विज्ञान एवं प्रौद्योगिकी विभाग
DEPARTMENT OF SCIENCE & TECHNOLOGY
DST@50 1971-2021

Azadi Ka Amrit Mahotsav

ARCI

ANNUAL REPORT

2021-22

इंटरनेशनल एडवांस्ड रिसर्च सेंटर फॉर पाउडर मेटलर्जी एंड न्यू मेटीरियल्स
INTERNATIONAL ADVANCED RESEARCH CENTRE FOR POWDER METALLURGY AND NEW MATERIALS

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ARCI

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Translating Research to Technology

ARCI is an autonomous R&D Centre of Department of Science and Technology (DST), Government of India, set-up with a mission to develop unique, novel and techno-commercially viable technologies in the area of advanced materials and subsequently transfer them to industries.

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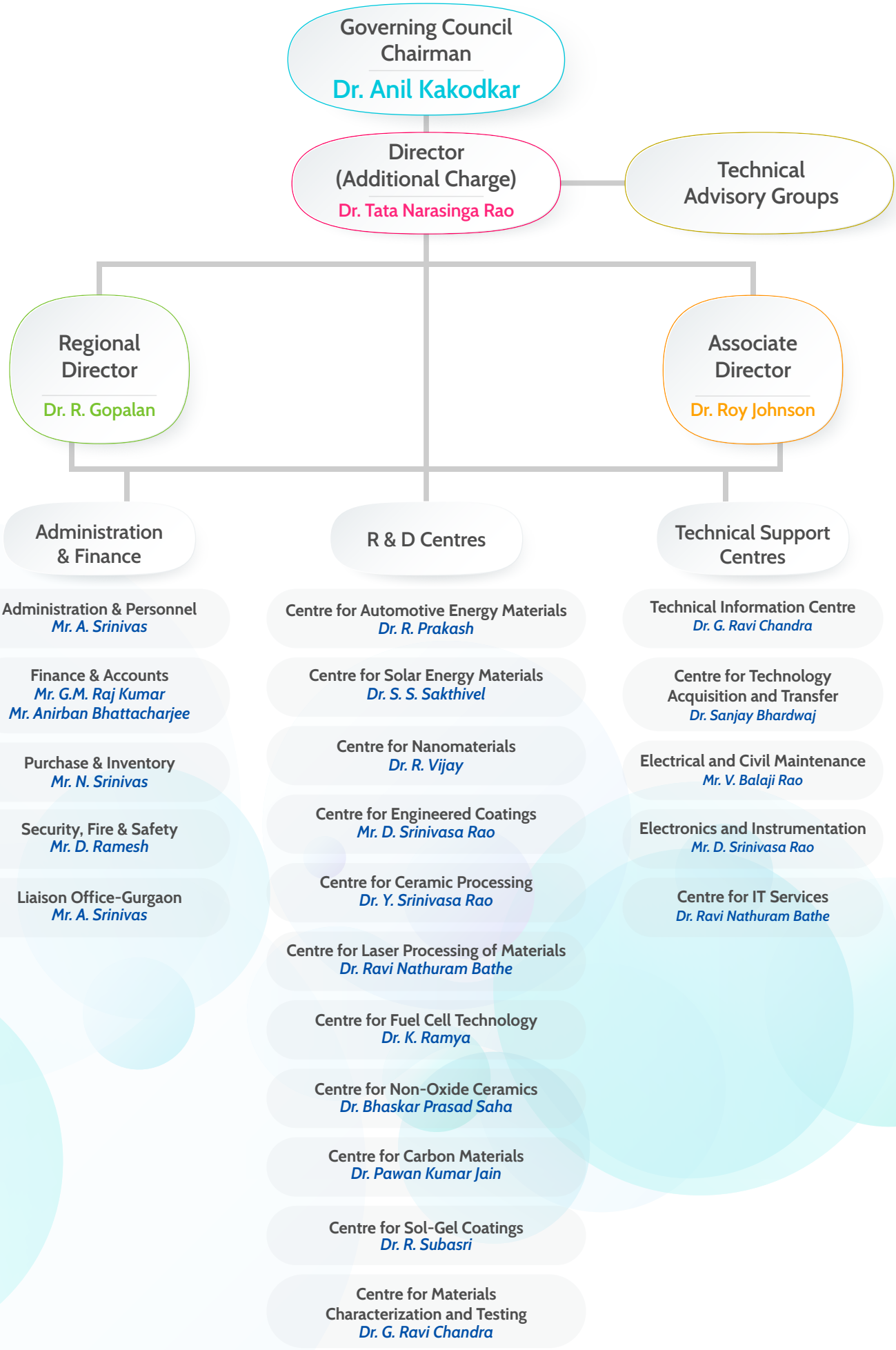
Organizational Structure



International Advanced Research Centre for Powder Metallurgy & New Materials

Governing Council (as on March 31, 2022)

Dr. Anil Kakodkar (Chairman)
Chancellor, Homi Bhabha National Institute,
Chairman, Rajiv Gandhi Science & Technology Commission,
Former Chairman, Atomic Energy Commission

Dr. S. Chandrasekhar
Secretary
Department of Science and Technology

Professor Indranil Manna
Vice Chancellor
Birla Institute of Technology Mesra

Mr. Vishvajit Sahay
Additional Secretary & Financial Adviser
Department of Science & Technology

Dr. G. Madhusudan Reddy
Director
Defence Metallurgical Research Laboratory

Dr. Jaiteerth R. Joshi
Programme Director - LR SAM (IN & IAF)
Defence Research & Development Laboratory

Professor Shatendra Sharma
Professor and Director
University Science Instrumentation Centre
Jawaharlal Nehru University

Professor Satish V. Kailas
Department of Mechanical Engineering
Indian Institute of Science

Shri. S. K. Varshney
Head, International Cooperation (Bilateral)
Department of Science and Technology

Dr. (Mrs.) Anita Gupta
Head, National Entrepreneurship Development Board,
Department of Science and Technology

Dr. Tata Narasinga Rao
Director (Additional Charge), ARCI
Non-Member Secretary

Dr. R. Gopalan
Regional Director, ARCI

Technical Advisory Groups (as on March 31, 2022)

Chairman and Members of Technical Advisory Group (TAG) of Each Centre of Excellence

Centre for Automotive Energy Materials and Centre for Fuel Cell Technology

Prof. Suddhasatwa Basu (Chairman)
Director, CSIR – Institute of Minerals & Materials Technology (CSIR-IMMT), Bhubaneswar

Dr. Ajay Dhar
Associate Director (Student Affairs), Academy of Scientific & Innovative Research (AcSIR), CSIR- Human Resource Development Centre Campus, Ghaziabad

Prof. Sreenivas Jayanthi
Professor, Department of Chemical Engineering, New Academic Complex
IIT Madras

Prof. Aninda J. Bhattacharyya
Professor, Solid State & Structural Chemistry Unit,
Indian Institute of Science, Bengaluru

Dr. N. Lakshminarasamma
Associate Professor, Department of Electrical Engineering,
IIT Madras

Mr. NS Ramanathan
GM, Lucas-TVS "AALIM" Centre, Chennai

Dr. V. Natarajan
Scientist G and Head, Material Science & Engineering Group & Project Director, MEMS Regional Centre,
Defence Research & Development Organization, Naval Physical & Oceanographic Laboratory, Kochi

Centre for Ceramic Processing, Centre for Non Oxide Ceramics & Centre for Sol-Gel Coatings

Prof. Vikram Jayram (Chairman)
Chair Division of Mechanical Sciences, Department of Materials Engineering, Indian Institute of Science, Bengaluru

Prof. K. V. Shriram
Director, LEOS,
Vikram Sarabhai Space Centre (VSSC),
Thiruvananthapuram

Prof. H. S. Maiti
Govt.College of Engineering & Ceramic Technology, Kolkata

Dr. K. G. K. Warrier
Emeritus Scientist, National Institute for Interdisplinary Science & Technology- Retd. Thiruvananthapuram

Dr. V. V. Bhanuprasad
Scientist G & Head, Ceramics Division
Defence Metallurgical Research Laboratory, Hyderabad

Dr. Vivekanand Kain
OS & Head, Materials Processing & Corrosion Engineering Division Bhabha Atomic Research Centre, Mumbai

Centre for Solar Energy Materials

Prof. A. Subrahmanyam (Chairman)
Dean of Sciences, GITAM University,
Vishakhapatnam (Former Professor at IIT Madras)

Dr. O. S. Sastry
Senior Consultant at International Solar Alliance (ISA)
(Ex-Director General National Institute of Solar Energy)

Prof. Kiran Deshpande
Chair Professor- Bank of Maharashtra,
Savitribai Phule Pune University, Pune

Prof. K. Srinivasa Reddy
Department of Mechanical Engineering, IIT Madras

Prof. Monica Katiyar
Department of Material Science & Engineering, IIT Kanpur

Centre for Nanomaterials & Centre for Carbon Materials

Dr. Ashok K. Ganguli (Chairman)
Deputy Director (Strategy & Planning), Institute Chair Professor, IIT Delhi

Prof. Lakshmi Kantam Mannepalli
Dr. B. P. Godrej Distinguished Professor,
Department of Chemical Engineering,
Institute of Chemical Technology, Mumbai

Dr. Sagar Mitra
Associate Professor, Department of Energy Science & Engineering, IIT Bombay

Dr. B. L .V Prasad
Director, Centre for Nano & Soft Matter Sciences,
Arkavathi Campus, Hubli

Prof. Amlan J. Pal
Director, UGC-DAE Consortium for Scientific Research
University Campus, Indore

Prof. Vivek Polshettiwar
Associate Professor,
Department of Chemical Sciences (DCS),
Tata Institute of Fundamental Research (TIFR), Mumbai

Centre for Engineered Coatings

Dr. Indranil Chattoraj (Chairman)
Director, National Metallurgical Laboratory, Jamshedpur

Dr. M. Kamaraj
Professor, Dept. of Metallurgical & Materials Engineering
IIT Madras

Dr. V. S. Raja
Institute Chair Professor, Dept. of Metallurgical Engineering & Materials Science, IIT Bombay

Dr. Deepak K. Das
Scientist H (Metallurgical).
Defence Metallurgical Research Laboratory, Hyderabad

Dr. D. A. Karandikar
Chief Executive cum Technical Officer,
Kinetic Surface Technologies, Pune

Centre for Laser Processing of Materials

Prof. Indranil Manna (Chairman)
Vice Chancellor, Birla Institute of Technology Mesra

Dr. Suhas S. Joshi
Director, IIT Indore
Dean 'Alumni & Corporate Relation' & 'Rahul Bajaj Chair Professor', Department of Mechanical Engineering, IIT Bombay

Dr. T. Jayakumar
Visiting Professor, NIT-Warangal,
Department of Metallurgical & Materials Engineering,
National Institute of Technology, Warangal

Prof. Amitava De
Professor, Department of Mechanical Engineering, IIT Bombay

Prof. J. E. Diwakar
Professor, Centre for Product Design & Manufacturing,
Indian Institute of Science, Bengaluru

Prof. Jyotsna Dutta Mujumdar
Professor, Department of Metallurgical & Materials Engineering, IIT Kharagpur

Centre for Material Characterization & Testing

Prof. Indradev Samajdar (Chairman)
Department of Metallurgical Engineering & Materials Science, IIT Bombay

Dr. G. K. Dey
Raja Ramanna Fellow & Former Director of Materials Group, Bhabha Atomic Research Centre, Mumbai

Dr. Avanish Srivastava
Director, CSIR-AMPRI Bhopal

Prof. Satyam Suwas
Department of Materials Engineering
Indian Institute of Science, Bengaluru

Prof. P. Venkata Satyam
School of Basic Sciences, IIT Bhuvneshwar

Dr. Balamuralikrishnan
Scientist G & Head, Special Steels Group,
Defence Metallurgical Research Laboratory, Hyderabad

Centre for Technology Acquisition & Transfer

Prof. Rishikesha T. Krishnan (Chairman)
Director and Professor of Strategy
Indian Institute of Management Bangalore

Dr. Aravind Chinchure
Founder & CEO, QLEAP Academy, Pune

Dr. Premnath Venugopalan
Head, NCL Innovations, National Chemical Laboratory, Pune

Ms. Poyni Bhatt
Chief Executive Officer, Society for Innovation & Entrepreneurship (SINE), IIT Bombay

Dr. Anita Gupta
Scientist-G /Adviser & Head National Science & Technology Entrepreneurship Development Board,
Department of Science & Technology, New Delhi

Director's Report

It is a matter of great pleasure and distinct honour for me to present the Silver Jubilee edition of ARCI's Annual Report this year. The research advances and technological accomplishments of the Institute can be judged by its performance indicators in terms of patents, technologies transferred and the publications. ARCI has quickly grown into an applied research and technology development institute from a joint research centre for powder metallurgy, thanks to the invaluable guidance of visionaries like Prof. P. Rama Rao (Distinguished ARCI Chair, former Secretary, Govt. of India; former Chairman, Governing Council of ARCI; former Chairman, Atomic Energy Commission); Dr. V. S. Arunachalam (then Scientific Adviser to Raksha Mantri, DRDO); Sri S.L.N. Acharyulu (former Director, DMRL & former Project Director, ARCI and former CC R&D, DRDO) and Prof. Oleg V Roman (from Belarussian Powder Metallurgy Association (BPMA), of the then USSR). In the year 1991, Sri G. S. Bhattacharjee took over as Chief Project Officer of ARCI. The transformation of the institute from a project phase to an independent research centre involved several steps during 1996-97 and Dr. G. Sundararajan was appointed as Director in 1997. While ARCI started with three technical divisions: powder metallurgy, engineered coatings and ceramic processing, it saw a tremendous growth during Dr. Sundararajan's tenure by establishing various new technical centres of excellence including laser processing of materials, nanomaterials, fuel cells, non-oxide ceramics, solar energy materials and automotive energy materials, Dr. G. Padmanabham added new emerging activity on additive manufacturing after he took over as Director in 2016. Dr. Padmanabham made significant contributions in advanced laser processing techniques and laser additive manufacturing, which brought great visibility to this field in India in a short span of time. I sincerely thank all former Directors of ARCI who have made immense contributions to the establishment and growth of ARCI.

ARCI with its unique mandate of translational materials research, developed several technologies relevant to automotive, aerospace, nuclear, power, manufacturing, energy, defence and other civilian sectors. Ever since its inception, ARCI has been mainly focusing on indigenizing the technologies in line with the Atma Nirbhar Bharat. ARCI is unique in balancing the strong fundamental science with application development at high Technology Readiness Levels (TRLs), so that a large fraction of its inventions convert to technologies. The details of inventions and technologies are listed in the inner pages of this report. The success of ARCI in technology transfer / commercialization is mainly due to its handholding with technology receiving industries until the product reaches marketplace. ARCI follows flexible business models based on the purpose of interaction with industrial / user organizations and entry of these partner organizations at different TRLs of technology development / demonstration chain.

Another unique feature of ARCI is its changing orientation towards emerging technologies in line with the government policies, which enabled ARCI to contribute significantly to various national missions, including nanomission, e-mobility, solar mission, hydrogen mission and so on. ARCI has made significant contributions to these missions, in terms of technology transfers, participating in policy and standards development, manpower training in new technologies, demonstrating processes at pilot scale etc. Presently, ARCI has placed itself as one of the key players at national level in battery and fuel cell technologies by showcasing its capabilities in indigenous development of materials as well as systems. ARCI raised to the occasion and acted swiftly during the recent COVID-19 pandemic by developing technologies for SARS CoV 2 disinfection and a few of the technologies were actually commercialized. ARCI has been in the media on several occasions for its technological developments and related achievements. ARCI has recently initiated its active participation in green hydrogen production through electrolysis.

The rapid growth and success of ARCI is due to the vision of the former and present leaders and a wide range of expertise built over the years balancing between science, engineering and technology. I would like to acknowledge the support from Department of Science and Technology (DST), Government of India during these 25 years' journey of ARCI. I would like to place on record the great guidance from the esteemed Chairman and members of Governing Council (GC) in moulding the performance of ARCI. I am extremely thankful to the reviews made by the Chairman & Members of Research Advisory Council (RAC), Technology Advisory Board (TAB) & centre-wise Technical Advisory Groups (TAG) from time to time that have helped ARCI immensely in shaping both basic research as well as technological aspects.

Students are the strong workforce, energized and bubbling with enthusiasm to translate their ideas into reality. To tap their talent and enhance their skills, students and researchers are trained in large numbers at ARCI. The collaboration of academic and R&D institutes both from India and abroad have played a key role in the growth of ARCI.

Finally, I would like to thank scientists and engineers, who are directly visible due to their high level of contributions in basic science and technology demonstrations, experts who work towards implementing novel strategies for effective utilization of intellectual property and processing of patents, connecting right industries to facilitate technology transfers, and costing of technologies / projects to help generate good revenues for the institute. I also take this opportunity to thank all employees of ARCI at all levels who directly or indirectly supported and contributed to the development of ARCI. It is with the collective unstinted efforts of all these people that ARCI is placed in its present respectable position and we enthusiastically look forward to achieving all our major goals.

Dr. Tata Narasinga Rao
Director (Additional Charge), ARCI

Testimonials

Dr. Anil Kakodkar

Chancellor, Homi Bhabha National Institute,
Chairman, Rajiv Gandhi Science & Technology Commission,
Former Chairman, Atomic Energy Commission
Chairman, Governing Council, ARCI

ARCI has now completed 25 years of its illustrious journey. Today, ARCI in my view is a unique institution that is recognised for its excellence in scientific research as well as providing solutions to industry in meeting their needs for advanced materials. I wish to congratulate on this occasion all its pioneers and leaders, members of ARCI family and all stake holders associated with the journey of ARCI. ARCI has made tremendous contributions in the fields of materials, processes and related technologies in aerospace, automotive, energy and such other key sectors. ARCI has been very successful in taking its development in critical areas to higher levels of technology readiness resulting in several technology transfers.

The technology areas in which ARCI is working are very relevant and in fact crucial to national needs. ARCI has quickly adopted to newly emerging technologies such as additive manufacturing, glass ceramics, high power energy storage devices, fuel cells and hydrogen generators. ARCI has significantly contributed to national self-reliant capability in these high technology areas. I am very encouraged and enthused to see a much bigger horizon ahead of ARCI as it makes its forays into the future.

I wish ARCI a bright and successful future.

Dr. S. Chandrasekhar

Secretary, Department of Science and Technology (DST), Government of India

I am happy to note that International Advanced Centre for Powder Metallurgy and New Materials (ARCI) has successfully completed 25 glorious years and I congratulate ARCI family on this occasion as we march in this 75 years of independence "Azadi Ka Amrit Mahotsav".

ARCI is a prestigious national laboratory under the Department of Science and Technology, Ministry of Science and Technology with a unique mandate of translational materials research. ARCI has consistently demonstrated success in the development of technologies, relevant for industry and other users. Being a resident of Hyderabad, I have known ARCI for more than a decade and have had the opportunity to interact with colleagues from ARCI on many occasions.

ARCI is well acknowledged for transfer and commercialization of technologies in advanced materials such as Nanomaterials, Engineered coatings, and Solar energy materials. ARCI has also taken up the development of technologies related to Lithium-ion batteries, an area in which Government of India has been giving a lot of thrust. I am confident that ARCI's contribution in this field of advanced materials and associated processing technologies will assist transforming India as a truly Atma Nirbhar nation. It is a pleasure to note that ARCI has also been venturing into the development of indigenous technologies of national importance such as low expansion transparent glass ceramics, solid oxide fuel cells, Sodium-ion batteries, and technologies useful for aerospace and biomedical sectors. I wish a great success to the entire ARCI family on this occasion and look forward to more success stories coming from ARCI.

Prof. P. Rama Rao

Former Secretary, Department of Science and Technology (DST), Government of India and
Former Chairman, ARCI Governing Council

ARCI is a product of the integrated long-term programme (ILTP) of cooperation between India and the former Soviet Union, which is a mammothly conceived bilateral programme like never before between any two countries in the world. The stalwarts who steered ARCI to its initial momentous years were Dr. V.S. Arunachalam and Prof. Oleg V. Roman of Belarus, Shri. S.L.N. Acharyulu and Dr. G.S. Bhattacharjee implemented their farsighted vision with exemplary dedication. Dr. G. Sundararajan, a gifted scientist, headed ARCI during 1996-2015. ARCI story continues to unfold magnificently with promising projects and programmes.

ARCI is a unique organization under the DST family with expertise in translational research in the field of advanced materials and processes. There are very few institutes in the country that can take technologies to higher technology readiness levels (TRLs) and ARCI with its great scientific & technical strengths, good infrastructure and visionary leadership has been able to make an indelible mark in this field. In addition, ARCI has illustrated or delivered commendable work by providing an array of technological solutions to public and private sector organizations through its specific R&D projects. ARCI has been implementing novel strategies to collaborate with industry, academia, and research institutes for accomplishing the fundamental as well as application-centric R&D work aimed at transfer of robust technologies. ARCI is known for its continuous re-orientation of goal posts in coherence with the emerging technologies and national missions, and meet the objectives successfully. As ARCI celebrates its 25th anniversary, I would like to congratulate and extend my best wishes to Team ARCI.

Prof. V.S. Ramamurthy

Emeritus Professor and Former Director, NIAS
Former Secretary, Department of Science and Technology (DST), Government of India
Former Chairman, ARCI Governing Council

Recognizing that laboratory-to-market place has always been a challenge in the deployment of technologies developed in research laboratories, Government of India created ARCI in Hyderabad, with a specific objective of developing technologies to a level where they can be deployed at the industrial level. ARCI has made substantial contributions in the development and transfer of novel engineering materials and processes to manufacture industry-ready components by adopting an industry-centric approach. ARCI has also contributed to the national missions, especially in the fields of PEM Fuel Cells and Automotive Energy Materials.

I compliment ARCI on completing 25 years of glorious journey and realizing its mandate of development, demonstration and transfer of technologies. I am sure, ARCI shall continue to achieve newer heights in the years to come with its visionary leadership, committed team combined with appropriate strategies.

Dr. T. Ramasami, FASc., FNA, FNAE, FNAS, FTWAS

Former Secretary, Department of Science and Technology (DST), Government of India
Distinguished Professor of Eminence (Honorary), Anna University

A Felicitation message to ARCI

I learn with delight that ARCI is observing a landmark jubilee of its establishment. Having known the contributions of the institute in translational research with a culture of converting knowledge into products and processes with scope for commercialization and adding socio-economic benefits to people, I consider it my duty to offer this felicitation message.

National research laboratories are built to address and redress national problems through the tools of scientific knowledge. ARCI born out of an international S&T cooperation has acquired global research culture from the very beginning. The back pages of the progress of ARCI are filled with many landmark achievements. It has emerged as a small body with wings to fly high in the horizon of Indian science. The institution is unique and specializes upon precision surface coating with designed properties to the product.

The leadership of the institute has ensured that several self-actualized scientists choose to dissolve their personal identities into the cause of research and work as one extended family. ARCI is its own bench mark. Let the journey of ARCI from silver to gold add further lustre and glow to the institution and Indian science, technology and innovation landscape.

Wish the institution a glorious future studded with many milestones and land mark achievements.

With deep affection to all.

Prof. Ashutosh Sharma

Institute Chair Professor IIT, Kanpur &
Former Secretary, Department of Science and Technology (DST), Government of India

ARCI is an exceptional Institute. It combines very deep basic knowledge with practical applications. There are very less institutes of this kind in the country that can go seamlessly from fundamentals of nanomaterials to industrial coatings. It has very deep strengths built over the years – with great infrastructure, visionary leadership and the right mix of people. They also have set up Technology Research Centre (TRC) at ARCI. This is a significant effort spending Rs.100 Crores over a span of five years. TRC at ARCI is on automotive energy materials and systems. This is a huge initiative that is very important in the current national context. Most of the work performed under TRC projects is related to Li-ion battery, polymer electrolyte membrane (PEM) fuel cell and solar energy materials & systems. ARCI has made tremendous progress in these areas and transferred a few technologies during the project period.

I am very happy that ARCI has completed 25 years, and I congratulate every member of ARCI family a great success in the years to come.

Prof. G. Sundararajan

Distinguished Emeritus Scientist, ARCI
Retd. Professor from IIT Madras and
Former Director, ARCI

I served as the Director of ARCI for 19 years (1997-2015) during which a strong foundation for translational research could be built and the relevant eco-system was established. A lot of new technologies were developed and transferred to the industry. Gradually, technological requirements for industry kept on changing and new thematic areas were to be added so that ARCI's R&D efforts can continue to support industry including established companies and start-ups. Accordingly, we have worked towards formation of Centres of Excellence, sometimes in collaboration with some other countries also. Due to its unique approach to technological collaborations and technology transfer, ARCI has grown as a premier laboratory in the domain of advanced materials and related processes in India.

In its journey of 25 years, ARCI is fortunate to have received guidance from its Governing Council composed of highly eminent scientists, academicians and engineers. So far, ARCI has achieved important milestones in realizing its unique mandate of conducting materials R&D for demonstration and transfer of technologies to the industry.

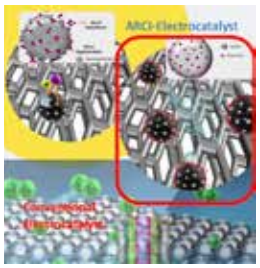
I am very happy that ARCI has completed 25 years of its successful journey and I look forward to ARCI reaching even greater heights in the years to come.

Technology Transfers

During the year 2021-22, the following technology transfer/ know-how agreements were signed/completed:

Indigenously developed Platinum based Electrocatalyst for Low-cost Durable Fuel Cells

ARCI developed an efficient procedure for the synthesis of platinum-based electrocatalyst. For use in fuel cells, various parameters pertaining to the facileness of scaling up, efficacy after the introduction of the electrocatalyst in the fuel cell and corrosion resistance of the substrate material were benchmarked.



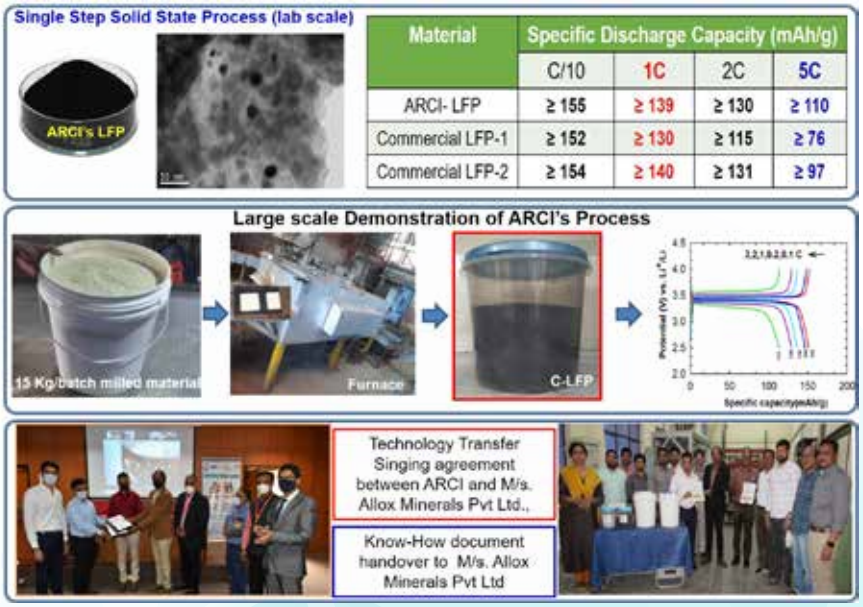
An illustration comparing the commercial catalyst and the indigenous ARCI electrocatalyst, showcasing the superior durability

This electrocatalyst showed properties comparable to those of the commercially available electrocatalyst, in terms of its performance in fuel cells and superior corrosion resistance and durability. While the acceptable limits of loss in the active surface area of the catalyst after a rigorous and stringent testing protocol are within 40% of the starting surface area, the ARCI-developed electrocatalyst showed less than 20% loss. This enhances the lifetime of the fuel cell stack performance. Las Engineers and Consultants Pvt. Ltd, a Mumbai-based company engaged in designing and building plants for the chemical, pharmaceuticals and allied industries received the technology know-how document on March 11, 2022 for mass manufacturing of this electrocatalyst.

Know-how document handing over ceremony to LAS Engineering and Consultants, Mumbai, at ARCI-Chennai

Development and Demonstration of Large Scale Production of Lithium Iron Phosphate (LFP) Cathode Material

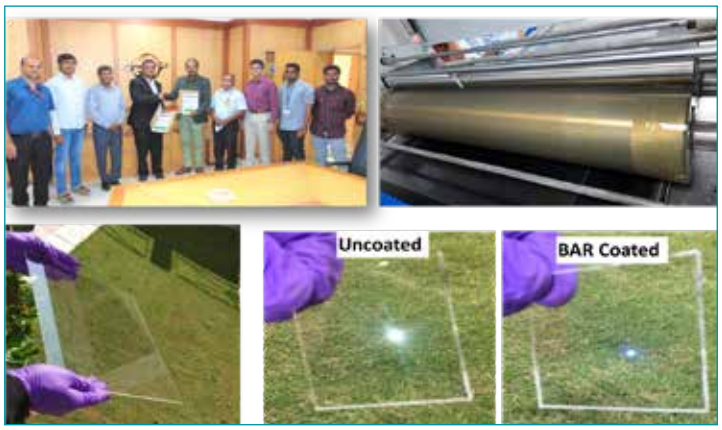
Indigenous electrode materials technology and associated components, that are essential for the manufacturing of Li-ion batteries within the country, are the need of the hour. ARCI has developed an innovative and low-cost solid-state process for the synthesis of in-situ carbon-modified LFP for Lithium-ion batteries. The manufacturing process was successfully demonstrated at 15 kg C-LFP /batch in collaboration with the Indian industry (Innomet Advanced Metal Powders Ltd., Hyderabad) under public-private partnership. The electrochemical performance of large-scale synthesized C-LFP exhibits capacities of 1.75 Ah and 1.45Ah at formation and 1C current rate respectively. An Indian patent application (202011056608) and an International patent application (WO/2022/144917) were filed for the invention ('A method of producing high-performance in-situ carbon coated lithium iron phosphate cathode material for lithium ion battery applications and the product thereof'). Technology Know-how for the production of carbon-coated LFP was demonstrated and transferred to Allox Minerals Pvt Ltd., on a non-exclusive basis. ARCI is providing technical support to the technology receiver for setting up the LFP plant of 3000 Ton/Year capacity (i.e., 1GWh).



Development of C-LFP Material Technology at lab scale, Large-scale synthesis of LFP by high Energy attrition milling and Technology Transfer and its Demonstration

Broadband Antireflective Coating Technology for Solar Photovoltaic Applications

Transparency of the photovoltaic (PV) cover glass is an essential feature for accomplishing high power conversion efficiency. Fresnel reflections in PV cover glass result in lower power conversion and these losses have proven to be the most disconcerting phenomenon. ARCI has designed and developed novel organic and aqueous based Broadband Antireflective (BAR) Coating with high stability by using nanoparticles (e.g. MgF_2 and SiO_2). The BAR Coated PV glass plate showed > 96% transmittance in the active solar region (300–1500 nm) and > 98% in the visible part. The cost-effectiveness and scalability of this coating to wide areas led the way forward to a potential technology. Recently, the coating has been tested with industrial roller coating at Borosil Renewables Ltd. (BRL), and the BAR coating exhibited an average increment of > 2% in transmission on a single side compared to uncoated glass. The technology has been transferred successfully to BRL.



Technology Transfer to Borosil Renewables Ltd.; BAR coated PV glass plate; Coating development by roller coating technique

Key features

- High transmittance (>96 %)
- High weather stability (withstands humidity > 90%)
- High mechanical stability

Applications

- Solar PV module glass, CSP Cover glass and Solar Thermal collectors
- Automobile window glasses, mirrors, eyeglass lenses or goggles etc.

Easy-to-Clean Coating Technology for Solar Photovoltaic (PV) Applications

The soiling of PV modules constrains photovoltaic power generation. Anti-soiling can be a potential solution to mitigate soiling losses. ARCI has identified a novel nanocomposite-based coating technology to minimise the energy losses due to soiling. It is a single layer protective coating with excellent weather, mechanical stabilities and anti-soiling property with no loss of power conversion efficiency on PV panels. The nanocomposite coating reduces the amount of dust deposited on the panel and cleans itself by the action of water on the modules. ARCI had previously transferred the technology to NTPC Ltd and during the year 2021-22, ARCI successfully transferred and handed the know-how document to Marichin Technologies Pvt. Ltd. and Allox Resources LLP.

Technology Transfer to Allox Resources, NTPC, and Marichin Technologies; Technology demonstration at Ground and rooftop power plants; Coating validation results on solar PV panels

Key features

- Highly transparent (no loss in transmittance)
- Hydrophobic property: > 110° WCA
- High weather & mechanical stability
- Easy to coat and curable in ambient condition

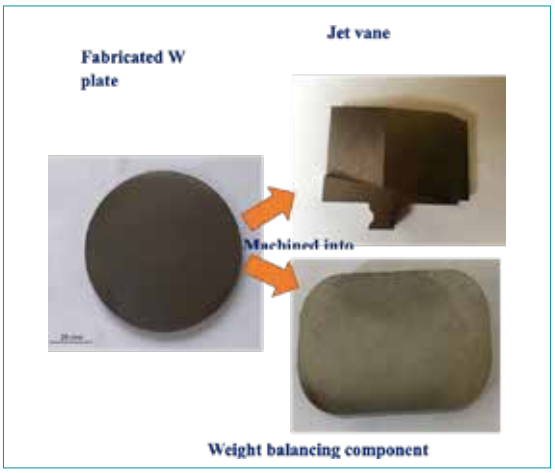
Applications

- Solar PV panels
- Automobiles, Architectural glass, Compressor Blades, Wood, Textile and Plastic etc

Dispersion Strengthened Tungsten Plates by Spark Plasma Sintering

Dispersion strengthened tungsten plates were fabricated by a powder metallurgy process involving spark plasma sintering. This process enables retention of fine equiaxed grains of ~2.5 µm and achieves high-density ≥18.85 g/cc along with hardness ≥ 400 MPa and fracture strength ≥ 750 MPa in the plates in a single-step process, making them suitable for high temperature strategic applications. These plates were machined into components such as jet vanes and balancing weights and successfully qualified for the envisaged application. An Indian patent application (201911014933) was filed and a technology transfer agreement was signed with Innomet Advanced Materials Pvt. Ltd., Hyderabad on a non-exclusive basis.

Signing of ToT with representatives of Innomet Advanced Materials Private Limited



Tungsten plates and the machined components

Development of UVC Disinfection Devices to Combat COVID-19

ARCI has developed several solutions for COVID-19 disinfection in collaboration with academia and industry and transferred them to respective industries within a short time. The activities included the design and fabrication of UVC-based disinfection systems. Coronavirus (SARS CoV 2), the virus that causes COVID-19 is sensitive to UVC light as in the case of other viruses and bacteria. The germicidal effects of UVC irradiation with a peak intensity at 254 nm result in cellular damage of the virus thereby inhibiting cellular replication. Unlike chemical approaches to disinfection, UV light provides rapid and effective inactivation of microorganisms through a physical process. Mainly three systems including a trolley (University of Hyderabad, Mekins Industries Ltd, Hyderabad), a cabinet- safe box and handheld safe blade (Mekins Industries Ltd., Hyderabad) and a baggage scanner (Vehant Technologies, New Delhi) have been designed, fabricated and successfully commercialized for their deployment at hospitals, research labs, airports and public and commercial establishments to combat COVID-19.

Exchange of MoU with Mekins Industries Pvt. Ltd., Hyderabad

Trolley

Disinfection cabinet

Baggage scanner & disinfection box

Establishment of Li-ion cell (LFP/graphite) Pilot Facility (1 MWh) and Manpower Training

ARCI signed an agreement with Nsure Reliable Power Solution, Bengaluru in November 2021. The scope of the work is to provide complete technical support for the establishment of Li-ion cell (LFP/Graphite) manufacturing facility for the capacity 1 MWh per annum and manpower training using ARCI's existing facility. The major tasks are as follows: Task 1: Technical support for Establishment of Li-ion cell manufacturing/testing facilities; Design and layout dry rooms/laboratories; Derive specifications for dry rooms/ Equipment; Pre-dispatch inspection; Assist installation/commissioning; Demonstration, testing and Quality Control support. Task 2: Providing theoretical course on Li-ion Battery (LIBs) and hands-on training for the Li-ion cell fabrication and Testing; Support in supply chain establishment.

