varied from 2500 to 5500 rpm, atomic force microscopy images reveal a change in film morphology after thermal annealing, indicating that higher spin speeds are associated with larger grain sizes and increased uniformity. The smoother surface resulting from the 5500 rpm sample leads to lower absorbance of incident light. In contrast, lower spin speeds increase thickness, roughness, and absorption (~ 0.92). The current-voltage (I-V) measurements offer valuable insights into the dynamics of charge carriers within the thin films. We also demonstrate the ease of synthesizing these films on other substrates. In this talk, the impact of the processing parameters will be discussed in relation to the optical and electrical properties of the synthesized α -MoO₃ films.

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CONTRIBUTORY SPEAKERS (ORAL)

Synthesis and Characterisation of $\text{Na}(\text{Li}_{0.1}\text{Ti}_{0.5}\text{Ni}_{0.4})\text{O}_2$, a Layered-Transition Metal Oxide, as a Cathode material for Sodium-Ion

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We report the synthesis and prospective electrochemical evaluation of a sodium-transition metal layered oxide with composition $\text{Na}(\text{Li}_{0.1}\text{Ti}_{0.5}\text{Ni}_{0.4})\text{O}_2$, developed as a potential cathode material for sodium-ion batteries. The compound was synthesized via a modified citric acid-assisted sol–gel route, offering precise compositional control and homogeneity at the molecular level. Sodium, lithium, and nickel acetates were used as aqueous precursors, while titanium butoxide, pre-dissolved in butanol, ensured uniform titanium incorporation and controlled hydrolysis. Gelation was induced at 120 °C, followed by multistep thermal treatment including preheating at 250 °C and intermediate calcination at 450 °C. Final crystallization was achieved at 850 °C for 12 hours under nitrogen atmosphere, a condition shown to suppress sodium volatilization, stabilize oxygen stoichiometry, and enhance structural integrity.

The sol–gel synthesis route achieves phase-pure layered oxide formation at reduced temperatures compared to conventional solid-state methods, minimizing cation disorder and promoting uniform particle morphology. Planned structural and electrochemical characterization using X-ray diffraction (XRD), cyclic voltammetry (CV), galvanostatic charge–discharge (GCD), and electrochemical impedance spectroscopy (EIS) will provide insight into phase composition, redox behavior, and transport kinetics. The high Ti content is expected to enhance structural stability and cycling performance, though with a tradeoff in theoretical capacity. This work demonstrates the effectiveness of tailored precursor design and atmosphere-controlled annealing in producing chemically stable, electrochemically promising cathode materials for next-generation sodium-ion energy storage systems.

Densification of Zinc Oxide (ZnO) Ceramics at Low Temperature by Hydrothermal Cold Sintering Process

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Sintering is a process in which coalescence of powder particle occurs by application of heat. Conventional sintering takes place at elevated temperatures ($>0.5T_m$) for most of the ceramics. For example, ZnO (melting point $\sim 1975^\circ\text{C}$) sintered at $>1000^\circ\text{C}$ temperature. In this study we have used a novel sintering technique to achieve dense ceramics at low temperature ($< 400^\circ\text{C}$). In cold sintering process (CSP) water is utilised as a transient solvent under uniaxial pressure [1]. Small amount of water helps in partially decomposing and dissolving solid surfaces in water. In this study, densification ($>95\%$) of ZnO ceramic at low temperature (225°C) has been demonstrated. The starting material was commercially obtained ZnO ceramic powder with particle size $\sim 1\mu\text{m}$. It was mixed with 10wt% of various concentrations of acetic acid aqueous solution and subsequently pressed at 225MPa at 225°C for 30mins. The ceramic pellets were kept at 400°C for 2 hours to remove excess water present. Geometrical density and Archimedes density (with xylene) was calculated. ZnO powder mixed with pure water reached $\sim 72\%$ of its theoretical density (TD). It has been observed that addition of acetic acid improved the density of ZnO compact. It was observed that with increase in acetic acid concentration, density increases up to 94% of TD at 0.83M acetic acid aqueous solution. However, further increase in acetic acid amount caused a reduction in density. The density decreased to 82% of TD at 2.91M acetic acid aqueous solution.

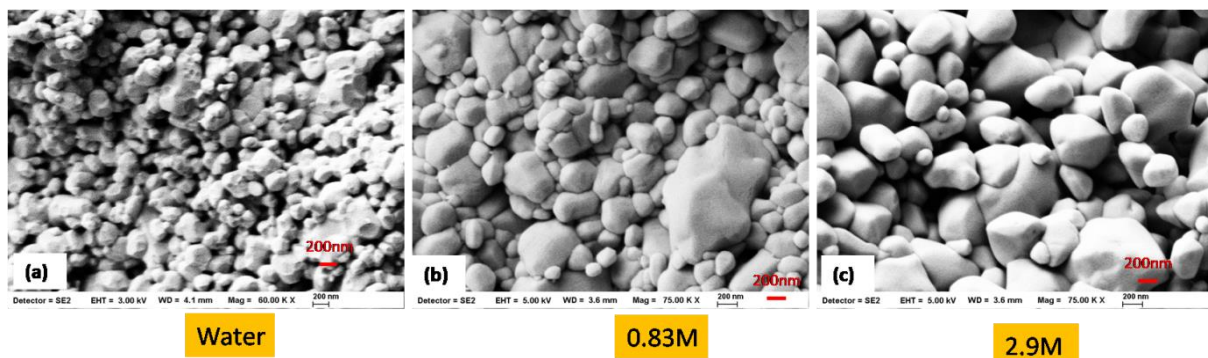


Fig. 1. SEM images of microstructure of cold sintered ZnO samples at 225°C at various acid concentrations

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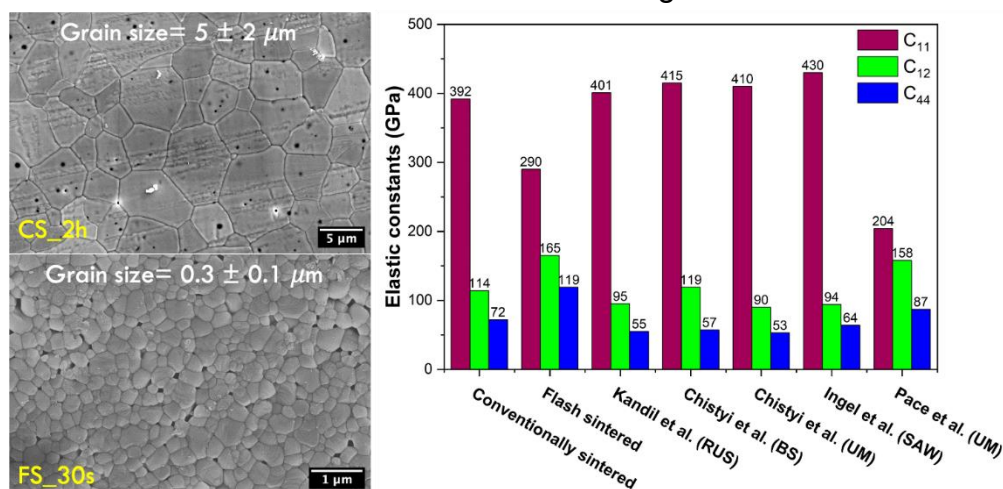
Influence of sintering on elastic anisotropy of cubic ceramics via miniaturized mechanical testing