Agreement signing with Nsure Reliable Power Solution, Bengaluru at ARCI Chennai

Technology Transfers Undertaken/Collaborations Forged

Based on the perceived market size of products/ services based on ARCI technologies, ARCI has adopted exclusive and non-exclusive modes of technology transfer to facilitate healthy competition in the market. So far, ARCI has successfully transferred 30 technologies to 44 receivers (Know-How Document has been handed over) and few technologies are under transfer. The following table depicts the technologies transferred:

S.N	Technology	Industry Targeted	Status
1-8	Electro Spark Coating (ESC) Equipment	Hard, wear resistant coatings	Transferred to 8 companies on nonexclusive basis
9	Magnesia Aluminate Spinel (MAS)	Steel, cement and power plants	Transferred on exclusive basis
10	Ceramic Crucibles	Carbon and Sulphur analysis	Transferred on exclusive basis
11	Energy Efficient Air Heaters from Ceramic Honeycombs	Industrial heating	Transferred on exclusive basis
12-15	Detonation Spray Coating (DSC)	Wear and corrosion resistant coatings on various components	Transferred to 4 companies on region exclusive basis
16	Reinforced Graphite Sheets and Seals	Automotive sector	Transferred on exclusive basis
17	Heat Pipes Heat Sinks	Waste heat recovery systems, solar energy applications, power electronics	Transferred on exclusive basis
18	Evaporation Boats	Metallization	Transferred on exclusive basis
19	Ceramic Honeycomb Molten Metal Filters	Molten metal filtration	Transferred on exclusive basis
20	Calcium Aluminate Cements and Furnace Sealants	Refractory castables	Transferred on exclusive basis

S.N	Technology	Industry Targeted	Status
21-23	Micro Arc Oxidation (MAO)	Hard (1800 VHN) wear resistant coatings on Aluminum and Titanium alloys	Transferred to 3 companies on region exclusive basis
24	ESC Equipment Manufacturing	Diverse segments	Transferred on non-exclusive basis
25	Nanosilver Impregnated Ceramic Water Filter Candles to Impart Antibacterial Function	Water purification	Transferred on non-exclusive basis
26	Nanosilver based Textile Finishes for Antibacterial Applications	Anti-bacterial applications	Transferred on exclusive basis
27	Nanotitaniumdioxide based Textile Finishes for Self Cleaning Applications	Self-cleaning applications	Transferred on exclusive basis
28	Decorative Coatings on Glass	Aesthetic applications	Transferred on non-exclusive basis
29	Aerogel Flexible Sheet Technology	Thermal Insulation applications	Transferred on exclusive basis
30	Ceramic Honeycomb Based Energy Efficient Air Heaters and Eco-friendly Sanitary Napkin Incinerators	Incinerator Applications	Transferred on exclusive basis
31	Laser Cladding Technology for burner tip nozzles	Thermal Power Plants Applications	Transfer Complete
32	LWIR ZnS Domes	IR Seeker Application	Transfer Complete
33	MWIR ZnS Domes	IR Seeker Application	Transfer Complete
34	Ceramic Inserts for Anti-mine Boots	Strategic Application	Transfer Complete
35-37	Development of Super Hydrophobic Easy to Clean Coatings	Solar PV Panels	Transfer Complete to 3 companies
38	High Temperature Complaint Glass sealants	For missile applications	Transfer complete
39	UVC based Tunnel Baggage Disinfection System for Disinfection of Baggage to Fight COVID-19	Commercial Complexes, Hospitals etc.	Transfer complete
40	UVC based Disinfection Trolley to Fight against COVID-19 by Rapid Cleaning of Hospital Environment.	Hospitals, Medical Care Centres etc.	Transfer complete
41	UVC based Disinfection Cabinet (UVC Safe box and UVC Safe Blade Handheld) to Fight against COVID-19	Offices, Hospitals etc.	Transfer complete
42	Lithium Iron Phosphate (LFP) Cathode Materials Technology for Li-ion Batteries	Li-ion Batteries for Electric Vehicles	Transfer complete
43	Synthesis of Electrocatalysts for use in Fuel Cells	Fuel Cells	Transfer complete
44	Anti-reflective Sol from organic solvent based composition for solar PV glass	Solar PV glass	Transfer complete

Technologies Available For Adaptation / Ready For Transfer

S.N	Technology	Key Features	Possible Applications
01	Lithium Ion Battery (LIB) cell (LFP/graphite) fabrication technology	• Cylindrical/Prismatic cells with 3.2V, 2−50 Ah fabricated • Cyclic stability > 1200 cycles with > 85% capacity retention at 1C • Energy density 100-110 Wh/kg	Electric Mobility and Energy Storage Systems
02	LIB cell (NMC/graphite) fabrication technology	• Cylindrical/Prismatic cells with 3.6V, 2.5-25 Ah fabricated • Cyclic stability > 500 cycles with >80% capacity retention • Energy density 100-115 Wh/kg • Self-discharge < 3% per year • 2C charge/discharge with ΔT < 10 °C	Electric Mobility
03	Fe-P soft magnetic materials	• Bs (saturation induction) > 2 T • μmax (Permeability) ~ $1.5x10^4$ • Coercivity < 1 Oe • Core loss ~ 170 - 200 W/kg	Motors, Alternators, Relay and other electromagnetic devices
04	Skutterrudite thermoelectric materials and device	• Thermoelectric Figure of merit at 723 K is greater than 1.8. • Cost-effective materials	Recycling of the waste heat into power generation in heavy industries and other static applications
05	Exfoliated graphite and its value-added products	• Binder-free compaction of material • Shape-tailored material • Very lightweight • Density-controlled compaction • Sandwich or reinforced material with better mechanical properties • Efficient and cost-effective	• Flexible sheets • Flexible tapes • Bipolar plates • Seals • Reinforced seals, sheets and tapes • Ultra-lightweight boards
06	Scalable production of ultrathin graphene nanoplatelets	• Very high aspect ratio (width to thickness) • Majority of platelets are less than 10 nm in thickness • Compatible with almost all polymers • Thermally and electrically conductive • Contains naturally occurring functional groups like carboxyl and hydroxyl • Scalable production process (0.5 kgs per batch)	• Electrode for Supercapacitor • Thermally conductive additive • Electrically conductive additive • Wear and friction modifier • Additive for composite materials (polymer, metal and ceramic matrix) • Anode material for metal-ion batteries (Li, Na and K)
07	Layered two-dimensional graphene nanosheets for nanolubrication	• Various kinds of nanostructured carbon materials • Microwave irradiation for rapid synthesis • Surfactant-free dispersion in oil • Minimum quantity lubrication is focused in terms of additive concentration • Scalable manufacturing process (0.5 kgs per batch) • Homogeneous dispersion • Stability for a few months	• Engine oils for automobiles • Regenerative braking system • As grease additives in high load bearing joints • Thermal property enhancer in radiator coolants • Non-corrosive coatings for bottleneck joints
08	Transparent conducting Al:ZnO (AZO) thin film on a large area	• AZO thin films with high transmittance and conductivity on 300 mm x 300 mm glass substrate • Highly uniform films (Std deviation 2.65%) with visible light optical transmittance 84% and least resistivity of 4.07 X 10-4 Ω.cm. • Figure of merit confirms the suitability of AZO thin films for various optoelectronic device applications as compare to other existing Transparent Conducting Oxides (TCO) films	• Solar energy • Electrical and electronics • Sensors

S.N	Technology	Key Features	Possible Applications
09	CIGS thin film solar cells and monolithically integrated modules	• Unique non-toxic two-step, sputtering of precursor and atmospheric selenization process. • Device configuration: Ag/AZO/ZnO/CdS/CIGS/Mo/Glass • Tooled to make monolithically integrated CIGS thin film solar modules on 300 mm x 300 mm. • Potential to make devices on flexible substrates.	• Building integrated photovoltaics (BIPV) • DC power appliance
10	Molybdenum (Mo) thin film on a large area for metal contact application	• Mo thin films of 500 nm thickness using rotating DC magnetron on Soda Lime Glass (SLG) substrate of the size of 300 mm x 300 mm • High uniformity of thickness (Std. Dev. 3.17%), best electrical (resistivity of 1.59E-05 Ω.cm), mechanical and optical properties of Mo thin film over large area. • High reflectance in IR region • High adhesion strength on Mo to glass substrate	• Solar energy • Electrical and electronics • Sensors
11	Advanced detonation spray system	• PLC controlled system with easy programmable • Import or Export programs with a predefined template • Firing frequency enhanced to 6Hz from 3Hz • Integration of Mass Flow Controllers (MFCs) to control the flow rates precisely • Optimized process parameters for oxide & cermet coatings	• Aerospace • Power sector • Paper and pulp • Petrochemical • Agriculture
12	Cold spray coating technology - Issues:	• Programmed coating operation • Attractive ergonomics	Repair and refurbishment applications especially related to Cu, Al, Ti based materials
13	Micro Arc Oxidation Technology	• Ultra hard coatings up to 1800 HV on a variety of Al alloys • Ability to coat difficult to anodizable Al-Si cast alloys • Coatings for Wear, Corrosion, Thermal insulation and Fatigue tolerance • Coating thickness ranging from 10 – 100 microns • Patented in India and USA • Availability of custom built designs ranging from 25 kVA R&D scale to 450 kVA industry scale systems • Provide turnkey installation support for implementing the entire project	Textile, Automotive, Petrochemical, Wire-drawing, Electronics, Aerospace components needing wear, corrosion, fatigue resistances and thermal/electrical insulation properties
14	High Performance Varistor made from Doped ZnO Nanopowders	• Break down voltage 10-33 kV/cm • Low leakage current density 0.7μA/cm^2 • Coefficient of non-linearity (70-160) • Superior to the commercially available varistors	• Power distribution • Automobiles and Electronics
15	Bio-friendly Self-disinfecting coating on Fabric Against COVID-19, H1N1 and Bacteria	• Efficacy > 99.9% against gram positive and negative bacteria. • Efficacy ≥99.2% and≥ 99.997% against SARS-CoV-2 (CCMB) and H1N1 (Bureau Veritas), respectively (ISO 18184). • The four layers mask exhibited bacterial filtration efficiency ≥ 99.7% (ASTM F2101), particulate filtration efficiency at 0.3 microns : ≥ 99.3 (ASTM F 2299/F2299M-03: 2017) • Breathability: 61.2 Pa/cm2 (EN 14683: 2019). • Developed in collaboration with Centre for Cellular and Molecular Biology (CCMB) and Resil Chemicals Pvt. Ltd. • Splash resistance and water repellent and classified as class 1 in flammability test	• Self-disinfection mask • Medical suits • Medical textiles Sports textiles

S.N	Technology	Key Features	Possible Applications
16	Hydroxyapatite Nanopowders for Biomedical Applications	• Ca10(PO4)6 (OH)2 particle size having less than 23 nm with narrow size distribution • Phase purity greater than 99% • Process parameters for production of phase pure HAP and mixture of HAP and Ca3(PO4)2 (TCP) nanopowders of different sizes at 1 Kg level have been optimized	• Bone tissue engineering; Bone void fillers for orthopedic, traumatology, spine, maxillofacial & dental surgery • Orthopedic and dental implant coating; Restoration of periodontal defects • Desensitizing agent in post teeth bleaching; Remineralizing agent in toothpastes
17	Nano-sized Lithium Titanium Oxide (LTO) Material for High Power Li-ion Battery Application	• Process for the large-scale production (15 kg/batch) of LTO was developed. • LTO delivers a superior rate capability of 145 mAh/g at 4C with good cyclic stability • Patented in India, USA, and China	• Electrode material for rechargeable batteries in electric vehicles • Stationary storage applications
18	Petcoke-based high energy Supercapacitor and its demonstration for EV Application	• Process for the production of supercapacitor grade porous carbon • Indigenous Supercapacitor devices of 1200 F, 2.7V and 1.2Wh produced. • Supercapacitor module of 75F, 43V, 19.2 Wh demonstrated • Developed in collaboration with Hindustan Petroleum Corporation Limited (HPCL), Bengaluru	• Automotive (E-bicycle, public transportation) • Stationary energy storage applications • Smart grid applications
19	Two-dimensional tungsten disulfide and molybdenum disulfide powder	• Production capability: 1 kg per day (scalable up to 2 kg per day) using the existing pilot-scale reactor. • Particle size: Can be customized based on required use or properties. Typical size: thickness = 8 to 12 nm, lateral dimension = 800 to 1200 nm • Thermal stability: Up to 350oC in air for free-standing 2D-WS2 powder (Up to 450 oC in composite form); Up to 250 oC in air for free-standing 2D-MoS2 powder. • Purity: Grade I: 99%+ purity; Grade 2: 98% purity (with up to 2% C)	• As a solid lubricant. • As nano-additive to automotive lube oil for enhanced performance. • As nano-additive to EP-Grease for improved performance. • As casting and forging mould release lubricant additive. • For polymer bonded lubricating coatings. • As a candidate for petrochemical and hydrogen evolution reaction catalyst.
20	Sol-gel product developed to impart anti-bacterial (AB) property to an abrasive pad made of non-woven nylon fabric	• AB sol-gel formulation can be deposited as a top coat on the finished abrasive pad • AB powder product can be used as an additive to resin and abrasives mix to apply on a semi-finished abrasive pad • AB properties with a zone of inhibition and > 95% log reduction of bacterial strains, E. coli, S. aureus and K. pneumoniae	Scrub pads for domestic and industrial application
21	Sol-gel coating formulation for imparting anti-bacterial property by inhibiting the biofilm formation	• Aqueous formulation • Room temperature curable coating • Anti-bacterial • Hydrophobic • Improved mechanical properties at 800C curing temperature	• Surgical sutures, • Contact lens case, • Hearing aids and surgical instruments"

ARCI
Patent Portfolio

National Patents Granted

S.N	Title of Patent	Patent Number	Date of Grant	Application Number	Date of Filing
01	A solar drier	184674	23/09/2000	487/MAS/1994	08/06/1994
02	A solar cooker	184675	25/05/2001	498/MAS/1994	13/06/1994
03	An indirect heated catalytic converter for use with vehicles	185433	10/08/2001	809/MAS/1994	25/08/1994
04	A process for the preparation of short ceramic fibres	186751	07/06/2002	537/MAS/1994	20/05/1994
05	A process of producing chemically treated expanded graphite and a device having such graphite	187654	05/12/2002	562/MAS/1994	07/06/1995
06	A process for preparation of reaction bonded silicon carbide components	195429	31/08/2006	1886/MAS/1996	28/10/1996
07	New composite material having good shock attenuating properties and a process for the preparation of said material	194524	02/01/2006	976/MAS/1998	06/05/1998
08	Improved process for the preparation of magnesium aluminate spinel grains	200272	02/05/2006	29/MAS/1999	07/01/1999
09	Ceramic honey comb based energy efficient air heater	200787	02/06/2006	30/MAS/1999	07/01/1999
10	A process for the preparation of improved alumina based abrasive material, an additive composition and a process for the preparation of the composition	198068	16/02/2006	122/MAS/2000	18/02/2000
11	A process for the production of dense magnesium aluminate spinel grains	198208	16/02/2006	520/MAS/2000	06/07/2000
12	An improved method for making honeycomb extrusion die and a process for producing ceramic honeycomb structure using the said die	198045	13/01/2006	538/MAS/2001	03/07/2001
13	Device for gas dynamic deposition of powder materials	198651	25/01/2006	944/MAS/2001	22/11/2001
14	An evaporation boat useful for metallization and a process for the preparation of such boats	201511	01/03/2007	882/CHE/2003	31/10/2003
15	Process for carbothermic reduction of iron oxide in an immiscible flow with constant descent in vertical retort of silicon carbide	205728	09/04/2007	546/CHE/2003	01/07/2003
16	A process for preparing ceramic crucibles	207700	20/06/2007	806/MAS/2000	26/09/2000
17	A process for forming coatings on metallic bodies and an apparatus for carrying out the process	209817	06/09/2007	945/MAS/2001	22/11/2001
18	A method and a device for applying a protective carbon coating on metallic surfaces	211922	13/11/2007	719/MAS/1999	08/07/1999
19	An improved boronizing composition	220370	27/05/2008	289/MAS/2001	03/04/2001
20	Titanium based biocomposite material useful for orthopaedic and other implants and a process for its preparation	228353	03/02/2009	2490/DEL/2005	14/09/2005
21	An improved method of forming holes on a substrate using laser beams	239647	29/03/2010	3205/DEL/2005	29/11/2005
22	A method of and an apparatus for continuous humidification of hydrogen delivered to fuel cells	247547	19/04/2011	670/CHE/2007	30/03/2007
23	An improved process for the preparation of doped zinc oxide nanopowder useful for the preparation of varistors	254913	03/01/2013	1669/DEL/2006	20/07/2006
24	A device for controlling the on & off time of the metal oxide semi conductor field effect transistor (MOSFET), a device for spark coating the surfaces of metal workpiece incorporating the said control device and a method of coating metal surfaces using the said device	262189	05/08/2014	1610/DEL/2005	21/06/2005

S.N	Title of Patent	Patent Number	Date of Grant	Application Number	Date of Filing
25	An improved catalyst ink useful for preparing gas diffusio electrode and an improved PEM fuel cell	277778	30/11/2016	680/DEL/2008	18/03/2008
26	An improved process for the preparation of exfoliated graphite separator plates useful in fuel cells, the plates prepared by the process and a fuel cell incorporating the said plates	281504	20/03/2017	1206/DEL/2006	17/05/2006
27	Improved method of producing highly stable aqueous nano titania suspension	282988	28/04/2017	730/DEL/2009	09/04/2009
28	A process for the preparation of nanosilver and nanosilver-coated ceramic powders	284812	30/06/2017	2786/DEL/2005	19/10/2005
29	An improved method for preparing nickel electrodeposited having predetermined hardness gradient	285178	14/07/2017	1455/DEL/2009	15/07/2009
30	An improved method for the generation of hydrogen from a metal borohydride and a device therfor	285257	17/07/2017	1106/DEL/2007	23/05/2007
31	Improved process for the preparation of stable suspension of nano silver particles having antibacterial activity	289543	14/11/2017	1835/DEL/2010	04/08/2010
32	Improved method for producing carbon containing silica aerogel granules	290370	07/12/2017	2406/DEL/2010	08/10/2010
33	An improved composition for coating metallic surfaces, and a process for coating such surfaces using the composition	290592	14/12/2017	620/DEL/2010	17/03/2010
34	Improved catalyst ink for catalyst coated membrane of electrode membrane assembly and the process thereof	290765	18/12/2017	631/DEL/2008	13/03/2008
35	Improved process for the preparation of bi-functional silica particles useful for antibacterial and self cleaning surfaces	291408	04/01/2018	3071/DEL/2010	22/12/2010
36	A hydrophilic membrane based humidifier useful for fuel cells	291871	18/01/2018	95/DEL/2007	16/01/2007
37	An improved method for producing ZnO nanorods	293775	05/03/2018	2759/DEL/2010	19/11/2010
38	Improved scratch and abrasion resistant compositions for coating plastic surfaces, a process for their preparation and a process for coating using the compositions	295221	28/03/2018	2427/DEL/2010	12/10/2010
39	An improved abrasion resistant and hydrophobic composition for coating plastic surfaces and a process for its preparation	297072	24/05/2018	1278/DEL/2011	02/05/2011
40	Improved fuel cell having enhanced performance	301158	19/09/2018	606/DEL/2007	20/03/2007
41	An improved process for preparing nanotungsten carbide powder useful for fuel cells	303338	22/11/2018	81/DEL/2007	12/01/2007
42	An improved solar selective multilayer coating and a method of depositing the same	303791	30/11/2018	1567/DEL/2012	22/05/2012
43	An improved method of preparing porous silicon compacts	304349	12/12/2018	912/DEL/2011	31/03/2011
44	An improved coating composition to provide flame retardant property to fabrics and process of preparing the same	305214	01/01/2019	201611040091	23/11/2016
45	An improved process for producing silica aerogel thermal insulation product with increased efficiency	305898	18/01/2019	2141/DEL/2015	15/07/2015
46	Novel copper foils having high hardness and conductivity and a pulse reverse electrodeposition method for their preparation	306501	29/01/2019	1028/DEL/2009	19/05/2009
47	A process for preparing nanocrystalline olivine structure transition metal phosphate material	310620	31/03/2019	405/DEL/2012	14/02/2012
48	Process for producing anti-reflective coatings with scratch resistance property	314900	27/06/2019	1777/DEL/2012	11/06/2012

S.N	Title of Patent	Patent Number	Date of Grant	Application Number	Date of Filing
49	A method for synthesis of tungsten disulphide nanosheets	320209	11/09/2019	1703/DEL/2012	04/08/2012
50	Improved magnetron cathode and a process for depositing thin films on surfaces using the said cathode	320582	16/09/2019	21/DEL/2008	03/01/2008
51	Fuel cell system equipped with oxygen enrichment system using magnet	321825	27/09/2019	2985/DEL/2012	25/09/2012
52	An improved hybrid methodology for producing composite multilayered and graded coatings by plasma spraying utilizing powder and solution precursor feedstock	323443	22/10/2019	2965/DEL/2011	17/10/2011
53	A high thermal stable selective solar absorber layer with low emissive barrier coating over a substrate and a process of producing the same	323497	23/10/2019	3312/DEL/2012	29/10/2012
54	Catalytically and chemically modified carbon nanostructures for storage of hydrogen	323653	24/10/2019	405/CHE/2013	30/01/2013
55	An improved process for preparation of nanosilver coated ceramic candle filter	327532	17/12/2019	1249/DEL/2011	28/04/2011
56	An improved gas flow field plate for use in polymer electrolyte membrane fuel cells (PEMFC)	332242	18/02/2020	2339/DEL/2008	13/10/2008
57	Production of graphene-based materials by thermal spray	335723	22/04/2020	2626/DEL/2015	25/08/ 2015
58	Method of producing multifunctional self assembled mixed phase titania spheres	335724	22/04/2020	3777/DEL/2014	19/12/2014
59	A method and an apparatus for preparing nickel tungsten based nanocomposite coating deposition	337108	20/05/2020	201611001190	13/01/2016
60	A novel electrochemical method for manufacturing cigs thin film containing nanomesh like structure	337455	28/05/2020	426/DEL/2015	16/02/2015
61	An improved process to make coating compositions for transparent, UV blocking coatings on glass and a process of coating the same	338641	17/06/2020	1152/DEL/2014	29/04/2014
62	A polymer electrolyte membrane (PEM) cell and a method of producing hydrogen from aqueous organic solutions	338862	19/06/2020	3313/DEL/2012	29/10/2012
63	Methods of preparation of high performance ZnO varistors and improved compositions	339072	22/06/2020	2765/DEL/2015	03/09/2015
64	Process for producing anti-reflective coatings with anti-fogging (super hydrophilic), UV, weather and scratch resistance properties	339326	25/06/2020	2919/DEL/2013	03/10/2013
65	Enhanced thermal management systems for fuel cell applications using nanofluid coolant	339836	30/06/2020	1745/DEL/2012	07/06/2012
66	An improved composition for coating anodizable metal surfaces and a process of coating the same`	339945	30/06/2020	1310/DEL/2013	03/05/2013
67	An improved composition for solar selective coatings on metallic surfaces and a process for its preparation and a process for coating using the composition	340426	03/07/2020	3324/DEL/2011	22/11/ 2011
68	Method of producing nano structured C-TiO2 composite material for visible light active photocatalytic self-cleaning applications	340592	06/07/2020	201811011478	28/03/2018
69	An improved composition for antireflective coating with improved mechanical properties and a process of coating the same	342046	20/07/2020	2330/DEL/2013	05/08/2013
70	An improved process for obtaining a transparent, protective coating on bi-aspheric / plano-convex lenses made of optical grade plastics for use in indirect ophthalmoscopy	343375	05/08/2020	3072/DEL/2013	17/10/2013
71	A novel laser surface modification technique for hardening steel	343960	12/08/2020	337/DEL/2013	06/02/2013
72	An improved performance of nanocomposite oxide selective absorber coating with excellent optical and thermal resistant properties and method of manufacturing the same	345443	28/08/2020	1111/DEL/2015	22/04/2015

S.N	Title of Patent	Patent Number	Date of Grant	Application Number	Date of Filing
73	Method of producing hollow MgF2 nanoparticles, anti-reflection coating sols and coatings for optical and solar applications	348807	07/10/2020	201611041804	07/12/2016
74	A process to improve strength and fatigue life of HR grade low carbon steel sheet by laser surface hardening adaptable to produce automotive component	349560	19/10/2020	600/KOL/2012	25/05/2012
75	A method of preparation of supported platinum nano particle catalyst in tubular flow reactor via polycol process	350276	28/10/2020	1571/DEL/2013	24/05/2013
76	Electronically and ionically conducting multi-layer fuel cell electrode and a method for making the same	351830	20/11/2020	2198/DEL/2012	17/07/2012
77	Method of deposition of double perovskite of Sr-Fe Niobium oxide film on a substrate by spray coating technique and the coated substrate thereof	356708	27/01/2021	1151/DEL/2014	29/04/2014
78	Ambient condition curable transparent super hydrophobic coating for easy to clean applications and method of producing the same	361991	18/03/2021	201911009429	11/03/2019
79	A method of producing high performance lithium titanate anode material for lithium ion battery applications	365560	28/04/2021	201711006147	21/02/2017
80	A method of preparing of anti-tarnishing organic-inorganic hybrid sol-gel and coating the same	366131	05/05/2021	2049/DEL/2015	07/07/2015
81	An improved process for preparing durable multifunctional coatings on metal/alloy substrates	366262	06/05/2021	201711020529	12/06/2017
82	An improved test control system useful for fuel cell stack monitoring and controlling	366702	14/05/2021	269/DEL/2013	31/01/2013
83	Exfoliated graphite separator-based electrolyzer for hydrogen generation	369206	14/06/2021	3073/DEL/2013	17/10/2013
84	A device for and a method of cooling fuel cells	370365	25/06/2021	1408/DEL/2012	08/05/2012
85	An improved coating composition to provide prolonged corrosion protection to anodizable metal surfaces and process of preparing the same	370802	30/06/2021	3082/DEL/2015	28/09/ 2015
86	Multi-track laser surface hardening of low carbon cold rolled closely annealed (CRCA) grades of steels	375427	26/08/2021	1411/KOL/2013	13/12/2013
87	An improved process of carbon - metal oxide composites prepared by nano casting of wood and the product thereof	376509	06/09/2021	201611034531	07/10/2016
88	An improved method for making sintered polycrystalline transparent sub-micron alumina article	378836	07/10/2021	1358/DEL/2011	10/05/2011
89	A process and a multi-piston hot press for producing powder metallurgy component, such as cerametallic friction composite	379250	13/10/2021	3844/DEL/2011	28/12/ 2011
90	A super hydrophobic coating with high optical properties having easy to clean property, UV and corrosion resistance properties, a process of preparation and application of the same	382971	29/11/2021	402/DEL/2014	13/02/2014
91	A system for treating a surface of bearing components and a process thereof	388398	03/02/2022	201711046511	23/12/2017
92	Process for producing the nano Boron by cryo-milling	391804	11/03/2022	201911025690	27/06/2019

National Patent Applications Awaiting Grant

S.N	Title of Patent Application	Application Number	Date of Filing
01	Novel ceramic materials having improved mechanical properties and process for their preparation	3396/DEL/2005	19/12/2005
02	An improved gas and coolant flow field plate for use in polymer electrolyte membrane fuel cells (PEMFC)	1449/DEL/2010	22/06/2010
03	An improved aqueous method for producing transparent aluminium oxy nitride (ALON) articles	1409/DEL/2012	08/05/2012
04	An improved solar selective absorber coating with excellent optical absorptance, low thermal emissivity and excellent corrosion resistance property and a process of producing the same	1129/DEL/2013	16/04/2013
05	High temperature polymer electrolyte membrane fuel cells with exfoliated graphite based bipolar plates	494/DEL/2014	20/02/2014
06	Method of producing porous MgF2 nanoparticles, antireflection coating suspension and coatings for solar optical UV and IR transparent window applications	4041/DEL/2014	31/12/2014
07	Process and apparatus for protection of structural members from wear, corrosion and fatigue damage	1839/DEL/2015	22/06/2015
08	Solar selective coating for solar energy collector / absorber tubes with improved performance and a method of producing the same	2142/DEL/2015	15/07/ 2015
09	A process for in-situ carbon coating on alkali transition metal oxides	201611007451	03/03/2016
10	An improved process for the preparation of stable nano silver suspension having antimicrobial activity	201611027145	09/08/2016
11	A laser-based surface processing apparatus and a method to process metallic materials and components	201611034362	07/10/2016
12	A method for producing inorganic bonded silica based eco-friendly artificial marble articles and the product thereof	201611036479	25/10/2016
13	Method of producing graphene like structured nanoporous carbon material from jute stick based bio-waste for energy storage applications and the product thereof	201711006697	24/02/2017
14	An improved gas dynamic cold spray device and method of coating a substrate	201711006749	26/02/2017
15	A novel equipment to accomplish power metallurgy processing starting from the 'raw materials' to finished product	201711011552	30/03/2017
16	An ecofriendly incinerator to dispose of the used sanitary napkins and bio medical waste	201821021430	07/06/2018
17	Process for preparing durable solar control coatings on glass substrates	201811024034	27/06/2018
18	Laser based clad-coatings for protecting the power plant components for life enhancement	201811039663	19/10/2018
19	Process of electroless nickel/nickel phosphide (EN) deposition on graphite substrates	201811041418	01/11/2018
20	A grid independent fuel cell system with a unitized (DC & AC) power conditioner	201911006700	20/02/2019
21	Refurbishment of aircraft components using laser cladding	201911007994	28/02/2019
22	Microwave assisted sol-gel process for preparing in-situ carbon coated electrode materials and the product thereof	201911008004	28/02/2019
23	Method of fabricating tungsten based composite sheets by spark plasma sintering technique for making components	201911014933	13/04/2019
24	Transition metal-based solar selective absorber coated substrate and method of manufacturing the same	201911019139	14/05/2019
25	Process for producing the nano boron by cryo-milling	201911025690	27/06/2019

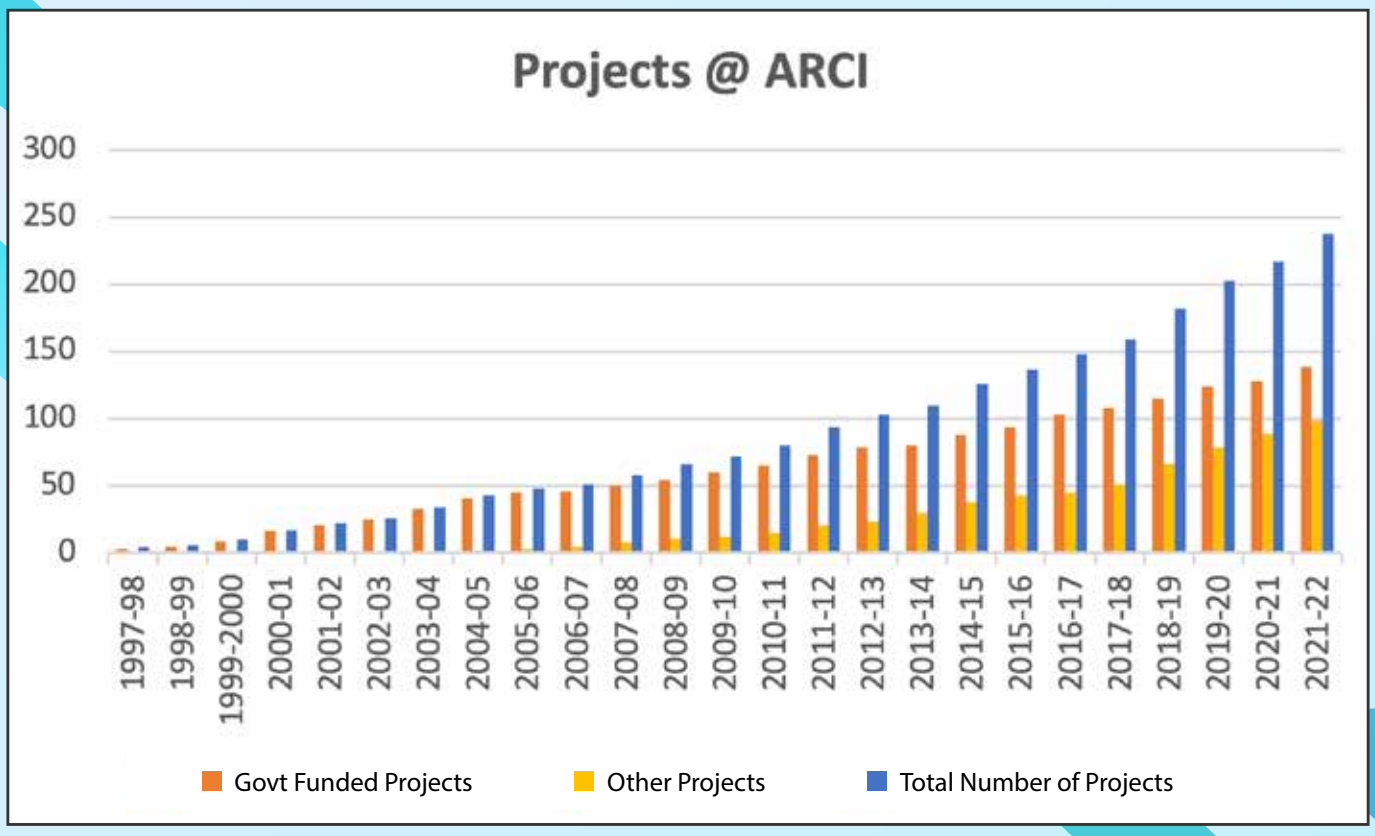
S.N	Title of Patent Application	Application Number	Date of Filing
26	Method of preparing gas diffusion layer for the electrode of ECMR cell for hydrogen generation	201911030852	31/07/2019
27	Antimicrobial aqueous based sol-gel composition for coating on substrate and process of preparing the same	201911045386	07/11/2019
28	A method of preparing the thermoelectric module for power generation from automotive exhaust and the thermoelectric module thereof	201911045857	11/11/2019
29	Method of producing nanoporous graphene sheet-like structured high and low surface area carbon sheets from petroleum coke	202011007399	20/02/2020
30	Method of producing carbon nanostructure materials for heat transfer, lubrication and energy storage applications	202011017775	25/04/2020
31	A device for disinfecting and/or decontaminating personal protective equipments and themethod thereof	202011020124	13/05/2020
32	Method for preparing multifunctional isotropic and uni-directional superhydrophoic surfaces on substrates using femtosecond laser	202011022242	27/05/2020
33	Method of producing porous particles-fibers carbon composite material for supercapacitorapplications and the product thereof	202011027265	26/06/2020
34	Method of preparation of carbon supported platinum electrode catalyst for PEM fuel cells and product thereof	202011035825	20/08/2020
35	A device and method for converting sunlight into heat energy using semiconducting materials immersed in a stable organic solvent for electricity generation	202041039082	10/09/2020
36	Oxide dispersion strengthened iron aluminides with high strength and ductility andmethod of preparation of the same	202011044124	09/10/2020
37	Method of manufacturing the catalyst coated membrane for the proton exchange membrane fuel cells	202011046496	25/10/2020
38	Method of producing single layer omnidirectional broadband antireflective and super hydrophilic coatings for solar and other applications	202011051833	27/11/2020
39	Process for the fast formation of solid electrolyte interphase layer on the anode surface in lithium-ion battery	202011052906	04/12/2020
40	Method of producing in-situ carbon coated lithium iron phosphate cathode material for lithium ion batteries	202011056608	28/12/2020
41	Biofilm inhibiting sol-gel composition for coating on substrates and process of preparing the same	202111001104	11/01/2021
42	Post-calcination modification of morphology and improvement of coercivity in high energy-milled strontium hexaferrite powders	202111003235	23/01/2021
43	A method of producing strontium hexaferrite powders having high coercivity suitable for bonded magnets	202111008252	26/02/2021
44	Method of preparation of highly efficient skutterudite thermoelectric materials for thermoelectric modules and the product thereof	202111036278	11/08/2021
45	Directed energy deposition by means of laser using novel vario-build technology	202111037254	17/08/2021
46	Antibacterial scrub pads and process of preparing the same	202111041925	16/09/2021
47	Durable corrosion resistant coating for fuel cell separator and the process thereof	202111051526	10/11/2021
48	Method for reducing friction on metallic substrates by preparing micro dimpled textures by ultrafast laser	202111051880	12/11/2021
49	Autogenous laser welding system and method for joining thick metallic parts without filler wire feeder	202211005404	01/02/2022
50	Anti-clogging cold-spray nozzle to deposit clog-prone materials	202211017972	28/03/2022

International Patent Applications – Granted and Awaiting Grant

S.N	Title of Patent	Country	Patent Number/ Application Number	Date of Grant	Date of Filing with the Patent Office
01	Process for forming coatings on metallic bodies and an apparatus for carrying out the process	USA	US6893551B2	17/05/2005	02/08/2002
02	A device for controlling the on & off time of the metal oxide semiconductor field effect transistor (MOSFET), a device for spark coating the surfaces of metal workpiece incorporating the said control device and a method of coating metal surfaces using the said device	USA	US8143550B2	27/03/2012	20/03/2006
03	A process for the preparation of nanosilver and nano silver-coated ceramic powders	South Africa	2006/8591	30/04/2008	13/10/2006
		Sri Lanka	14258	02/11/2011	17/10/2006
		Indonesia	IDP000044402	06/02/2017	18/10/2006
04	A process for continuous coating deposition and an apparatus for carrying out the process	South Africa	2009/06786	26/05/2010	30/09/2009
		UK	2464378	15/05/2013	02/10/2009
		USA	US8486237B2	16/07/2013	14/10/2009
		Japan	5442386	27/12/2013	15/10/2009
		France	2937342	18/12/2015	12/10/2009
05	Method of depositing electrically conductive electrode material onto the surface of an electrically conductive work piece	USA	US8674262B2	18/03/2014	12/08/2011
06	Improved process for the preparation of stable suspension of nano silver particles having antibacterial activity	UK	GB2496089	18/06/2014	19/07/2011
07	A process for continuous coating deposition and an apparatus for carrying out the process	USA	US9365945B2	14/06/2016	17/08/2012
08	An improved hybrid methodology for producing composite, multilayered and graded coatings by plasma spraying utilizing powder and solution precursor feedstock	South Africa	2012/02480	28/11/2012	05/04/2012
		Canada	2784395	16/09/2014	31/07/2012
09	Multi-track laser surface hardening of low carbon cold rolled closely annealed (CRCA) grades of steels	USA	US11186887B2	30/11/2021	10/12/2014
		Australia	AU2014362928	21/02/2019	10/12/2014
		Europe	EP3080313A1	---	10/12/2014
10	A method of producing high performance lithium titanate anode material for lithium ion battery applications	Japan	2019-520394	---	10/04/2019
		Germany	112018000205.5	---	28/06/2019
		USA	US11001506	11/05/2021	22/05/2019
		China	CN110023245B	11/01/2022	22/05/2019
		Korea	10-2019-7019218	---	02/07/2019
11	An improved gas dynamic cold spray device and method of coating a substrate	Russia	2744008	01/03/2021	24/09/2019
12	Microwave assisted sol-gel process for preparing in-situ carbon coated electrode materials and the product thereof	Japan	2020-550159	---	16/09/2020
		Republic of Korea	10-2020-7025994	---	09/09/2020
		Europe	20763813.1	---	11/09/2020
13	Method of producing single layer omnidirectional broadband antireflective and super hydrophilic coatings for solar and other applications	---	PCT/IN2021/051099	---	25/11/2021
14	Method of producing in-situ carbon coated lithium iron phosphate cathode material for lithium-ion batteries and the product thereof	---	PCT/IN2021/051138	---	06/12/2021

Projects at ARCI

ARCI during the course of its journey of 25 years has contributed to the research and development (R&D) of advanced materials, processes and systems in the areas of powder metallurgy, nanomaterials, surface engineering, laser processing of materials, energy materials and systems etc. ARCI has implemented several projects by engaging with various Government and Private organizations through various modes including sponsored R&D and contract R&D programmes. The projects undertaken by ARCI have catered to application development in strategic sectors as well as to other industrial segments like manufacturing, automotive, solar energy etc. In the past 25 years, ARCI has contributed to about 240 such projects. In addition to these, ARCI has also undertaken many other assignments in the form of job works and characterization to provide technical solutions to the industry.



Cumulative representation of Projects undertaken by ARCI in 25 years

List of of Projects undertaken by ARCI during the year 2021-22 is as follows:

S.No	Topic	Funding Body
1	Smart hydrogen supply chain supported polymer electrolyte membrane fuel cell in telecom tower power backup	DST
2	Integrated Clean Energy Material Acceleration Platform (IC-MAP)	DST
3	Development of C/C-SiC, C/C-ZrC and C/C-SiC-ZrC based composites through Reactive Melt Infiltration (RMI)	VSSC, ISRO
4	Development of hard chrome replacement Ni based alloy coating for gun barrel application using pulsed current electrodeposition	ARMREB-DRDO
5	Centre for electrochemical energy storage: Design, development, fabrication and evaluation of utility-scale high-performance batteries	SERB
6	Development and pilot-scale production of a novel nano fertilizer nDAP and a nanobiopesticide Harpin loaded Chitosan	DST
7	Recycling of polymer electrolyte membrane fuel cell for use as an electrolyte in all solid state lithium battery	SERB
8	Teachers associateship for research excellence (TARE)	SERB
9	Technical Research Centre (PHASE-2)	DST
10	Fabrication of cost effective new transparent conductive material by inkjet printing for touch sensing application	SERB
11	Advanced processing technology development for rare earth magnets for automotive and EV application	SERB
12	Reclamation of 7 pinion housing through laser cladding	SERB
13	Synthesis of high purity high surface area Iron : properties optimization & literature survey	TATA Steel Ltd
14	Vacuum melting and gas atomization in Argon atmosphere to produce spherical powders	Naval Materials Res Lab
15	Development of AM process for M2 tool steel	TATA Steel Ltd
16	Development of Hydrophonic coating on spinel Dome	RCI
17	Development of rust preventive and ready paintable universal coating system on CRCA and GI steel sheet	TATA Steel Ltd
18	Development of reagent formulation and process for the surface cleaning of low gas expansion glass ceramics	RCI
19	Development of oxidation corrosion resistant coating for aerospace	United Technologies Corporation India
20	Development and fabrication of NBA Sodium beta Alumina Ceramics	RCI (DRDO)
21	Development of Novel & low cost porous Carbon materials for high performance super capacitor and their application for e-mobility	HPCL

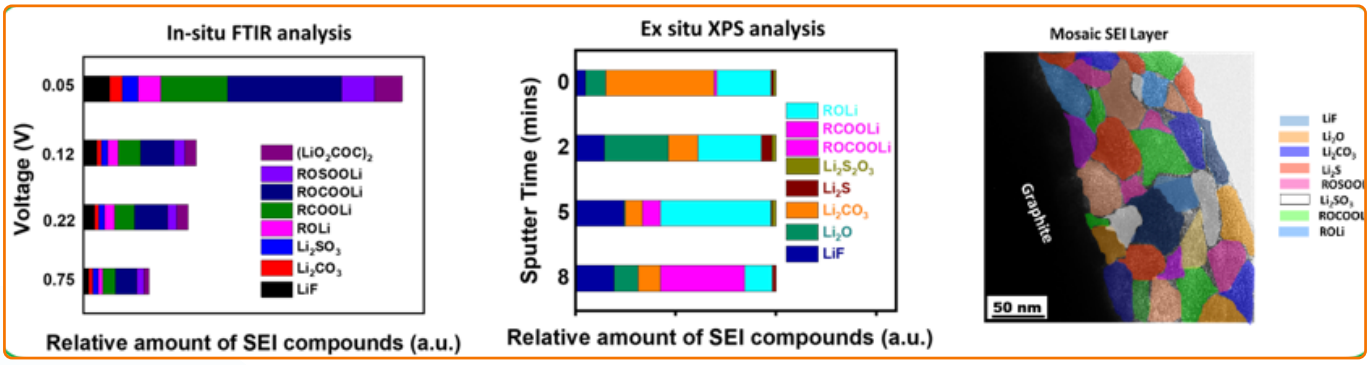
Research Highlights

Research Highlights

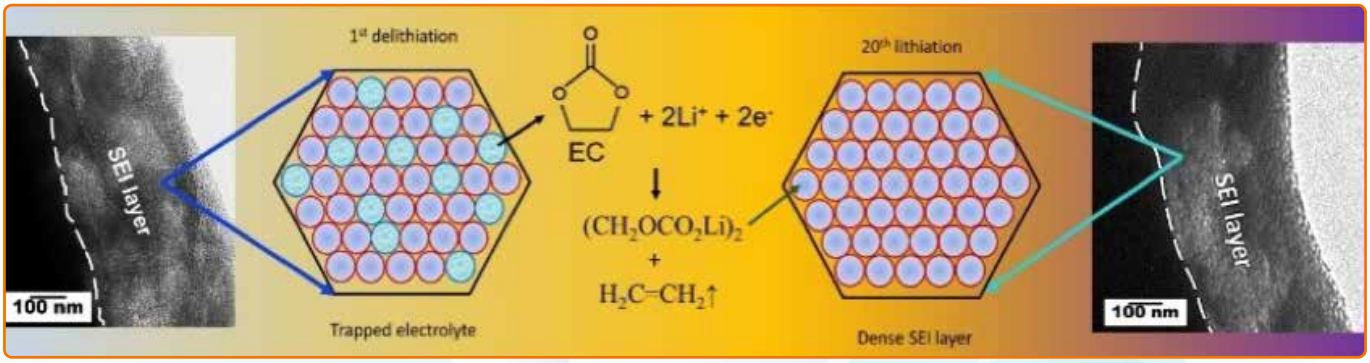
Composition-Dependent Long-Term Stability of Mosaic Solid-Electrolyte Interface for Long-Life Lithium-Ion Battery

Contributors: R. Prakash, V. R. Rikka, S. R. Sahu, R. Gopalan, G. Sundararajan

Lithium-ion batteries (LIBs) have emerged as vital energy storage devices for stationary and mobility applications due to their higher cycle life, fast charging, and safety. Graphite is the most commonly used anode material in LIBs. During the formation process, a thin passivation layer (as a solid electrolyte interface (SEI) layer) forms on the graphite anode. The SEI layer determines the fast charging capability and cycle life of a lithium-ion battery. An in-depth investigation of the mosaic SEI layer formation, growth, and stability at different C-rates (0.05-0.5 C) confirmed that the inorganic and organic compositions of the SEI layer are governed by the current density-dependent formation process. The inorganic compounds' rich outer SEI layer and organic compounds' rich inner SEI layer formed after the first lithiation are found to help in preventing SEI breakdown and growth during cycling. The SEI layer densifies during cycling as a result of the decomposition of the entrapped electrolyte. The composition dependent stability of the mosaic SEI layer opens up a new avenue for extending the cycle life of LIBs.



SEI compositions at various voltages and sputter time; mosaic SEI layer model.



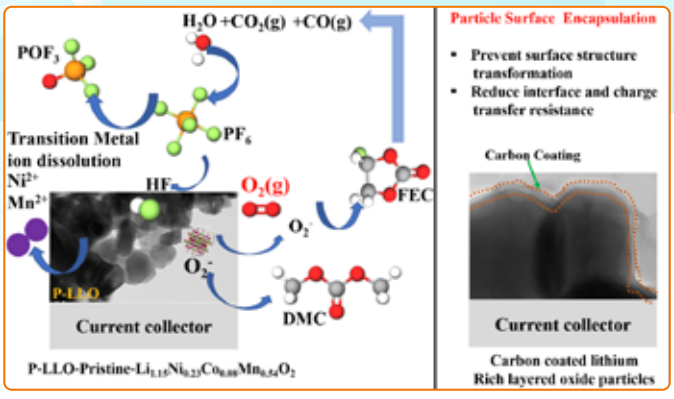
The "sponge model" of the mosaic SEI layer for initial and after cycling

Reference: Batter. Supercaps, 2021, 4, 1-12.

Surface Oxygen Vacancy Engineering and Physical Protection by In-Situ Carbon Coating Process of Lithium Rich Layered Oxide

Contributors: M. B. Sahana, S. Vasu and R. Gopalan

Lithium-rich layered oxide (LLO) , with a large specific capacity (> 250 $mAhg^{-1}$) and a wider voltage window (2.0 – 4.8 V), delivers an energy density of about 1000 Wh/kg. However, oxygen release from the surface of LLO and decomposition of electrolyte solvents lead to increased electrode-electrolyte interface resistance. A novel in-situ carbon encapsulation on $Li_{1.15}Ni_{0.23}Co_{0.08}Mn_{0.54}O2$ by the industrially viable co-precipitation process followed by solid-state reaction is developed to engineer the oxygen vacancies at the surface. Carbon-coated LLO retains an excellent capacity of 94% after 300 cycles at 2C rate cycling, while the pristine LLO retained only 77.8% of capacity.



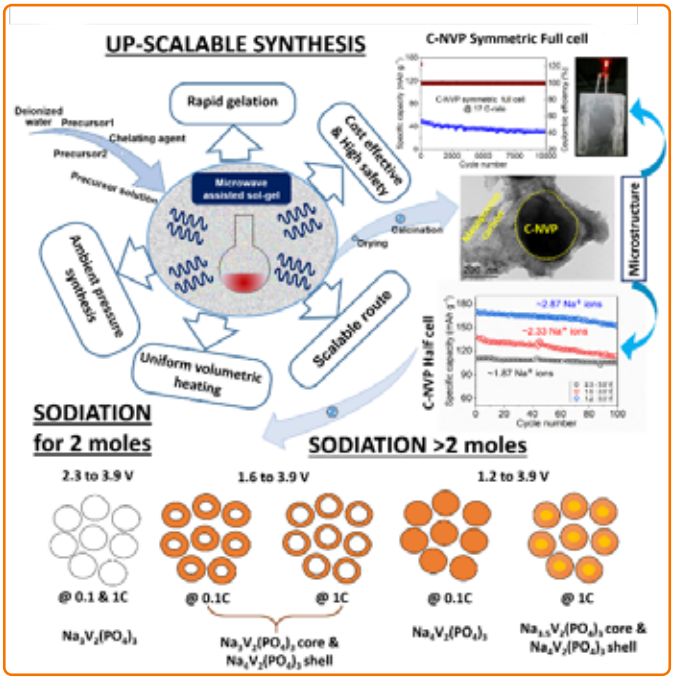
Reference: J. Power Sources, 515, 2021, 230623

Development of Sodium Ion Battery for Stationary and Grid Energy Storage Applications

Contributors: Bijoy Kumar Das, P. Laxman Mani Kanta, N. Lakshmi Priya, R. Gopalan, G. Sundararajan

The growing demand for the production of renewable energies such as wind and solar to reduce the carbon footprint, critically require a large-scale energy storage solution of low-cost, high efficiency and long durability for the smooth integration into grids and thus ensuring grid sustainability. Sodium-ion batteries (SIBs) have been considered as an attractive energy storage system due to their elemental abundance and encouraging electrochemical performance. The main objective is to develop the SIB from the indigenously developed electrodes and electrolytes. The in-situ carbon coated NASICON-type sodium vanadium phosphate ($Na_3V_2(PO_4)_3$) , prepared through ultra-fast gelation using microwave, has shown high and stable specific capacity (Fig.). The carbon coated ($Na_3V_2(PO_4)_3$) showed ~102 mAh/g at 1C-rate which is stable up to 500 cycles with a capacity retention of 92%. Medium scale synthesis (250 g/ batch) of these cathodes has been accomplished.

Reference: ACS Applied Energy Materials 4 (2021) 12581-12592: Japanese patent JP2020550159 (Accepted for Grant).

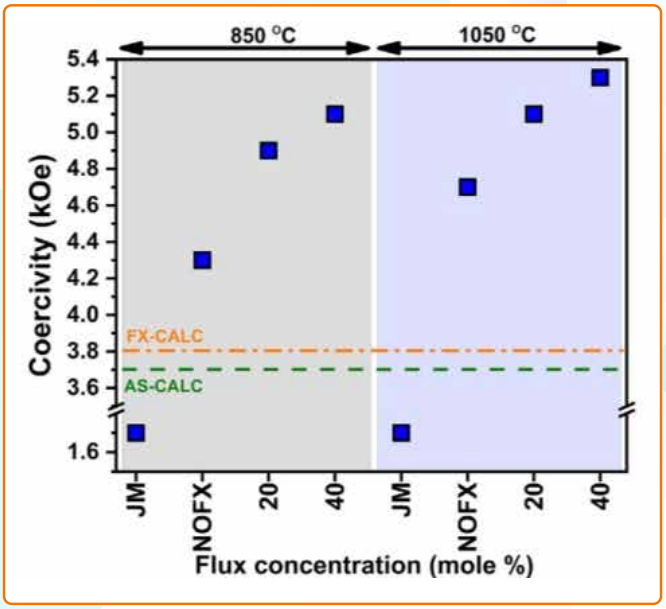


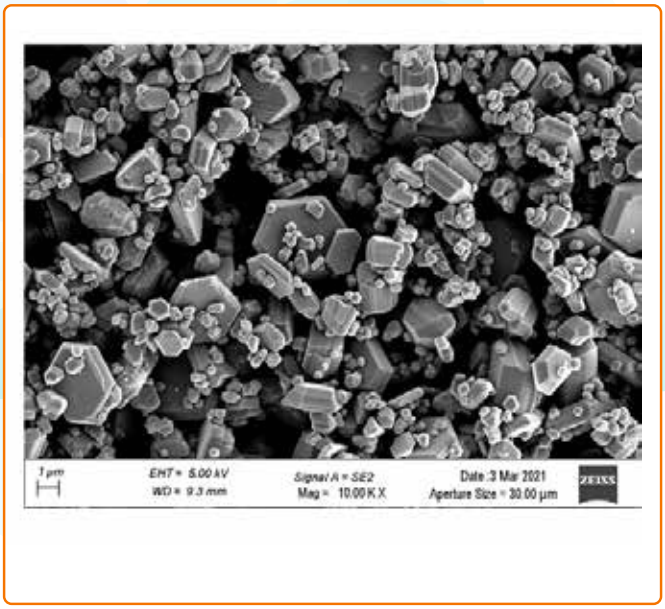
Synthesis of in-situ carbon coated $Na_3V_2(PO_4)_3$ for energy storage applications.

NaCl Flux-treated Strontium Hexaferrite Powders for Anisotropic Bonded Magnet Applications

Contributors: D. Prabhu, U.V. Varadaraju, Pavana S.V. Mocherla, Priya Ganesan, R. Gopalan

Annealing is a critical step in the preparation of anisotropic strontium hexaferrite powders for removing the milling-induced strain. As part of the ongoing magnetic materials program at the Centre for Automotive Energy Materials, ARCI, a novel method of post-synthesis annealing using NaCl flux of milled strontium hexaferrite powders is developed. The method involves heating the strained ferrite powders in the presence of molten NaCl. An enhancement in the coercivity of milled powders from 1.6 kOe to a maximum of 5.3 kOe has been observed. It is also found that the average particle size and shape of the ferrite particles can be controlled by altering the concentration of NaCl and annealing temperature.



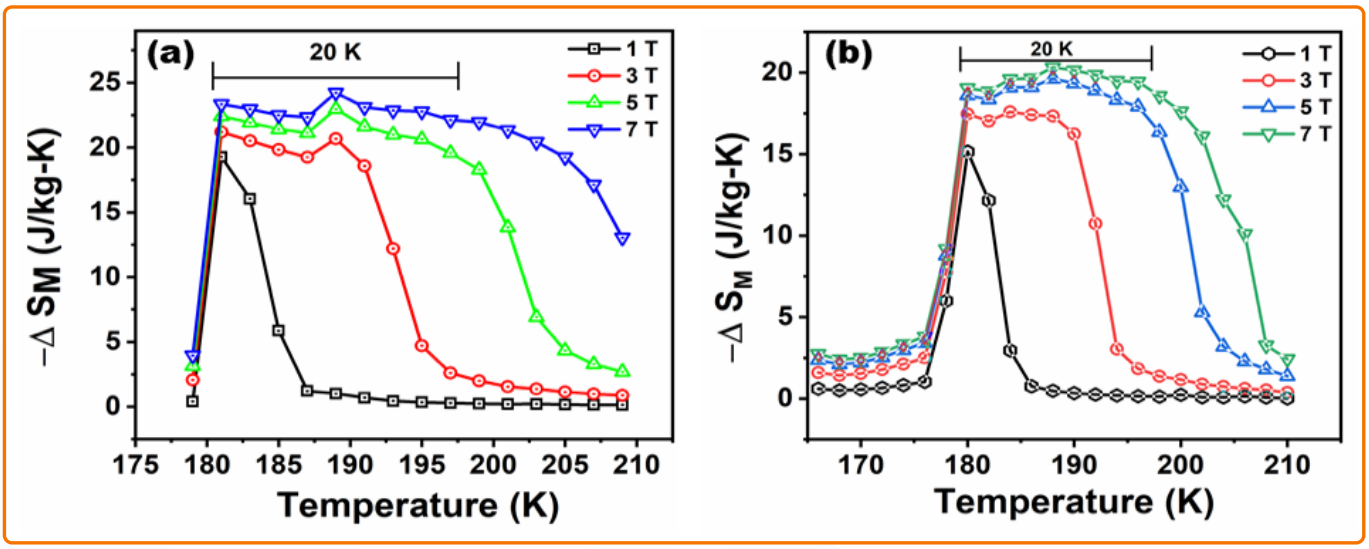


Reference: Journal of the American Ceramic Society Vol. 105 p. 1116, 2022

Table-like Huge Magnetocaloric Effect in La-Fe-Si Alloys for Magnetic Refrigeration Applications

Contributors: Srikanti Kavita, V.V. Ramakrishna, Archana. R, Debendranath Kar and R. Gopalan

Among the many promising magnetocaloric materials, La(Fe,Si)-based compounds are the most attractive candidates and are widely studied from the perspective of fundamental and practical applications. These alloys consist of low-cost and light rare-earth elements compared to other MCE alloys, e.g. Gd_5(Si, Ge). They exhibit first-order magnetoelastic transition. Huge table-like magnetic entropy changes of 19.73 J/kg-K and 15.24 J/kg-K were observed at a low field change of 1 T in $La_{1.3}Fe_{11.6}Si_{1.4}$ ($La_{1.3}$) and $La_{1.7}Fe_{11.6}Si_{1.4}$ ($La_{1.7}$) alloy, respectively. The magnetic entropy change further increases to 23.48 J/kg-K at 183 K and 19.51 J/kg-K at 180 K (Fig.) under an applied field change of 7 T and the effective magnetic refrigeration capacity was found to be 672 J/kg and 581 J/kg in $La_{1.3}Fe_{11.6}Si_{1.4}$ and $La_{1.7}Fe_{11.6}Si_{1.4}$ alloys. An increase in La content leads to an increase in the mechanical strength suggesting better machinability, thus making them suitable for viable magnetic refrigeration applications.



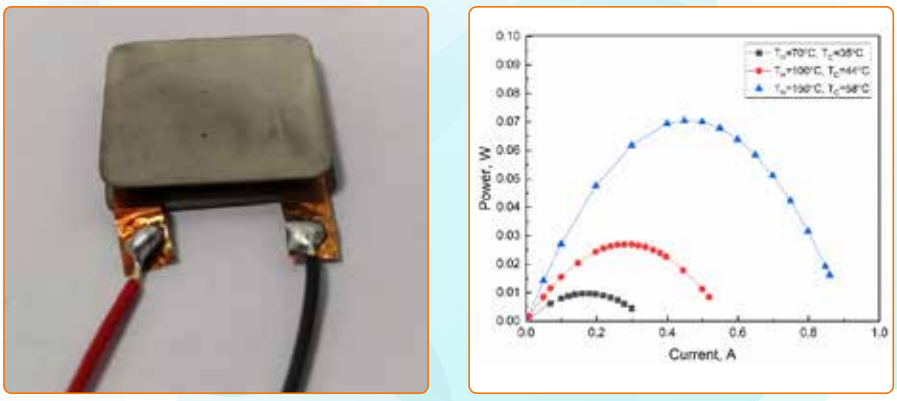
Isothermal magnetic entropy change of (a) La1.3 alloy (b)La1.7 alloy as a function of temperature under different applied fields.

Reference: Journal of Alloys and Compounds, Volume 895, Part 2, 162597(2022)

Thermoelectric Devices for Power Generation from Industrial Waste Heat

Contributors: D.Sivaprahasam, T. Sujitha, U. Gowtham, B. Jayachandran, R. Gopalan

Converting the heat let out in various industrial processes into electricity has significant environmental and economic benefits. Thermoelectric power generation is the ideal technology for this purpose. The DC power generated can be stored and used for various applications. A scalable fabrication method, to produce thermoelectric modules usable up to 150^{0}C, has been developed for utilizing steel plant waste heat and tested for its performance.



16 legs thermoelectric module and its Power – current characteristics

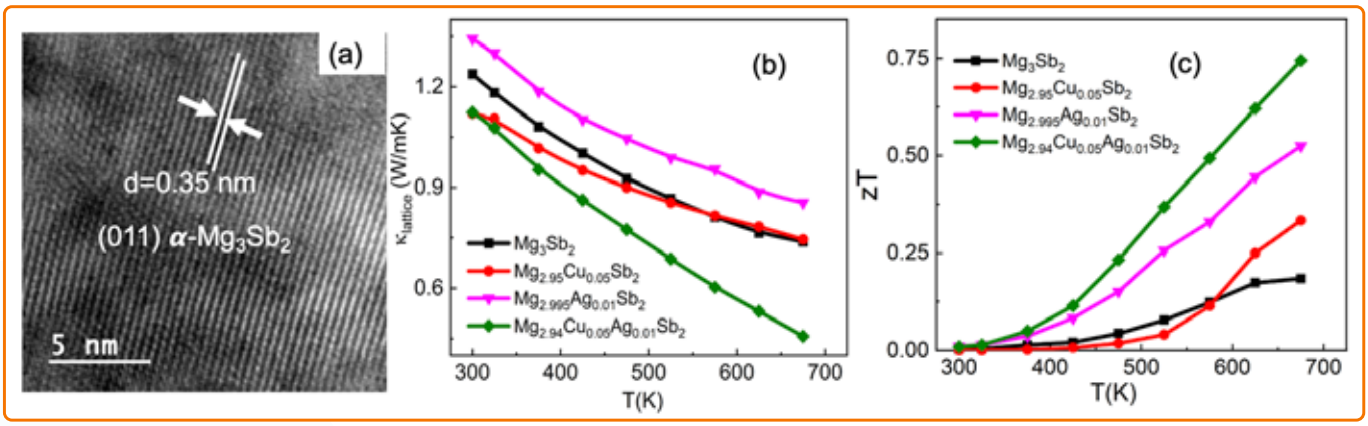
A pair of patented M+ doped bismuth telluride materials was successfully assembled into a device of 16 legs delivering a P_{max} of 0.07 W with a temperature difference of 92^{0}C. At a similar temperature difference, P_{max} close to 1.3 W can be realized in 258 legs modules.

Reference: Ceram. International, 47, 16133-161, 2021

Enhancing the Thermoelectric Efficiency in p-type Mg_3Sb_2 via Mg Site Co-doping

Contributors: Manjusha Battabyal, Minati Tiadi, P K Jain, Avnee Chauhan, Dillip K Satapathy & R Gopalan

Due to the abundance of magnesium and antimony in the earth, the Mg_3Sb_2 based Zintl compounds are potential thermoelectric materials for commercial applications. However, the main hindrance in realizing the full potential of Mg_3Sb_2 compounds for thermoelectric applications is the low figure of merit (zT) of p- type Mg_3Sb_2, in comparison with its n-type counterpart. Therefore, to enhance the thermoelectric properties of p-type Mg_3Sb_2, a heavy atom co-doping has been adapted and synthesized p-type Cu and Ag co- doped Mg_3Sb_2 by solid-state synthesis. The processed materials contain a Mg_3Sb_2 as a major phase along (Fig. 1a) with elemental Sb as a minor phase. The doped Mg_3Sb_2 compounds are thermally stable up to 773 K, irrespective of the presence of a small amount of Sb. The co-doping of Ag and Cu in Mg_3Sb_2 is found to enhance the power factor to 0.8mW/mK2 and the thermoelectric figure of merit to 0.76 at 673 K. This is the highest figure of merit among doped p-type Mg_3Sb_2 reported till date. The rattling of the heavy atoms in co-doped Mg_3Sb_2 is found to significantly reduce the lattice thermal conductivity which enhances the thermoelectric figure of merit (Fig.). Our work sheds an insight to enhance the zT of p-type Mg_3Sb_2 via Cu-Ag co-doping at Mg sites.



HRTEM image showing the lattice spacing, lattice thermal conductivity and figure of merit (zT) of the doped Mg_3Sb_2 materials.

Reference: Sustainable Energy & Fuels, 5(16) 2021, 4104-4114.

Iron Aluminide Coatings Developed using Detonation Spray Coating Technology at ARCI for High Temperature Erosion and Corrosion Resistant Applications

Contributors: : D. Vijaya Lakshmi, P. Suresh Babu, L. Rama Krishna, R. Vijay, D. Srinivasa Rao, G. Padmanabham

Thermally sprayed CrC-NiCr and WC-Co coatings have been widely used for superior wear and high temperature oxidation resistance applications like thermal power plant turbine blades, aerospace engine blades, landing gear shafts, steel rolls in the paper industry. This is mainly attributed to their high hardness, toughness and better corrosion resistance up to 550^{0}C in the case of WC-Co coatings and up to 850^{0}C for CrC-NiCr coatings. However, these coatings have certain limitations such as higher powder cost due to the presence of Co and Ni and presence of toxic Cr in its hexavalent state. Replacement of these coatings with simple Fe based coatings with novel microstructural constituents is a very promising alternative. In this regard, ARCI has recently developed gas atomized Fe aluminide powder with a nominal composition of Fe-12wt%Al-5wt%Cr which was subsequently deposited onto mild steel substrates by Detonation Spray Coating (DSC) technique up to a coating thickness of ~350 µm with good interfacial bonding, without any cracks or spalling. These coatings have 4 times better corrosion resistance in the aqueous corrosive media (~0.05N NaCl and 2N H_2SO_4) and increased wear resistance by 30-40% than the mild steel under solid particle erosion wear mode, demonstrating potential use of FeAlCr coatings for high temperature erosion resistance applications. More studies are currently underway to qualify the FeAlCr coatings for fireside corrosion protection of boiler components i.e., device level trials on boiler components in collaboration with the NTPC to enhance their life.

Reference: D. Vijaya Lakshmi, P. Suresh Babu, L. Rama Krishna, R. Vijay, D. Srinivasa Rao, G. Padmanabham, "Corrosion and erosion behavior of iron aluminide (FeAl(Cr)) coating deposited by detonation spray technique", Adv. Powder Technol.,32 (2021) 2192-2201

Development and Field Demonstration of Paddy Straw based Briquetting Plant for Decentralized Application in State of Punjab

Contributors: Pooja Miryalkar, Sekhar Chavitlo, Nitin Tandekar, and Krishna Valleti

ARCI's Role in the Joint Project: Development of abrasive wear resistant coatings for briquetting machine wearing components for field trials. Of the several wear resistant coatings developed by ARCI using CAPVD, TiCrN coating was identified as the best option to enhance the wear resistance of briquetting machine components. Subsequent to detailed R&D studies at ARCI, coatings were deposited on machine components that were deployed in the field including, Hammer blades - 100 nos., Ram - 8 nos., Shredder blades - 24 nos., Wearing - 10 nos. and Scrapper Ring - 10 nos. The component life evaluation was carried out at Kulburchan, Patiala (where 350 Kg/hour briquetting plant is established under this programme by the other consortium partners). The real-time test results indicated a two-fold life improvement in most of the components. The activity is expected to be concluded by the end of June 2022.

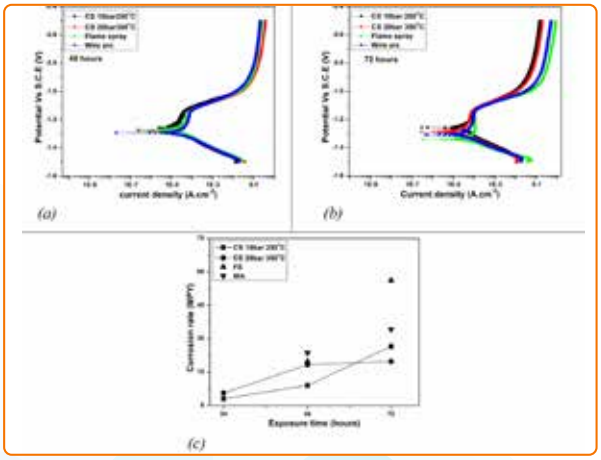
Shredder blades (mounted in vacuum system) after the TiCrN coating deposition

Reference: "Improving the abrasive wear resistance of biomass briquetting machine components using cathodic arc physical vapor deposition coatings: A comparative study" Pooja Miryalkar, Sekhar Chavitlo, Nitin Tandekar, and Krishna Valleti, Journal of Vacuum Science & Technology A 39 (2021) 063404

Development of Corrosion Resistant Zinc Coatings

*Contributors: Gidla Vinay , Naveen Manhar Chavan *, S. Kumar , A. Jyothirmayi , Bolla Reddy Bodapati*

Cold sprayed zinc coatings have the potential to provide barrier as well as sacrificial protection to steels. In the present work, zinc coatings were deposited on mild steel substrates and their microstructure and properties such as hardness, elastic modulus and corrosion performance were evaluated. Owing to the purity of the feedstock and the use of anti-clogging nozzle, improved microstructure and properties, especially corrosion resistance were achieved in the as-sprayed condition itself, obviating the need for a cost and time consuming post-treatment. In addition to this, a microstructure-property comparison was made with zinc coatings deposited using other spray techniques such as wire arc spray and flame spray. It was found that cold sprayed coatings fared better than their counterparts from other techniques in the as-sprayed condition itself. Improved inter-splat bonding was one of the major reasons for the superior performance of cold sprayed coatings.



Potentiodynamic plots of selected CS samples, FS and WA samples (a) 48 h exposure (b) 72 h exposure (c) Corrosion rate with respect to exposure time

Reference: Improved microstructure and properties of cold sprayed zinc coatings in the as sprayed condition Gidla Vinay, Naveen Manhar Chavan *, S. Kumar, A. Jyothirmayi, Bolla Reddy Bodapati, Surface & Coatings Technology 438 (2022) 128392

High-Performance of $SrMg_{0.1}Mo_{0.9}O_{3-\delta}$ (SMMO)/$Gd_{0.1}Ce_{0.9}O_{2-\delta}$ (GDC) Based Composite Anode for Solid Oxide Fuel Cells

Contributors: Amit Das, M. Buchi Suresh

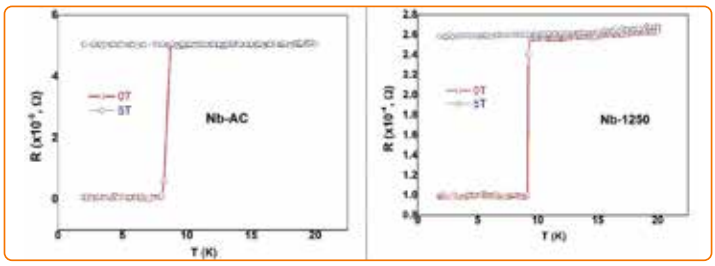
In this study, the electrochemical performances of the porous ceramic composite of SMMO/GDC were investigated for SOFC anode in the symmetrical-cell configuration. It was observed that 70 wt.% GDC+30 wt.% SMMO composite anode showed the lowest area-specific resistance (ASR) values of 0.069 $\Omega.cm^2$, 0.091 $\Omega.cm^2$, 0.110 $\Omega.cm^2$ at 850^{0}C, 800^{0}C and 750^{0}C in hydrated H_2 condition respectively. It was also observed that when the sintering temperature of the GDC buffer layer was decreased from 1500^{0}C to 1100^{0}C, the ASR was decreased (Example: at 800^{0}C the ASR of 0.7GDC/SMMO-1100^{0}C and 0.7GDC/SMMO-1500^{0}C was estimated to be 0.65 $\Omega.cm^2$ 0.091 $\Omega.cm^2$).

Reference: Amit Das, Sunil Kumar, Biswajit Jana, M. Buchi Suresh, Chalavadi Prashanthi, Shobit Omar, Electrochemical Performance of $SrMg_{0.1}Mo_{0.9}O_{3-\delta}$ -Based Composites for Solid Oxide Fuel Cells Anode, ACS Applied Energy Materials, 2022

Superconducting Niobium Coating Deposited using Cold Spray

Contributors: S. Kumar, A.S. Dhavale, Naveen M. Chavan , S. Acharya

New fabrication techniques associated with cost reduction are gaining attention in the field of superconducting (SC) accelerators. Owing to the low process temperature, cold spraying is a suitable technique to obtain SC cavities. In this work, the superconducting properties of cold sprayed Niobium (Nb) are evaluated and compared with other techniques. Critical temperature (Tc) for superconductivity of cold sprayed coatings was estimated to be ~ 8.6 K as against 9.2 K for the same of bulk Nb. Residual Resistivity Ratio (RRR), critical fields (Hc1 and Hc2) were also compared. It was found that cold spraying can be an alternate route to obtain Nb superconducting cavities.



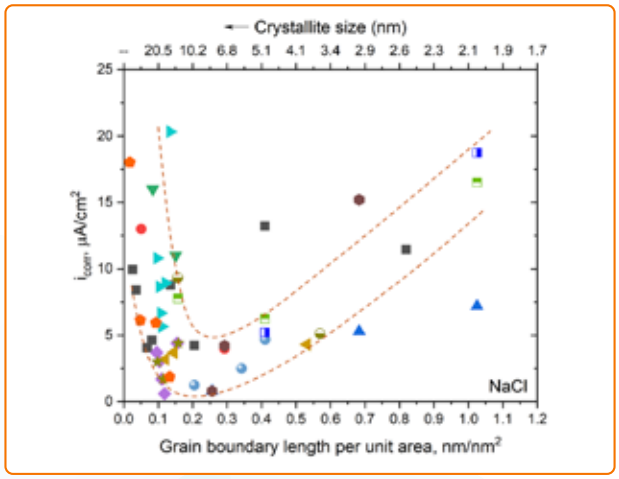
RRR measurement of (a) Nb-AC and (b) Nb-1250C samples.

Reference: Superconducting niobium coating deposited using cold spray S. Kumar *, A.S. Dhavale, Naveen M. Chavan, S. Acharya, Materials Letters 312 (2022) 131715

Corrosion Behaviour of Nanocrystalline Metals

Contributors: N. P. Wasekar

An attempt has been made to rationalize the higher corrosion rates of nanocrystalline passivating metals in ~3.5 wt% NaCl environment when grain size approaches below 10 nm. A simple model is proposed correlating the grain size with corrosion current utilizing the contribution from triple junctions. The higher corrosion rate below critical grain size was attributed to the presence of a high volume fraction of triple junctions demonstrating inverse Hall-Petch type (corrosion) relation. The relationship proposed reveals the application window of nanocrystalline metals demanding improved corrosion resistance. These results greatly enhance the understanding of the corrosion behaviour of PED coatings being developed at ARCI for various applications.



Corrosion current as a function of grain boundary length per unit grain area for nanocrystalline Ni and Ni-W alloys

Reference: N. P. Wasekar, Scripta Materialia 213 (2022)114604

3D Printing of Alumina Ceramics: Influence of Printing Parameters

Contributors: S. Mamatha, Papiya Biswas and Roy Johnson

Alumina paste with optimum rheology was 3D printed and the influence of printing parameters was investigated. Out of the various printing parameters studied, printing speed and self-standing distance are found to be most critical. The surface finish and surface chemistry of the substrate are also found to have a prominent effect on dimensional tolerance. However, filling angle and filling patterns have shown only a negligible effect. A printing speed of 5-6 mm/s, self-standing distance of 1.25±0.25mm are found to be optimum. Further, a filling pattern of rectilinear geometry along with filling angle of 90° is found to be desirable. Substrate with aluminium foil sintered samples exhibited a density of 3.88 g/cc (97% of theoretical density) and a hardness of 16.5 GPa.3D printing facility along with the printed samples are shown in figure below.

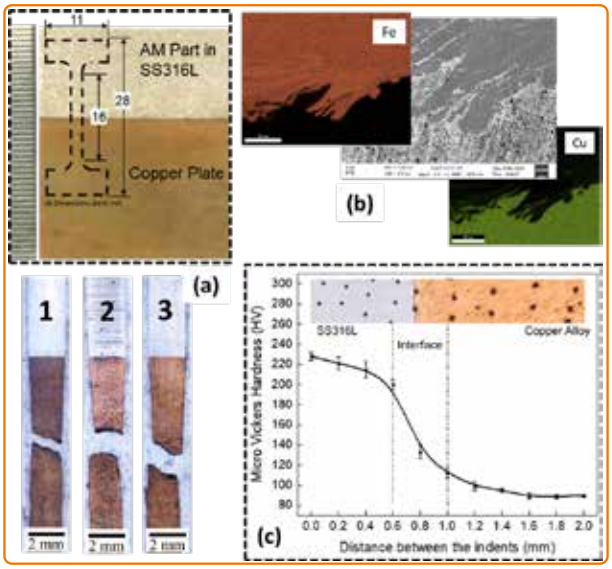
3D printer and printed samples

Reference: Sirisala Mamatha, Papiya Biswas, Pandu Ramavath, Dibakar Das and Roy Johnson, Effect of parameters on 3D printing of alumina ceramics and evaluation of properties of sintered parts, Journal of Asian Ceramic Societies 9 (2021) 858-864

High Strength Bi-metallic Interfacial Strength Achieved by Selective Laser Melting for Copper-SS Dissimilar Material Structure

Contributors: Gururaj Telasang, S Narayanaswamy, DM Santhoshsarang, Ravi Bathe

The copper alloy-stainless steel, bimetallic combination using the selective laser melting (SLM) method of additive manufacturing (AM), was successfully demonstrated by building the stainless steel (SS316L) alloy powder on the copper alloy plate (Fig.a). The tensile coupon having an interface at the center of gauge length failed on the copper alloy side away from the interface region and manifested higher interfacial strength due to the interlocked interface with Cu and Fe-rich regions across the interface (Fig.b) at different length scales. Also, the diffusion of Fe, Cr, and Ni elements led to the solid solution strengthening of copper near the interface, as supported by the micro-hardness profile (Fig.c).



(a) photographs of as-built Cu-SS bimetallic structure and tensile tested samples, (b) SEM and EDS images of the bi-metallic interface, and (c) Micro-hardness profile across the bi-metallic interface

Reference: Gururaj Telasang, S Narayanaswamy, DM Santhoshsarang, Ravi Bathe, Selective laser melting of stainless steel on the copper alloy: An investigation of the interfacial microstructure and mechanical properties, Journal of Manufacturing Processes 80, 920-929, 2022

High-Performance Conformally Cooled Core Pin for Pressure Die Casting

Contributors: D. M. Santhoshsarang, K. Divya, Gururaj Telasang, S. Soundarapandian, Ravi Bathe, G Padmanabham

The performance and life of pressure die casting tools and inserts can be improved by providing efficient conformal cooling. Selective laser melting (SLM) investigation was carried out on AISI H13 tool steel to obtain a 99.87% theoretical density of the AM-built H13 material. The AM-built H13 alloy possessed ultrafine supersaturated microstructure with ultimate tensile strength (UTS) of 1895 MPa and yield strength (YS) of 1550 MPa which is higher than the conventional processed AISI H13 tool steel, but the lower elongation of 10.4% as listed in Table Post heat treatment investigations were carried out to achieve a desirable microstructure of refined martensite and precipitates of secondary carbides. Based on the AM process developed and post-heat-treated procedure optimized, the core pin modified with the conformal cooling channel needed for a pressure die casting application was additively manufactured (shown in figure) and validated in an actual industrial environment, which performed much better compared to a recorded 15 to 20 % reduction in the surface temperature with 2 seconds reduced cycle time. This application , developed and demonstrated, is now ready for industrial adaptation.

Sample ID	Samples	Details	Yield Strength (MPa)	UTS (MPa)	Elongation (%) (calculated)
1	H13	Conventional (Quenched & Tempered)	1247	1434	14.4
2	AM	AM (as-built)	1550	1895	10.4
3	AM650	AM (heat treated at 650°C)	1315	1491	14.6

Tensile properties recorded for AISI H13 tool steel in different conditions

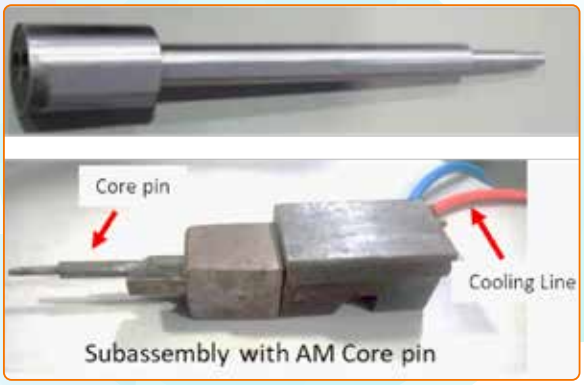


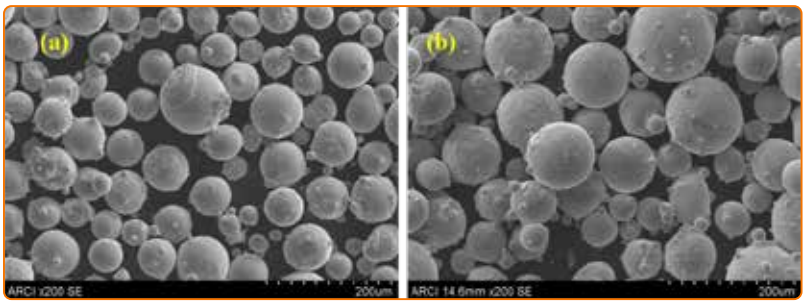
figure: Photographs showing additively Manufactured AISI H13 tool steel (a) core pin designed with conformal channel and (b) Core pin validation assembly

Reference: D. M. Santhoshsarang, K. Divya, Gururaj Telasang, S. Soundarapandian, Ravi Bathe, G Padmanabham, Additively Manufactured High-Performance Conformally Cooled H13 Tool Steel Die Insert for Pressure Die Casting, Transactions of Indian National Academy of Engineering, 6(32), 2021.

Repair and Refurbishment of Aero Engine Components using Directed Energy Deposition Additive Manufacturing Process

Contributors: Y.N. Aditya, T. Dharish Srichandra, Manish Tak, G. Padmanabham

Aero-engines are made of various components and various superalloys suitable to sustain extreme conditions and functional requirements. These components must meet stringent quality criteria and be rejected even for small manufacturing defects or wear during service. Ni-based superalloys are extensively used in the aero-engines. Two of such alloys were chosen for the investigation, for which no repair technology is available.



ARCI developed AM powders for selected Ni based superalloys

Few scrapped components were used to develop powders suitable for additive manufacturing. An inert gas atomizer available at ARCI was used for powder development (figure). The directed energy deposition (DED) additive manufacturing method was used for refurbishment. The rapidly solidified microstructure exhibited a fine dendritic microstructure in the melt zone with the precipitation of carbides at inter-dendritic regions and was found to have solidification cracks. The heat-affected zone (HAZ) revealed the dissolution of the eutectic phases near the fusion boundary. Mixing different alloys to eliminate solidification cracking resulting in crack-free deposition identified a new alloy composition.