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Single crystal elastic constants (SECs) are fundamental to understanding the deformation behaviour of the materials, dislocation interactions, force field validation in micromechanical modelling, and in applications such as lasers, semiconductors, and jet engine turbine blades. However, the diffraction-based experimental models that are followed for the estimation of the SECs are not easy to access [1]. With a novel methodology developed for the calculations of the elastic constants with an X-ray diffractometer [2], the experimental validation has been carried out with polycrystalline 8-mol% yttria stabilized zirconia (8YSZ). To evaluate the effect of sintering processes on the anisotropy of the crystals, C_{11} , C_{12} , and C_{44} values obtained from the conventionally sintered (CS) samples are compared with the flash sintered (FS) counterparts. Due to the nonequilibrium nature of flash sintering, high densities of defects such as dislocations, stacking faults, and chemical segregations along grain boundaries are formed [3]. The presence of these defects in the samples increases their fracture susceptibility compared to conventionally sintered 8YSZ. During in-situ uniaxial compression testing used for elastic constants calculation, a decrease in C_{11} value was observed alongside increases in C_{12} and C_{44} . The results indicate that flash sintering reduces the stiffness of the material in its principal crystallographic direction while enhancing its resistance to shear deformation.

Fig. 1. SEM micrographs of CS (left top) and FS (left bottom) 8YSZ. The graph shows calculated SECs of 8YSZ compared with literature reported values (right)



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CONTRIBUTORY SPEAKERS (POSTER)

Mechanical behaviour of high entropy oxides

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Rocksalt structure high entropy oxides (HEOs) were synthesized using solution combustion synthesis. Up to 5 component solid solutions were obtained, with various combinations of oxides chosen from CoO, CuO, FeO, MgO, MnO, NiO, TiO₂, and ZnO. Pressureless sintering was employed to obtain dense HEOs as well as their individual constituent oxides. The crystalline nature and phase uniformity of the sintered samples were studied using X-ray diffraction, electron microscopy, and atom probe tomography. To assess the influence of solid solution formation on the mechanical properties of HEOs, nanoindentation, microhardness, as well as single-edge notched beam bending tests were performed. Hardness, elastic modulus, and fracture toughness were evaluated and correlated with microstructure as well as the potential role of the individual cations.

CERAMIC METAL COMPOSITES: THE START OF A NEW ERA

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Ceramic Metal Composites are nothing short of a wonder material combining the desirable and most useful properties of Ceramics and Metals. From aerospace and defence industry, biomedical engineering, automotive industry till other fields of Electronics, Energy etc. CMCs have a varied application. The thermal expansion behaviour of composite is important when it is used in conjunction with other material. Different from monolithic materials, it is possible to tailor the coefficient of thermal expansion (CTE) of composite by varying its phase ratio. A dilation strain is generated as a body is subjected to a temperature change. The CTEs of two-phase materials depend strongly on their micro-structural characteristics. Cermets are also being developed to be wear resistant. It has been found that the wear resistance of the composites is attributed to increased friction force, surface oxidation, and material mixing under high loads, along with the high inter-facial binding strength between the matrix and reinforcing grains. The reinforcement particles act as barriers to the movement of dislocations, the presence of reinforcement particles refined the grain size, and enhanced the hardness and wear resistance. Nowadays a new biometric approach is being used for the design of high performance ceramic-metal composites. It draws inspiration from natural materials like nacre and bone, which are hybrid composites with intricate architectures that provide a balance of high strength, stiffness, and toughness. The goal is to replicate these structures synthetically. The fabrication method used for this is called “ice templating”. It has been observed that the composite so formed has high fracture toughness and good tensile strength. With the new found ways, it won't take long enough for CMCs to become the start of a new era of ever-growing developments.

Sonochemical-assisted synthesis of Chemically Functionalized Borophene quasi-2D nanomaterials from AlB_2

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Metal diborides have emerged as promising candidates for realizing boron-based flatland nanomaterials. The past decade has witnessed several methods to exfoliate metal borides into quasi-2D counterparts – XBenes. Ultrasonication has emerged as an efficient exfoliation method for synthesising metal-deficient boron-rich quasi-2D nanostructures. In this study, we have proposed a newer approach to exfoliate AlB_2 by combining sonication and chelation to obtain nearly metal-free quasi-2D nanomaterials. Morphological analysis reveals these nanomaterials' crumpled nature with several crystalline and amorphous regions. AFM analysis indicates the thickness of these nanomaterials ranges from 1 to 6 nm, with a length-to-thickness ratio extending up to 800, supporting the 2D nature of nanomaterials. Chemical analysis indicates heavy surface functionalization and nearly metal-free stoichiometry, rendering these nanomaterials chemically functionalized borophene nanosheets. We also found that these nanomaterials possess inherent reduction capabilities. These nanosheets serve as a reducing agent and a catalyst for gold salt reduction into gold nanoparticles. These nanosheets also stabilize the growth of gold nanoparticles. This study lays the basis for a newer top-down approach to synthesizing boron-rich nanomaterials from metal-diboride to leverage the unique properties of boron.

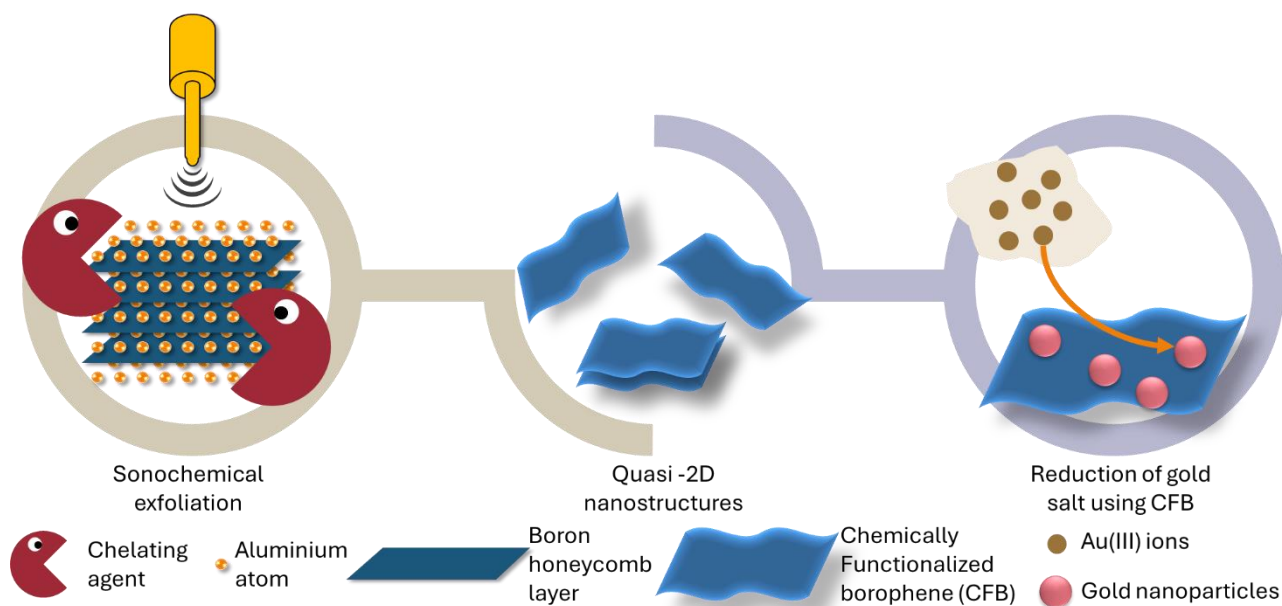


Fig. 1. Graphical Abstract.

Student Session

CONTRIBUTORY SPEAKERS (Oral)

Cellulose Based ZnO-nano Composite for Heavy Metal Removal

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Abstract: ZnO particles has been recognized as efficient materials for heavy metal removal. [1,2]. The surface morphology and surface roughness of ZnO particles is responsible for adsorbing positive metal ions in different water matrix effectively. A limited study was carried out for the removal of metal ions like Cd(II), Cr(VI) and Pb(II) ions by ZnO nanorods system. Wang et. al. reported that the ZnO hollow microspheres enhanced the removal of Cu(II), Cd(II) and Pb(II) cations compared with the commercial ZnO particles. We have synthesized cellulose paper based ZnO nanorods for the study of heavy metal removal efficiency. ZnO nanorods are thoroughly characterized by FESEM, XRD, IR and surface porosity analysis. Metal removal studies have done for the removal of Pb(II), Cd(II), and Cr(VI) ions by cellulose paper based ZnO nanorods and found the excellent performance.

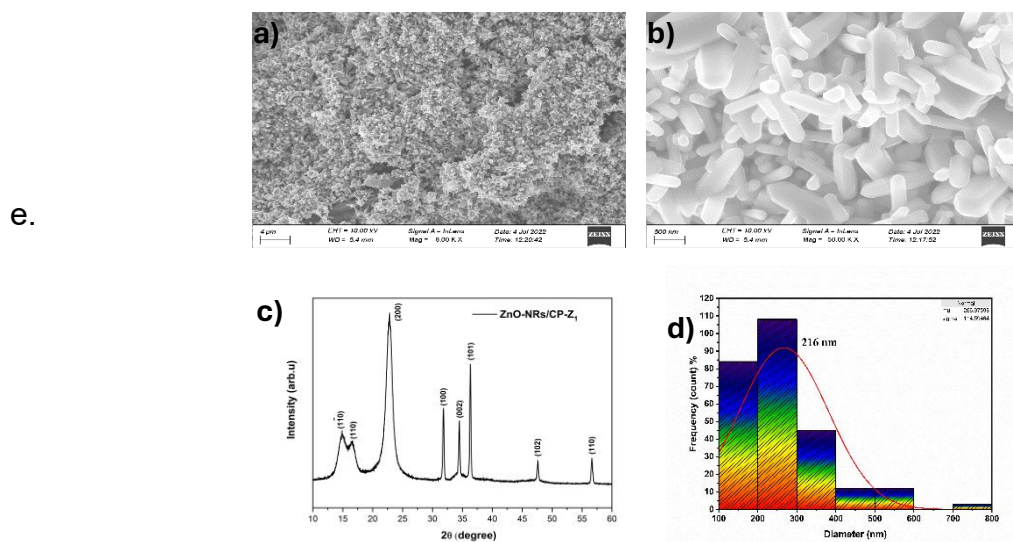


Fig. 1. a, b-: FESEM image of CP-ZnO nanorods, c-XRD and d- average particle size.

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Ordered Gold-Copper Alloy Nanocrystals Induced Phase Transformation in Two-Dimensional (2D)-MoS₂ for Functional Applications

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We report the synthesis of ordered gold–copper alloy nanocrystals (Au₃Cu, ~10±1 nm) and their application in inducing semiconductor-to-metal (2H → 1T) phase transformation in atomically thin 2D MoS₂ (1 - 2 nm) synthesized via chemical vapor deposition (CVD) over a large-area substrate. The ordered Au₃Cu nanocrystals (NCs) were dispersed on 2D MoS₂, and the phase transformation was confirmed by Raman spectroscopy and X-ray photoelectron spectroscopy (XPS). Surface electronic properties were further analyzed using XPS valence band studies and ultraviolet photoemission spectroscopy (UPS). Electrocatalytic assessment for the hydrogen evolution reaction (HER) revealed that Au₃Cu/MoS₂ exhibited an overpotential reduction of 83.2 mV and a decrease in Tafel slope by 58.25 mV dec⁻¹ under light irradiation. This enhancement arises from the light-induced 2H - to - 1T phase transition, which improves carrier concentration, lowers the valence band edge, enhances electronic conductivity, and reduces the free energy of H* adsorption/desorption.

Moreover, Au₃Cu/MoS₂ substrates demonstrated high sensitivity for the detection of trace organic molecules, including potential pollutants and disease biomarkers. The ordered Au₃Cu NCs with homogeneous interparticle nanogaps generate stronger localized electromagnetic fields, resulting in superior plasmonic enhancement compared to pure Au or Cu, enabling efficient surface-enhanced Raman spectroscopy (SERS) detection. Density functional theory (DFT) calculations and complementary surface characterizations corroborate that Au₃Cu-induced phase transformation yields durable metallic characteristics, lowers surface potential and Gibbs free energy, and accelerates photo-electrocatalytic and molecular sensing performance.

Our findings suggest that ordered Au₃Cu NCs dispersed on MoS₂ provide a multifunctional platform with enhanced electrocatalytic activity, plasmonic capability, and SERS sensitivity, opening new opportunities for efficient molecular detection and energy-related applications.

Keywords: Au₃Cu, ordered structure, nanocrystals (NCs), 2D-MoS₂, phase transformation (2H-1T) Surface Enhanced Raman Spectroscopy (SERS).