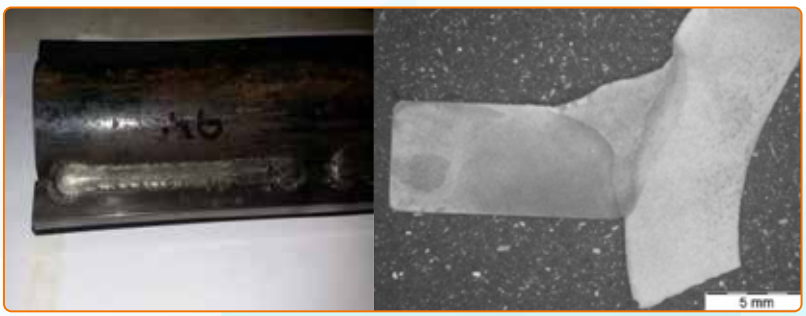
References:

1. **Y.N. Aditya, T. Dharish Srichandra, Manish Tak, G. Padmanabham, "Study the Laser Cladding of ultra-high strength AerMet-100 alloy powder on AISI-4340 steel for repair and refurbishment", Materials Today: Proceedings 41 (2021) 1146–1155 https://doi.org/10.1016/j.matpr.2020.09.154**
2. **Indigenously developed powders from unused scrape materials to be used for the repair of aero-engine components made of Ni-based superalloy, Release ID: 1748582, Posted On: 24 AUG 2021 5:15PM by PIB Delhi**

CO_2 Laser-MIG Hybrid Welding Feasibility Studies in Joining Tube to Fin

Contributors: L. Subashini, K.V.P. Prabhakar, S. Ghosh and G. Padmanabham

In subcritical, supercritical boilers, an evaporative membrane panel is fabricated in a multi-torch Gas Metal Arc Welding (GMAW) machine with a few torches at the top and a few torches at the bottom, producing fillets on 45 mm dia tubes to 6 mm thick and 12 mm wide fins in 1F (top side) and 4F (bottom side) welding positions separately. The GMAW process is slow and leads to distortion of the panels since a lot of heat is imparted from the tube to the fin joint.



(a) Laser Hybrid Welded 1Tube 2 fin, and (b) Macrostructure of the welded joint.

An attempt is made through feasibility studies with CO_2 Laser-MIG Hybrid Welding facility to develop a proof of concept in laser hybrid welding of tubes alternating with narrow fin plates (figure) made of carbon steel which can simultaneously produce a fillet on both sides of the tube to fin joint, i.e., weld side and back side in a single pass, i.e., 1F welding position, thereby enhancing productivity at an optimal cost with improved performance.

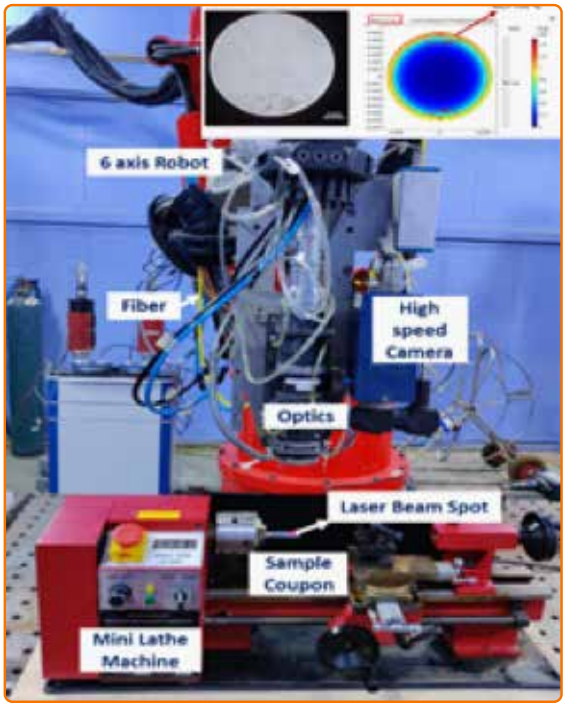
Reference:

L. Subashini, K.V.P. Prabhakar, S. Ghosh and G. Padmanabham, Comparison of laser-MIG hybrid and autogenous laser welding of M250 maraging steel thick sections-understanding the role of filler wire addition, International Journal of Advanced Manufacturing Technology, Vol. 107 (3-4), p 1581-1594, 2020

A Novel Laser Surface Treatment Employing Quasi-stationery Dynamic-Beam Shaping Technique

Contributors: E. Anusha, Adepu Kumar and S M Shariff

A novel laser processing technique, employing a quasi-stationary dynamic circular laser beam engulfing the circular periphery of a symmetrical job by rotating at high speed rotating mini-lathe (figure), has been developed and tested. The technology has been proven to bear a solid steel rod of 15-mm diameter that exhibited complete elimination of softening and melting with a homogenous hardened surface throughout its periphery (inset of figure). Suitable FEM model, employing COMSOL Multiphysics software for thermal profile and temperature monitored employing pyrometer, facilitated precisely controlling critical processing parameters and conditions. Field trials on evaluating static and dynamic mechanical properties are in progress.



Quasi-stationary laser processing setup

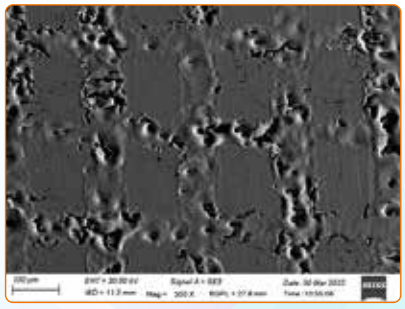
References:

1. **E. Anusha, Adepu Kumar and S M Shariff, "Finite element analysis and experimental validation of high-speed laser surface hardening process" (2021) The International Journal of Advanced Manufacturing Technology, 115(7), 2403-2421**
2. **E. Anusha, Adepu Kumar, S M Shariff, "Numerical and Statistical Modelling of High Speed Rotating Diode Laser Surface Hardening Process on a Steel Rod" (2021) Journal of Optics and laser Technology, 143,107309**

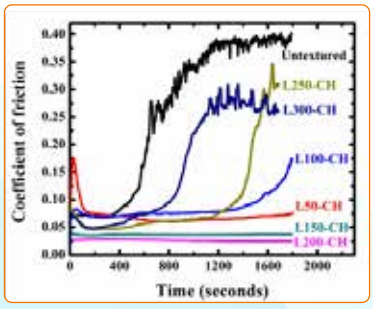
Nanosecond Laser Surface Textures on Gray Cast Iron

Contributors: Ravi. N. Bathe, G. Padmanabham, S. Thirumalini, R. Vaira Vignesh

Laser surface texture (LST) is of increasing importance in automotive applications. Surface textures offer many benefits for tribological applications, including enhanced load capacity, wear resistance, lubrication life, and reduced coefficient of friction. Laser processing allows precise control of the surface texture features such as size, shape, and density. LST technology was developed for automotive applications, improving the fuel efficiency of internal combustion engines. The surface textures were created on the gray cast Iron samples using 100 ns pulse duration and 527 nm wavelength Nd:YLF laser (Fig.a). The tribological performance of textured surface samples with different area densities and patterns was tested using a ball-on-disk test. The results showed a significant reduction in the coefficient of friction and wear (Fig.b). The same technology can also be applied to many industrial applications and sectors, including aerospace, automotive, and gear transmissions, with similar benefits.



(a) Micro-crosshatches on Gray Cast Iron sample surface



(b) Graph of friction coefficient Vs time

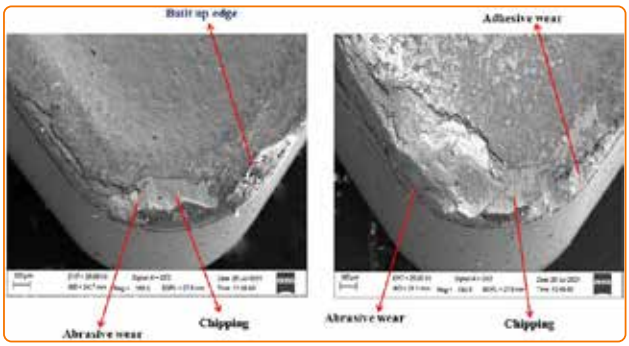
References:

1. **Ravi N. Bathe, G. Padmanabham, S. Thirumalini, R. Vaira Vignesh. Impact of laser surface texturing (LST) on the tribological characteristics of piston rings and cylinder liners – a review. Part 2: application of the process. Transactions of the IMF 100(3),119-127, 2022**
2. **Ravi N. Bathe and G. Padmanabham and S. Thirumalini and R. Vaira Vignesh, Impact of laser surface texturing (LST) on the tribological characteristics of piston rings and cylinder liners – a review. Part 1: development of LST technology, Transactions of the IMF, 99(5), 231-237, 2021**

Laser-Assisted Machining for Boiler Applications

Contributors: Ajit M. Hebbale, S. Rajesh K. Reddy, Mirza Abdul Hadi Baig, Manish Tak, Ravi N. Bathe

Laser-assisted machining process was developed at ARCI for turning IN625 alloys. Laser-assisted turning process was optimized using a statistical approach. Response Surface Methodology statistical model with 3 factor 3 level Box-Behnken Design of Experiments method was adopted for desired multi-response optimization. The optimized process parameters, obtained through the statistical model, were validated using experimentation and found in correlation with the calculated results. Laser-assisted turning results with optimal parameters were compared with conventional turning and about a 15% reduction in cutting forces and a 7.4% reduction in max. Flank wear and an 18.8% reduction in surface roughness were observed (figure).



SEM Images of Tool wears in Laser assisted turning and conventional turning

References: A chapter on An Experimental Investigation of Laser-Assisted Machining of EN24 Steel, Authored by Ajit M. Hebbale, S. Rajesh K. Reddy, Mirza Abdul Hadi Baig, Manish Tak, Ravi N. Bathe, in the book on Sustainable Machining Strategies for Better Performance, Editors: Dr. P. Srinivasa Pai, Dr. V. Krishnaraj, Publisher: Springer Singapore, ISBN: 978-981-16-2277-9, 2021

Setting up of Automated Pilot Line for PEMFC Stack Fabrication

Contributors: Dr. K.Ramya , Dr. R.Balaji, Dr. Raman Vedarajan, Dr. N.Rajalakshmi

ARCI is working on setting up of automated proton exchange membrane fuel cell (PEMFC) stack fabrication pilot line with Advanced Manufacturing Technology Development Centre (AMTDC), Chennai. This attempt will pave way to address the existing gap in establishing the manufacturing capability of PEMFC stack in India and easy adoption of technology for the commercial market. The various work packages and process parameters were identified and design layout completed. The required infrastructure at the lab was established for setting up of PEMFC assembly line and required key automation components were procured and its integration and trial runs are underway at ARCI. It is aimed to produce 100kW in a year as rated capacity of the existing fabrication line.

PEMFC Automated Assembly Pilot line setup at CFCT

References:

1. **Method of preparing gas diffusion layer for the electrode of ECMR cell for hydrogen generation R.Balaji, N.Rajalakshmi, K.Ramya, R.Vasudevan, K.Sudalayandi. Indian Patent Application No: 201911030852**
2. **Method of manufacturing the catalyst coated membrane for the proton exchange membrane fuel cells N. Rajalakshmi, R.Balaji, E.Ganesan, D.Uday kiran, R.Vasudevan. Indian Patent Application No. 202011046496**

Metallic Flow Field Plates for PEM Fuel Cell

Contributors: Dr. N.Rajalakshmi, Dr. K.Ramya , Dr. R.Balaji, Dr. Raman Vedarajan, Mr. Ramakrishnan, Mr. V. Tarun Kumar

Metallic flow field plates , based on stainless steel and titanium, are considered promising candidates for replacing the conventional graphite plates in proton exchange membrane fuel cells (PEMFC). The use of metallic bipolar plates is essential for reducing the weight and volume of the PEMFC stack for transportation applications. The centre has tried to develop metal-based flow field plates through various techniques like stamping, hydroforming, chemical etching and additive manufacturing.

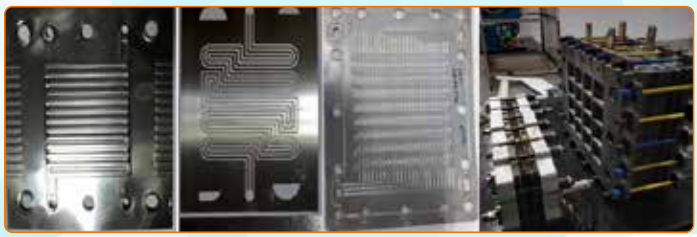


Figure: Metallic bipolar plates formed by stamping, etching, hydroforming and stack with commercial plates compared to graphite based plates

To combat the corrosion of such metal-based plates in the fuel cell operating environment, the centre has developed technologies using chemical vapour deposition, electrochemical nitriding, patterned noble metal coating, conducting polymer-based coating etc. Short stacks have been developed using these techniques and their characteristics were mapped for the development of large systems and compared with commercial metal flow field plates.

Reference: Durable corrosion resistant coating for fuel cell separator and the process thereof, Inventors: Sundararajan Ramakrishnan, Natarajan Rajalakshmi, Krishnan Valleti, Patent Filing No.: 202111051526, Date of Filing: 10.11.2021

PEMFC Materials Recycling: Fast Screening of Membrane with Crystallinity

Contributors: Raman Vedarajan

The maximum cost incurred in building a Polymer Electrolyte Membrane fuel cell and electrolysers can be attributed to the proton exchange membrane and catalyst. Recycling of these precious components after their life, has been speculated to increase the commercial viability of hydrogen based energy conversion systems. Most of the existing research focused on recycling or reusability predictions. Hence for the first time, we have identified a quick screening parameter which can be used to check the quality of the membrane and further map the reusability in different applications. Based on the crystallinity of the membrane removed from the fuel cell or electrolyzer after their end-of-life, the course of further use in a different energy device was determined and investigated.

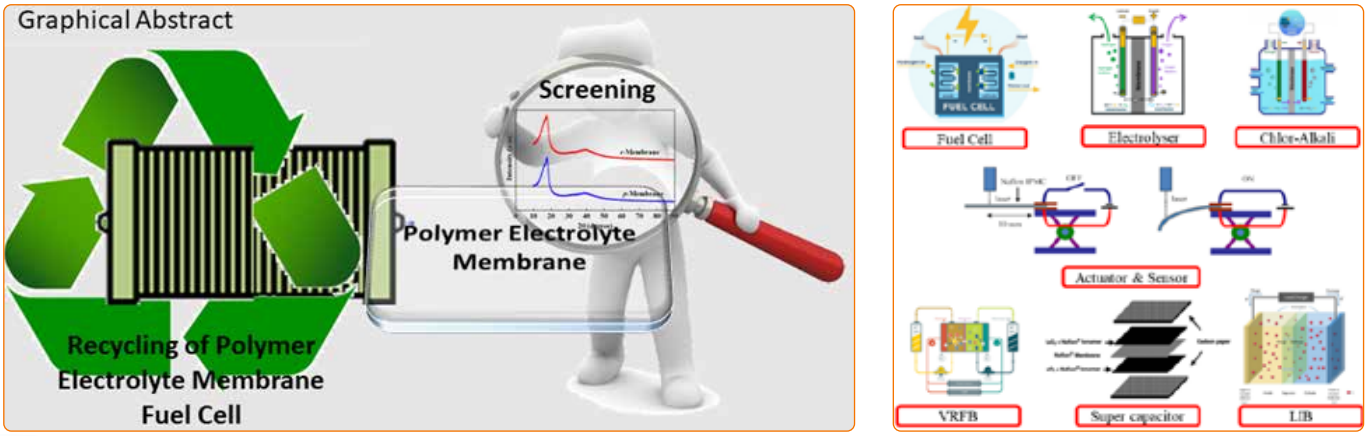


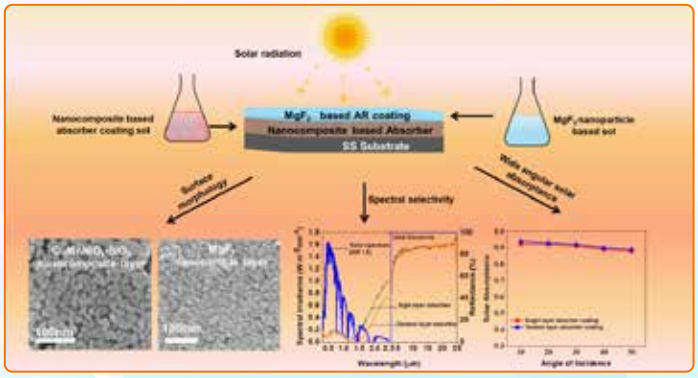
Illustration of the membrane screening and their after-life usage in different energy devices

Reference: Sreeraj P, Raman Vedarajan, N. Rajalakshmi, Venkatasailanathan Ramadesigan, Screening of Recycled Membrane with Crystallinity as a Fundamental Property, International Journal Of Hydrogen Energy, Vol. 46(24), p 13020-13028, 2021

Solar Selective Absorber Coatings with Wide Angular Solar Absorptance for Solar Thermal Conversion Applications

Contributors: KK. Phani Kumar, Sudhanshu Mallick, and S. Sakthivel

Solar Energy is one of the renewable energies and is abundant in nature. Several conversion techniques are available to convert solar energy into electrical energy and heat energy. Solar thermal conversion systems convert solar energy into heat energy. Receiver systems are the crucial components in solar thermal systems and should be capable of absorbing all the incidence of solar energy. Application of solar selective absorber coatings (SSACs) with wide angular solar absorptance aids in attaining high photo-thermal conversion efficiency for solar thermal systems. In this regard, ARCI developed nanoparticles-based absorber coatings on stainless steel grade 304 cost-effective wet chemical and dip-coating processes to get the best optical and physical properties.



Key features:

- Spectral selective properties (Solar Absorptance α = 0.94; Emittance ε = 0.14)
- Wide angular solar absorptance α = 0.89 (at 50^0 incidence angle)
- Mechanical stable
- Thermal stable at 400^0C for 100 h.

Reference: KK. Phani Kumar, Sudhanshu Mallick, and S. Sakthivel, "Nanoparticles based single and tandem stable solar selective absorber coatings with wide angular solar absorptance" Solar Energy Materials and Solar Cells, Volume 242, 2022, 111758, ISSN 0927-0248, https://doi.org/10.1016/j.solmat.2022.111758.

Development of Rechargeable Zn based Electrochemical Cells

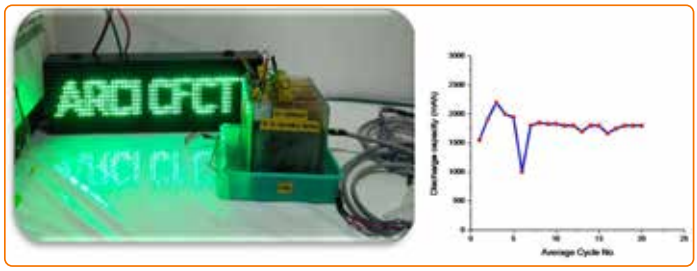
Contributors: K.Ramya, R. Balaji

The growing need to develop low-cost, safe batteries suitable for power electronic devices, for energy storage of the renewable energy and automotive applications has led to research on rechargeable Zinc based electrochemical cells such as Zn-Air and Nickel-Zinc batteries. Advantages of using Zinc based battery include high specific and power density, stable metal in aqueous electrolyte solutions, recyclability and high theoretical capacity.

1. Development of Zn/Air electrochemical cell Zn/air batteries have high specific energy of 1300 Wh/kg and their commercialization has been limited by the complexity of the reactions that take place at the air electrode, i.e, the oxygen reduction reaction and the oxygen evolution reaction, rechargeability, dendrite growth etc.. Developments at ARCI include the fabrication of several bifunctional catalysts based on transition metal, noble metals, doped carbon and graphene-based materials. At the cell level, 50 and 100 Wh cells based on freely air breathing mode, forced air circulation mode and flowing electrolyte mode have been developed. The cells have been tested for more than 500 cycles at single cell levels.

Prototype 50Wh

1. 2. Development of 15 Whr alkaline Nickel-Zinc Secondary Battery Development of rechargeable alkaline Nickel-Zinc for energy storage application at ARCI includes fabrication of electrodes of area from 35 sq.cm to 150 sq.cm and studies at the single cell and multicell levels. The stable cell performance was found to be around 1600 mAh over 100 cycles and tested upto 200 cycles with a capacity fade of about 30%. A 15Whr battery has been assembled and tested.



15 Whr alkaline Ni-Zn battery and its performance characteristics

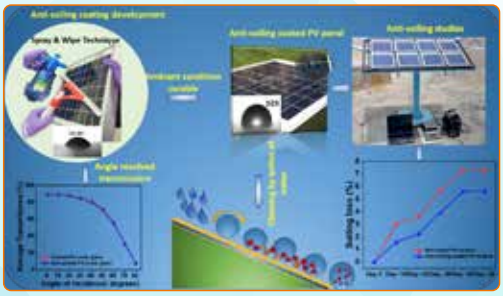
References:

1. **Imran K., Ramya. K., P. C. Ghosh, A. Sarkar, and Rajalakshmi N., Co-doped carbon materials synthesized with polymeric precursors as bifunctional electrocatalysts, RSC Advances, 2020, 10(59), pp. 35966-35978**
2. **Imran K., Ramya. K., P. C. Ghosh, A. Sarkar, and Rajalakshmi N., Nickel integrated carbon electrodes for improved stability, Journal of the Electrochemical Society, 2020, 167(13), 130510**

Ambient Condition Curable, Highly Weather Stable Anti-soiling Coating for Photovoltaic Application

Contributors: Narendra Chundi, Ganesh Kesavan, Easwaramoorthi Ramasamy, Sudhanshu Mallick, Anil Kottantharayil, Shanmugasundaram Sakthivel

A novel anti-soiling coating with excellent weather stability to counter the challenges posed by soiling was developed. The developed anti-soiling coating characteristics like ambient condition curability, good mechanical and weather stability to encounter the real field conditions are because of the bonding of the functionalised hybrid Zr-O-Si network with the glass. The coating also exhibited good thermal stability. The developed coating showed no loss in angle-resolved transmission in the range of 10–80^0. The coated panel exhibited an excellent anti-soiling effect, and a net reduction of 24.5 % in the soiling losses was observed compared to that of the not-coated panel over 50 days.



Development and validation of ambient condition curable highly weather stable Anti-soiling coating

Key features:

- The coated panel exhibited a net reduction of 24.5 % in the soiling losses compared to the not-coated panel
- The coating exhibits no loss in transmission and a water contact angle of 103^0

Applications:

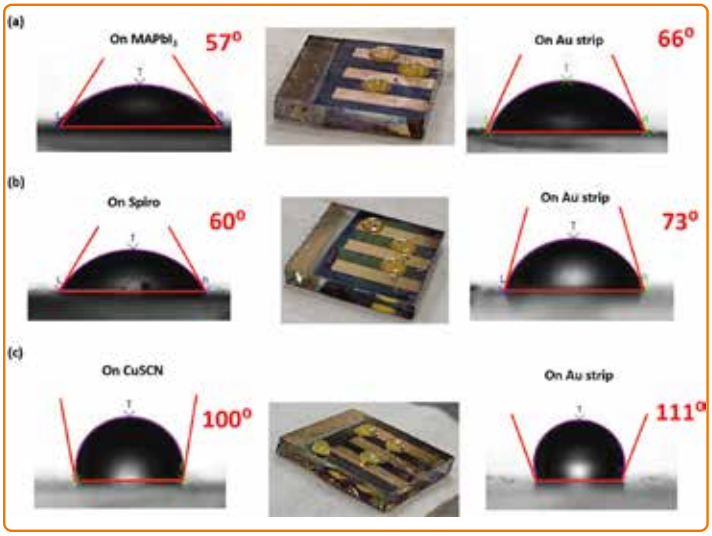
- Solar PV module glass

Reference: Narendra Chundi, Ganesh Kesavan, Easwaramoorthi Ramasamy, Sudhanshu Mallick, Anil Kottantharayil, Shanmugasundaram Sakthivel, "Ambient condition curable, highly weather stable anti-soiling coating for photovoltaic application", Solar Energy Materials and Solar Cells, Volume 230, 2021, 111203, ISSN 0927-0248, https://doi.org/10.1016/j.solmat.2021.111203.

Dual Functional Inorganic CuSCN HTM for Efficient and Durable Perovskite Solar Cells

Contributors: Ramyakrishna, V. Ganapathy, R. Easwaramoorthi

Most high-performing organic-inorganic hybrid perovskite solar cells (PSCs) are fabricated using expensive organic hole-transporting materials (HTMs). Inorganic HTMs are promising cost-effective alternatives to achieve high efficiencies with enhanced stability. To compare the impact of atmospheric conditions on the stability of the device, they were stored under dark ambient conditions, and their performance was recorded for 1500 h. PSC with CuSCN retained nearly 70% of its initial PCE for more than 1500 h, whereas both the PSC-HTM-free and PSC-spiro devices exhibited similar performance degradation and retained only 30% of their initial PCE. The moisture resistance of the CuSCN film is understood from the high water contact angle. We demonstrate that the inherent stability and the absence of dopants in the inorganic CuSCN HTM decelerate the degradation compared to its organic counterparts.



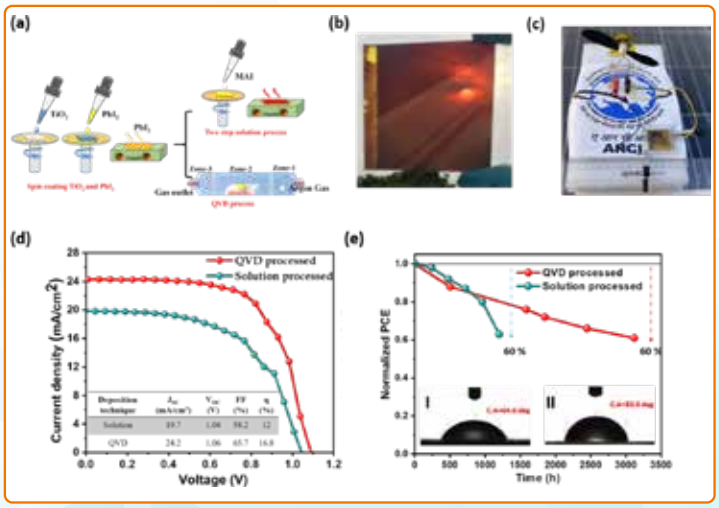
WCA of (a) PSC-HTM-free, (b) PSC-spiro and (c) PSC-CuSCN. The left-hand side image shows the WCA on the non-gold portion of the device, the righthand side image shows the WCA on the Au strip of the device and the centre image shows the pictorial image of the device with water droplets on the film

Reference: Dual-functional inorganic CuSCN for efficient hole extraction and moisture sealing of MAPbI3 perovskite solar cells, Materials Advances, DOI: 10.1039/D1MA00861G

Quasi-vapour Deposition for Highly Efficient, Scalable and Stable Perovskite Solar Cells

Contributors: V. Ganapathy, R. Easwaramoorthi

The performance and stability of perovskite solar cells are highly dependent on the perovskite layer deposition and film quality. However, the solution processing techniques are still lacking to produce high-quality perovskite films for large scale device fabrication. This work develops high-quality and uniform MAPbI3 perovskite films by quasi-vapour deposition (QVD) at low temperature, low working pressure, with short reaction time and without post-annealing. MAPbI3 films deposited at 100^{0}C showed a uniform film with a grain size of 375 nm. The PSCs prepared with the film exhibited the highest power conversion efficiency (PCE) of 15.6% and excellent stability. This QVD method could answer large-scale film deposition with very good uniformity at low cost and high stability and efficiency.



(a) Schematic diagram representing perovskite formation from solution process and quasi-vapour deposition methods, (b) digital photograph of large area (50mm x 50mm) uniform film, (c) digital photograph of large size (50mm x 50mm) perovskite device powered fan in outdoor conditions, (d) Current-voltage spectrum of the solution and QVD processed perovskite solar cells, and (e) Normalized PCEs with respect to time of QVD devices and solution-processed devices. Insets I and II show the water contact angle of the solution and QVD processed films, respectively.

Reference: Temperature dependence of MAPbI3 films by quasi-vapor deposition technique and impact on photovoltaic performance and stability of perovskite solar cells, Journal of Alloys and Compounds, doi.org/10.1016/j.jallcom.2021.161448

Bar Coating of Charge Selective Contacts for Reproducible Large-area Perovskite Solar Cells

Contributors: Sreekanth, Reshma, V. Ganapathy, R. Easwaramoorthi

Towards realising large-scale perovskite solar cells (PSCs), this work presents an economical, sustainable and scalable bar coating with high throughput for electron transport layers (ETL) on 50 mm × 50 mm substrates. Bar coating is systematically engineered to obtain conformally covered TiO_2 layers of desired thickness. Simultaneously, spin-coated TiO_2 on similar size substrates are compared. PSCs on bar coated ETL exhibit comparable efficiencies with good reproducibility and reduced hysteresis compared to conventional spin-coated ETL devices. Photovoltaic performance homogeneity on larger substrates is significantly higher for bar coated ETL devices than the spin-coated ones. The study provides a scalable, sustainable and appropriately engineered bar coating technique of ETL for perovskite solar modules development.

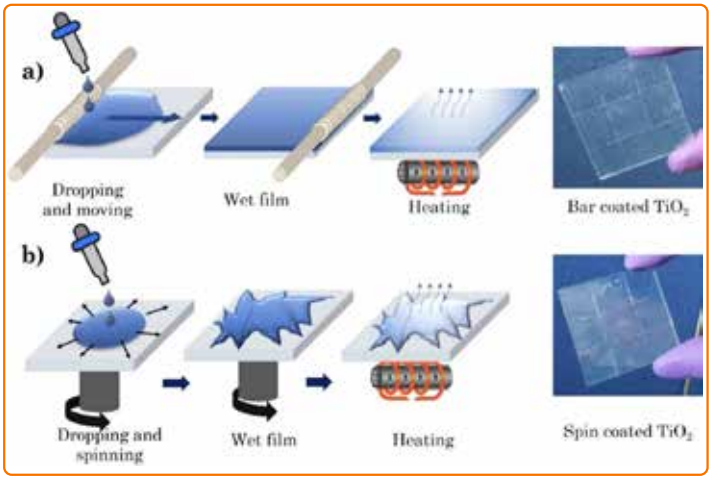


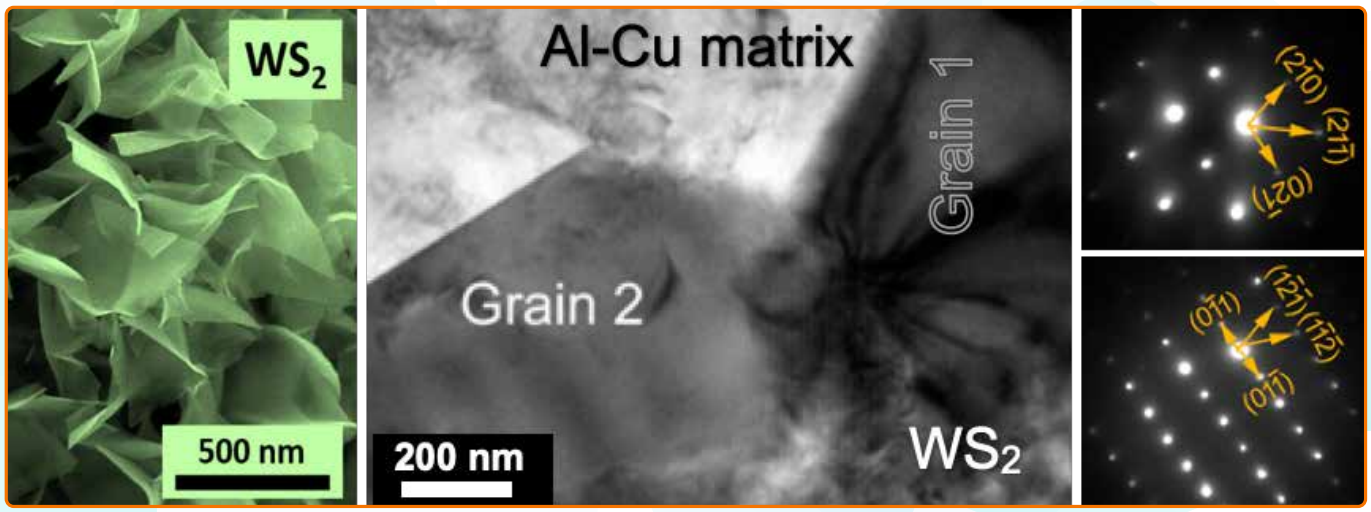
Fig. Schematic of a) bar coating and b) spin coating employed for the large area TiO_2 electron transport layer deposition. Pictures of actual substrates with TiO_2 coating by respective methods are shown in a and b. Titanium diisopropoxide bis(acetyl acetonate) precursor is used for spin and bar coating of the compact layer, while TiO_2 sol is used for the mesoporous layer in both the coating techniques.

Reference: Large area bar coated TiO_2 electron transport layers for perovskite solar cells with excellent performance homogeneity, Solar Energy, doi.org/10.1016/j.solener.2022.04.060

Development of 2D-WS_2 Reinforced Al-4Cu Alloy Matrix Composites

Contributors: Joydip Joardar, Adigilli Harish Kumar, P. V. V. Srinivas, Anirudha Karati and P. Suresh Babu

The unique lubricating properties of 2D-WS_2 (Fig. a) and the mechanical behaviour of Al-4Cu alloy were coupled together to develop novel Al-4Cu-2D-WS2 based self-lubricating nanocomposites via spark plasma sintering (SPS). In-situ formation of Al-W-Cu ternary phase (space group:$Im\bar{3}$) at the grain boundaries of the Al-rich matrix phase was observed as confirmed by high-resolution transmission electron microscopy (HRTEM) (Fig. b). The ternary intermetallic phase along with the retained 2D-WS_2 contributed to about 41% increase in the hardness of the composite. The composite, in age-hardened state, also showed a low Coefficient-of-friction (CoF) of about 0.15 to 0.2 with 10% 2D-WS_2 addition.



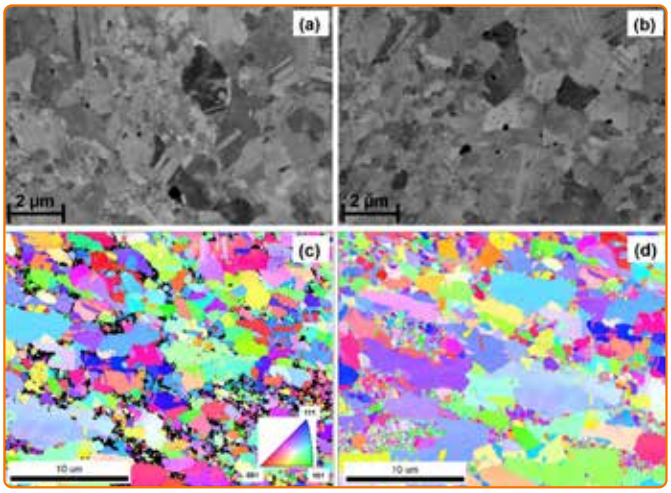
(a) FESEM of 2D-WS_2 particles (b) HRTEM of Al-Cu-2D-WS_2 composite. Inset shows the SAED from Grain 1 (Top inset) and Grain 2 (bottom inset) indicating bcc structure.

Reference: The first report on formation of Al-W-Cu grain boundary phase and its influence on mechanical behavior of 2D-WS_2 reinforced Al-4Cu alloy matrix composites, Journal of Alloys and Compounds 883 (2021) 160792.

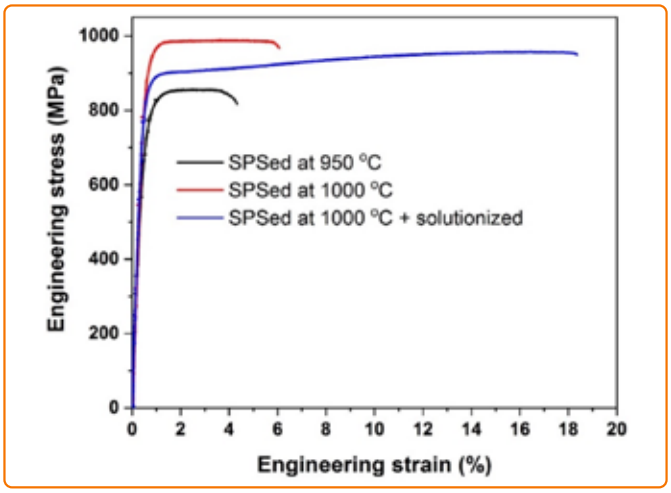
Microstructure and Mechanical Properties of Spark Plasma Sintered Austenitic ODS Steel

Contributors: S.B. Chandrasekhar, P.S. Ninawe, S. Ganesh, P. Sai Karthik and R. Vijay

Austenitic oxide dispersion strengthened (AODS) steel of composition > Fe–16Cr–16Ni–1.5W–0.21Ti–0.3Y_2O_3 (wt. %) was fabricated using ball milling followed by spark plasma sintering (SPS). SPS of milled powder was carried out at 900, 950, 1000 and 1050^{0}C. A relative density of ~99% was obtained for samples sintered at 950 and 1000^{0}C. Yield strength and elongation were measured as 851 MPa and 18%, respectively at room temperature. These values are the best combination of strength to elongation achieved on AODS alloys processed using mechanical alloying and SPS, which makes this AODS steel more promising for high temperature applications. Further studies on the evaluation of properties at high temperatures are in progress.



FE–SEM image of solutionized samples sintered at (a) 950°C, (b) 1000°C, IPF image of samples are shown in (c) and (d), respectively. The bimodal grain size distribution was found in both the cases.



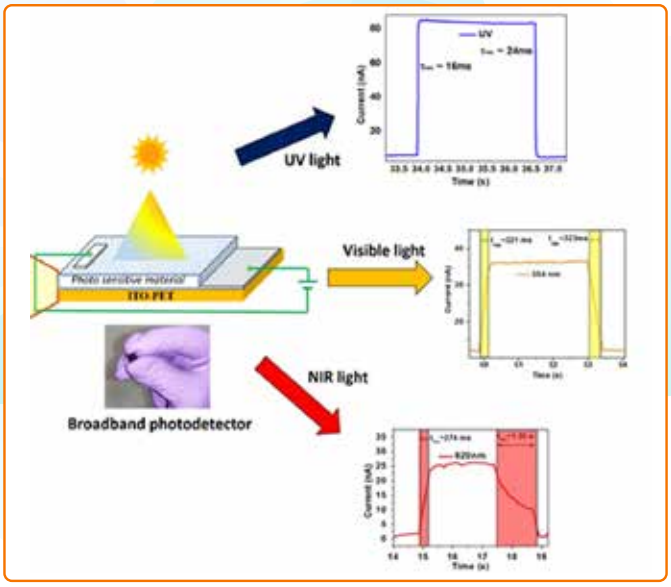
Engineering tensile stress–strain curves of AODS samples under various conditions.