Synthesis and Characterization of Mullite Whiskers from Biomass-derived Amorphous Silica

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Recycling of biomass is an emerging field of current research to mitigate the environment related issues as well as the sustainability of natural resources. This investigation explores the synthesis of mullite whiskers by using biomass-derived amorphous silica as a precursor. A molten salt method was applied for the synthesis of mullite whiskers in the temperature range of 900 to 1000 °C. The obtained whiskers were investigated by using scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD) and differential scanning calorimetry and thermogravimetric analysis (DSC-TGA) techniques. The XRD and microscopic studies clearly indicates the development of mullite whiskers with orthorhombic structure and mullite single crystals are grown in the [111] crystal plane. The diameter of the whiskers is in the range of 50 to 200 nm and lengths of over several microns. The DSC analysis further confirms the nucleation and growth of mullite crystals at relatively low temperature, which can be attributed to the liquid phase sintering enhancing the diffusion of ingredient components. Due its unique morphology it can be potentially used for strengthening the ceramic or metal matrix composites. Further studies are underway to modify the morphology of the mullite crystals by altering its reaction kinetics and mechanisms.

Development of Polymer-Derived Mullite Structures Through Spark Plasma Sintering Technique

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The transformation of polymer precursors into advanced ceramics, known as the polymer derived ceramics (PDCs) route, offers a flexible and cost-effective approach for fabricating complex ceramic components and ceramic cores. This study presents the development of polymer-derived mullite ceramics using a novel hybrid precursor and Spark Plasma Sintering (SPS). The precursor, based on vinyl methoxy siloxane, was modified to enhance printability and cross-linking. After curing and pyrolysis at 1000 °C, the green body produced amorphous cristobalite (SiO₂). Stoichiometric alumina was introduced after pyrolysis and the mixture is then sintered at 1500 °C for different soaking durations using SPS. This technique facilitated precise control over grain growth, densification, structural stability, and phase composition through pressure-assisted sintering in minimal processing time. Amorphous cristobalite is less ordered, provides high reactivity and greater atomic mobility during sintering which facilitates earlier and more complete reaction with alumina to form mullite. X-ray Diffraction analysis revealed a progressive increase in mullite phase with optimized sintering profiles, especially under multistage heating and Molar ratio conditions. Morphological observations showed dense microstructures with transgranular fracture patterns, indicative of strong intergranular bonding and enhanced mechanical properties. These results underscores the critical influence of precursor homogeneity and sintering conditions on phase formation and mechanical properties, offering a tunable approach for fabricating high-performance mullite ceramics.

Keywords: Polymer derived ceramic, Precursor route, hybrid precursor, pre-ceramic polymer, spark plasma sintering, Mullite ceramics

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Synthesis and Characterization of Mullite Nanofibres by Electrospinning Method

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Ceramic fibres are excellent reinforcing materials due to their high thermal shock damage resistance, flexibility, chemical and thermal stability. In this study, we investigate the synthesis of continuous mullite nanofibres by electrospinning method. Precursor sol was prepared by maintaining proper molecular ratio of aluminium isopropoxide (AIP), hydrated aluminium nitrate (AN) and tetraethylorthosilicate (TEOS) and by applying appropriate processing conditions. An optimized viscosity of the binder solution was prepared by varying amounts of either polyvinyl alcohol (PVA) or polyvinyl butyral (PVB). Electro spinnable sol was prepared by mixing both the precursor sol and the binder solution. Dense webs of nanofibres were calcined at different temperatures to obtain high quality mullite nanofibres. The electrospun mullite nanofibres were investigated by using scanning electron microscopy (SEM), X-ray diffraction (XRD) and differential scanning calorimetry and thermogravimetric analysis (DSC-TGA) techniques. Phase analysis clearly indicates the formation of mullite phases at above 1000 °C, that is corroborated by the crystallization peak on the DSC spectrum. Microstructural observation shows that viscosity of the polymer binders plays an important role resulting in distinct morphology of the mullite nanofibres. The size of the mullite nanofibres is in the range of 50 to 150 nm depending on the viscosity of the polymer binder solutions and the calcination temperature. The obtained mullite nanofibres may have various industrial applications for designing ceramic- or polymer-matrix composite materials.

Keywords: Electrospinning; Mullite nanofibre; Polyvinyl butyral; polyvinyl alcohol; Morphology

Development of thin lithium-ion conductive ceramic film by tape casting

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Solid State Electrolytes are in growing demand for next-generation solid-state batteries due to their safety and performance advantages, while tape casting provides a scalable route to fabricate thin, dense electrolyte layers required for practical devices. This work explores the synthesis of Ga-doped LLZO ($\text{Li}_{6.25}\text{Ga}_{0.25}\text{La}_3\text{Zr}_2\text{O}_{12}$) by Solution Combustion Synthesis (SCS) and its subsequent shaping into thin films through the tape casting method. The phase purity and morphology of the prepared Ga-LLZO powders were analysed. The slurry composition was optimized by varying the weight percentage of ceramic filler, and molecular weight and the weight percentage of binder to achieve uniform green tapes. Rheological studies were carried out to understand the nature of the slurry as well as the influence of the molecular weight of the binder on the slurry viscosity and flow behaviour. The results of rheological studies indicated that the slurry exhibited pseudoplastic (shear-thinning) behaviour, which is desirable for uniform tape casting. The uniform and flexible tapes were achieved through the optimization of slurry composition and binder. This preliminary study indicates that the combination of solution combustion synthesis and tape casting, along with careful rheological tuning, may offer a promising pathway to prepare thin films of Ga-LLZO solid-state electrolytes.

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CONTRIBUTORY SPEAKERS (POSTER)

Investigation of SS316L coated mild steel substrate in accelerated galvanizing and acidic corrosion conditions

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Stainless steel grade SS316L has a varied range of uses specifically to high corrosive area with high temperatures [1]. Being a costly grade, it is evident to focus on less material consumption for its various applications. SS316L coating on mild steel can be used for various applications where only the surface phenomenon are critical and mechanical properties or bulk properties can be compromised [2]. In this work, stainless steel coating on mild steel were investigated through cross-sectional morphologies and phase evolutions for as sprayed samples. The coated sample was dipped in separate baths of galvanizing composition (Zn-0.13%Al) and 10% HCl along with plates of SS316L to check the performance of the coating and bulk samples. All the samples were analysed for the corrosion products, which were investigated through morphologies and phase evolution studies. SS316L coated samples shown stable protective phases which has enhanced the performance of the coated samples in both the corrosive media as shown in fig. 1.

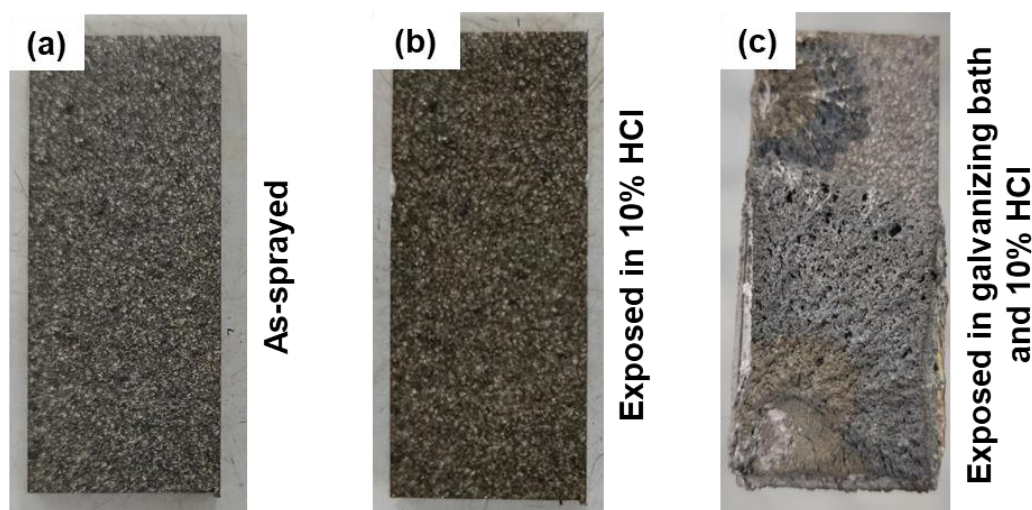


Fig. 1. Visual appearance of SS316L coated samples (a) as sprayed, (b) in 10% HCl and (c) galvanizing bath and 10% HCl

Keywords: galvanizing; sink roll; SS316L coatings; acid attack; corrosion evaluation

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Impact of a novel thermal coatings on heat Retention in torpedo ladle system

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Zircon (ZrSiO_4) is a material known for its excellent refractory insulation properties specifically at higher temperature [1]. Zircon based coatings can be an excellent solution for high temperature zones where high insulation is required for longer period of time. Torpedo ladle could be one such application where high insulation is required at the outer surface whereas molten iron is poured inside [2]. A unique water based refractory coating compound with zirconia ceramics provides excellent erosion / corrosion resistance extending the service life of torpedo ladle. ZrSiO_4 being the major component of material followed by SiO_2 . Indicated through XRD analysis. Apparent Porosity being 27% at 1000°C is found to influence the thermal conductivity of the material due to insulating behaviour of pores. The thermal diffusivity of the material also seems to reduce the thermal conductivity as the heat flow through the material slows down. It is observed that, the average shell temperature on the side of torpedo ladle coated with zirconia-based material is around 11.2°C less than that of the other side. It is also expected that in a longer run, this lower shell temperature helps in retainment of hot metal temperature throughout the campaign.

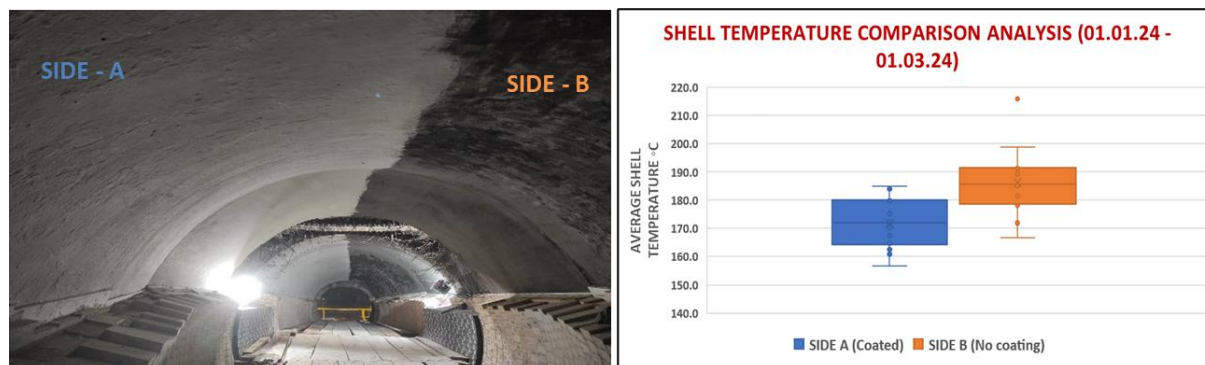


Fig. 1. Torpedo ladle coated with zircon material and heat retention study

Keywords: steel ladle; zircon coatings; thermal insulation; corrosion evaluation; spray coating

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Improvement of the refractory life of basic oxygen Furnace

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The basic oxygen Furnace (BOF) is an important part in Primary steel making where high thermal, mechanical and chemical stresses impact refractory lining life. Corrosion of refractory brick is the one of the crucial problems for BOF. Optimizing refractory performance is essential for cost efficiency, continuing operation and steel quality. Effective maintenance strategies such as timely gunning repairs and advance monitoring tools like infrared scanning plays a major role in extending refractory service life. Slag splashing, in particular, creates a protective coating over the working lining, reducing erosion, corrosion. Slag dosing in another technique which is reduce the aggressive nature of slag by mixing some fluxing agent. Control oxygen blowing is essential to avoid excessive localized heating, which can lead to refractory erosion. Moreover, proper tapping and charging practices help in avoiding thermal shocks and localized damage. This paper explores practical, cost-effective methods to extend refractory life while minimizing maintenance, focusing on material selection, process optimization and smart monitoring.

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Effect of Fabutit-734 On ULCC Castable

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Ultra-Low Cement Castable a specialized type of monolithic refractory used for high-temperature environments (e.g. furnaces, kilns, petrochemical equipment). In this castable, Cement contains varies from 1-3% and lime contain 0.25-0.8%. FABUTIT 734 is a modified sodium tripolyphosphate (STPP) which acts as a deflocculant. This study investigates the role of FABUTIT 734 in improving the rheology, setting behaviour, and high-temperature performance of castable. Results indicate that FABUTIT enhances the workability and reduces water demand, leading to a denser microstructure. Additionally, its fine particle size and phase purity promote rapid strength development, improved thermal shock resistance, and increased hot modulus of rupture. FABUTIT also contributes to better phase stability at elevated temperatures, making it suitable for demanding high thermal environments. The findings highlight FABUTIT's potential as an effective binder for optimizing ULCC formulations in performance for refractory application.

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Steel Meets Sustainability: The Rise of Hydrogen Fuel

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Iron and steel manufacturing is one of the most energy and carbon-intensive industries worldwide. The steel sector is a significant contributor to carbon emissions accounting for 7-9% the total global carbon dioxide emissions and for 30% of global industrial emissions. A transition from conventional, coal-based steelmaking to hydrogen enriched blast furnace and in direct reduced iron (H₂-DRI) production represents a great opportunity for producing low carbon steel. By recirculation of blast furnace gas (BFG) and coke oven gas (COG) helps to making H₂ production in association with carbon capture and storage (CCS) which helps to reduce CO₂ emissions and carbon footprint from 0.65 tons to 0.53 tons. Hydrogen is projected to take over the role of reducing agent for iron oxides. By partial replacement of coke by hydrogen fuel in blast furnace since iron ore can be reduced at lower temperatures (about 1000°C) the process still requires lots of energy. 50 kg of hydrogen required to produce 1 ton of steel, it would require about 100 terawatt-hours (TWh) of renewable energy to fully decarbonise the annual production if 42 Mt of steel. This review penetrates of hydrogen into the steel industry where the driving forces of energy efficiency change and technology progress is the key factor determining energy intensity. Some opportunities lie in CCS retrofit and fuel substitution, particularly hydrogen, carbo-neutral biomass and zero-carbon electricity but only provide low or partial greenhouse gas reductions. Some foreign countries like Germany, Australia, Sweden, Japan etc actively exploring the use of hydrogen fuel to achieve low carbon emissions in blast furnaces. Recently in India TATA Steel makes some technological innovations for decarbonizing the iron and steel industries to reach net zero emissions by 2050.