Reference: Microstructure and Mechanical Properties of Spark Plasma Sintered Austenitic ODS Steel, Advanced Powder Technology, Vol. 33 (2022) 103584

Fabrication of a Scalable, Solution Processed Economic, Flexible High Performance Photodetectors

Contributors: P. H. Borse, B. Kumaar Swamy Reddy, R.N.Bathe, S.R.Dhage, S.Nirmala & Roy Johnson (Sensor Development Group)

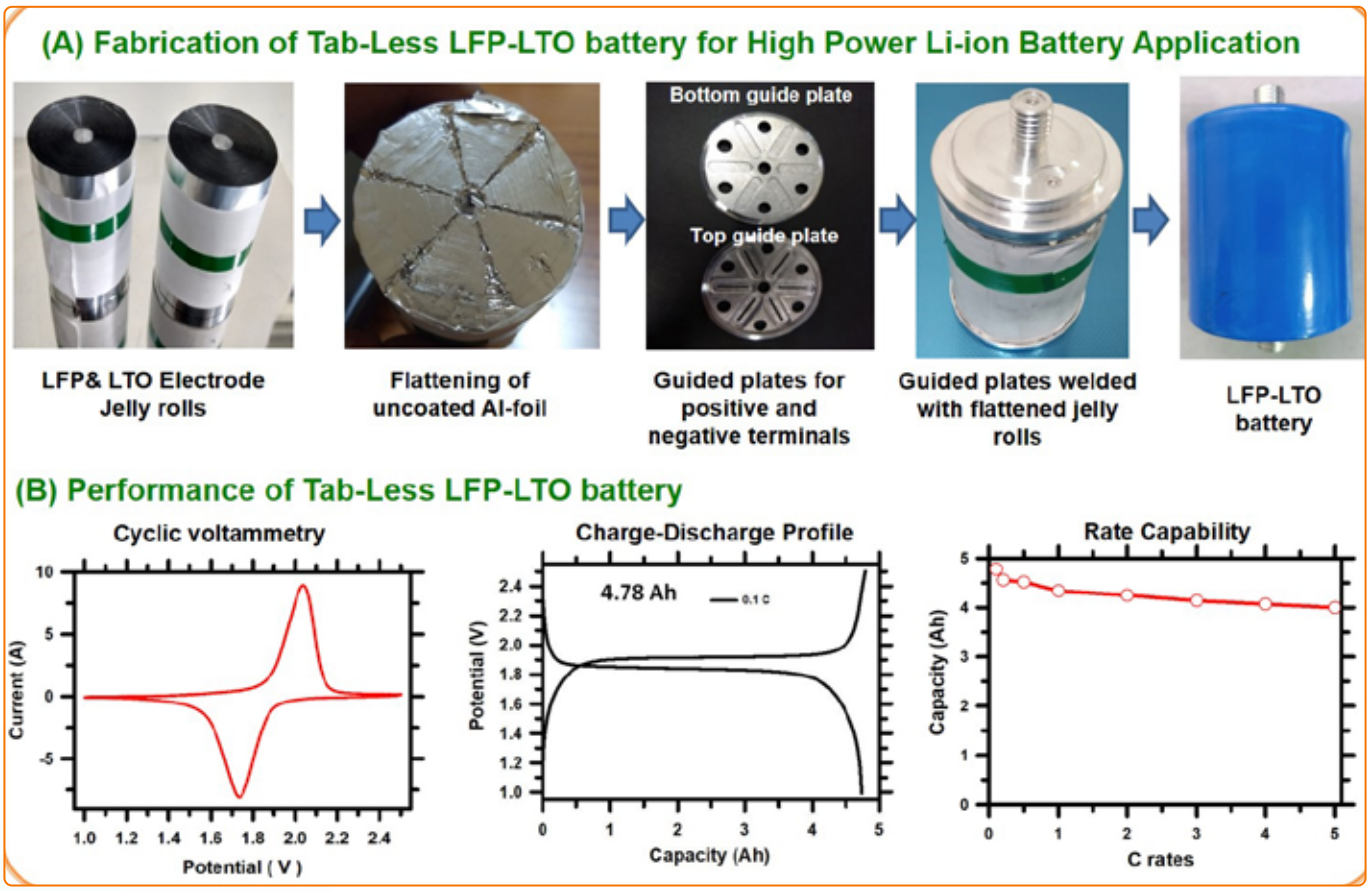
Light detection is the most important aspect of life on earth. Photo-detector or photo-sensor is an optoelectronic device that converts the incident photons into electrical output. A nanomaterial based hybrid organic-inorganic hetero-junction broadband photo-detector has been developed at ARCI. This broadband photo-detector is engineered to detect the three regions of wavelengths in UV, Vis and NIR ranges of the electromagnetic spectrum. They show superior response as well as the required stability after 1000s of operational cycles under service conditions. Major application areas of these photo-detectors are in communication, remote sensing, safety and security, process control-automation, environmental sensing, astronomy, defence etc. The novel flexible device is currently undergoing fine-tuning and scaling up of the process to higher Technology Readiness Levels (TRLs) for commercialization.



Reference: A flexible, rapid response, hybrid inorganic–organic $SnSe_2$–PEDOT:PSS bulk heterojunction based high-performance broadband photodetector, Mater. Chem. Front. 2022, 6, 341-351

Fabrication of Tab-less LFP-LTO Battery for High Power Li-ion Battery Application

Contributors: S. Anandan, K. Nanaji, R. Vijay, T.N. Rao



Schematic for the fabrication (A) and performance of Tab-less LFP-LTO Battery

In line with the Electric Vehicle's (EVs) requirement of long driving range and fast charging, ARCI has initiated the fabrication of large size Li-ion battery using indigenously developed $LiFePO_4$ as cathode and high power LTO as an anode. Unlike conventional Li-ion batteries, tab-less terminal made in the present LFP-LTO battery by flattening uncoated Al-foils exists in both cathode and anode electrodes in which all electrodes are connected to positive and negative terminals and thus are expected to deliver high power performance. The tab-less cylindrical battery delivers a capacity of 4.78 Ah, with a high capacity retention of 4 Ah at high 5C rates for 800 cycles.

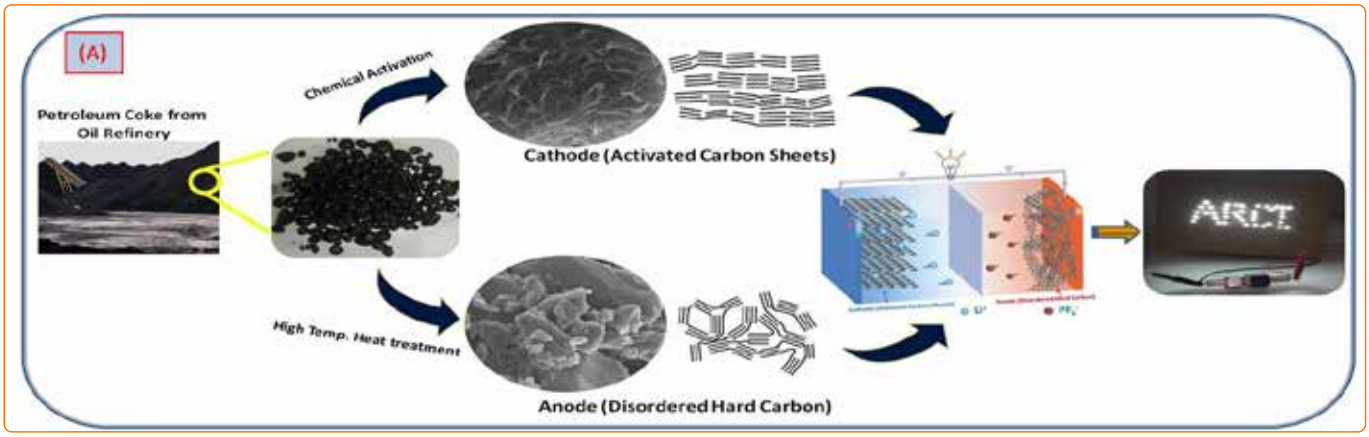
References:

1. **A method of producing high performance in-situ carbon coated lithium iron phosphate cathode material for lithium ion battery applications and the product thereof, S. Anandan, R. Vijay, Tata Narasinga Rao, PCT International Publication Number WO/2022/144917 dated July 07, 2022, & Indian Patent Application No. 202011056608 dated December 28, 2020.**
2. **A method of producing high performance lithium titanate anode material for lithium ion battery applications, S. Anandan, P.M. Pratheeksha, R. Vijay and Tata N. Rao, Indian Patent (No. of 36556) dated April 28, 2021; US Patent (No. 11001506) May 11, 2021; Chinese Patent (No. IIC190527) dated December 01, 2021; Japan Patent Application No. 2019-520394 dated April 16, 2019; Germany Patent Application No. 112018000205 T5 dated August 14, 2019; South Korea Patent Application No. 10-2019-0121291 dated October 25, 2019**

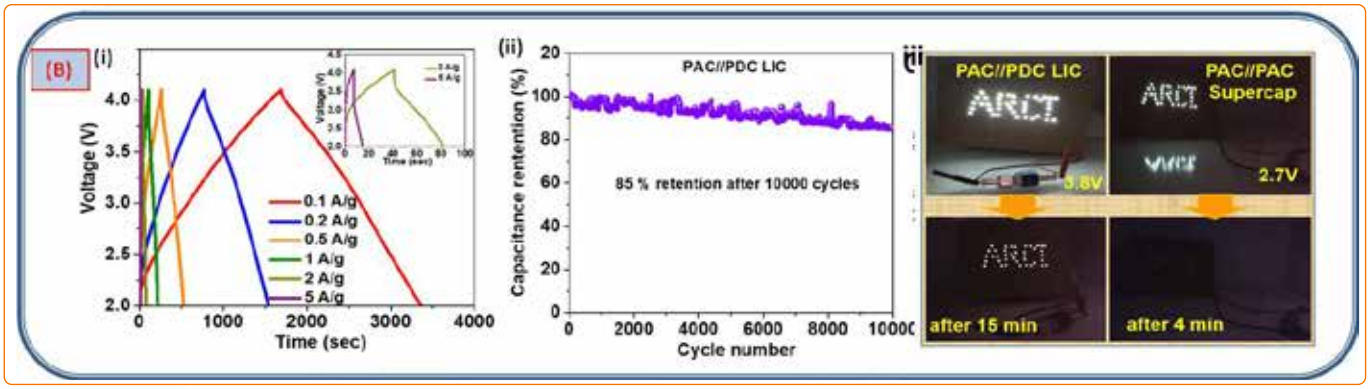
All Petroleum Coke derived Carbon for Lithium-ion Capacitors with High Energy and High Power Density

Contributors: K.Nanaji, P.V.V. Srinivas, S. Anandan, Tata N. Rao

Lithium-ion capacitors (LICs), with high energy and high power, are considered to be attractive for advanced energy storage applications. However, the design and fabrication of suitable electrode materials with desirable properties by a facile approach using cost-effective precursors is still a great challenge. Petroleum coke, an unavoidable industrial waste with high carbon content, is utilized as a single carbon source to synthesize both high surface area activated carbon cathode and low surface area disordered carbon anode for LIC application.



(A) Schematic representation of fabrication of all Petroleum coke waste derived Li-ion capacitor,



(B) Electrochemical properties of fabricated Li-ion Capacitor and its demonstration for practical usage

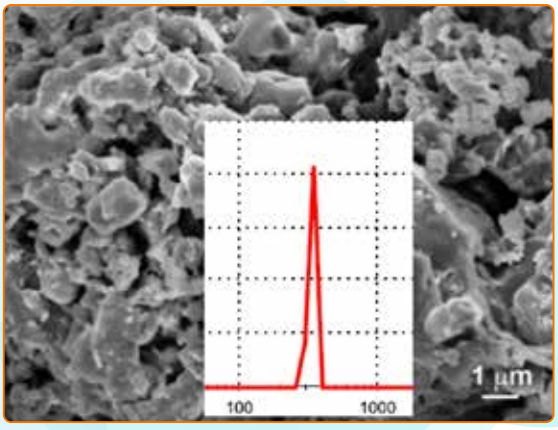
LIC fabricated using all petroleum coke derived carbon materials exhibits a high energy density of 80 Wh/kg, a high power density of 8.4 kW/kg as well as long cyclic stability. The facile approach, adopted to synthesize both cathode and anode materials from a single source, is an effective way for high value-added utilization of petroleum coke at the commercial level.

Reference: "Petroleum coke as an efficient single carbon source for high energy and high power Lithium-ion capacitors" Energy & Fuels, 2021,35, 9010-9016

Nano DAP (Di-ammonium phosphate) Fertilizers by Cryo-Milling

Contributor: S.Sudhakara Sarma, Tata.Narasinga Rao

Higher agricultural productivity is of utmost importance for a growing population in India and its food security. Proper use of chemical fertilizers is one of the vital elements to increase the yield in agriculture. Still, excessive use of chemical fertilizers irreversibly damages the fertile land and causes a serious threat to future food security. In the conventional method, excess fertilizers are used in excess of the uptake need of the plant thereby causing chemical contamination of water and soil. Nano fertilizers are emerging as substitute fertilizers for soil restoration, conservation of phosphorous nutrients, and reduction in fertilizer imports. The orthophosphate (Pi) is a bioavailable form of phosphorous with limited availability.



Nano DAP with narrow size particle distribution

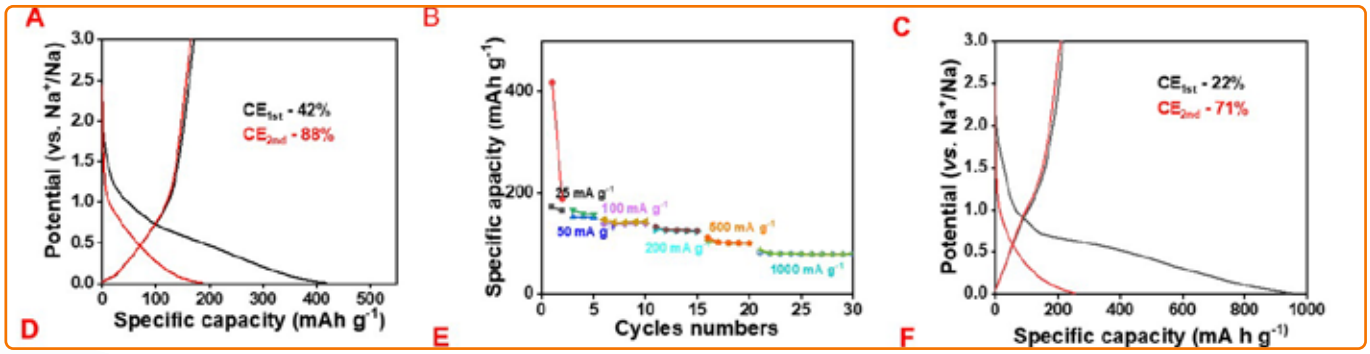
The Pi is a micronutrient that regulates plant growth and development. The nano Di-ammonium phosphate fertilizer (n-DAP) is conceptualized and demonstrated successfully at the lab level. The n-DAP is prepared by cryo-milling at ARCI without altering the chemical structure and tested for efficacy at the University of Hyderabad. The cryo-milled n-DAP , with particle size 5000 times lesser but specific surface area 14000 greater than that of commercially available DAP (C-DAP), enhanced the growth of monocot (wheat) and dicot (tomato) plants. The improved agronomic factors such as higher leaf biomass, longer shoot, shorter root, and extraordinary efficacy were observed with n-DAP for 75% lesser input than C-DAP.

Reference: Cryo-milled nano-DAP for enhanced growth of monocot and dicot plants, Nanoscale Advances, 3 (2021) 4834 – 4842.

Surface Engineering of Jute Stick derived Amorphous Carbon with SnO_2 Nanowires to Enhance the Efficacy of Li/Na-ion Battery

Contributors: Ramakrishna Sahoo, K. Nanaji, S.Praveen, Rekhamadhuri, S. Anandan and Tata N. Rao

Amorphous carbon can be considered an excellent anode material for rechargeable batteries if the specific capacity is enhanced by making a composite with appropriate material. On the contrary, although SnO_2 exhibits a very high specific capacity as Li/Na-ion battery anode due to its conversion-alloying mechanism, the low cyclic stability limits its practical application. In this work, the facile synthesis of SnO_2 composite with non-activated carbon (NAC) derived from jute stick using wet chemical dispersion followed by an annealing route which is not only cost-effective but also scalable compared to the conventional synthesis routes. The as-prepared C/SnO_2 composite exhibited high specific discharge and charge capacity of 1657 and 868 mA h g^{-1}, respectively at 25 mA g^{-1}. Upon assembling the composite with C/LFP as cathode, the full cell exhibited a maximum energy density of 384 Wh kg^{-1} having an average voltage of 2.3 V. Hence, this scalable synthesis route and excellent battery performance of the aforementioned composite may endorse the pathway for the development of low-cost rechargeable battery anode.



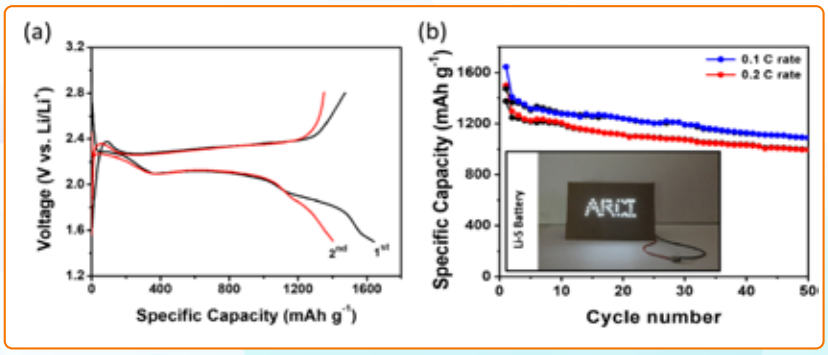
Half-cell electrochemical study as Na-ion battery; (A) Galvanostatic charge-discharge curve and (B) rate capability curve of NAC, (C) Galvanostatic charge-discharge curve

Reference: Facile Surface Engineering of Bio-Waste Derived Amorphous Carbon with SnO_2 Nanowires to Enhance the Efficacy of Li/Na Storage, RSC Energy Advances, 2022 1, 205-215

One-Step Synthesis of Bio-inspired Porous Graphitic Carbon Sheets for Improved Lithium-Sulfur Battery Performance

Contributors: Tata Narasinga Rao, E. Hari Mohan, K. Nanaji and S. Anandan

Lithium-sulfur (Li-S) battery, with high specific energy, is recently attracting attention as a suitable candidate to meet the increasing demands of smart grids, advanced electronic devices, and electric vehicle (EV) technology. However, Li-S batteries face challenges including the formation and high solubility of intermediate polysulfide species, causing the shuttle effect which results in low cycle life and loss of cell capacity. In order to alleviate the disadvantages, a facile one-step in-situ chemical activation process was adopted to synthesize porous graphitic carbon sheets (GCS) from tissue paper. The resulting GCS exhibits high specific surface area, large pore volume and a highly graphitized carbon structure with graphene-like morphology. Sulfur infused graphitic carbon sheets with optimum sulfur loading along with GCS coated separator deliver a high initial discharge capacity of 1643 mAh g^{-1} at 0.1 C rate. Moreover, when the electrode is tested at a high current rate of 1C, the cell delivered excellent cyclic stability of 652 mAh g^{-1} over 200 cycles. The improved electrochemical performance attributes to the unique properties of GCS, which functions as an efficient host matrix as well as an interlayer by constraining the dissolved polysulfides in addition to the enhancement in ionic and electronic conductivities.

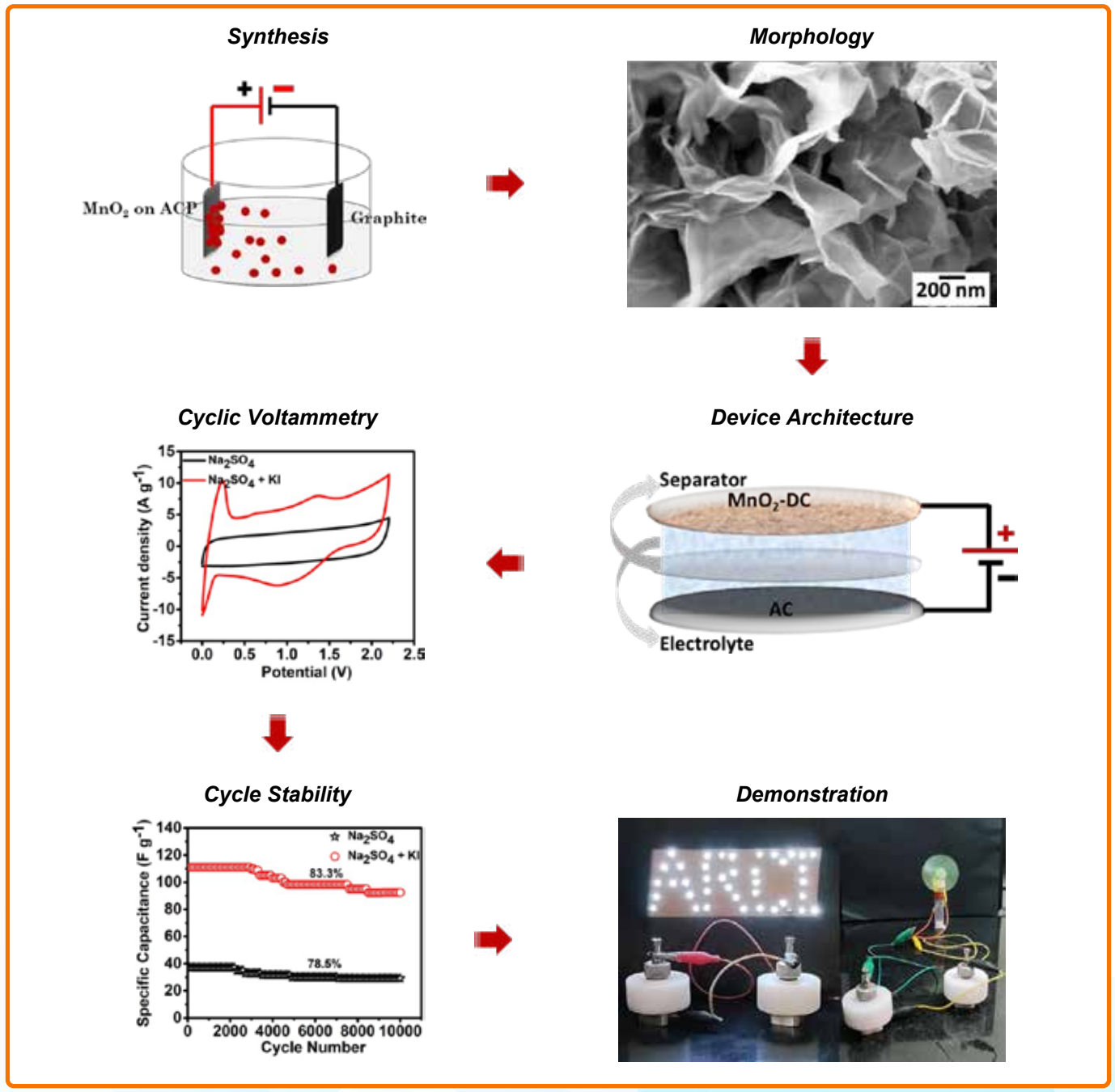


(a) and (b) are the charge/discharge and cycle performance curves of GCS-2/S/GCS-2 electrode measured at 0.1 C rate

Reference: A facile one step synthesis of bio-inspired porous graphitic carbon sheets for Improved Li-S battery performance" International Journal of Energy Research, 2022,46, 4339-4351

Design of 2.2 V high energy density aqueous supercapacitor with electrodeposited β-MnO_2 cathode

Contributors: B. V. Sarada, Tata N. Rao, Samhita Pappu



Schematic of electrodeposition setup, surface morphology of β-MnO_2, device architecture, cyclic voltammetry at 30 mV s^{-1}, cycle stability analysis, and device demonstration

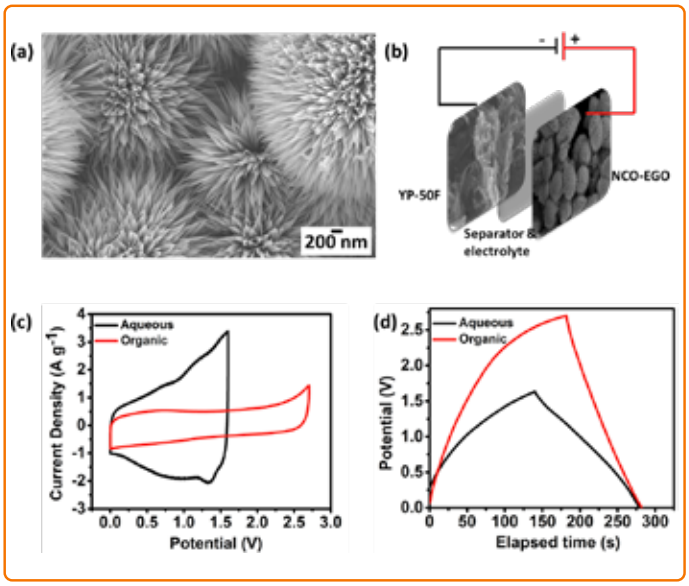
MnO2, as a prospective electrode material for supercapacitors, has attracted wide attention due to its ease of availability, cost-effectiveness, and environmental benignity. Here, β-MnO2 nanosheets have been synthesized by the electrodeposition route and utilized as positive electrode for supercapacitor. When coupled with an activated carbon negative electrode, the aqueous supercapacitor was found to be stable until 2.2 V with a specific capacitance (Csp) of 40 Fg-1 at 3 Ag-1 current density. Further, the effect of potassium iodide in the electrolyte to boost the device performance was analyzed and found to yield a Csp 3.35 times superior (134 F g-1 at 3 A g-1). The cyclic stability of the device was also found to be excellent with 83% capacitance retention at the end of 10000 charge-discharge cycles along with a high energy density of 90 Whkg-1 at a power density of 555 Wkg-1. Device demonstration was carried out with LED and fan. Plans are ahead for making a pouch cell.

Reference: Electrodeposited Manganese Oxide based Redox Mediator Driven 2.2 V High Energy Density Aqueous Supercapacitor, Energy, 243 (2022) 122751

Electrochemically Exfoliated Graphene Oxide $NiCo_2O_4$ Composite for Aqueous and Non-aqueous Asymmetric Supercapacitors

Contributors: B.V. Sarada, P. Samhita, S. Anandan and Tata N. Rao

Graphene-metal oxide composites have attracted attention as supercapacitors owing to the excellent reversible redox properties of metal oxides leading to high capacitance and energy density due to the high conductivity and stability of graphene nanosheets. Graphene oxide (EGO) nanosheets are developed by a more benign and cost-effective electrochemical exfoliation route. Further, EGO-$NiCo_2O_4$ (NCO-EGO) composites were synthesized by hydrothermal route resulting in micro flower morphology. The developed composite was tested as a positive electrode for supercapacitor application in both aqueous and non-aqueous electrolytes. Owing to the lower ionic radii and high conductivity of the aqueous electrolytes (KOH), the supercapacitor device could achieve a specific capacitance of 89 Fg^{-1} at 0.5 Ag^{-1}. However, the lower thermodynamic voltage (1.6 V) of aqueous electrolytes limits its energy density. The assembled device tested in organic electrolyte with $TEBF_4$ in acetonitrile could achieve a wide electrochemical window of 2.7 V with an energy density of 37.8 $Whkg^{-1}$ at a power density of 1350 Wkg^{-1} and good stability.



(a) Surface morphology of $NiCo_2O_4$, (b) schematic of asymmetric supercapacitor architecture, (c) CV at 30 mV s^{-1} scan rate, and (d) CD at 1 A g^{-1} current density

Reference: High-performance hybrid supercapacitor with electrochemically exfoliated graphene oxide incorporated $NiCo_2O_4$ in aqueous and non-aqueous electrolytes, Journal of Energy Storage, 50 (2022) 104598

Oxide Dispersion Strengthened Iron Aluminides for Power Plant Ppplications

Contributors: P. Vijaya Durga , Kiranchand, M. Nagini, N. Narsaiah, A.V. Reddy and R. Vijay

Iron aluminide (Fe_3Al) based intermetallics can be potential candidates for advanced ultra-supercritical (AUSC) power plants because of their lower density, high strength, good resistance to oxidation/corrosion, and low cost. However, these materials could not be used since they have insufficient ductility at room temperature and are low creep-resistant at high temperatures. Efforts are being made at ARCI to improve these drawbacks by the addition of Cr, grain refinement (690 nm), and dispersion of stable and nano-sized (6.6 nm) oxides. The EBSD orientation maps of ODS-Fe_3Al and Fe_3Al are shown in Fig. 1, which show the effect of nano oxide dispersoids in the refinement of grains. The oxide dispersion strengthened Fe_3Al developed at ARCI has exhibited ductility of 16% with a yield strength of 1093 MPa at room temperature. The high temperature strength of this material is higher up to 600^{0}C and similar at 700^{0}C when compared to IN617. Oxidation studies at 900 and 1050^{0}C and yield strength of ODS-Fe_3Al are shown in Fig. 2 (a) and (b) respectively.

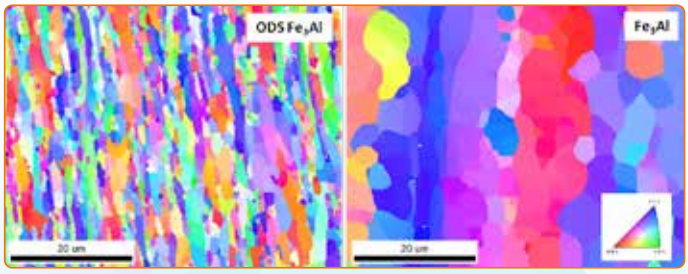


Fig. 1 EBSD orientation maps

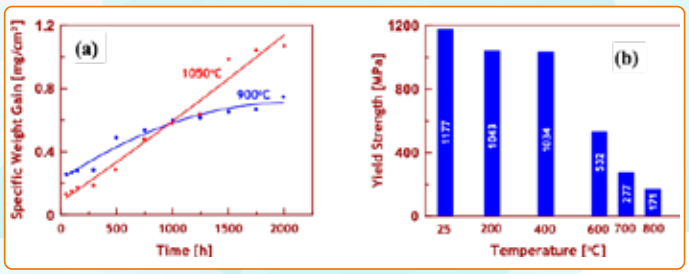


Fig. 2 (a) Oxidation and (b) Yield strength of ODS Fe_3Al at various temperatures

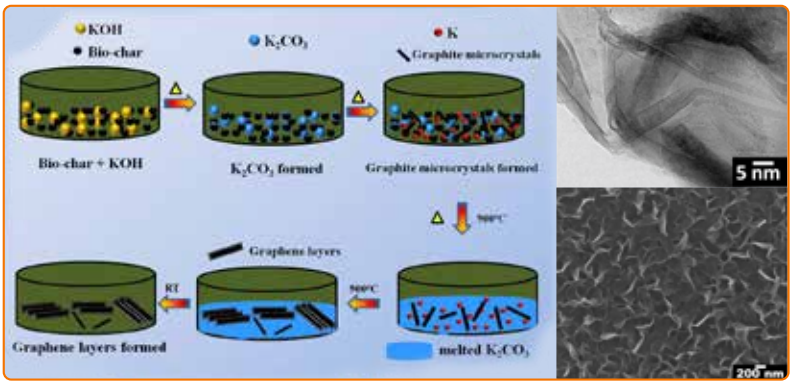
The material exhibited a very low oxidation rate at both temperatures indicating that the materials can be exposed to high temperatures. Further studies on thermal ageing, creep and fatigue are in progress.

Reference: "Effect of Fine Grain Structure and Nano Oxide Dispersoids on Improved Strength and Ductility of Iron Aluminide Based Intermetallics", Metallurgical and Materials Transactions A, 53 (2022), 1597-1603.

A novel approach to synthesize porous graphene sheets by exploring KOH as pore inducing agent as well as a catalyst for supercapacitors with ultra-fast rate capability

Contributors: K. Nanaji, B.V. Sarada, Tata N. Rao, U. V. Varadaraju and S. Anandan

An earth-abundant bio-waste is effectively transformed into porous graphene sheets at a low temperature of 900^{0}C by utilizing Potassium hydroxide (KOH) as an activation agent to create porosity as well as a catalyst to induce graphitization by a simple synthetic approach. The resulted carbon material possesses good textural properties such as high specific surface area (2308 m^2/g), high pore volume (1.3 cm^3/g), graphene sheet-like morphology with an interlayer d-spacing of 0.345 nm and a highly ordered sp2 carbon as evidenced from the detailed textural analysis. A detailed mechanism for the formation of graphene sheets is further explored.



Synthesis process for the formation of graphene like sheets from the mixture of bio-char and KOH and FE-SEM and HR-TEM images.

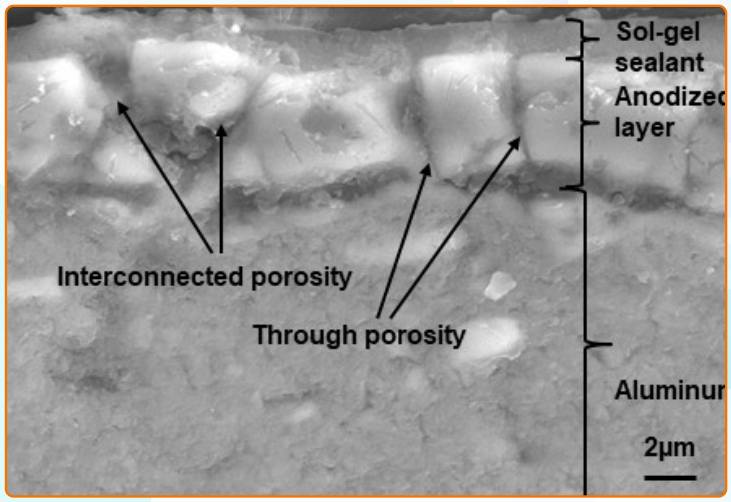
The assembled symmetric supercapacitor exhibits ultra-fast rate capability of 87% capacitance retention at high current rates (50 A/g), exceptional cyclic stability (93% retention after 25,000 cycles) and displays outstanding energy density of 21.37 W h kg^{-1} at a high power density of 13,420 W kg^{-1}. The strategy developed here reveals a facile, low-cost, eco-friendly design of graphene sheets at large-scale production.

Reference: A novel approach to synthesize porous graphene sheets by exploring KOH as pore inducing agent as well as a catalyst for supercapacitors with ultra-fast rate capability, K. Nanaji, B. V. Sarada, Tata N. Rao, U. V. Varadaraju, S. Anandan, Renewable Energy, 2021, 172, 502-513.

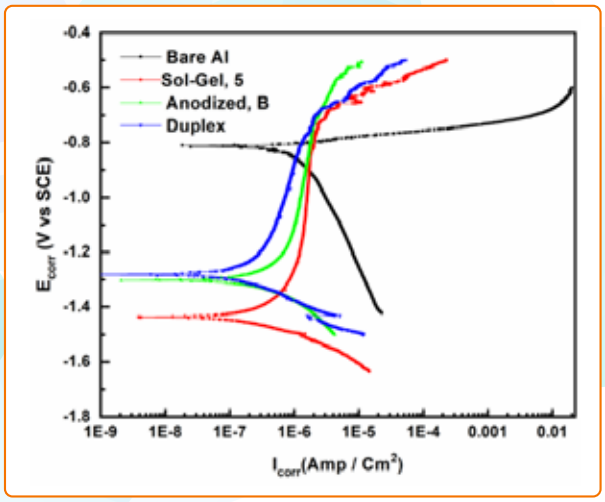
Sol-gel Coatings as Sealants for Improved Corrosion Protection of Anodized Aluminium

Contributors: K. R. C. Soma Raju, A. Jyothirmayi, L. Rama Krishna, R. Subasri

Low density, high thermal conductivity and excellent formability favour aluminium and its alloys for their widespread use in all sectors of life. Anodizing is routinely used for imparting corrosion protection of aluminium. Anodizing results in a thin oxide layer with good corrosion protection but interconnected porosity and hence is susceptible to corrosion upon exposure to acidic and saline environments thereby limiting its service life. Low temperature curable hybrid sol-gel nanocomposite coating applied as a top coat was (as depicted) found to act as a better sealant for anodized layer, when compared to hydrothermal sealing. Corrosion test results presented in the following figure confirmed that duplex (anodized+sol-gel) coating performed superior to individual anodizing layers of identical thickness.



Cross-sectional image of the duplex coatings



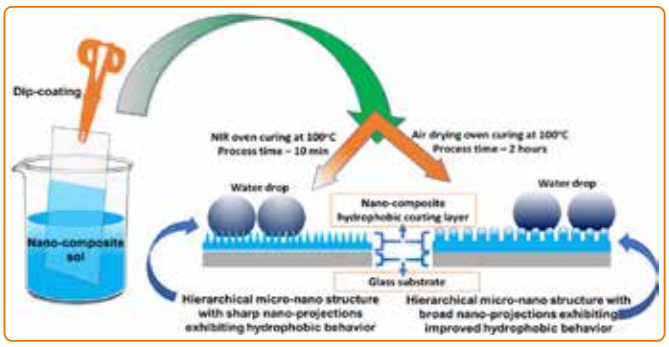
Polarization plots of uncoated, sol–gel and anodized and identically thick duplex coated samples

Reference: K. R. C. Soma Raju, A. Jyothirmayi, L. Rama Krishna, R. Subasri, Corrosion Behavior of Anodized and Sol–Gel Duplex Coatings on AA3004, Trans Indian Inst Met https://doi.org/10.1007/s12666-022-02595-5, April 2022

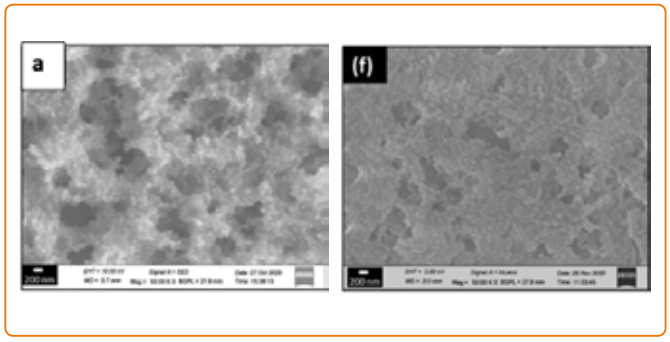
Effect of Heating Rate on Asperities Pattern formed in Sol-gel derived Nanocomposite Hydrophobic Coatings

Contributors: K. R. C. Soma Raju, K. Murugan, R. Subasri

Curing condition is an important parameter to tune the hierarchical distribution, shape and size of nanoscale asperities in highly hydrophobic coatings, affecting the water contact angle (WCA) of the surface. Sol-gel based nanocomposite hydrophobic coating was applied on soda lime glass surface and cured at different heating rates, soaking temperatures, durations and cured using near infra-red (NIR) radiation and conventional thermal curing methods. It is concluded that oven curing can be preferred over NIR curing to obtain relatively higher WCA due to the formation of stable asperities on it as shown in the schematic, whereas NIR curing can also be adopted to achieve a high rate of production by compromising a slight reduction in WCA.



Schematic representation of effect of (a) NIR oven curing and (b) Air drying oven-heating mechanism on topography of coated surface



Surface morphology of sol-gel derived hydrophobic coatings densified at different curing conditions
a) 100°C for 5 min – NIR oven at 74 deg C/min;
b) 100°C for 1 h at 2.3 °C/min in air drying oven

Reference: Ramay Patra, K. R. C. Soma Raju, K. Murugan, R. Subasri, Effect of heating rate on asperities pattern formed in sol-gel derived nanocomposite hydrophobic coatings, J Sol-Gel Sci Technol https://doi.org/10.1007/s10971-022-05762-8

Graphene/Phase Change Materials Composite with Augmented Thermal Conductivity and Compatible Melting/Freezing Behaviour for Battery Thermal Management

Contributors: Balaji Padya and P. K. Jain

To transform the traditional transportation system into green and sustainable e-mobility, electric vehicles (EVs) are at the forefront. Consequently, EVs are a potential candidate to support green transportation, which relies on Li-ion batteries (LIB) with high energy density. During the charging/discharging (CD) of LIB, it produces enormous heat. Heat accumulation and abrupt temperature shoot-up in LIB battery pack may trigger fire and explosion.

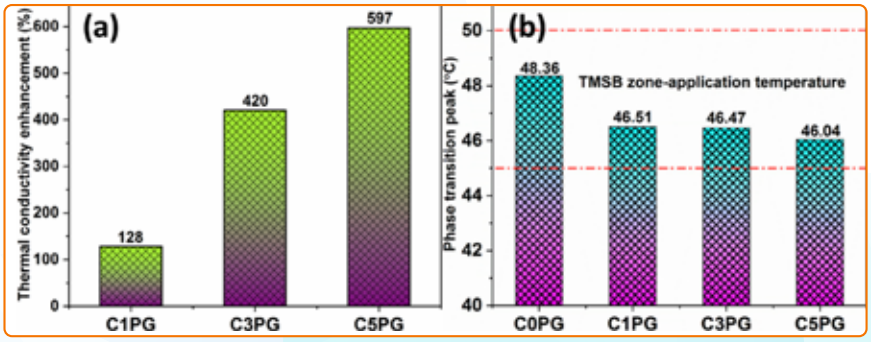


Fig.1 Thermal transport of CPCM: (a) thermal conductivity improvement and (b) phase transition peak

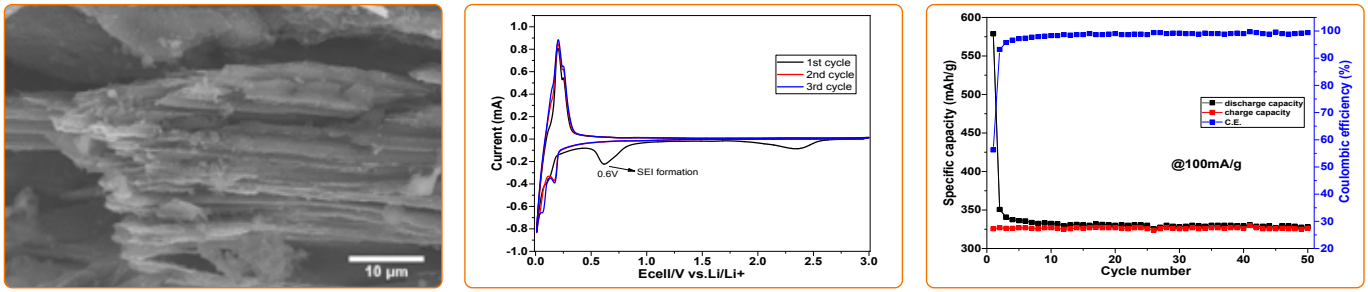
As a remedy for thermal regulation, a passive battery thermal management (TMSB) based on composite phase change materials (CPCM) are widely attractive to solve the current issue by absorbing the excess heat generated during LIB's CD. Platelet-structured graphene (PG) with variable loading was incorporated into eutectic CPCM to improve thermal transport. They showed an increase in thermal conductivity by 128%, 420% and 597% for C1PG, C3PG and C5PG, respectively as indicated in Fig.1a. In addition, they exhibited a phase transition temperature peak of 48.36, 46.51, 46.47 and 46.04 ºC for C0PG, C1PG, C3PG and C5PG, respectively. The composites exhibited a phase transition peak in the range of 45-50ºC (TMSB zone within two dotted red lines) that is perfectly suitable for the TMSB system, as indicated in Fig. b. This systematic approach could lay a step forward for controlling extreme operational temperature for thermal safety of an efficient high-powered Li-ion battery system to achieve prolonged life and energy density using phase change materials.