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From Bone Grafts to Drug Carriers: Evolving Role of Bio Ceramics

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This review focuses on the evolving role of bio-ceramics as drug delivery systems, highlighting their use in both hard and soft tissue therapies through the development of meso-porous particles and functionalised structures and surfaces. Traditional drug delivery systems often struggle with maintaining effective drug concentration levels due to the ever-changing physiological conditions inside the human body; this leads to fluctuations that can reduce treatment efficiency or cause side effects. Bio-ceramics, however, offer the advantage of sustained and localised drug release, enabling a more consistent therapeutic effect through controlled perfusion. Their relevance grows as precision medicine and targeted therapies continue to evolve. Bio-ceramics are biocompatible ceramic materials often made from compounds like calcium phosphate or silica that can safely interact with the human body. They are known for their chemical stability, customisable porosity, and ability to bond with tissues, making them ideal carriers for delivering drugs directly to targeted sites.

Traditionally, bio-ceramics have been widely used in orthopaedic and dental applications due to their ability to integrate with bone. They have served as bone graft substitutes, coatings for metallic implants, and for bone regeneration, especially in treating fractures, defects, and tooth replacements.

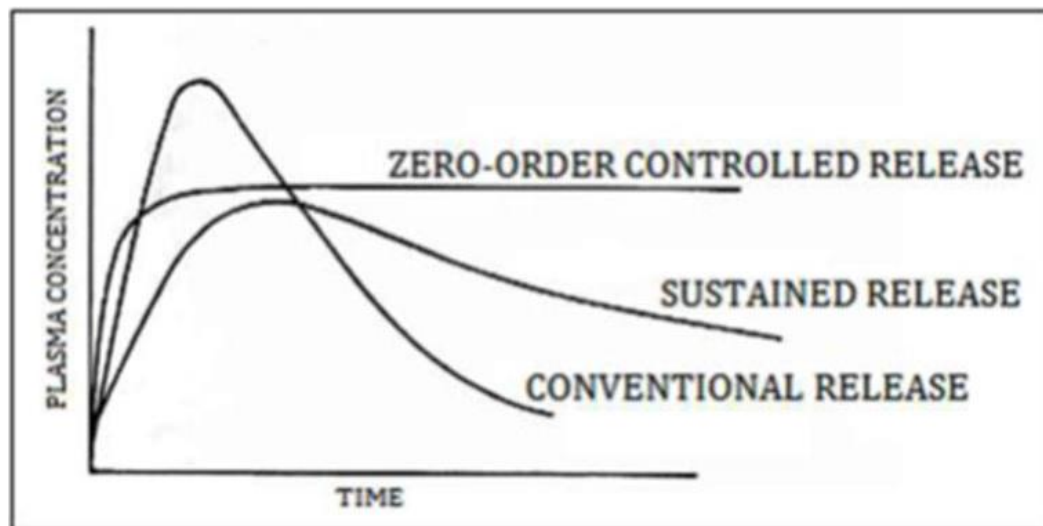


Fig. 1. Schematic plot of drug concentration over time for different drug administration ways.

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Green Energy Converges With Ceramics: Advancements In Microbial Fuel Cells Technologies

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Ceramic materials are on the cusp of becoming integral elements in the field of sustainable energy, especially in the advancement of microbial fuel cells (MFCs), a revolutionary green technology that converts organic waste into electricity using microbial metabolic processes. Historically, costly polymer-based membranes such as Nafion 117 have tended to hold sway over MFC systems, but ceramic membranes have now been considered as cost-efficient and effective substitutes because of their chemical stability, porosity regulation, no degradation in wastewater of high temperature and environmental friendliness. Recent studies identify clay- based ceramics, such as alumina and silicate-rich compositions, as promising proton exchange membranes. Their porous nature can be tailored to selectively permit proton conduction while rejecting unwanted ions, thus enhancing power generation and system efficiency. Ceramic materials have also been shown to exhibit high compatibility with electrode components, improving adhesion of bacteria and electron transfer through their large surface area and biofilm-friendly texture. Despite certain drawbacks, including excessive pore size leading to undesirable oxygen and substrate diffusion, improvements in ceramic membrane modification— such as doping with conductive materials (e.g., graphene or carbon nanotubes, TiO_2 , ZrO_2 - carbon composites) hold great promise for enhancing conductivity and strength. These materials also possess superior thermal and chemical resistance, rendering them ideal for use within high-temperature and industrial wastewater applications. The potential of ceramic materials in energy technology is substantial. With ongoing advancement, ceramic-based systems have the potential to be a key factor in replacing expensive polymers, making MFCs more economically feasible and environmentally friendly designs. This field offer sustainable way to generate electricity from organic waste, it reducing the dependence on fossil fuel and decreasing green house gas emissions. It is potential for innovation in clean energy, wastewater treatment, and decentralized power generation—something that aligns exactly with worldwide sustainability objectives.

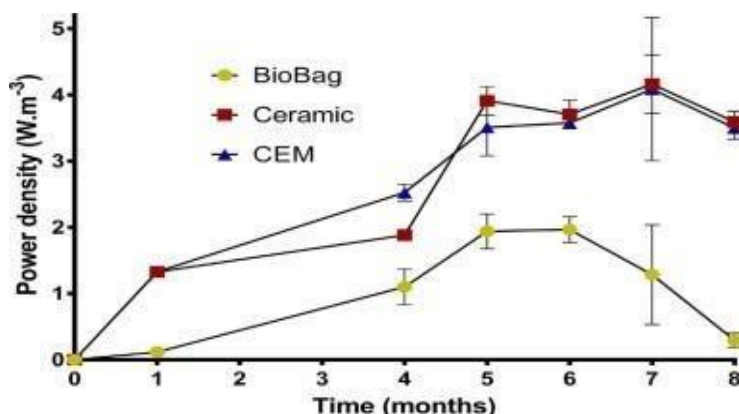


Fig. 1. Schematic diagram of power density over time among biobag, ceramic and CEM.

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Ceramic Oxides in Modern Semiconductor Devices: From SiO₂ to Functional Composites

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Ceramics are non-metallic and inorganic compounds that are chemically non-corrosive, very stiff, brittle, long durable and can resist high temperatures. Ceramics are electrical insulators and have many electronic applications. Ceramics are used in capacitors, carbon resistors, wire-wound resistors, etc. By altering electrical conductivity, ceramic materials are used in the semiconductor industry. Silicon dioxide (SiO₂), which is available in abundance, is considered a ceramic material due to its structural characteristics. A thin layer of silicon dioxide (SiO₂) is used as an insulated gate in between gate and channel in the Metal-Oxide Semiconductor Field-Effect Transistor (MOSFET) as shown in Fig.1. Silicon which is an ingredient of silicon dioxide (SiO₂) is produced in the clean room environment and has various applications in the semiconductor industries. By doping some pentavalent atoms (trivalent atoms in the case of germanium) conductivity of silicon is increased and is used as a P-N junction diode, transistor, etc. Silicon-based transistors are used as amplifiers, oscillators, switching circuits, etc. Silicon is also used in solar cells. In MOSFET, electron flows from source to drain through the channel, and by applying a suitable voltage at the gate, the width of the channel can be changed. In this way, the flow of electrons can be controlled in the MOSFET. By applying positive and negative gate voltage, channel width can be increased and decreased. MOSFETs are used in voltage regulators, amplifiers, switching circuits, IC, memory, microprocessors, etc. Scientists are carrying out research to improve the features of MOSFET by using various ceramic-based composite materials like GaN-SiO₂ to improve breakdown voltage [1], SiC-SiO₂ to increase channel resistance [2], Al₂O₃-SiO₂ to reduce flat-band voltage shift [3], ZrO₂-SiO₂ to improve breakdown field [4], etc. So, ceramic materials are extensively used in semiconductor industry and in future more intended ceramic materials will be used in semiconductor industry.

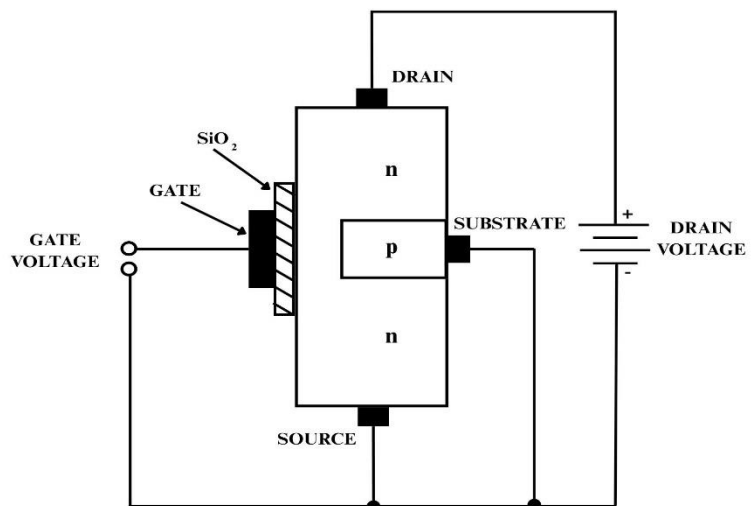


Fig. 1. Block Diagram of n-channel MOSFE

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Synthesis of Cobalt (Co) Tin(Sn) and Aluminum(Al) co doped Zinc Oxide (ZnO) Nano powders by Solution Combustion Method for Photocatalytic Degradation of Textile dye

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The toxic organic dye effluent from textile industry creating problem around the world. In these days most researchers used photocatalytic degradation method using ZnO as catalyst using ultraviolet rays as source of energy. The ZnO was prepared by solid state, solgel, solvothermal, hydrothermal, chemical precipitation and solution combustion method.

In this work instead of ultraviolet rays, easily available visible light is used as energy source. To get the photocatalytic effect from visible light the energy bandgap of ZnO catalyst is reduced by doping of trivalent and divalent cations such as Cobalt, tin and Aluminum respectively in zinc site. The Cobalt tin and Aluminium co doped ZnO nano powders are synthesized by simple, energy effective, quick method called solution combustion using Cobalt nitrate Hexahydrate, tin nitrate, aluminum nitrate Nona hydrate and zinc nitrate as oxidizer and urea as fuel. The photocatalytic degradation of doped ZnO nano powders was studied using Methylene blue as a dye in presence of sunlight.

The effect of dopant, doping concentration, loading of catalyst on photocatalytic degradation was carried in presence of sunlight. The degradation was directly proportional to doping concentration. The divalent transition metal dopant and trivalent metal dopant reduced the bandgap of ZnO which can be seen by decolorization of methylene blue. The trivalent metal dopant increased the yield of product than divalent. required for crystallization, demonstrating their attractiveness for potential applications.

Keywords: ZnO; Energy bandgap; Solution Combustion; Photocatalytic application.

SYNTHESIS OF GEOPOLYMER CONCRETE FROM SOLELY GROUND BLAST FURNACE SLAG AND ITS CHARACTERIZATION.

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This investigates the strength development of solely ground granulated blast furnace slag geopolymers (GGBFS). An optimal combination of GGBFS with various solid/liquid and alkaline activator ratios had been determined by performing a number of compressive strength tests. It was found that GGBFS with 3.0 solid/liquid ratio and 2.5 alkaline activator ratio resulted in high compressive strength at 168.7MPa after 28 days of curing. The microstructure analysis of the GGBFS geopolymers using SEM, FTIR and XRD revealed the formation of tobermorite and calcite (CaCO_3) phases within a three-dimensional system. In addition, an advanced characterisation non-destructive technique using the synchrotron micro-XRF was performed to reveal detail phase distribution in the system. It displayed that the calcium concentration was higher at silica and alumina regions, which described the formation of tobermorite and CaCO_3 as the contributing factor towards high compressive strength.

Eco-Friendly Refractory Ceramics: Transforming Industrial Waste into High-Performance Materials

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This study presents environmentally-friendly methods of producing high-temperature ceramic materials from industrial waste rather than conventional raw materials. We initially recycled used refractory bricks and mixes through a proprietary process known as electrodynamic fragmentation to produce clean, high-quality powders. The recycled powders were subsequently converted into new refractory products with the same strength and thermal resistivity as conventional ones. Then, we produced ceramic batches with industrial waste materials such as fly ash, steel slag, red mud, and ceramic roller waste, as well as minerals such as magnesite and silica. By optimizing the mixture and sintering it at best temperatures, we obtained ceramics that possessed good density, low porosity, excellent strength, and good thermal stability. These materials yielded desirable mineral phases such as mullite and cordierite. The results prove that waste industry can be converted into high-performance, low-cost refractory ceramics that reduce waste, save energy, reduce carbon emissions, and facilitate sustainable, circular production.