B. Padya et al. Materials Today Communications 30 (2022) 103024

Li-ion Storage Characteristics of Graphene-like Carbon Nanostructures Produced via Simplified Arc Underwater

Contributors: Ravi Kali, Balaji Padya and P. K. Jain

An adaptable and simplified arc underwater set-up is designed for the synthesis of multidimensional nanostructured carbon materials (NSCM) such as multi-shelled onion-like carbon (OLC), an elongated tubular carbon structure (ETCS) and graphene-like carbon nanostructures (GCN). Transmission electron microscopic analysis confirmed that the cathode deposit, floating particles and settled materials consist of ETCS, OLC and GCN, respectively. This kind of NSCM formation is critically governed by temperature gradient and cooling rate created due to bubble collapse in nucleate boiling during the arcing process. The high rate and moderate rate of cooling will determine the growth of ETCS and OLC, respectively. Graphene-like particles were used as anode materials for lithium ion batteries and exhibited the stable specific capacity of 325 $mAhg^{-1}$ with lithium half-cell after 50 cycles at a current density of 100 mAg^{-1}.



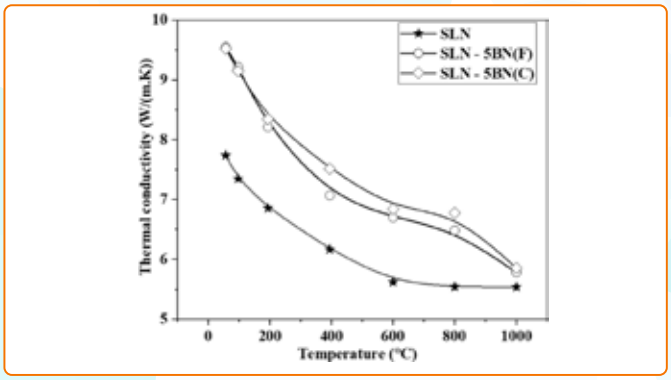
Surface morphology, cyclic voltammetry and cyclic stability of graphene-like carbon nanostructures

Reference: Ravi Kali et al. Facile synthesis of multidimensional nanoscaled-carbon via simplified arc underwater: An integrated process for 0-D, 1-D and 2-D, Nano-Structures & Nano-Objects 26 (2021) 100684

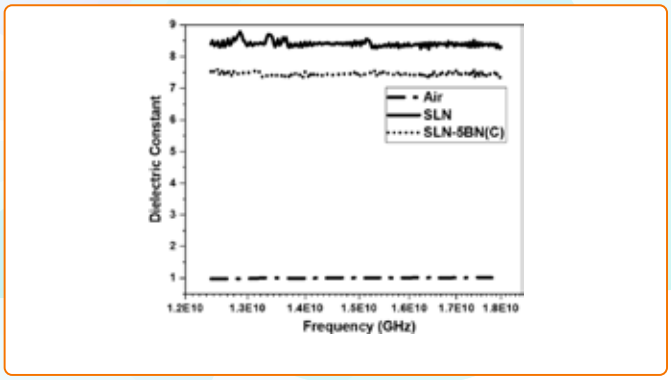
Effect of Hexagonal Boron Nitride (h-BN) Addition on Mechanical, Thermal, and Dielectric Properties of β-SiAlON Ceramic

Contributors: P. Barick, B.V. Shalini, R. Anbarasu, B.P. Saha

β-SiAlON is a potential material for wave transparent window application. In this context, an investigation was carried out to examine the influence of h-BN addition on mechanical, thermal and dielectric properties of β-SiAlON, with an objective to tailor its properties. The experimental results show that with the increase in h-BN content up to 5 wt. %, the bulk density of β-SiAlON decreases from 3.22 to 3.05 $g.cm^{-3}$. The mechanical properties like Young's modulus, hardness, flexural strength, and fracture toughness of pristine β-SiAlON are greater by ≈ 20%, ≈ 25%, ≈ 10%, and ≈ 15% respectively in comparison to that of β-SiAlON-BN ceramic. However, an increment in thermal conductivity value with a reduced dielectric constant for BN added SiAlON was observed as shown in Fig.a and Fig.b, respectively. Therefore, BN addition is a promising approach to tailor the dielectric constant of β-SiAlON required for the above-mentioned application.



(a)- Thermal conductivity as a function of temperature : SLN – Pristine SiAlON ; SLN-5BN(F) and SLN-5BN(C) - SiAlON with fine and coarse h-BN powder, respectively.



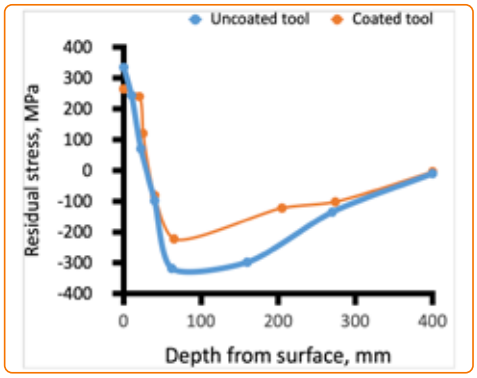
(b) Dielectric constant versus frequency at room temperature: SLN – Pristine SiAlON ; SLN-5BN(C) - SiAlON with coarse h-BN powder.

Reference: Prasenjit Barick, Bhaskar Prasad Saha, Effect of Boron Nitride Addition on Densification, Microstructure, Mechanical, Thermal and Dielectric Properties of β- SiAlON Ceramic, J. Mater. Eng. Perform. Vol. 30 (2021), pp. pages pp3603-3611. https://doi.org/10.1007/s11665-021-05692-6.

Depth Profiles of Residual Stresses in Inconel 718 Machined with Uncoated and Coated Tools

Contributors: N. Ravi

Residual stresses affect the engineering performance of Inconel718 and other superalloys. In this work, Inconel718 workpieces were machined using uncoated and TiN-coated cutting tools. The residual stresses in the workpieces were evaluated using the x-ray diffraction method. From the figure, it is seen that the tensile stresses in the starting layer of the machined surfaces are lower in the case of the coated tool (265 MPa) than that with the uncoated tool (335 MPa). However, the compressive stress values obtained in the sub-surface levels are higher when machined with the uncoated tool (332 MPa) than when machined with a coated tool (248 MPa). Since surface tensile stresses favour initiation or nucleation of the surface cracks, machining is better with coated tools.



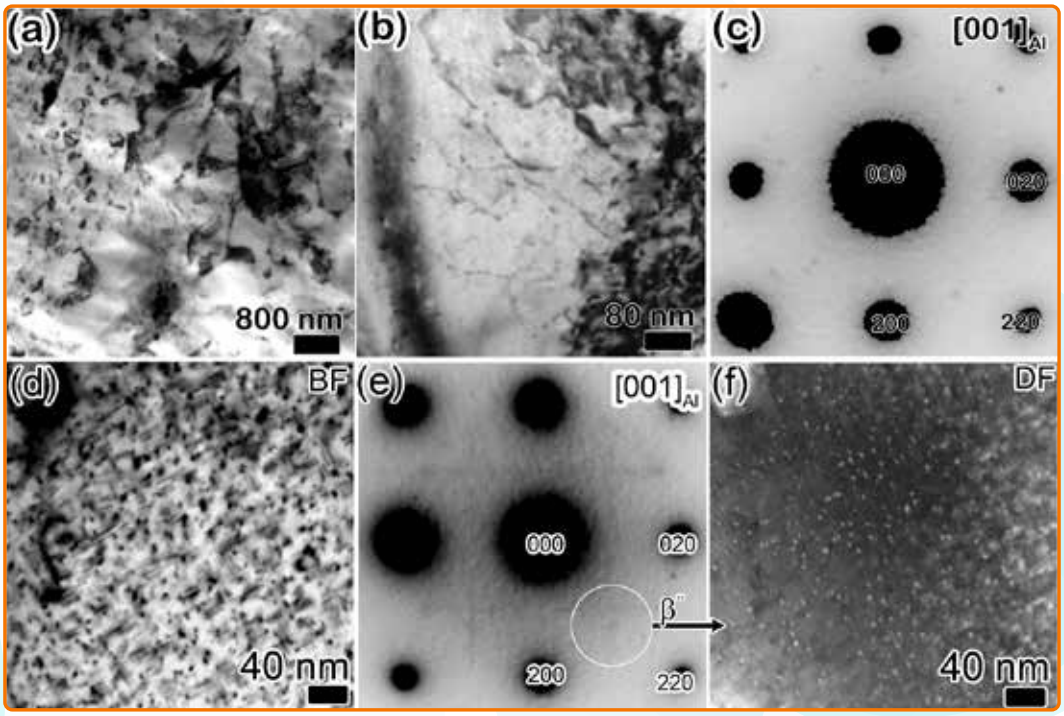
Residual stress distribution along the depth

Reference: K Satyanarayana, N Ravi, T Karthik Reddy, K Rajkiran, and Kuldeep K Saxena, Indian J. Engg. Mater. Sci. 28 (2021) 567

Precipitation Behavior of Cold Sprayed Al6061 Coatings

Contributors: M. Tarun Babu, S. Kumar and K. Suresh

Precipitation behaviour of the cold sprayed Al6061 coatings was investigated in the directly aged (as-deposited and aged) and solutionized aged conditions. Coatings were deposited using a convergent-divergent (De-Laval) nozzle at a pressure of 20 bar and a temperature of 400°C using air as a carrier gas. The peak hardness of the directly aged coatings (107±3 $HV_{0.3}$) is similar to that of the bulk counterpart (110±2 $HV_{0.3}$) and is attributed to a mixture of highly strained microstructure, and fine and coarse grains. There is no precipitation in the directly aged coatings whereas needle-shaped β" (Mg_5Si_6) precipitates contribute to the peak hardness of solutionized aged coatings. There is an improvement in bonding for directly aged coatings, and a significant improvement in solutionized aged coatings.



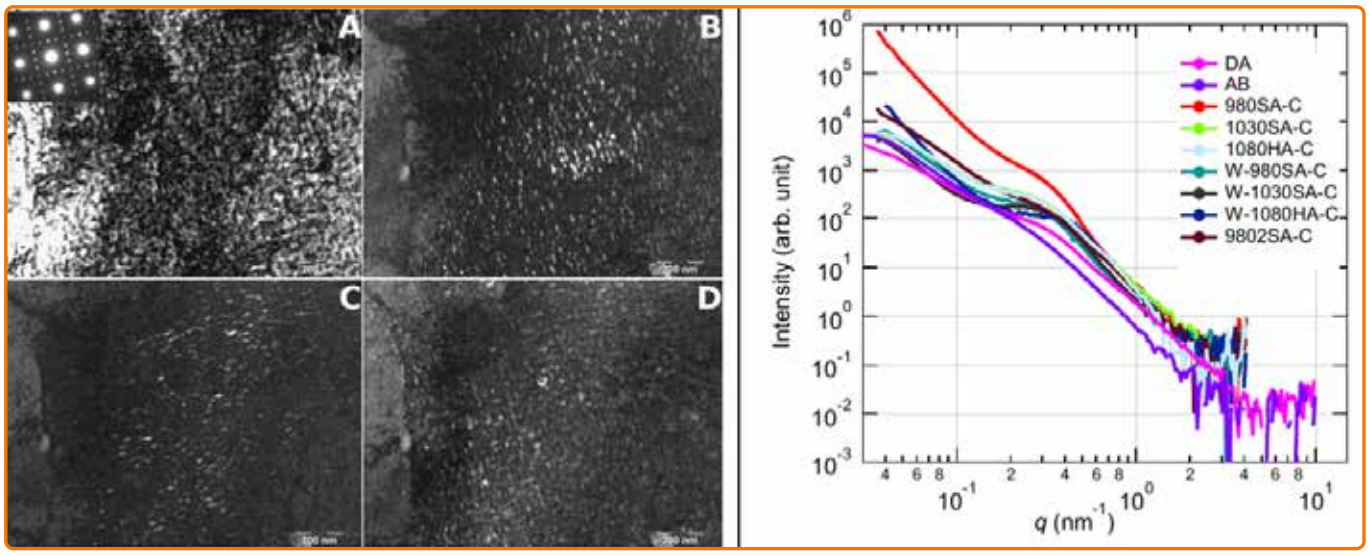
In-plane TEM low and high magnification bright field (BF) micrographs and SAED patterns of peak aged (a-c) directly aged and (d-f) solutionized and aged coatings at for 175°C for 2 and 16 hours, respectively. Solutionized and aged coatings possess GP Zones (β") whereas directly aged coating does not exhibit GP Zones (β").

Reference: T.B. Mangalarapu, S. Kumar, M. Ramakrishna, P. Gandham, K. Suresh, Materialia, 24 (2022) 101510

Precipitation in Inconel 718: Additive Manufactured Vs Wrought

Contributors: M Ramakrishna, Suresh Koppoju, Gururaj Telasang and G. Padmanabham

Inconel 718 is primarily a Nickel based super alloy designed to perform below 650C with γ″ and γ′ as strengthening phases. The primary objective of this work was to study the response of heat-treated AM IN718 with that of the conventionally processed one. Transmission electron microscopy (TEM) and Small angle X-ray scattering (SAXS) were utilized for the study. When solutionized at 1080C both AM and wrought alloy were found to have γ″ with similar size and volume fraction, thus confirming that the precipitate evolution is similar in both the processing routes.



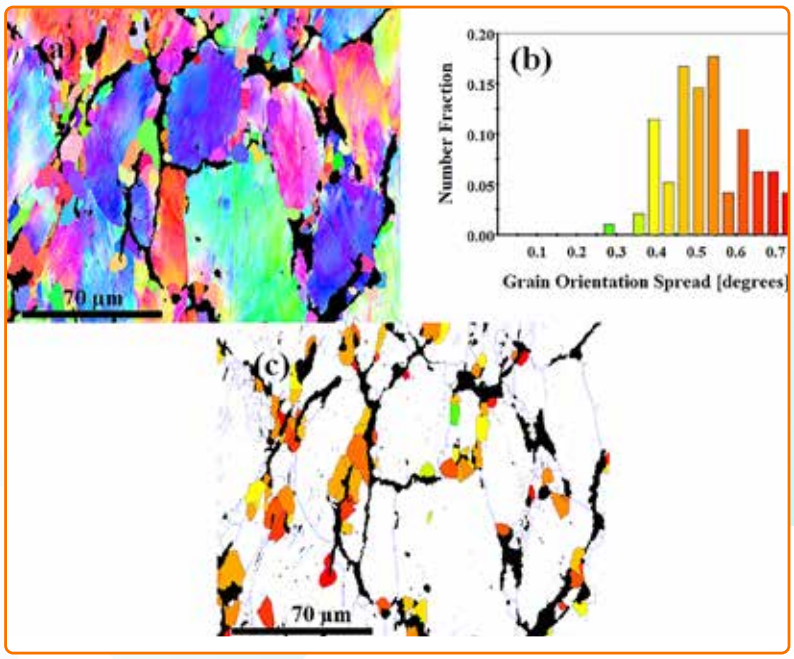
TEM bright and dark field images showing γ" and γ' in AM IN718 (on the left). SAXS curves showing signal from γ" and γ' in both AM and wrought IN718 after various post heat treatments.

Reference: Ramakrishna M, Suresh Koppoju, Gururaj Telasang and Padmanabham G, Materials Characterization 172 (2021) 110868 https://doi.org/10.1016/j.matchar.2020.110868

Study of the Refractory Multicomponent Alloy Mo-Nb-TaW

Contributors: K. Anjali and G. Ravi Chandra

MoNbTaW refractory multicomponent alloy was synthesized by vacuum arc melting. Analysis by x-ray diffraction showed that the alloy forms as a single phase with the body-centred cubic structure. The as-cast alloy, which formed with dendritic microstructure, was subjected to thermomechanical processing and further homogenization. As compared to other mechanisms (grain boundary strengthening and strain hardening), the maximum contribution to strength comes from solid solution strengthening due to lattice distortion, which is one of the proposed core effects of high entropy alloys (HEAs). The Tabor's factor for this alloy for various processing conditions was found to be in the range of 2.6-2.9. The numbers were in good agreement with those found for various metallic materials, including HEAs.



Crystal orientation map, grain orientation spread and recrystallized grains in a sample after homogenization.

Reference: Anjali Kanchi, Koteswararao V. Rajulapati, B. Srinivasa Rao, D. Sivaprahasam and Ravi C. Gundakaram, Materi Eng and Perform (2022). https://doi.org/10.1007/s11665-022-06855-9


Major Facilities
Created During
2021-22

A medium-range Slurry Mixer (PDDM, 5 L volume, Ross India) facility in the Li-ion Battery (LIB) process line was established at Centre for Automotive Energy Materials (CAEM), ARCI, Chennai. This is highly useful in screening and optimizing the electrode materials using minimum required quantity of materials/solvents. In addition, a 96-Channel cell formation cycler (Biologic, 0-9V, 15 A) has been commissioned. This equipment helps to perform the crucial cell formation process with the in-house developed fast formation test protocol for a large number of cylindrical as well as prismatic lithium-ion cells produced simultaneously. This equipment can also be used to perform impedance measurement, cyclic stability and rate capability tests for the pouch and cylindrical cells.

The Data Centre is a facility composed of a network of computing and storage resources that enable the delivery of shared applications and data using Hyper Converged Infrastructure (HCI) Technology. The facility is the NUTANIX HCI cluster architecture designed with three nodes Data Centre (DC) at ARCI, Hyderabad and three nodes Disaster Recovery (DR) at ARCI, Chennai as shown in the figure. The DC and DR have Smart Rack infrastructure consisting of inbuilt redundant UPS, precision cooling, fire detection and suppression system, intelligent security, and environment monitoring system. The DC can improve resource utilization, including data protection, Virtual Machines (VM) mobility, high availability, and data efficiency. All existing Databases, Applications, and other IT Services are successfully migrated to the new DC setup.

DC - Hyderabad *DR - Chennai*

ARCI established a Surface and Contour Measuring equipment (Zeiss make) which is useful for measuring surface characteristics with high precision and is an essential tool to understand the surfaces of various materials and coatings. The system can be used to measure the roughness, contour and topography parameters as per ISO/DIN standards, which assist the designers to estimate the clearances and tolerances. Roughness parameters such as Ra, Rz, Rt, Rq, core roughness, etc. along with contour details in terms of distance, angles, curvature, area and volumetric measurements, etc. can be determined. Additionally, the system is capable of generating a three-dimensional representation of surface textures including continuous 3D visualization of roughness & contour profiles along with an assessment of both micro and macro structures using photo simulation.

X-Ray Photoelectron Spectroscopy (XPS) is one of the most extensively used analytical equipment due to its ability to analyse, with high sensitivity, the elemental composition and chemical bonding near the surface specimen (top 10 nm). The Thermo Fisher make, Nexsa model XPS system is a highly sophisticated system and possesses a high level of automation. The state-of-the-art system installed at the Centre for Fuel Cell Technology (CFCT), ARCI, Chennai is very user-friendly in operation, has high reliability of the collected data, ease of chemical interpretation through specialized software, fool-proof maintenance and the analysis is performed under ultra-high vacuum. The instrument can handle organic, inorganic, metallic and polymeric samples. In addition, the instrument has the capability to record 32 samples of similar nature, without any manual intervention. XPS gives a unique signature for each element with their states and can be used for their most accurate identification.

The Confocal Micro-Raman Spectrometer with Mapping Facility (Witec make) contains a compact and flexible platform optimized for high-end spectroscopy applications and confocal Raman imaging consisting of a research-grade optical microscope with 6x objective turret, video CCD camera, LED white-light source for Köhler illumination, manual sample positioning in x- and y-direction and fibre coupling. The specifications of the spectrometer are contains two LASER Sources of 532 nm and 633 nm, Raman spectral imaging is obtained by acquisition of complete Raman spectra at every image pixel. The system is capable of providing a three-dimensional image of the chemical composition with micrometer resolution.

Solar PV panels are tested as per International Electrotechnical Commission (IEC) laboratory conditions and certified for guaranteed performance and 20 years lifetime. However, the outdoor performance of solar panels is critical because ambient parameters such as temperature, humidity and solar Irradiation largely affect both power production and lifetime. Validating the factory performance in the real field operating conditions is critical for facilitating the widespread adoption of solar PV technologies for sustainable electricity generation. Hence, ARCI, through the “Technology Research Centre for Alternative Energy Materials & System” project, set-up an exclusive solar PV outdoor testing facility with a state-of-the-art maximum power point tracking and monitoring system. The facility is one of the unique facilitiesin the country, capable of continuously monitoring the long-term performance of existing as well as emerging solar PV panels with a cumulative capacity of 5 kW. Long-term performance, stability and techno-economic analysis of in-house developed easy- to- clean and antireflective coatings for solar panel applications are being thoroughly studied using this facility.

ARCI installed and commissioned a High pressure and high-temperature autoclave system (Make AmAr Equipments Pvt Ltd (Model A3213)) which is a closed vessel-based machine used to carry out industrial and scientific processes (chemical reactions or blowing) at high temperature and high pressure. The system has specifications such as 100 bar (max) pressure and 500 °C (max) temperature. The system is used for applications such as reaction at high temperature and pressure to generate porous materials, supercritical drying, sterilization and chemical reactions for nanoparticle synthesis.

Events Data and Statistics

Major Events

Azadi Ka Amrit Mahotsav and 25 years of ARCI

Commemorating 75 years of India's Independence, Nation is celebrating 'Azadi Ka Amrit Mahotsav' with various activities planned during the period from April 2021 to August 2023. A wide spectrum of events were planned and organized at ARCI.

International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI), Hyderabad became a full-fledged autonomous R&D Centre of Department of Science and Technology (DST), Govt. of India during the year 1996-97. Hence, the period from April 2021 to March 2022 marks the 25th Anniversary of ARCI. A special Logo was designed and launched marking the journey of 25 years of ARCI.

All the events organized at ARCI during the period were brought under the umbrella of both the celebrations.

World Health Day

On the occasion of 'World Health Day' on April 09, 2021, ARCI organized two lectures by eminent speakers, Dr. R. Hemalatha, Director, ICMR-National Institute of Nutrition (NIN) Hyderabad on "How nutrition can help build immunity and health in today's world" and Prof. T. Pradeep, Institute Professor, Indian Institute of Technology-Madras, Chennai on "Affordable clean water: evolving technology landscape" in virtual mode.

Jayanthi Celebrations

Dr. B. R. Ambedkar, Dr. Babu Jagjivan Ram and Mahatma Jyothirao Phule Jayanthi celebrations were held at ARCI on April 14, 2021. Dr. Kaliyan Hembram, President ARCI SC/ST Employees Welfare Association welcomed the gathering. Dr. T. Narasinga Rao, Dr. Roy Johnson and ARCI SC/ST Employees Welfare Association members paid rich floral tributes and spoke about the immense contributions made by Dr. Ambedkar, Dr. Babu Jagjivan Ram and Mahatma Jyothirao Phule towards the upliftment of downtrodden and women.

DST Foundation Day celebrations at ARCI

As part of the Golden Jubilee Celebrations of Department of Science and Technology @ ARCI, a panel discussion on "Materials Technologies for Environmental Remediation" was organized on DST Foundation Day on May 03, 2021. The panel discussion started with brief talks by Prof. Ligy Philip, IIT Madras - "Bioremediation of contaminated soil, air and water" Dr. R. Ratheesh, Director, CMET, Hyderabad - "e-Waste remediation" Dr. K Srinivas, Ramky Enviro Systems Hyd. - "Recycling of waste management" Prof. Sachida Nand Tripathi, IIT Kanpur - "Air pollution and Climate change" followed by interaction session with all the panelists including Dr. R. Gopalan, Regional Director-ARCI, Dr. T. Narasinga Rao and Dr. Roy Johnson, Associate Directors, ARCI.

National Technology Day

Dr. U. Kamachi Mudali, Vice Chancellor, VIT Bhopal University & Former Distinguished Scientist, Department of Atomic Energy (DAE) delivered a popular lecture on "Production of Heavy Water and Specialty Materials for Indian Nuclear Power Programme" on the occasion of National Technology Day organized on May 11, 2021 in virtual mode.

International Yoga Day

An online lecture on "Yoga for Self-Care" followed by live demo by Ms. G. Prameela, Yoga Trainer, Founder-Prameela Yoga Studio, Secunderabad was organized to celebrate "International Yoga Day" on June 21, 2021.

Workshop on Hydrogen Potential Study of both Demand and Supply Sides

The Introductory workshop on Hydrogen Potential Study of both Demand and Supply Sides was jointly organized virtually by Economic Research Institute for ASEAN and East Asia (ERIA), IEE, Japan and ARCI, India on June 25, 2021. The event was marked with lectures on hydrogen supply and demand by various personnel from industry, government agencies etc., from Japan.

Virtual Introductory workshop on Hydrogen Potential Study of both Demand and Supply Sides

Independence Day

ARCI, Hyderabad celebrated Independence Day on August 15, 2021. Dr. T. Narasinga Rao, Director (Additional Charge), ARCI hoisted the National Flag. In view of Covid-19 pandemic, the recorded events of the celebrations in digital format were shared among staff members, project staff and students.

At ARCI-Chennai celebrations began on August 13, 2022 with inaugural address by Dr. R. Gopalan, Regional Director followed by a Freedom Walk for pollution free tomorrow on the Theme 'Clean Energy' at IIT-M Research Park. Scientists and Students carrying slogans befitting the need for clean energy participated in the Freedom walk. The program culminated with a skit highlighting the consequences of pollution and the desperate need for clean energy in future. To augur the atmosphere of India's Independence, patriotic songs were sung by Scientists and Students.

Freedom walk and Skit performed at ARCI-Chennai

Official Language (Hindi) Implementation at ARCI

The Official Language Implementation Committee (OLIC) under the Chairmanship of Dr. G. Padmanabham former Director and Dr. T. Narasinga Rao, Director (Additional Charge) has been successful in the implementation and progressive use of Hindi at ARCI. Following Covid-19 protocols, quarterly OLIC meetings were conducted virtually to review the progressive use of Hindi at ARCI. The minutes of the meeting were sent to DST and Quarterly reports on Hindi works were sent to DST, Department of Official Language (D.O.L), and Regional Implementation Office (South), Bengaluru with a copy to Town Official Language Implementation Committee (TOLIC-3) and by online to D.O.L. Ministry of Home Affairs, Govt. of India for review. During the year, ARCI achieved the target set by the D.O.L, Ministry of Home Affairs, Govt. of India in terms of proper and progressive implementation of official language. Along with regular Rajbhasha lectures in quarterly workshops, scientific & technical lectures in Hindi were also delivered by ARCI Scientists. The motive of OLIC in introducing these scientific lectures in Hindi workshops is to motivate the scientists to present their original R&D works in Hindi. ARCI conducted virtual Hindi workshops on a quarterly basis for its employees as well as to the nominated research students. ARCI has also been imparting regular training in Hindi to its employees under the Hindi Teaching Scheme. Employees who have successfully completed Prabodh, Praveen, Pragya and Parangath were given cash awards and incentives as per norms. To encourage the employees to carry out their day-to-day official works in Hindi, a cash incentive scheme is in place and six employees received cash awards, during the year for carrying out official works in Hindi.

Dr. R. Gopalan, Regional Director, ARCI-Chennai addressing the participants at the Hindi Workshop held at ARCI-Chennai

Dr. Rambha Singh giving a talk at the Hindi Workshop held at ARCI-Chennai

Shri Ranvir Singh, Deputy Director, Hindi Teaching Scheme, Department of Official Language, Ministry of Home Affairs, giving a talk at the Hindi Workshop organized at ARCI-Chennai

Hindi Saptha Celebrations

ARCI celebrated "Hindi Saptha" during September 13-17, 2021 in virtual mode. Essay, poems, debate, typing etc., competitions were conducted in which employees and students participated. Shri Ajay Malik, Deputy Director, Central Hindi Training Institute, New Delhi delivered a lecture on "Information of usage of Hindi Softwares". Employees and research students actively participated in the Hindi Saptha celebrations, which concluded on September 17, 2021. All the winners were given cash prizes.

Dr. T. Narasinga Rao lighting the lamp on the occasion

Dr. T. Narasinga Rao, Director (Additional Charge), Shri D. Srinivasa Rao, Scientist-G & OSD (Admin, Finance & Stores) and Dr. Sanjay R Dhage, Scientist-E presenting of Cash awards to employees for carrying out official works in Hindi

Annual Medical Check-up

Annual Medical Check-up (AMC) programme for ARCI employees for the year 2021 was carried out during August 24-26, 2021. Employees were categorized under two age groups i.e. below 45 years and above 45 years and prescribed medical tests were carried-out for them. Apart from prescribed medical tests, special tests such 2D Echo, Prostate Specific Antigen test for male employees, Ultra Sound Scanning and Mammogram tests for female employees who were 45 years & above were carried out. AMC was also carried out for Chennai and Gurugram employees.

Release of ARCI Technical & Scientific Glossary

First edition of "ARCI Glossary (English-Hindi)" approved by the "Commission for Scientific and Technical Terminology, Ministry of Education, Government of India was released during TOLIC-3 hybrid meeting held on February 21, 2022 at CSIR-NGRI, Hyderabad. This glossary contains 1100 scientific and technical words and 2200 administrative terminology, words and phrases.

ARCI Glossary (English-Hindi) released during TOLIC-3 Hybrid Meeting

4th One-day workshop on Hydrogen Day on "Hydrogen – A green Indian future"

Fourth One-day workshop on Hydrogen day on 'Hydrogen-A green Indian future' was organized to commemorate "National Hydrogen and Fuel Cell Day", which was created to raise awareness of clean energy technology based on Hydrogen. October 8th was chosen as a 'National Hydrogen and Fuel Cell day' in reference to its atomic weight of hydrogen (1.008 amu.).

The theme for the year 2021 workshop "Hydrogen – A green Indian future" was focused on pathways to accelerate Hydrogen and Fuel Cell technologies by nurturing state-of-the-art ideas and innovations across the country to benefit the niche energy market. Inspiring talks entitled "Green Hydrogen for Green Future of India", "Hydrogen Production by Alkaline Water Electrolysis: Past, Present and Future", "Green Hydrogen from Solar Energy" etc., were delivered by eminent scientists, industrialists and academicians, which resulted in interaction with leading researchers/technologists in this domain and allied fields.

World Students Day

On the occasion of 90th Birth Anniversary of Former President of India, Dr. A. P. J. Abdul Kalam, which is also celebrated as "World Students Day", ARCI organised a talk by Shri Srinivas Chamarthy, Chief Innovation Executive & MD, CYME Automation Systems Pvt. Ltd., Hyderabad on “Young Scientists - Focus, Approach, Methods and Challenges” on October 15, 2021.

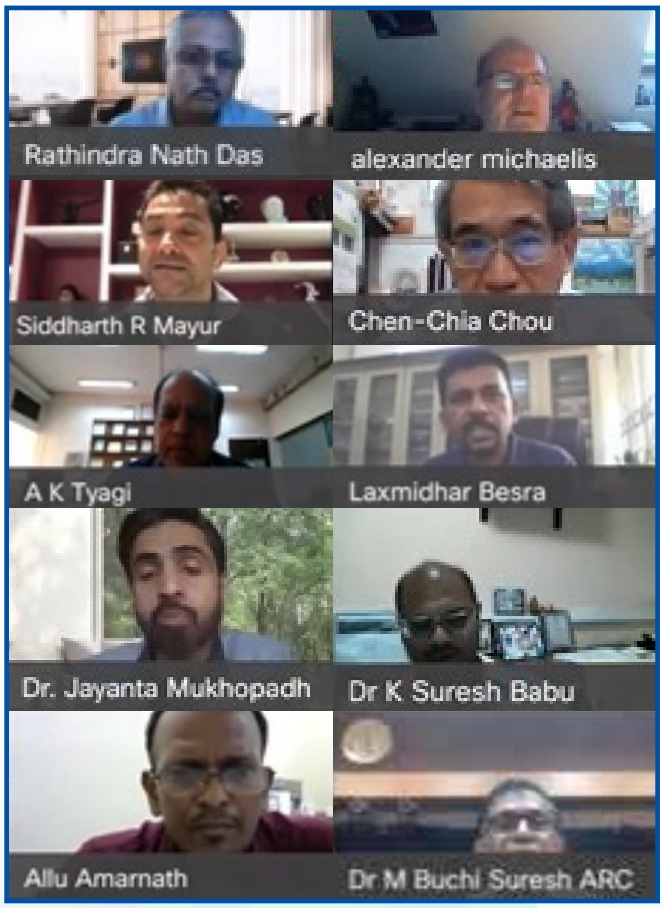
One-day workshop on Ceramic Materials for Solid Oxide Fuel Cells

A One-day workshop on “Ceramic Materials for Solid Oxide Fuel Cells (SOFC)” was jointly organized by ARCI, Indian Ceramic Society (ICS) Hyderabad Chapter and University of Hyderabad (UOH) on October 21, 2021 as a part of Azadi Ka Amrit Mahotsav on the virtual platform. Dr. Roy Johnson, Associate Director, ARCI in his introduction to the workshop mentioned that SOFC, because of its inherent ceramic nature is an environmentally benign and efficient power generation technology and focus of the workshop is on ceramic materials for SOFCs. Dr. T. Narasinga Rao, Director (Additional Charge), ARCI in his address mentioned that in addition to the SOFC, hydrogen generation should also be focused through electrolysis and ARCI is launching consortium project for development in this area shortly. Dr. Suman Kumari Mishra, Director, CSIR-CGCRI told that there is lot of space for material research in the area of SOFC. Mr.A.R.Raju, President, ICS (Hyderabad chapter) and Prof. Dibakar Das also made their remarks on the occasion.

Dignitaries speaking on the occasion

In his inaugural address, Prof. Suddhastwa Basu, Director, Institute of Minerals and Materials Technology (IMMT), Bhubaneshwar told that currently commercial SOFC modules are readily available from global players and growing usage in stationery power markets. In India realization of SOFC is in the early stage of research and a consortium approach of different laboratories with expertise in the area is essential for early realization of usable devices.

Workshop had invited lectures from eminent speakers from India and abroad followed by a dedicated presentation session for students. Prof. Alexander Michaelis, President, IKTS, Frunhofer, Germany and industrial participants Mr. Siddharth R. Mayur, h2e Power Systems Private Limited and Dr.R.N.Das, Dense Power Private Limited were also the part of the event. The participants and students all over India participated very enthusiastically during the sessions. The Workshop concluded with concluding remarks and vote of thanks by Mr. A.D. Manohar, Secretary, ICS-Hyderabad chapter.



Invited Speakers speaking during the Workshop

Vigilance Awareness Week

Vigilance Awareness Week was observed at ARCI from October 26 to November 01, 2021. The theme of the Week was “Independent India @ 75: Self Reliance with Integrity". The messages from the honourable President, honourable Vice President and Central Vigilance Commission (CVC) were shared among the employees, project staff and research students. Following COVID-19 norms, concerned heads have administered Integrity Pledge at their respective Centres of Excellence/Buildings. They were encouraged to take Integrity Pledge Online/e-pledge by visiting CVC website. On this occasion, posters on vigilance awareness were displayed in the Administrative Building and slogans were also displayed on all the digital boards.

Silver Jubilee Celebrations of ARCI

International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI), Hyderabad became a full-fledged autonomous Research and Development Centre of Department of Science and Technology (DST), Government of India during 1996-97. Hence, the period from April 2021 to March 2022 rightly marks the 25th Anniversary of ARCI. The Centre celebrated the occasion on December 23, 2021 with an official programme during the forenoon and cultural programme in the afternoon session.

The event started with welcome address by Dr. P. K. Jain, Scientist 'G' and Dr. T. Narasinga Rao, Director (Additional Charge) presided over the event. Dr. Jain welcomed the dignitaries and spoke about the 25 years' journey of ARCI, 50 years of Department of Science and Technology (DST) and 75 years of Azadi Ka Amrit Mahotsav celebrations across the country. He spoke about how ARCI started in 1991 with 11 employees and grew in to a nationally unique laboratory in the field of Advanced Materials and Processing Technologies over the years.

Speaking on the occasion Dr. T. Narasinga Rao, Director (Additional Charge) said that 25 years ago, ARCI embarked on a journey of shaping the future in the area of Powder Metallurgy, Ceramic Processing and Surface Engineering and later expanded to Nanomaterials, Laser processing of materials, fuel cell technology, sol-gel coatings, solar energy materials and Automotive energy materials, aligning our programmes towards National Missions. He also enumerated on how ARCI powered through the years with great enthusiasm and zeal towards developing technologies and transferring them to industries. Dr. Narasinga Rao emphasized that it is a proud moment to celebrate the silver jubilee event of ARCI, where the success is on account of the collaborative efforts of the entire ARCI family. ARCI could transfer technologies to 40 companies and provide more than 200 technological solutions to industries. He also said that there are a number of major projects in hand and more awaiting sanction. At this juncture, Dr. Narasinga Rao said that Scientists are working towards not only transferring the technical know-how to industries but hand holding them till its commercialization. In this process, ARCI is developing highly saleable human resources and striking a right balance between applied and basic research. He also said that ARCI has been maintaining Indian as well as International Patents leading to several technologies and Publications record with high impact factors.

Dr. R. Gopalan, Regional Director-ARCI, Chennai spoke on the establishment and developments in the Li-Ion battery line, magnetic materials and fuel cell technologies. He emphasized the need for tuning our research directions in line with emerging technologies and reiterated that ARCI is working in that direction both in materials based and process based technologies. He recollected the initial days of setting-up the Centre for Automotive Energy Materials (CAEM) and shifting of Centre for Fuel Cell Technology (CFCT) to IIT-M Research Park at Chennai. Technical Research Centre on Alternative Energy Materials and Systems was awarded to ARCI and major chunk of activities have been initiated at Chennai Centres in setting up the Lithium Ion Battery plant for fabrication of Li-ion cells and its successful on road demonstration. Dr. Gopalan also said that the figure of merit of ARCI is 'Deliverability" i.e. the ability to deliver on time.

Dr. Tata Narasinga Rao, Director (Additional Charge), Dr. Roy Johnson, Associate Director and Dr. P. K. Jain, Scientist 'G' and Chairman, Welfare Committee-ARCI, inaugurating the Silver Jubilee Celebrations by lighting the lamp

Dr. T. Narasinga Rao, Director (Additional Charge) addressing the gathering on the occasion of ARCI Silver Jubilee Celebrations

Dr. R. Gopalan, Regional Director, ARCI-Chennai speaking on the occasion

Dr. Anil Kakodkar, Chairman, Governing Council-ARCI addressing the gathering

Dr. S. Chandrasekhar, Secretary, Department of Science and Technology wishing the ARCI family on the occasion of Silver Jubilee Celebrations

Glimpses of few events organized as part of the celebrations

Many industries have forged agreement with us and one such success story is transfer of technical know-how for Li-ion cell manufacturing to an industry along with technical manpower training and establishment of a plant for a high technology fee in the history of ARCI.

Dr. Roy Johnson, Associate Director in his address said that the glorious achievements of ARCI are the fruit of the hard work of each employee with an organisational spirit. He also emphasised that, it is important to nurture innovative ideas in combination with dedicated hard work to reach new heights in the future as well. He pointed out that in the area of ceramics, the centre has demonstrated its capability though commercialising the technologies in the area of ceramic honeycombs, transparent ceramics and silicon carbide space components. Currently a mega project on low glass expanding ceramics is ongoing and a project on indigenisation of solid oxide fuel cell (SOFC) for environmentally benign energy generation is also being initiated. Centre is also perusing sol-gel based anti-bacterial and anti-corrosion coatings and activities on semiconductor based solar thermal power generation.