Keywords: Refractory Materials, ceramic, recycle, sintering, porosity, density

Low Temperature Sintering Additive Strategies for Energy Efficient Refractory-production: a Path to CO₂ Reduction in refractory Industries

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The transition toward decarbonized refractory industry needs innovation in its manufacturing process, particularly the energy-intensive firing stages should be optimized. This report reviews recent development in dopant-assisted low-temperature sintering for alumina-zirconia-silica (AZS) refractories. The integrating dopant enabled sintering at 1400 °C reduces Kiln energy use by up to 15%, and cuts CO₂ emission equivalently, without compromising bulk density and corrosion resistance. Co-dopant strategies further enhanced densification, achieving bulk densities exceeding 3.22 g/cm³ surpassing conventionally fired AZS at 1500°C. Similar finding was seen that 60% of product's carbon footprint stems from kiln fuel consumption, confirming the impact of firing innovations. Further more Ozkan et al. (2016) provided information for LCA data for magnesia spinel bricks, establishing a firing-stage energy demand of up to 9700Kj/kg, reinforcing the criticality of reducing firing temperatures. Some industrial case studies (Krischanitz et al., 2024) also highlighted that the use of 50% recycled raw material combined with optimized firing profile reduced CO₂ emissions by nearly 50% in rotary kiln refractories. Collectively, these findings advocate for the industrial feasibility and environmental relevance of additive-assisted sintering approaches, laying the groundwork for new class of energy-efficient, low carbon refractories compatible with zero-carbon target.

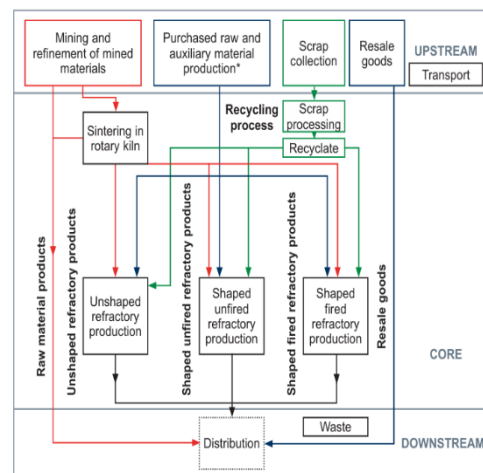


Fig. 1. Process included in product system to manufacture refractories, divided into upstream, core, and downstream processes.

Property	Conventional AZS (1500°C)	Low-Temp Sintered AZS (1400°C, Co-dopants)
Bulk Density (g/cm ³)	3.15	>3.22
Apparent Porosity (%)	18	15
Corrosion Resistance	Good	Excellent

Table 1. Table showing the difference in bulk density, apparent porosity and Corrosion resistance of AZS refractories in different temperature.

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Non-oxide Ceramics

CONTRIBUTORY SPEAKERS (Poster)

Influence of Sintering Additives on Microstructure Evolution and Densification of High-Entropy Borides

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High entropy metal diborides (HEBs) are a family of Ultra High-Temperature Ceramics, part of the High Entropy Ceramics concept derived from High Entropy Alloys. HEBs exhibit a unique layered hexagonal crystal structure with alternating rigid two-dimensional (2D) boron nets and high-entropy 2D layers of metal cations as shown in Figure 1. These materials surpass the average performance of their five separate equivalents in mechanical and thermal properties. The densification behaviour of these materials plays a crucial role in determining their final microstructural, mechanical, and functional properties. However, UHTCs exhibit high sintering temperatures and sluggish diffusion kinetics, often resulting in residual porosity and incomplete densification. In the present work, multicomponent transition metal borides ($\text{Ti}_{0.2}\text{Nb}_{0.2}\text{Zr}_{0.2}\text{Hf}_{0.2}\text{Ta}_{0.2}\text{B}_2$) were produced by boro/carbothermal reduction at 1600°C, and systematically investigated the effect of sintering additives on the densification mechanism and microstructural evolution of the HEB system. HEBs are densified using hot pressing and spark plasma sintering techniques, which resulted in a relative density ~96% and with the silicide additives, MoSi_2 the rate of densification increased along with the relative density. Synthesis studies varied with the temperature and charge modification to obtain phase-pure compounds. X-ray diffraction (XRD) confirmed the formation of single phase and Thermal analysis, Scanning Electron Microscopy (SEM), and density measurements were used to assess the sintering behaviour and resulting microstructures. The densification kinetics are studied through the Coble creep rate model. The rate of densification was found to be 0.09min^{-1} and have an activation energy of $\sim 520 \pm 40$ KJ/mol.

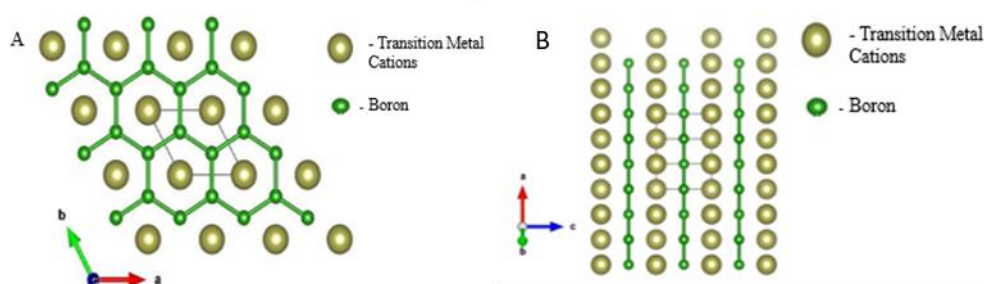


Figure 1. Schematic diagram of (A) crystal structure and (B) Layered Structure representation of HEB.

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Sintering and characterisation of additive-free B₄C/SiC_w composites using high-pressure techniques

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Dense B₄C-based ceramics reinforced with SiC whiskers (SiC_w) were successfully fabricated via high-pressure (4 GPa) and high-temperature sintering at 1650 °C and 1850 without any sintering additives. Composites containing 2.5–10 wt% SiC_w were systematically investigated to assess the influence of whisker content and sintering temperature on microstructure, densification, mechanical properties, and thermal diffusivity. Results showed that increasing SiC_w content initially improved mechanical performance; however, excessive whisker addition caused a decline in both hardness and fracture toughness due to whisker agglomeration and microstructural inhomogeneities. The composite with 5 wt.% SiC_w sintered at 1850 °C exhibited the optimal balance, achieving the highest relative density (99.25%), Vickers hardness (30.97 GPa), and fracture toughness (3.24 MPa .m^{1/2}). This sample demonstrated the most stable thermal diffusivity at elevated temperatures, with minimal degradation from room temperature up to 1400 °C. Conversely, the 10 wt.% SiC_w composite sintered at 1650 °C showed the highest thermal diffusivity at room temperature (18.5 mm²/s) but suffered from reduced thermal stability at elevated temperatures. These findings underscore the crucial role of SiC whisker content and sintering conditions in tailoring the interplay between mechanical strength and thermal transport in B₄C-based ceramics, providing valuable insights for their application in extreme environments.

Keywords: B₄C-based ceramics, high-pressure sintering, mechanical properties, microstructure, thermal properties