Dr. Anil Kakodkar, Chairman, Governing Council-ARCI and Dr. S. Chandrasekhar, Secretary, Department of Science and Technology, congratulated ARCI on this occasion and wished for ARCI to reach greater heights of success in the years to come. They reiterated the fact that 25 years marks a very significant milestone for ARCI during which time ARCI showed tremendous achievements in the field of Advanced Materials and Processing and emerging technologies in the area of Lithium-Ion batteries and systems, supercapacitors, low-expansion glass ceramics, SOFC, Clean coal technologies etc.

Prof. P. Rama Rao, Former Chairman, Governing Council-ARCI and Distinguished ARCI Chair, Prof. G. Sundararajan, Former Director-ARCI and Distinguished Emeritus Scientist, Dr. Shrikant V. Joshi, Former Additional Director-ARCI, Dr. Y. R. Mahajan, Former Joint Director and Dr. H. Purushotham, Former Head, Centre for Technology Acquisition and Transfer-ARCI spoke on the occasion reminiscing on their stint at ARCI.

Technology receivers shared their experience with ARCI and the handholding they received from the Scientists for successful commercialization of the technologies transferred to them. Several ex-students and ex-scholars sent their messages on the valuable guidance, experience and exposure they received at ARCI which helped them to reach greater heights in their career.

Later in the day, the employees and their family members along with students and scholars actively participated in the cultural programme with rangoli competition, songs, dance and skits.

Earlier on December 22 2021, employees who have completed 25 years of service at ARCI were given mementoes for their commitment and dedication.

Republic Day

ARCI celebrated Republic Day on January 26, 2022. Dr. T. Narasinga Rao, Director (Additional Charge), ARCI hoisted the National Flag. In view of COVID-19 pandemic, the recorded events of the celebrations in digital format were shared among staff members, project staff and research students.

National Science Week (Vigyan Sarvatra Pujyate) celebrations at ARCI

A series of events were organized at ARCI on the occasion of National Science Week (Vigyan Sarvatra Pujyate) celebrations from February 23-28, 2022 on the lines of Azadi Ka Amrit Mahotsav. All the events were organized in Hybrid (online and offline) mode.

1. The celebrations started on February 23, 2022 with oral presentation competition by ARCI Students on topics of their research interest followed by Science Quiz for all ARCI employees, students and research fellows.

ARCI Research Fellows enthusiastically presented at the oral presentation competition organized on February 25, 2022 on topics ranging from materials for health care, renewable energy, water treatment, sustainable agriculture, bioinspired materials, zero emission, green smart homes, e-waste recycling etc.

Both the competitions were evaluated based on a five minutes' presentation by Students and 10 minutes' presentation by Research Fellows selected by a panel of senior scientists based on the novelty, scientific/technical content and relevance to societal needs.

Dr. P. K. Jain, Scientist-G & Chairman, Azadi Ka Amrit Mahotsav Committee enthused the Students and Research Fellows for presenting their innovative ideas at the competitions. In order to encourage and inculcate the habit of planting trees, all the participants were presented with a sapling.

Dr. T. Narasinga Rao, Director (Additional Charge) and Dr. P. K Jain, Scientist-G with participants of Oral Presentation competitions

2. ARCI organized a "One-Day Workshop on Materials and Technologies for Biomedical Implants" on February 24, 2022 in virtual mode, as a part of National Science Week Celebrations. The workshop brought together leading academicians, scientists, researchers and industry personnel to exchange and share their achievements and the challenges on all aspects of Biomedical Implants and Devices. The topics of the workshop included 'Manufacturing technologies for implants and devices', 'Surface engineering of medical implants, 'Clinical aspects of Biomedical implants and devices', 'Critical analysis of in-vivo testing of the implants' and 'Commercialization and Market opportunities for implant manufacturing'. The technical sessions included lectures by eminent scientists from India and abroad belonging to Materials & manufacturing technologies, medical experts and industrialists. The workshop also included a panel discussion. The panel discussion witnessed exchange of views by experts from the mentioned fields, the necessity to build a good network and lead to fruitful collaborations for manufacture of indigenized medical implants and devises supporting 'Atma Nirbhar Bharat'. The workshop attracted 160 participants in total from various academia, research institutes and industry. It provided a premier platform for researchers, medical practitioners, educators, industry and students to focus on the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Biomedical Implants and Devices. It also paved way in initiating future collaborations between the institutes and industries.

Participants interacting at the one-day workshop on Materials and Technologies for Biomedical Implants

3. Dr. Tata Narasinga Rao, Director (Additional Charge), ARCI delivered a Popular Science Talk for School Children, Teachers and Faculty on "ARCI Technologies for Nation-Building" at the National Science Week (Vigyan Sarvatra Pujyate) Festival of SCoPE for All, held at National Institute of Technology-Warangal on February 23, 2022.

Dr. T. Narasinga Rao, Director (Additional Charge) delivering a Popular Science Talk

4. The National Science Day was celebrated on February 28, 2022. Prof. V. Ramgopal Rao, Former Director, Indian Institute of Technology-Delhi delivered the National Science Day talk on “Connecting Academic R&D with Product Requirements; a need for an Atmanirbar Bharat”. Prof. V. Ramgopal Rao, in his talk elucidated on the current status of Indian R&D and setting up a large portfolio of patents as a first step towards translating research to technology, technology transfer and to its commercialization. He also encouraged the young researchers and Scientists to pick the research problems relevant to majority of the society i.e. the common man and provide solutions. In this regard, Prof. Rao mentioned that the academic institutions like IITs and R&D institutions like ARCI should work together to become unique solution providers in translating the knowledge generated through research in to technology. Prof. V. Ramgopal Rao, distributed prizes to the winners of the oral presentations by Students and Research Fellows as well as winners in the science quiz competitions organized as part of the National Science Week (Vigyan Sarvatra Pujyate) celebrations at ARCI.

Prof. V. Ramgopal Rao delivering the National Science Day talk

Prof. V. Ramgopal Rao and Dr. T. Narasinga Rao with participants on the occasion of National Science Day

ARCI Internal Complaints Committee (AICC)

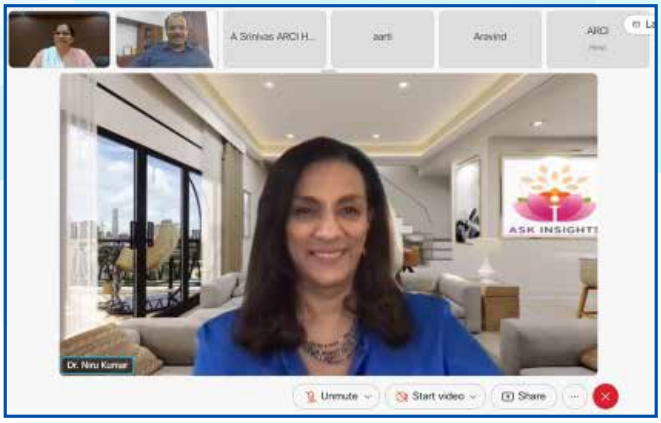
Internal Complaints Committees (AICCs) are functioning both at ARCI, Hyderabad and Chennai, Campuses. AICCs are actively involved in promoting awareness regarding Sexual Harassment of Women in the Workplace. As a part of ensuring a safe work environment for women, AICC had a one-on-one interaction with each of the girl students to understand their working environment. ICC received and resolved one complaint.

AICC organized an online Awareness Programme on Sexual Harassment (POSH) of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013 on December 09, 2021 through WebEx virtual platform to mark the occasion of the 8th Anniversary of Notification of this Landmark Legislation. The Chief Guest Smt. Soma Sinha, PoSH Compliance Expert and Trainer & Founder director of Progressive Planner Foundation with vast experience in training and conducting development programmes on child development, positive parenting, barefoot counselling, case management, life skills, sexual health, child rights laws and gender inclusivity issues, discussed elaborately the various sections of POSH Act, type of sexual harassments, the importance of Internal committee and the impact of sexual harassment on an organisation. Case studies were presented to drive home the point.

Smt. Soma Sinha conducting the online training programme

Lecture on Gender Intelligence

Padma Shri Dr. Niru Kumar, CEO - Ask Insights & Diversity and Inclusion Consultant, delivered a very engaging online lecture on ‘Gender Intelligence” on March 10, 2022.



Dr. Niru Kumar giving a lecture on ‘Gender Intelligence”

International Women's Day

International Women's Day at ARCI was organized in a hybrid mode (Online & Office) on March 08, 2022 for Hyderabad and Chennai campuses. The occasion was marked by conducting various programmes for women during March 7- 8, 10th 2022. Themes such as 'Gender Equality', 'Role of women in our lives' were artistically expressed by women at ARCI through Paintings, Drawings, Rangoli, Drama and Poetry. Ms. Priya Anish Mathews, Member Secretary ICC, welcomed the participants, Dr. Neha Hebalkar, Presiding Officer ICC, Hyderabad briefed them about various activities taken up by ICC and the importance of celebrating International women's day. Dr. K. Ramya, Presiding Officer ICC, Chennai delivered her message on the occasion. Dr. T. Narasinga Rao, Director (Additional Charge), Dr. R. Gopalan, Regional Director, ARCI-Chennai and Dr. Roy Johnson, Associate Director extended their greetings and emphasized ARCI's commitment to providing a safe and secure working environment for the women.

Chief Guest, Prof. Sulabha K. Kulkarni, INSA Senior Scientist CMET, Pune delivered an insightful online lecture on "Pathbreaker Women in STEMM" (Science, Technology, Engineering, Mathematics and Medicine). With an aim to make the programme more inclusive, an interactive session was conducted for both men and women. Dr. Rambha Singh, Member ICC welcomed the participants and the interactive session witnessed an enthusiastic participation from all quarters. Dr. P. Suresh Babu, Member ICC delivered the Vote of thanks.

Dr. T. Narasinga Rao, Director (Additional Charge) extending greetings on the occasion of International Women's Day

Prof. Sulabha K. Kulkarni, INSA Senior Scientist, CMET, Pune delivering the lecture

Participants at the International Women's Day celebrations at ARCI, Hyderabad

Safety Day Celebrations

National Safety day was celebrated on March 11, 2022 at ARCI. On the occasion, safety pledge was administered and lectures and interactive sessions were organized focusing on relevance and importance of safety in work place. As part of the celebrations safety slogan competitions for employees and students were conducted and prizes were distributed. The event started with welcome address by Dr. Roy Johnson, Associate Director and Chairman, Safety committee. He highlighted that ARCI, as an organization has the policy which gives high priority for the safety, health and environment. In his message, Dr.Tata Narasinga Rao, Director (Additional Charge), ARCI emphasized that safety should evolve as a habit of every person, which shall propagate as the culture of the centre. He urged everyone in the organization to remain committed to safety and follow procedures and protocols for a sustainable organization with conducive working environment. In his address Dr. R. Gopalan, Regional Director, ARCI-Chennai said that safety should be of prime concern as it plays an important role in the socio-economic sectors in a significant way, which will affect the growth of the institutions and have impact on a national level. Dr. R. Venugopal, Joint controller of explosives, POSO, Government of India has delivered the safety day lecture on "Safety leadership in turbulent times". During his talk he has brought out his experience as case studies from various sectors, importance of awareness of rules and brought out role of a leader in critical situations. Dr. Nitin P Wasekar, Scientist 'E' also delivered a lecture on Safety practices at ARCI. Dr. PK Jain, Scientist G & Chairman, Azadi ka Amrit Mahotsav celebrations Committee also spoke on the occasion and Mr. D Ramesh, Safety Officer presented the activities of ARCI safety committee. The event ended with vote of thanks. The employees and students participated enthusiastically during the interactive sessions.

Fire and safety training

As part of fire and safety awareness programme at ARCI, an on job training programme on firefighting was conducted by Shri. D Ramesh Security, Fire and Safety Officer in all the centres of Excellence in ARCI. Associate Director, Head of centre of Excellence, Scientists, officers, Employees, Project staff and research students attended the programme.

Dr. T. Narasinga Rao, Director (Additional Charge) and Dr. Roy Johnson, Associate Director & Chairman, Safety Committee administering the safety pledge with other employees on the occasion

Human Resource Development

Recognition of ARCI as an External Centre for Carrying Out Ph.D. Research

A. Foreign University

Deakin University, Australia

B. Indian Academic Institutions/Universities

Apart from the above, the following Indian academic institutes recognized ARCI as an External Centre for carrying out Ph.D. Research. Accordingly, interested ARCI employees, Project Scientists and Research Fellows are encouraged to register for Ph.D. (as per university norms) at the Institute/University.

01. Indian Institute of Technology – Bombay
02. Indian Institute of Technology – Kharagpur
03. Indian Institute of Technology – Kanpur
04. Indian Institute of Technology – Hyderabad
05. Indian Institute of Technology – Madras
06. National Institute of Technology – Warangal
07. National Institute of Technology – Tiruchirappalli
08. National Institute of Technology – Surathkal

List of Project Scientists/Research Fellows who Completed Ph.D. during the year 2021-22

S.N	Name of the Project Scientist/Fellow	Topic	Ph.D. Registered at	Degree Awarded on
01	Dr. VVN Phani Kumar	Investigations on Natural and Synthetic Polymers as an Aqueous Binder for Anodes of Lithium-Ion Batteries (LIBs)	NIT, Warangal	31.05.2021
02	Dr. Atchuta Srinivasa Rao	Development of Stable Selective Solar Absorber Coatings for Concentrated Solar Thermal Applications	CSIR-NAL, Bangalore	02.06.2021
03	Dr. Brijesh Singh Y adav	Investigations on Inkjet Printed CIGS Thin Film Absorber Layer for Solar Cell Application	IIT, Hyderabad	02.06.2021
04	Dr. Ravi Gautam	Microstructure- Magnetic Properties Correlation of Fe-P based Soft Magnetic Alloy	IIT, Madras	25.06.2021
05	Dr. E. Anusha	Investigations on the influence of different Thermal Processing Conditions in Laser Surface Hardnening of Bearing Steel and Bearing Elements	NIT, Warangal	14.07.2021
06	Dr. Swapnil H. Adsul	Development of Nanocontainer based Self-Healing Coatings for Corrosion Protection of Magnesium Alloy AZ91D	NIT, Warangal	19.07.2021
07	Dr. Shaik Mubina	Processing and Properties Evaluation of CNFs Dispersed SiC based Composites.	NIT, Warangal	22.07.2021
08	Dr. Tadepalli Mitravinda	Methods and Modifications of nano Porous carbon materials to Augment the Super Capacity Performance.	IIT, Hyderabad	23.08.2021
09	Dr. S. Harish	Design, Fabrication and Performance. Evaluation of a Thermoelectric Generator for Automotive Exhaust Waste Heat Recovery.	IIT, Madras	24.09.2021
10	Dr. S. Manasa	Nano Clay-based Self-Healing, Corrosion Protection Coatings on Aluminium Alloys AA2024-T4 and A356.0	NIT, Warangal	19.10.2021
11	Dr. Yarlagadda Madhavi	High Cycle Plain – Fatigue and Corrosion-Fatigue Behavior of Micro Arc Oxidation Coated Al Alloys	NIT, Warangal	19.10.2021
12	Dr. V.V. Ramakrishna	Micro Structure and Magnetic Property Correlation in Rare Earth Free Permanent Magnets – MnBi Alloy.	NIT, Tiruchirappalli	18.02.2022

S.N	Name of the Project Scientist/Fellow	Topic	Ph.D. Registered at	Degree Awarded on
13	Dr. B. Jayachandran	Interface Engineering in PbTe-Mg2Si1-xSnx Thermoelectric Devices	IIT, Bombay	26.02.2022
14	Dr. Vallabharao Rikka	Investigation on the Cycle Life of LiFePo4/Graphite Cylindrical Lithium-Ion Cells	IIT, Bombay	26.02.2022
15	Dr. M. Shiva Prasad	Development of Solar Selective Absorber Coatings for Concentrated Solar Thermal Powder Applications	NIT, Warangal	21.04.2022

Post-Doctoral Fellows, Research Scholars, Senior / Junior Research Fellows, Post Graduate/ Graduate Trainees and M.Tech. / B.Tech. / M.Sc. Project Students joined during the Year at ARCI.

Post Doctoral Fellows/Research Scholars	02
Junior Research Fellows	11
Junior Research Fellows	07
Graduate and Diploma Trainees	13
M.Tech. Project Students	40
Diploma/B.Tech. / M.Sc. Projects Students	23
Summer Research Interns	Nil*

**** Due to Covid-19, Summer Research programme could not be conducted.***

Project Scientist/ Research Fellows whose Ph.D. is Ongoing List of Project Scientists (as per date of Ph.D. registration)

S.N	Name of the Student Mr./Ms.	Ph. D. Topic	Ph.D. Registered at
1	Kumari Konda	Electrochemical Performance of various Cathode Materials using Half and Full Cell	Indian Institute of Technology, Bombay
2	P. Mahender	Development of Composite Cathode Materials for High Energy Density Li-ion Battery	Indian Institute of Technology, Madras
3	Muni Bhaskar Siva Kumar	Coercivity Modification in Nd-Fe-B Magnetic Material by Grain Boundary Diffusion of R-X Low Melting Eutectics	Indian Institute of Technology, Madras
4	Pothula Vijaya Durga	Development of Oxide Dispersion Strengthened Iron Aluminides with High Strength and Ductility for High Temperature Applications	Indian Institute of Technology, Madras
5	Puppala Laxman ManiKanta	Scalable Synthesis of NASICON type Sodium Vanadium Phosphate and its Doped Systems for Commercial Sodium Ion Batteries	Indian Institute of Technology, Madras
6	G. Vijayaraghavan	Microstructure-Property Correlation of High Performance Sm-Fe-N Permanent Magnetic Materials	Indian Institute of Technology, Madras
7	S. Ramakrishnan	Metallic Flow Field Plates for Low – temperature Proton Exchange Membrane Fuel Cell	Indian Institute of Technology, Kanpur
8	Minati Tiadi	Nanoscale Thermoelectric Materials and Devices for Sustainable Applications	Indian Institute of Technology, Madras
9	V. Tarun Kumar	Advanced Gas Diffusion Layer (GDL) Architecture for PEM Fuel Cell Application	Indian Institute of Technology, Bombay

Research Fellows whose Ph.D. is Ongoing (as per date of Ph.D. registration)

S.N	Name of the Student Mr./Ms.	Ph. D. Topic	Ph.D. Registered at
1	P. Tejassvi	Electro Spun Nano Fibrous Materials Li-ion and Li-s Batteries	National Institute of Technology, Warangal
2	T. Ramesh	Development of Novel Porous Carbons using Agricultural Biomass for High Performance and Cost Effective Electrodes for Super capacitor Application	National Institute of Technology, Warangal
3	B. Divya	Fabrication of Solar Cell Photovoltaic Energy System using Pulsed-Electrodeposited CIGS Absorber layer under n-type CdS Semiconductor Film Window	National Institute of Technology, Warangal
4	B. Priyadarshini	Synthesis and Characterization of Magnesium Silicide and Zinc Anti Monide based Thermoelectric Materials Applications	National Institute of Technology, Tiruchirappalli
5	Keerthi Sanghamitra Kollipara	Study of Thermo-physical Prorperties of Aerogel Products for Thermal Insulation Application	National Institute of Technology, Warangal
6	Adigilli Harish Kumar	2D-Nanolayered WS2 based Self Lubricating Composites	National Institute of Technology, Warangal
7	Mohd. Aqeel	Suitability of Laser Hybrid Welding of Inconel 617 Alloy for Steam Boilers	University of Hyderabad, Hyderabad
8	V.P. Madhurima	Synthesis of Carbon Nano Materials and their Composites	National Institute of Technology, Warangal
9	P. Samhita	Development of Nano structured Transition Metal Oxide Electrode Materials for Super Capacitors	Indian Institute of Technology, Hyderabad
10	KK Phani Kumar	Development of Nano Composite based Solar Thermal Absorber Coatings	Indian Institute of Technology, Bombay
11	P. Sreeraj	Recycling of Valuable Components from Fuel Cell	Indian Institute of Technology, Bombay
12	Narendra Chundi	Development of Anti Soiling Coating and their Evaluation for Applications of Photovoltaic Modules	Indian Institute of Technology, Bombay
13	Battula Ramya Krishna	Engineering Perovskite Absorber Layer for Stable and Efficient Perovskite Solar Cells	Indian Institute of Technology, Madras
14	Surabattula Yasodhar	Multiphase Flow Analysis and Performance of Aqueous Methanol Electrolyser	Indian Institute of Technology, Madras
15	V. Sai Harsha Swarna Kumar	Aspects of PEM based Electrolyzers for Hydrogen Production	Indian Institute of Technology, Madras
16	A. B. Aravind	Development of Materials for Aluminium Air Batteries.	National Institute of Technology, Tiruchirappalli
17	M. Tarun Babu	Structure Property of Cold Sprayed Aluminium Alloy Coatings	Indian Institute of Technology, Madras
18	D. Nazeer Basha	Laser Surface Texturing of Automotive Engine Components using Ultrafast Laser	Indian Institute of Technology, Madras
19	Bathini Lava Kumar	Mechanical and Electrochemical Behavior of Pulse Electrodeposited Functional Gradient Ni and Ni-W Coatings	Indian Institute of Technology, Bombay
20	K. Sriram	Development of Non-Noble Electrocatalyst for Alkaline Electrolyzer Application	Indian Institute of Technology, Madras
21	M. Venkatesh	Development of Low Cost and High specific Capacity Cathode Materials for Sodium – Ion Battery Appications	Indian Institute of Technology, Madras

S.N	Name of the Student Mr./Ms.	Ph. D. Topic	Ph.D. Registered at
22	Vikrant Trivedi	Nanostructured Co4Sb12 Skutterudite Thermoelectric Material for Waste Heat Recovery Applications	Indian Institute of Technology, Madras
23	P. Raju	Investigations on the Applicability of Pressure Slip Casting and 3D – Printing for Al2O3 and Al2O3-TiO2 Systems.	National Institute of Technology, Warangal
24	D. M. Santoshsarang	Design and Modelling of Residual Stresses of additive Manufacturing	Indian Institute of Technology, Madras
25	S. Mamatha	Near-net shaping of Simple and Complex Ceramic Parts by 3D Printing and Investigations on Physico-Chemical, Mechanical and Microstructural Properties	University of Hyderabad, Hyderabad
26	Jyothi Gupta	Investigation of Efficient and Stable Nanostructured Mo based Chalcogenides Electrocatalyst for Hydrogen Evolution Reaction	University of Hyderabad, Hyderabad
27	B. Amarendhar Rao	Laser Assisted Machining of Nickel based Super Alloys	National Institute of Technology, Warangal
28	Kanchi Anjali	Mechanical and Microstructural Behaviour of Refractory High Entropy Alloy	University of Hyderabad, Hyderabad
29	Rahul Jude Alroy	A study on Structure-Property Correlation of High Velocity Air -Fuel Sprayed CrC - NiCr Coatings for Improved Corrosion and Erosion Resistant.	Indian Institute of Technology, Madras
30	Aarti Gautam	Self Healing Corrosion Protection Coatings on Mild Steel	National Institute of Technology, Warangal
31	K. Reshma Dileep	Carbon based Perovskite Solar Cell	Indian Institute of Technology, Bombay
32	Guduru Neelima Devi	Cold Spray Deposition of Nickel based Alloys	National Institute of Technology, Warangal
33	Harita Seekala	Measuring the Size and Rate Dependence of Strength at Small Scales	Indian Institute of Technology, Madras
34	N. Ravikiran	Synthesis of Carbon 2D Hybrid Materials for Friction and Wear Reduction	University of Hyderabad, Hyderabad
35	Kumaar Swamy Reddy. B	Solution – Processed Photo Detector	Indian Institute of Technology, Hyderabad
36	Rentala Jayasree	Development of Functionally Graded Materials for Bio Applications	Indian Institute of Technology, Kharagpur
37	D. Vijaya Lakshmi	A Comprehensive Study on High Velocity Thermal Sprayed Thin Coatings for Wear and Corrosion Resistant Applications	Indian Institute of Technology, Bombay
38	Baswanta Sainath Patil	Additive Manufacturing of 15-5 PH Stainless Steel	Indian Institute of Technology, Hyderabad
39	P. Sankar Ganesh	Development of Laser Surface re-engineering Process on Automotive Structual Steels for Improved Forming and Manufacturability	Indian Institute of Technology, Hyderabad
40	Jonnareddy Sasikumar	Development of Advanced Humidification System for Effective Water management in PEMFC	Indian Institute of Technology, Madras
41	Chandra Gowthami	Synthesis, Characterization and Validation of Modified Electrode Materials for Battery Applications	National Institute of Technology, Warangal
42	Ramay Patra	Corrosion Sensing and Self-Healing Smart Nanocomposite Coatings	National Institute of Technology, Warangal
43	M. Swarna	Process development with Analysis of Laser post Processing for improved Mechanical Properties in DED Manufactured Super Alloy Component.	National Institute of Technology, Warangal

Visits by Students and Faculty to ARCI

1. 14 Faculty members from Military College of Electronics and Mechanical Engineering (MCEME), Secunderabad visited ARCI on August 24, 2021.

2. 31 Faculty members from Military College of Electronics and Mechanical Engineering (MCEME), Secunderabad visited ARCI on March 10, 2022.

Regular Appointments

ARCI has added the following employees to its fold to take up varied responsibilities:

Employee Name	Designation	Date of Joining
Sakina Hussain	Lab. Assistant "A" (On Compassionate grounds)	29.03.2022
Vemula Prashanth	Technician "A"	08.04.2021

Promotions

ARCI has been following its existing assessment and promotion policy since the year 2000-01. As per the policy, assessments were carried out for all eligible employees and the following were promoted during the year 2021-22:

Name of the Promotees	Effective Date	Promotion for the post:	
		From	To
Dr. L. Ramakrishna	October 1, 2021	Scientist “F”	Scientist “G”
Dr. Bhaskar Prasad Saha	October 1, 2021	Scientist “F”	Scientist “G”
Dr. Pardhasaradhi Sudharshan Phani	October 1, 2021	Scientist “E”	Scientist “F”
Dr. Nitin P. Wasekar	October 1, 2021	Scientist “E”	Scientist “F”
Dr. Dibyendu Chakravarty	October 1, 2021	Scientist “E”	Scientist “F”
Dr. Pandu Ramavath	October 1, 2021	Scientist “D”	Scientist “E”
Arun Seetharaman	October 1, 2021	Scientist “D”	Scientist “E”
R. Vijaya Chandar	October 1, 2021	Scientist “D”	Scientist “E”
K. Srinivasa Rao	October 1, 2021	Technical Officer "C"	Technical Officer "D"
A.R. Srinivas	October 1, 2021	Technical Officer "B"	Technical Officer "C"
E. Anbu Rasu	October 1, 2021	Technical Officer "B"	Technical Officer "C"
S. Sankar Ganesh	October 1, 2021	Technical Officer "B"	Technical Officer "C"
P. Anjaiah	October 1, 2021	Technician "D"	Technician "E"
G. Venkat Reddy	October 1, 2021	Technician "D"	Technician "E"
P. Suri Babu	October 1, 2021	Technician "C"	Technician "D"
Aan Singh	October 1, 2021	Technician "A"	Technician "B"
G.M. Raj Kumar	October 1, 2021	Finance & Accounts Officer	Senior Finance & Accounts Officer
Y. Krishna Sarma	October 1, 2021	Officer "B"	Officer "C"
G. Gopal Rao	October 1, 2021	Officer "A"	Officer "B"
Rajalakshmi Nair	October 1, 2021	Assistant "B" (MACP)	Officer "A"
Ramavathu Ranga Naik	October 1, 2021	Assistant "A"	Assistant "B"

Superannuation

Employee Name	Designation Held	Date of Superannuation
A. Jyothirmayi	Technical Officer "E"	30.06.2021
Roop Singh	Lab. Assistant "D"	30.09.2021
Md. Sadiq	Driver "C" (MACP)	31.03.2022

Resignations

Employee Name	Designation Held	Date of Relieving
Dr. L. Venkatesh	Scientist "C"	02.07.2021

Obituary

Employee Name	Designation Held	Date of Demise
Hussain Ali Khan	Lab. Assistant "D"	27.04.2021
Dr. G. Padmanabham	Director	03.06.2021

Reservations and Concessions

The Reservations and Concessions for SCs/STs/OBCs/EWS and persons with disabilities are followed as per Government of India orders from time to time. At ARCI, the overall representation of employees under SC is 19.16%, S.T is 5.38%, OBC is 28.14% and that of persons with disabilities is 1.79 % as on March 31, 2022.

Faculty Internship Programme

Under Faculty Internship Programme, teaching faculty from Engineering colleges who are interested to be associated with research work, to carry out a part of their research or wanted to become familiar with the latest R&D the activities and facilities are permitted to work for a period of 2 to 8 weeks during their vacation.

Outreach programme under Scientific Social Responsibility

Some of the Scientists on a voluntary basis have visited nearby government schools and delivered motivational talks /science talks for the benefit of the school students. On invitation by reputed government/private engineering colleges, scientists delivered lectures in the area of their specializations and shared their research experiences with the faculty and students.

Indian and Foreign Visitors for Technical Discussion

1. Mr. Srinivas Chamarthy, Managing Director, CYME Automation Systems Private Limited, Hyderabad, visited on November 12, 2021.

2. Mr. M Suresh Kumar, Chief Executive Officer (CEO), Manideep Techno Coats, Hyderabad, visited during January 04-05, 2022

3. Dr. Prasanna Deshmukh, Engineer - C, Indian Institute of Astrophysics (IIA)/ India TMT Management Advisory Committee (ITCC), Bengaluru, Mr. J.S. Jayakumar, Project Engineer I, QA, ITCC Bengaluru and Mr. Nikhil Naik, Production Support Manager, Thirty Meter Telescope International Observatory, TMT Project Office, Bengaluru visited during January 04-05, 2022

4. Prof P.M.Ajayan Rice University, USA visited on January 11, 2022.

Visits Abroad

1. Dr. Y. Srinivasa Rao, Dr. B. P. Saha, Dr. D. C. Jana and Dr. Papiya Biswas visited Jena, Germany during November 20 to December 07, 2021 for Factory Acceptance Test of LEGC Facility

Papers Presented at Conferences/Symposia

1. Ms. P. Samhita, (Dr. B. V. Sarada) presented a paper on "Oxygen Vacancy Induced NiCo2O4 Nanosheets: A Strategic Approach towards High Performing Supercapacitors" at the 'International Conference on Energy Storage and Technologies (ICOEST-2021)', Organized by Lovely Professional University, during April 09-10, 2021

2. Ms. Shaik Mubina (Dr. B. P. Saha) presented a paper on "Processing and Properties Evaluation of Long & Nano Carbon Fibers Reinforced SiC-based Hybrid Composites" at the '8th International Congress on Ceramics (ICC8)' organized online by BEXCO during April 25-30, 2021

3. Ms. Jyoti Gupta (Dr. Pramod H Borse) made an online poster presentation on "Nanosheets Decorated Spherical MoS2 Electrocatalyst for Water Splitting Application" at the 'ACS publication symposium The Power of Chemical Transformations', organized in partnership with the University of Hong Kong, during May 20-21, 2021.

4. Mr. Vikrant Trivedi (Dr. Manjusha Battabyal) presented a paper on "Thermoelectric and Transport Properties of Ta-filled and Ni-doped CoSb3 Skutterudites" at the 'Virtual Conference on Thermoelectrics' organized by International Thermoelectric Society (ICT) during July 20-22, 2021.

5. Dr. A. Karati (Dr. Pramod H Borse) presented a paper on "Enhancement in Hydrogen Evolution Activity via. Phase and Morphology Control in Nanostructure MoS2" at the 'International Conference on Condensed Matter and Device Physics – 2021' organized by School of Technology, Pandit Deendayal Energy University, Gujarat during September 09-11, 2021

6. Ms. Jyoti Gupta (Dr. Pramod H Borse) presented a paper on "Noble Metal doped MoS2 Electrocatalyst: A Comparative Study for Hydrogen Evolution Reaction" at the 'International Conference on Condensed Matter and Device Physics – 2021' organized by School of Technology, Pandit Deendayal Energy University, Gujarat during September 09-11, 2021

7. Mr. A. Vivek (Dr. Pramod H Borse) presented a paper on "Deposition and characterization of Phase variated Nickel Phosphide film for Improved Hydrogen Evolution" at the 'International Conference on Condensed Matter and Device Physics – 2021' organized by School of Technology, Pandit Deendayal Energy University, Gujarat during September 09-11, 2021

8. Mr. Riyaaz Uddien Shaik (Dr. Pramod H Borse) presented a paper on "Chemically Engineered Electro Catalytic Nickel-Phosphide Film Deposition on Graphite for HER application" at the 'International Conference on Condensed Matter and Device Physics – 2021' organized by School of Technology, Pandit Deendayal Energy University, Gujarat during September 09-11, 2021

9. Mr. Bathini Lava Kumar (Dr. Nitin P. Wasekar) presented a paper on "Compositional Gradient Nanocrystalline Ni-W Coatings by Electro Deposition for Superior Wear Resistance" at the '19th International Conference on Strength of Materials (ICSMA)' during June 26 – July 01, 2022

10. Dr. S. Sakthivel presented a paper on "Cost-Effective Scalable and High Temperature Stable Spinel Structured Solid Particles for High Temperature Solar Thermal Energy Storage Application" at the '11th Solaris 2021' organized by Niigata University, Japan during September 27-30, 2021

11. Mr. Ramay Patra, (Dr. R. Subasri) presented a paper on "Corrosion Studies on Biofilm Inhibiting Hydrophobic Nanocomposite Coatings on Stainless Steel 420 Substrates Used in Surgical Instruments" at the 'International virtual conference and expo on corrosion CORCON 2021' organized virtually by NACE International at NACE International Gateway India during November 18-20, 2021

12. Ms. Aarti Gautam (Dr. R Subasri) presented a paper on "Investigations on use of Inhibitor Loaded Halloysite Nanotubes and Polyelectrolyte Multi-layered Layer-by-layer as Self-Healing Materials for Corrosion Protection Coatings on Mild Steel" at the 'International virtual conference and expo on corrosion CORCON 2021' organized virtually by NACE International at NACE International Gateway India during November 18-20, 2021

13. Dr. Pradeep Prem Kumar K (Dr. R. Subasri) presented a paper on "Corrosion Protective and Self – Healing Hybrid Silica Sol-gel Sealed Porous Anodized Mg AZ31 Alloy for Aggressive Environments" at the 'International virtual conference and expo on corrosion CORCON 2021' organized virtually by NACE International at NACE International Gateway India during November 18-20, 2021

14. Ms. P. Samhita, (Dr. B. V. Sarada) presented a paper on "Recycled Spent Lithium-Ion Cathode Material for High-Performance Asymmetric Supercapacitor" at the 'International Online Conference on Recent Advances in Lithium-ion Batteries (LIBs) and their Recycling Methods for Sustainable Development', organized by The Open University, UK, and the IIT Hyderabad, during December 01-03, 2021

15. Ms. P. Samhita, (Dr. B. V. Sarada) presented a paper on “High Energy Density Aqueous Supercapacitor based on Redoxomer Assisted Electrodeposited Manganese dioxide” at the ‘Recent Advances and Innovation in Solar Energy (RAiSE 2021)- International Virtual Conference’ organized by DST Solar Energy Harnessing Centre (DSEHC) and IIT Madras, Chennai during December 02-04, 2021

16. Mr. Narendra Chundi (Dr. S. Sakthivel) presented a paper on “Development of Ambient Condition Curable Highly Weather Stable Anti-Soiling Coating and Evaluation of its Application for Photovoltaic Applications” at ‘RAiSE 2021- International Virtual Conference’ organized by DST Solar Energy Harnessing Centre (DSEHC) and IIT Madras, Chennai during December 02-04, 2021

17. Ms. Battula Ramya Krishna (Dr. R. Easwaramoorthi) presented a paper on “Rapid Crystallization of Perovskite Films Employing a Low Entropy Perovskite Ink for Solar Cell Applications” at ‘RAiSE 2021- International virtual conference’ organized by DST Solar Energy Harnessing Centre (DSEHC) and IIT Madras, Chennai during December 02-04, 2021

18. Ms. Reshma Dileep. K (Dr. V. Ganapathy) presented a paper on “La-Doped BaSnO3 as Electron Transport Layer for Carbon based HTM-Free Perovskite Solar Cells” at at ‘RAiSE 2021- International Virtual Conference’ organized by DST Solar Energy Harnessing Centre (DSEHC) and IIT Madras, Chennai during December 02-04, 2021

19. Mr. K. K. Phani Kumar (Dr. S.Sakthivel) presented a paper on “Nanocomposite based Solar Selective Absorber Coatings with High Thermal Stability and Wide-Angular Solar Absorptance” at ‘RAiSE 2021- International Virtual Conference’ organized by DST Solar Energy Harnessing Centre (DSEHC) and IIT Madras, Chennai during December 02-04, 2021

20. Mr. D. Nazeer Basha (Dr. Ravi Bathe) presented a paper on “Nanosecond Laser Surface Texturing for High Friction applications” at the ‘2nd Virtual International Tribology Research Symposium (ITRS 2021)’ organized by SRMIST during December 08-10, 2021

21. Mr. P. Raju (Dr. Y.S. Rao) made an oral presentation (flash talk) on “Comparative Wear Study of Pressure Slip Casting Sintered Alumina Solid Bodies” at the ‘International Conference on Advances in Ceramics and Cement Technologies: Materials & Manufacturing Innovative Processing of Ceramic Materials & Glass, 85th Annual Session of Indian Ceramic Society’ organized by Indian Ceramic Society, Kalburagi during December 13 -14, 2021

22. Mrs. S. Mamatha (Dr. Roy Johnson) made an oral presentation (flash talk) on “3D Printing of Clay Bonded Silicon Carbide for Kiln Furniture” at the ‘International Conference on Advances in Ceramics and Cement Technologies: Materials & Manufacturing Innovative Processing of Ceramic Materials & Glass, 85th Annual Session of Indian Ceramic Society’ organized by Indian Ceramic Society, Kalburagi during December 13 -14, 2021

23. Dr. Prasenjit Barick presented a paper on “Non Oxide Ceramics for High Temperature Applications” at the ‘Workshop on High Temperature Ceramics’ organized by Advanced Systems Laboratory, Hyderabad on December 14, 2021.

24. Ms. Keerthi Sanghamitra (Dr. Neha Y. Hebalkar) presented a paper on "Thermal Insulation Performance Study of Silica Aerogel-Eglass Fiber Composites using Test Method ASTM C335" at the ‘74th Annual Session of Indian Institute of Chemical Engineers (CHEMCON-2021)’ organized by CSIR - Institute of Minerals and Materials Technology, Bhubaneswar during December 26- 30, 2021

25. Dr. Sanjay Bhardwaj presented a paper on “Smart Self-healing Textiles: Analyzing Research Trends” at the ‘International Conference on Advances in Chemical and Materials Sciences (ACMS)’ organized by Indian institute of Chemical Engineers (IIChE), Kolkata on February 10, 2022

26. Ms. Reshma Dileep K (Dr. V. Ganapathy & Dr. T. N. Rao) made a poster presentation on “Large Area Perovskite Modules with Enhanced Stability for Niche Application” at the ‘National Conference of 12th Bangalore India Nano 2022’ during March 07-09, 2022

27. Mr. K. K. Phani Kumar (Dr. S.Sakthivel) made a poster presentation on “Novel Spinel Nanoparticles based Absorber Coated Receiver Tubes for Concentrated Solar Thermal Industrial Applications” at the ‘National Conference of 12th Bangalore India Nano 2022’ during March 07-09, 2022

28. Ms. P. Samhita (Dr. B. V. Sarada) made a poster presentation on “Cost-Effective and Eco-friendly MnO2 based 2.2 V High Energy Aqueous Supercapacitor” at the ‘National Conference of 12th Bangalore India Nano 2022’ during March 07-09, 2022

Lectures by ARCI Personnel

1. Dr. Gururaj Telasang delivered a keynote talk on “Sustainability of additive manufacturing and applications” at the ‘International Conference on Developments in Sustainable Materials, Manufacturing and Energy Engineering (ICDSME-2021)’ organised by Chaitanya Bharathi Institute of Technology (CBIT), Hyderabad during April 03-04, 2021

2. Dr. Joydip Joardar delivered an invited lecture on “Development of two-dimensional transition metal sulfides and their composites” at the ‘International Conference on Nano Materials (ICN 2021)’, organized by Mahatma Gandhi University, Kottayam during April 09-11, 2021

3. Dr. Sanjay Bhardwaj delivered an invited lecture on “Technology transfer and commercialization” at the ‘National Webinar’ organized by Pharma Tutor Edu Labs on April 17, 2021

4. Dr. Pramod H. Borse delivered an invited lecture on “Development of sensors at ARCI and upcoming prospects” at the ‘Indian Ceramic Society, Hyderabad Chapter, Online Lecture Series’ organized by Indian Ceramic Society, Hyderabad on April 19, 2021

5. Dr. Gururaj Telasang delivered an expert lecture on “Additive manufacturing of tool steel and applications” at the ‘Faculty Development Programme (FDP) on Metallurgical Aspects in Additive Manufacturing’ organised by the National Institute of Technology Andhra Pradesh NIT- AP) on April 19 -23, 2021.

6. Dr. Raman V delivered an invited lecture on “Advances in battery technologies – A materials perspective” at the ‘Energy Storage Devices Webinar’ conducted by Thiagarajar College of Engineering, Madurai on April 20, 2022.

7. Dr. R. Prakash delivered an invited lecture on “Indigenous development of lithium-ion battery materials and cell fabrication at ARCI for electric vehicles application” at the ‘India Russia Scientific Webinar on Electric Vehicle Technologies’ held during April 22-23, 2021.

8. Dr. Gururaj Telasang delivered expert lectures on “Additive manufacturing various aspects: SLM and applications” as a part of M. Tech course 2020-21 organized by Indian Institute of Technology (IIT) Tirupati during April 23-24, 2021.

9. Dr. Tata Narasinga Rao delivered a talk on “Power of nanotechnology: applications and implications” at Kendriya Vidyalaya Schools, Uppal & Begumpet, Hyderabad on April 29, 2021 and May 01, 2021 respectively.

10. Dr. Sanjay Bhardwaj delivered an invited lecture on “ARCI’s collaborative and technology transfer approach” at the ‘Incubators Meet’ organized by ARCI on April 30, 2021

11. Dr. Raman V. delivered an invited lecture on “Recent trends on application of chemistry in engineering” organized by Bharat Institute of Engineering and Technology, Hyderabad, during May 04 – 06, 2021.

12. Dr. S. M. Shariff delivered the following series of lectures: (a) “Basic concepts of laser surface engineering – alloying, cladding, glazing and metal additive manufacturing”, (b)“Application of laser based surface alloying and cladding for industry” and (c) “Repair and reclamation of industrial parts by laser cladding and deposition”, organized as part of ‘SAE India Southern Section (SAEISS) Online lecture Series on Laser based metal deposition and additive manufacturing technologies’ during May 08, 09 and 22, 2021, respectively

13. Dr. Gururaj Telasang delivered expert online lectures on “Additive manufacturing and applications” at the ‘Top-Tech Programme on Advanced Laser Manufacturing Process and Applications in Automotive Industry’ organised by SAEISS for industrial professional members during May 10 -15, 2021.

14. Dr. R. Gopalan delivered a guest lecture on “Opportunities and challenges in lithium-ion battery and magnet manufacturing technology” at the ‘AASEM, IIM, Chennai Chapter, Chennai on May 15, 2021

15. Dr. R. Gopalan delivered a special lecture on “Magnetism, magnetic materials and applications” at the Academy of Sciences, Chennai on May 29, 2021

16. Dr. Pramod H. Borse delivered an invited lecture on “Nanostructuring materials for solar hydrogen energy – basics and recent trends” at the ‘FDP on Nano Materials-Technologies for Energy & Sensor Applications (NTESA-2021)’, organized by GMR Institute of Technology, Rajam on June 07, 2021

17. Dr. R. Gopalan delivered an invited talk on “Hunting for functional materials for energy sustainability” during the ‘QIP - Short Term Course on Advances in Energy & Functional Materials’ held at IIT Bhubaneswar on June 17, 2021

18. Dr. M.B. Sahana delivered an invited talk on "Importance of electrode microstructure" at the ‘FDP’ organized by AICTE Training and Learning (ATAL) Academy, PDA College of Engineering, Kalaburgi, on June 19, 2021

19. Dr. K. Ramya delivered an invited lecture on “Fuel cells – materials and technology” at the FDP organized by NIT Rourkela during June 21-25, 2021

20. Dr. Balaji delivered an invited lecture on “An overview on hydrogen generation by water electrolysis” at the ‘Five-Day Online ATAL FDPon Fuel Cell Technology [FCT-2021]’ organized by NIT, Rourkela during June 21-25, 2021

21. Dr. Gururaj Telasang delivered a lecture on “Metal Additive Manufacturing: Engineering Applications” at a webinar organized by Robert Bosch Engineering and Business Solutions Private Limited, Bengaluru on June 24, 2021.

22. Dr. Sanjay Bhardwaj delivered invited lectures on “Technology commercialization and entrepreneurship: Understanding the upscaling process” and “Technology commercialization and entrepreneurship: Opportunities from ARCI” at a ‘Seminar on Early- Stage Entrepreneurs’ organized by University of Hyderabad (UoH) – Institution’s Innovation Council and Technology Enabling Centre -UoH during June 28-29, 2021

23. Dr. R. Prakash delivered an invited lecture on “Perspective of lithium-ion batteries in electric mobility” organized by ‘1st World Rechargeable cell Technology Conference (WRTC 1)’ during July 01-03, 2021.

24. Dr. R. Easwaramoorthi delivered a lecture on "Solar energy conversion devices" at the ‘ATAL FDP Workshop on Energy Conversion and Storage Devices’ organised by IIT Hyderabad during July 01-05, 2021

25. Dr. V. Ganapathy delivered lectures on "Emerging trends in photovoltaic technology" and “Solar cells and module fabrication” at the ‘ATAL FDP Workshop on Energy Conversion and Storage Devices’, organised by IIT Hyderabad during July 01-05, 2021

26. Dr. Srinivasan Anandan delivered an invited lecture on “Development of energy storage materials for electric vehicles” at the ‘AICTE Sponsored Online Short Term Training Program on Hybrid & Electric Vehicle Technologies for Sustainable Mobility (HEVTSM-2021)’ organized by Maharaj Vijayaram Gajapathi Raj College of Engineering, Vizianagaram on July 02, 2021.

27. Mr. Manish Tak, delivered a lecture on “Directed energy deposition for reclamation and refurbishment of engineering components” at the ‘ATAL FDP on Green Technology and Sustainability Engineering’ organized by Amrita Vishwa Vidyapeetham, Coimbatore during July 05 -09, 2021.

28. Dr. Ravi Bathe delivered an invited lecture on “Laser processing of materials and its impact on sustainability” at the ‘ATAL FDP on Green Technology and Sustainability Engineering organized by Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore on July 05-09, 2021.

29. Dr. G. Sivakumar delivered an invited lecture on “Coating and material solutions for clean coal technology applications in thermal power plants”, at the ‘ATAL FDP on Green Technology and Sustainability Engineering organized by Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore during July 05-09, 2021.

30. Dr. Srinivasan Anandan delivered an invited lecture on “Design, development and demonstration of energy storage (li-ion battery and supercapacitor) materials for electric vehicles application” at the ‘ICTE Sponsored FDP on Sustainable Technologies for Electric Transportation Systems’ organized by Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad on July 12, 2021.

31. Dr. S. Sakthivel delivered an invited lecture on "Functional coating technologies for solar thermal and PV applications”, at the ‘ATAL FDP on Novel Materials for Next-Generation Applications’ organised by M.S. Ramaiah Institute of Technology, Bengaluru during July 12-16, 2021.

32. Dr. P Sudarshan Phani delivered an invited lecture on "High speed nanoindentation mapping - A new paradigm in small scale mechanical testing" organized by Vellore Institute of Technology (VIT), Chennai on July 14, 2021.

33. Dr. R. Easwaramoorthi delivered a keynote lecture on "Solar cell fabrication and characterization" at the 'National Level Technical Workshop' organised SSN Engineering College, Chennai on July 19, 2021.

34. Dr. Gururaj Telasang delivered an expert lecture on "Powder bed additive manufacturing: Selective laser melting and applications" at the 'FDP on 3D Printing Design and Technology' at NIT, Silchar during July 19-23, 2021.

35. Dr. K. Ramya delivered an invited lecture on "PEMFC – trends and technology" at the 'FDP on Non-conventional Energy Sources: Technologies and Trends' organized by Government Engineering College, Kozhikode, during July 26-31, 2021.

36. Dr. Mani Karthik delivered a lecture on "Emerging materials and technology for energy harvesting, energy conversion and energy storage" at the 'SERB sponsored short-term course on Introduction to Computational Fluid Dynamics with applications in Energy Research' organized by IIT Indore during July 26-31, 2021.

37. Dr. Sanjay Bhardwaj delivered an invited lecture on "IP management for R&D organizations and its potential in extracting value from research outcome" during the 'Technical session on IP Management for R & D Organizations and its Potential in Extracting Value from Research Outcome' in the 'Virtual Workshop on Electrifying the Power & Value of Intellectual Property to Indian Industries and R & D Organization' organized by Confederation of Indian Industry (CII) on July 30, 2021

38. Dr. K. Suresh delivered an invited talk on "Probing nanostructures" at the webinar organized by Kakatiya Institute of Technology and Science (KITS), Warangal, on August 05, 2021

39. Dr. K. Suresh delivered an invited webinar talk on "New technology initiative (NTI): Materials characterization" organized by SAEINDIA on August 07, 2021

40. Dr. M. Buchi Suresh delivered an invited lecture on "Present and future of SOFC technology for clean energy production" at the 'Refresher Course on Contemporary Development Trends in Materials Science and Engineering' organized by UGC-HRDC, Jawaharlal Nehru Technological University, Hyderabad on August 11, 2021.

41. Dr. P. Sudarshan Phani delivered an invited lecture on "Nanoindentation: A powerful nanoscale research tool" organized as a part of Azadi ka Amrit Mahotsav celebrations at ARCI on August 13, 2021.

42. Dr. R. Gopalan delivered a guest lecture on "Development of Li-ion batteries for e-mobility & energy storage applications" at the 'Project Management Global Meet' organized by Project Managers Association of India at Chennai on August 13, 2021

43. Dr. R. Vijay delivered an invited lecture on "Nano and advance materials for high performance applications" at the 'International Conference on Manufacturing, Material Science and Engineering', organised by CMR Institute of Technology, Hyderabad during August 13-14, 2021.

44. Dr. R. Gopalan delivered a keynote lecture on "Materials technology for sustainable clean energy transportation" organized by VNR Vignana Jyothi Institute of Engineering & Technology, Hyderabad on August 16, 2021

45. Dr. R. Easwaramoorthi delivered MMEA-IIMSC expert lecture on "Next generation solar cells: materials and methods" organized by NIT Warangal on August 17, 2021.

46. Dr. R. Gopalan delivered a keynote talk on "Recent trends in magnetic technology" at the ' Platinum Jubilee Celebration & Conference on RE Road Map for Energy Security & Self Reliant India' organized by IIT Bhubaneswar on August 18, 2021

47. Dr. Pramod H. Borse delivered invited lectures on "Advanced energy materials for hydrogen renewable energy harvesting– photocatalytic H2" and "Material nanostructuring for sensor applications –technology development at ARCI" at the 'ATAL FDP on Emerging Materials, Sensors and Devices for IoT and Industry 4.0' organized by CV Raman Global University, Bhubaneswar during August 23-27, 2021

48. Dr. R. Balaji delivered an invited lecture on "Application of hydrogen fuel cell" at Prof. G.C. Carg Endowment Lecture organized by the Department of Automobile Engineering, MIT, Anna University, Chennai on August 26, 2021.

49. Dr. Gururaj Telasang delivered an expert lecture on “Selective Laser Melting Process and Engineering Applications” at the ‘FDP on Digital Additive Manufacturing (3D Printing)’ organized by ICFAI Tech, Faculty of Science and Technology, IFHE (deemed-to-be) University, Hyderabad during September 06-10, 2021.

50. Dr. R. Gopalan delivered an invited talk on “Transforming basic material physics & chemistry into sustainable technologies” organized by Bharathiar University, Coimbatore on September 08, 2021

51. Dr. Kaliyan Hembram delivered an online technical lecture on “Next generation biodegradable development of (biodegradable) implants” during Hindi Week Celebrations organized at ARCI on September 09, 2021

52. Dr. R. Gopalan delivered a guest lecture on “Critical materials technology for EV & automotive applications” organized by PSG College of Technology, Coimbatore on September 10, 2021

53. Dr. Tata N. Rao delivered a lecture on “Battery technologies for EV application in India” during EV Battery Session in WRI`s Annual event-Connect Karo 2021 on September 15, 2021

54. Dr. Ravi Gautam delivered an Hindi lecture on “Fe-P soft magnetic alloys” at ARCI on September 16, 2021

55. Dr. Sanjay Bhardwaj delivered a plenary lecture on “Development, demonstration and transfer of advanced materials technologies” at the ‘International Conference on Recent Innovations in Chemical and Biological Engineering (RICBE-2K21)’ organized by Rajiv Gandhi University of Knowledge Technologies (RGUKT), Nuzvid in association with IIChE – Amravati Regional Centre, Guntur during September 16 – 18, 2021

56. Dr. G. Sivakumar delivered an invited talk on “High temperature coatings by thermal spraying” at the ‘ATAL FDP programme on Advanced Materials Processing and Characterisation” organized by VIT School of Engineering on September 22, 2021.

57. Dr. R. Gopalan delivered a guest lecture on “Propelling materials technology for EV, automotive and stationary applications” organized by IIT Hyderabad on September 22, 2021

58. Ms. K. Divya delivered an invited lecture on "Laser-based metal additive manufacturing" at the ‘Virtual Workshop on Recent Trends in Additive Manufacturing” organized by Christian College of Engineering and Technology Kailash Nagar, Bhilai, during September 22-23, 2021.

59. Mr. Manish Tak, delivered a lecture on “Directed energy deposition AM and its applications on repair and refurbishment” at the ‘Virtual Workshop on Recent Trends in Additive Manufacturing’ organized by Christian College of Engineering and Technology Kailash Nagar, Bhilai during September 22-23, 2021.

60. Dr. Malobika Karanjai delivered invited talks on ‘Friction materials” and “Biomaterials” at the ‘PM Short Course – PMSC 21’, organized by Powder Metallurgy Association of India (PMAI) on September 28, 2021.

61. Dr. Srinivasan Anandan delivered an invited lecture on “Design and development of advanced energy storage materials for electric vehicles application” organized by the Millitary College of Electronics and Mechanical Engineering, Hyderabad on September 29, 2021.

62. Dr. G Ravi Chandra delivered an online invited lecture on “Introduction to materials” organized by University of Technology and Applied Sciences, Ibra, Oman on October 05, 2021

63. Dr. M. Buchi Suresh delivered an invited talk on “Role of interconnect in SOFC stack development” at the ‘Workshop on Ceramic Materials for Solid Oxide Fuel Cells” organized by ARCI, Hyderabad on October 21, 2021.

64. Dr. Tata N. Rao delivered a keynote lecture on “India specific energy storage options and technologies” at the ‘International Conference on Energy & Advanced Materials 2021 (ICEAM)’ organized by Jaypee Institute of Information Technology, Noida on October 22, 2021

65. Dr. R. Subasri delivered an invited talk on “Engineering surfaces through sol-gel nanocomposite coatings to achieve multi-functionalities” at the ‘Technical Webinar’ organized by ASM International, Chennai chapter, Indian Institute of Metals Chennai chapter & Madras Metallurgical Society (MMS) on October 23, 2021.

66. Dr. Tata N. Rao delivered a lecture on “India specific energy storage options and technologies” at the ‘International Hybrid Meeting on Physics and Chemistry of Advanced Materials (PCAM)’, organized by IIT Delhi during October 24-27, 2021

67. Dr. Gururaj Telasang delivered an expert lecture on “Selective laser melting process and tooling applications” at the ‘FDP on 3D Printing for sustainable development’ organized by the JNTUH – AICTE in association with Nalla Narasimha Reddy Education Society's Group of Institutions, Hyderabad during October 25-30, 2021.

68. Dr. Srinivasan Anandan delivered an invited lecture on “Development of indigenous energy storage materials for electric vehicles application” at the ‘FDP on International Virtual Conference on Role of Chemistry in Advanced Engineering Materials (RCAEM-2021)’ organized by Vasavi College of Engineering, Hyderabad on October 28, 2021.

69. Dr. Sanjay Bhardwaj delivered a keynote lecture on “Scaling-up of chemical and advanced materials technologies” at the ‘Webinar on the Changing Face of Chemical Engineering: Future Prospects and Career Opportunities” organized by BITS Pilani - Hyderabad campus during October 31-November 01, 2021

70. Dr. R. Subasri delivered an invited talk on “Surface modification using multifunctional sol-gel nanocomposite coatings” at the ‘Technical Webinar’ organized by Advanced Materials Research Centre & Faculty of Science, Rabindranath Tagore University, Bhopal on November 01, 2021.

71. Dr. Tata N. Rao delivered a lecture on “Energy storage technologies: challenges and solutions” organized by BITS Pilani, Hyderabad campus on November 10, 2021

72. Dr. Tata N. Rao delivered a lecture on “Science and technology of nanomaterials” at the ‘National Online Workshop on Nanomaterials’, organized by Sri YN College, Narasapur on November 12, 2021

73. Dr. Sanjay Bhardwaj delivered an invited lecture on “Importance of translational research for start-up ecosystem” at a ‘Webinar’ organized by Atal Incubation Centre , Dr. Babasaheb Ambedkar Marathwada University, Aurangabad on November 12, 2021

74. Dr. Tata N. Rao delivered guest lecture on “Translational materials research: Lab to market” at the ‘SAE International Conference on Advances in Design, Materials, Manufacturing and Surface Engineering for Mobility (ADMMS-21)’, organized by SAEINDIA on November 13, 2021

75. Dr. Tata N. Rao delivered a keynote lecture on “Translational materials research in energy storage technologies” at the ‘Platinum Jubilee ATM 2021’ organized by IIM on November 14, 2021

76. Dr. Pramod H. Borse delivered an invited lecture on “Nanoengineering of photocatalysts for solar hydrogen energy generation” at the ‘National Webinar on Research Trending Areas in Humanities and Basic Sciences’ organized by ACE Engineering College, Hyderabad on November 15-20, 2021.

77. Dr. R. Gopalan delivered an invited talk on “Basics of magnetism to advanced process technology for rare earth magnetic materials” organized by Pune University on November 17, 2021.

78. Dr. Gururaj Telasang delivered a keynote talk on “Selective laser melting: Engineering applications” at the ‘Webinar on Recent Trends in Metal 3D Printing and its Industrial Applications (RTM3DPIA 2021)’ organized by IIT Patna, IIT Hyderabad, and Defence Research and Development Laboratory (DRDL) on November 17, 2021.

79. Dr. Gururaj Telasang delivered an invited talk on “Selective laser melting for tooling applications” at the ’Training Programme for Engineering Students’ organized by Wipro 3D Bengaluru, on November 20, 2021.

80. Dr. Sanjay Bhardwaj delivered an invited lecture on “Research upscaling, collaborations and technology transfer strategies” at the ‘Science Administration Research Management (SARM) Programme’ sponsored by Department of Science and Technology (DST) and organized by Administrative Staff College of India (ASCI), Hyderabad on November 23, 2021

81. Dr. Srinivasan Anandan delivered an invited lecture on “Development of energy storage materials for electric vehicles application” at the ‘5th International Conference on Recent Trends in Applied Science and Technology’ organized by Manonmaniam Sundaranar University, Tamilnadu on November 27, 2021.

82. Dr. R. Gopalan delivered a guest lecture on “Exotic materials in material science and engineering” organized by PSG College of Technology on November 29, 2021.

83. Dr. G. Siva Kumar delivered an invited lecture on "Recent advancements in surface engineering to improve reliability of engineering components" at the ‘12th National Conference and Exhibition on Aerospace & Defence Mechanisms (ARMS 2021)’ organized by the Armament Research and Development Establishment (ARDE), Pune on December 02, 2021

84. Dr. M.B. Sahana delivered an invited talk on "Strategies to increase operating voltage window of lithium layered oxide cathode materials" at the 'Recent Advances and Innovations in Solar Energy (RAiSE) 2021' organized by IIT Madras, Chennai on December 02, 2021.

85. Dr. Tata N. Rao delivered a keynote lecture on "Importance of metallurgical & materials engineering education" organized by IIT Jodhpur on December 03, 2021

86. Dr. Tata N. Rao delivered an invited lecture on "Translational materials research in energy storage technologies" at the 'International Conference on Advanced Materials & Mechanical Characterization' organized by SRM Institute of Science and Technology, Tamilnadu on December 03, 2021

87. Dr. Tata N. Rao delivered an invited lecture on "India specific energy storage options and technologies" at the 'International Conference on Recent Advances in Lithium-ion Batteries (LIBs) and their Recycling Methods for Sustainable Development' organized by IIT Hyderabad on December 03, 2021

88. Dr. S. M. Shariff delivered an invited lecture on "Scope of laser welding technology for industry" organized by MVSR Engineering college, Hyderabad on December 03, 2021

89. Ms. Aarti Gautam (Dr. R. Subasri) delivered an online technical lecture on "Outline of application of sol-gel coatings" at the 'Hindi Workshop' organized by ARCI on December 06, 2021

90. Dr. Gururaj Telasang delivered expert lectures on "Powder bed additive manufacturing: selective laser melting" and "Selective laser melting: Applications" at the 'FDP on Additive Manufacturing in Industry 4.0 Strategy" organized by the NIT, Andhra Pradesh during December 06-10, 2021.

91. Dr. Sanjay Bhardwaj delivered an invited lecture on "Research collaborations" at the 'General Management Programme (GMP) for Women Scientists', sponsored by DST and organized by ASCI, Hyderabad on December 08, 2021

92. Dr. Rambha Singh delivered a Rajbhasha lecture on "Policy, Rules & Regulations of Official Language" at the 'Hindi Workshop organized by ARCI Chennai' on December 09, 2021

93. Dr. Roy Johnson, delivered an invited talk on "Transparent ceramics: processing and applications" at the 'International Conference on Advances in Ceramics and Cement Technologies: Materials & Manufacturing Innovative Processing of Ceramic Materials & Glass, 85th Annual Session of Indian Ceramic Society' organized by Indian Ceramic Society, Kalburagi during December 13 -14, 2021

94. Dr. Roy Johnson, delivered an invited talk on "Transparent polycrystalline ceramics for strategic applications" at the 'International Conference on Workshop on High Temperature Ceramics' organized by Advanced System Laboratory, Hyderabad on December 14, 2021.

95. Dr. R. Gopalan delivered a guest lecture on "Electric vehicle performance driven by nanoscale materials" organized by Sathyabama University, Chennai on December 14, 2021.

96. Dr. Neha Y. Hebalkar delivered a lecture on "Development of world class thermal insulation product based on nanoporous areaogel" at the '7th International Conference on Advanced Nanomaterials and Nanotechnology (ICANN2021)' organized by IIT Guwahati during December 14-17, 2021

97. Mr. Manish Tak delivered a lecture on "Directed energy deposition and repair and refurbishment" at the 'ATAL FDP on 3D Printing and Design' organized by Christian College of Engineering and Technology, Bhilai during December 14-18, 2021.

98. Dr. Malobika Karanjai delivered a lecture on "Friction materials and composites" at the 'ARCI Colloquium Series', organized by ARCI on December 15, 2021

99. Dr. R. Gopalan delivered an invited talk on "Materials research @ ARCI to support innovation for affordable solutions and self-reliance" at the 'iTEC India 2020-2021 Conference' organized by SAE India and IEEE IAS on December 17, 2021.

100. Dr. Srinivasan Anandan delivered an invited lecture on "Development of indigenous energy storage materials for electric vehicles application" at the 'Skill based Internship Program on Advanced Nano-Enabled Devices and Products' organized by National Centre for Nanoscience and Nanotechnology, University of Madras on December 19, 2021 .

101. Dr. Tata N. Rao delivered a keynote lecture on "Emerging technologies for energy storage materials: Towards self-reliant India" at the 'International Conference on Advances in Smart Materials and Emerging Technologies (ASMET, 2021)' organized by Indira Gandhi Technical University for Women, Delhi on December 20, 2021

102. Dr. D. Sivaprahasam delivered invited talk on “Design, fabrication and performance of NaxPb1-xTe - Mg2Si1- xSnx medium temperature thermoelectric device” at the ‘International Conference Third Indian Materials Conclave and 32nd Annual General meeting of MRSI-2021’ organized by MRSI, Chennai during December 20-23, 2021

103. Dr. R. Easwaramoorthi delivered an invited lecture on "Scalable fabrication of efficient perovskite solar cells" at the ‘International Conference Third Indian Materials Conclave and 32nd Annual General meeting of MRSI-2021’ organized by MRSI, Chennai during December 20-23, 2021

104. Dr. Manjusha Battabyal delivered an invited lecture on “Thermoelectric materials and application for energy harvesting and power generation" at the ‘ISTE AICTE Virtual Faculty Development Programme’ organized by Shri Mata Vaishno Devi University, Jammu during December 21-27, 2021.

105. Dr. Sanjay Bhardwaj delivered an invited lecture on “Research collaborations” at the ‘Science Administration Research Management (SARM) Programme’ sponsored by DST and organized by ASCI, Hyderabad on December 23, 2021.

106. Dr. Prabhu D. delivered an invited lecture on “Nano engineered magnets” organized by University of Madras, Chennai on January 05, 2022.

107. Dr.S.Kavita delivered a lecture on “Magnetotherapy in cancer treatment” at a ‘Webinar’ organized by Saveetha Dental College & Hospital, Chennai on January 06, 2022.

108. Dr. R. Subasri delivered a talk on “Nanocomposite coatings for healthcare applications” at the ‘AICTE –ISTE sponsored One Week Online Induction/Refresher Programme on Nanotechnology in Healthcare’ organized by PSG College of Technology, Coimbatore on January 10, 2022

109. Dr. Gururaj Telasang delivered expert lectures on “Tooling applications of AM” at the ‘ATAL FDP on 3D Printing & Design- 2022’ organised by Defence Institute of Advanced Technology, Pune during January 10-14, 2022.

110. Dr. Joydip Joardar delivered a lecture on "Two-dimensional X-ray Diffraction: basics and case studies" at the ‘ARCI Colloquium Series’ organized by ARCI on January 12, 2022.

111. Dr. Prithi Jayaraj delivered a lecture on “Electrocatalysts for PEMFC: A durability perspective” at the ‘Tech Talk series in Centre for Hydrogen and Green Technology (CH2GT)’ organized by RV College of Engineering, Bengaluru on January 12, 2022

112. Dr. R. Vijay delivered an invited lecture on “Synthesis of nanomaterials for various applications” at the ‘National FDP on Methods of Materials Synthesis’ organized by Bhavan’s Vivekananda College of Science, Humanities and Commerce, Hyderabad, during January 18-22, 2022

113. Dr. G. Siva Kumar delivered an invited lecture on "Thermal sprayed coatings for improved performance and life of thermal power plant component" at the ‘Discussion workshop on thermal spray coatings’ organized by Pratt & Whitney R & D Centre, Bengaluru on January 19, 2022

114. Dr. G Siva Kumar delivered an invited lecture on "National centre for development of advanced materials and manufacturing processes for clean coal technologies for power applications" at the ‘Future of Coal Research in India session at ICESE-2022’ organized by IIT Bombay, Mumbai on January 21, 2022

115. Dr. B. V. Sarada delivered an invited lecture on “Surface modification technologies for improving biocompatibility of metallic medical implants ” at the ‘Workshop on Advanced Manufacturing of Biomedical Devices for Precision Health Technologies’ organized by IIT Tirupathi during January 24-28, 2022.

116. Dr. P. Suresh Babu delivered an invited lecture on "Influence of substrate properties on the deformation behavior of TiN Coating under cyclic impact testing" at the ‘Micromaterials Users Meeting’ on 27 January 2022

117. Dr. Sanjay Bhardwaj delivered an invited lecture on “Research upscaling, collaborations and technology transfer strategies” at the ‘General Management Programme’ sponsored by DST at ASCI, Hyderabad on January 27, 2022

118. Dr. Tata N. Rao delivered lecture on “Energy materials and technologies for EV applications” at the ‘Online Refresher Course in Chemical Sciences’ organized by UGC-HRDC, Osmania University, Hyderabad on February 03, 2022

119. Dr. Sanjay Bhardwaj delivered an invited lecture on “Technology development, demonstration and transfer: Case studies” at the ‘Mini-workshop in Technology Transfer from R & D Labs’ organized by TechEx.in, a technology transfer hub operated by Venture Centre Pune (India) and supported by National Biopharma Mission, BIRAC (Government of India) on February 04, 2022

120. Dr. S.M. Shariff delivered a lecture on "Development of laser-clad coating technologies for power plant industry" at the 'ARCI Colloquium Series' organized by ARCI on February 09, 2022.

121. Dr. B. V. Sarada delivered an invited lecture on "Supercapacitors for electric vehicles" at the 'Industry Conclave on Electric Vehicles' organized by Geethanjali College of Engineering and Technology, Hyderabad during February 14 -19, 2022

122. Dr. R. Prakash delivered an invited talk on "Lithium-ion battery technology development at ARCI for EV/ESS application" at the 'E-Mobility workshop' organized by IIT Bombay, Mumbai on February 19, 2022

123. Dr. D. Prabhu delivered an invited lecture on "Magnetism at the nano scale" organized by St. Mary's College, Thoothukudi on February 21, 2022

124. Dr. Nitin P. Wasekar delivered an invited lecture on "Pulsed electrodeposition of nanostructured coatings: From synthesis to applications in automotive industry" organized by IIT Indore during February 21-26, 2022

125. Dr. Sanjay Bhardwaj delivered an invited lecture on "Research collaborations" at the 'Advance Techno Management Programme' sponsored by DST and organized by ASCI, Hyderabad on February 22, 2022

126. Dr. Pramod H. Borse delivered an invited lecture on "Material nanostructuring for sensor applications -Technology advancements at ARCI" at the 'Workshop on Standardization of Sensors, Devices, and their Applications' organized by TIET, Patiala during February 22-23, 2022

127. Dr. Tata N. Rao delivered a lecture on "ARCI's role in nation building" organized by NIT Warangal on February 23, 2022

128. Dr. B. V. Sarada delivered an invited lecture on "Materials and processes for biomedical implants @ ARCI" at the 'Workshop on Materials and Technologies for Biomedical Implants" organized by ARCI, Hyderabad on February 24, 2022

129. Dr. P. Sudharshan Phani delivered an online invited talk on "Nano-mechanical testing on recent works" at the 'TMS 2022 Annual Meeting & Exhibition', organized by TMS, USA during February 27 – March 03, 2022

130. Dr. R. Prakash delivered a chief guest lecture on "Integrated approach in science and technology for a sustainable future" organized by Aarupadai Veedu Institute of Technology (AVIT), Chennai on the occasion of National Science Day on February 28, 2022

131. Dr. S. Sakthivel delivered an invited lecture on "Nano functional coating technology for PV & solar thermal application" at the 'Science day Celebration One Day Lecture Workshop' organised by Central University of Kerala, on February 28, 2022.

132. Dr. M. Buchi Suresh delivered an invited talk on "Development of anode based Honeycomb SOFC and its testing @ ARCI" at the 'Workshop on Advanced Energy Materials & Devices -2022' organized by CSIR-CGCRI, Kolkata on March 03, 2022

133. Dr. Tata N. Rao delivered a lecture on "Supercapacitors" organized by Lovraj Kumar Memorial Trust on March 04, 2022

134. Dr. G. Siva Kumar delivered an invited lecture on "Coating solutions for high temperature applications through thermal spraying" at the 'DST-SERB Sponsored National Workshop on Nanomechanical and Tribological Characterization of Materials' organized by Satyabhama University, Chennai during March 04-05 2022.

135. Dr. R. Easwaramoorthi delivered an invited lecture on "Halide perovskites for high performance solar cells" at the 'Short Term Course in Renewable Energy' organised by UGH-HRDC, Osmania University, Hyderabad during March 07-12, 2022

136. Dr. Mani Karthik delivered a lecture on "Advanced materials and technologies for low, medium and high temperature thermal energy storage applications" at the 'Short Term Course in Renewable Energy' organised by UGH-HRDC, Osmania University, Hyderabad during March 07-12, 2022

137. Dr. B. V. Sarada delivered an invited lecture on "Technologies for solar energy conversion and storage" at the 'Short Term Course in Renewable Energy' organised by UGH-HRDC, Osmania University during March 07-12, 2022

138. Dr. Sanjay Bhardwaj delivered an invited lecture on "ARCI knowledge-base for strategic sector" for officers of Indian Army (Military College of Electrical and Mechanical Engineers, Secunderabad) organized by ARCI on March 10, 2022

139. Dr. R. Balajil delivered an invited lecture on “The journey of hydrogen fuel cell R&D activities at ARCI” at the ‘Webinar on Hydrogen Fuel Cell: Technology and Market Perspective’ conducted by Smart Energy Magazine during March 12, 2022

140. Dr. T. Mohan delivered an invited lecture on “Lithium-ion batteries design and development, status and challenges” at the ‘ ARCI Colloquium Series’ organized by ARCI on March 16, 2022.

141. Dr. S. M. Shariff delivered an invited lecture on “Laser: A powerful tool for applications in engineering, medicine and biology” at the ‘Seminar on Advances in Science and Technology’ organized by Anwarul Uloom College, Hyderabad on March 17, 2022

142. Dr. Srinivasan Anandan delivered invited lectures on “Development of indigenous Li-ion battery materials for electric vehicles application” and “Development of indigenous supercapacitor grade porous carbon materials using bio-/industrial wastes for electric vehicles application” at the ‘FDP on Power Electronics for Electric Vehicles and Renewable Energy Systems’ organized by E&ICT Academy & NIT Warangal in Association with Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad on March 24, 2022.

143. Dr. Kaliyan Hembram delivered an invited lecture on “Synthesis of nanopowders by flame spray pyrolysis for different applications: Laboratory to pilot scale” at the ‘Inter-University National Research & Innovation Festival’, organized by Rabindranath Tagore University, Bhopal during March 25-26, 2022.

144. Dr. Nitin P. Wasekar, delivered an online technical lecture on “Various Activities of the Centre for Engineered Coatings” during the ‘Hindi Workshop’ organized by ARCI on March 28, 2022

145. Dr. Neha Y. Hebalkar delivered an invited lecture on “Commercialization of nanotechnology based products: Opportunities and prospects” at the ‘Management Development Program (MDP) on Nanoscience and Nanotechnology- the Next Step to Industrial Innovations’, organized by Shivaji University, Kolhapur on March 29, 2022.

Participation in Training Programmes in India

1. Dr. Raman Vedarajan, Dr. J.A Prithi, Mr. Arvind B (Dr. K. Ramya) attended training programme on “AVANTAGE Software for XPS” conducted by Thermo Fisher Scientific on April 20, 2021

2. Ms. P.K. Rajalakshmi Nair and Mr. Ch. Venugopal attended online training programme on “Establishment Rules – II” organized by Institute of Secretariat Training & Management’s (ISTM) during June 07-11, 2021.

3. Dr. L. Ramakrishna attended online training on “Advance Course on Preventive Vigilance” conducted by National Productivity Council during July 06-07, 2021.

4. Dr. Koppoju Suresh, Mr. B. Sainath Patil and Mr. Tarun Babu (Dr.K. Suresh) attended a course on “Basics of Data Analytics in Metallurgy and Manufacturing Engineering” organized by Indian Institute of Metals, Kolkatta and Indian Institute of Technology(IIT) Bombay, Mumbai during July 19-21, 2021.

5. Dr. M. B. Sahana and Mr. R Vijaya Chandar attended an online training programme on “Emotional Intelligence at Workplace for Scientists/Technologists” at the Centre for Organization Development (COD), organized by Department of Science & Technology (DST) during September 20-24, 2021.

6. Dr. Raman Vedarajan, Dr. Naveen Akula, Mr. V. Tarun Kumar attended the training programme on “XPS Instrumentation and AVANTAGE Software” organized by Thermo Fisher Scientific during October 05-08, 2021.

7. Dr. Rambha Singh attended online training on “Online Translation Program” at the Central Translation Bureau, conducted by CSIR-NGRI, Hyderabad on October 24, 2021.

8. Dr. Malobika Karanjai and Dr. K. Ramya attended an online training programme on “Leadership and Organization Development for the Women Scientists/Technologists” conducted by Centre for Organization Development (COD), Hyderabad during October 25-29, 2021.

9. Dr. Pawan Kumar Jain attended an online training programme on “Policy for Science and Science for Policies” conducted by DST-NIAS during October 25-29, 2021.

10. Mr. Sankar Ganesh, Mr. K. Naresh Kumar and Mr. M. R. Renju attended an online training programme on “Deep Dive into Mobile Application Security Analysis” conducted by C-DAC, Hyderabad during November 22 - December 01, 2021.

11. Mr. Ramay Patra, Ms. Aarti Gautam, Dr. Pradeep Premkumar (Dr. R. Subasri) attended a training programme on “Industrial Corrosion and its Control”, organized by Electrochemical Society of India (ECSI), Bengaluru during December 16-18, 2021

12. Mr. M. Tarun Babu (Dr. K. Suresh) attended workshop on “Thermo-Calc TM Hands-on Training Course” conducted by IIT Madras and organized by ASM International, Chennai during January 24-28, 2022

13. Dr. M. B. Sahana and Ms. K. Divya attended an online training programme on “Emotional Intelligence at Workplace for Scientists/Technologists” at Centre for Organization Development (COD), Hyderabad organized by Department of Science & Technology (DST) during February 21-25, 2022.

14. Mr. K. Naresh Kumar attended an online training programme on “Block Chain Technology and Application Development” conducted by C-DAC, Hyderabad during March 02-15, 2022.

15. Mr. D. Nazeer Basha (Dr. Ravi Bathe) attended the AICTE sponsored short-term course (STC) on “Laser Applications in Machining and Material Processing (LAMMP)” organized by IIT Madras during March 07-12, 2022

Participation in Indian Conferences/ Symposia/ Seminars/ Workshops/ Exhibitions

1. Mr. K.K. Phani Kumar (Dr. S. Sakthivel) attended a webinar on “Corrosion Science and Technology 2021”, organized by IIM Kalpakam chapter on May 12, 2021

2. Ms. B. Ramya Krishna (Dr. Easwaramoorthi R) attended a webinar on “Interface Physics and Processes Behind Highly Stable and Efficient 2D/3D Perovskite Solar Cells” organized by PDEU, Gujarat on May 24, 2021

3. Mr. C. Narendra and Mr. K.K. Phani Kumar (Dr. S. Sakthivel) attended a seminar on “Energy Materials” organized by the Centre for Nanoscience and Nanotechnology, Centre of Excellence for Energy Research, Sathyabama Institute of Science and Technology on June 04, 2021

4. Mr. Ramakrishna S. attended workshop on "In-situ Electron Microscopy Online Symposium” conducted by IIT Kanpur, IIT Kharagpur and Electron Microscopy Society of India (EMSI) during July 08-09, 2021

5. Ms. Reshma Dileep K. (Dr. V. Ganapathy) attended workshop on “Organic/Perovskite/Quantum Dot Solar Cell/ OLED/Perovskite LED, Polymer LED Using Setfos Software” organized by Fluxim AG on July 19, 2021 (Virtual).

6. Ms. B. Ramya Krishna (Dr. Easwaramoorthi R.) attended a workshop on “Organic/Perovskite/Quantum dot Solar Cell/ OLED/Perovskite LED, Polymer LED) Using Setfos software” organized by Fluxim AG on July 19, 2021 (Virtual).

7. Mr. D. Nazeer Basha (Dr. Ravi Bathe) attended the 10th Summer School (online) on Trends and New Developments in Laser Technology" organized by TU Dresden during August 23-26, 2021

8. Mr. R.S. Sai Manoj Kumar (Dr. K. Ramya) attended a workshop on “CFD with Open FOAM” conducted by IIT Madras and PAANDUV Applications Private Limited during September 24-25, 2021

9. Mr. K.K. Phani Kumar (Dr. S. Sakthivel), Dr. Mani Karthik and Dr. S. Sakthivel attended the vitual “International Symposium on Solar Energy and Efficient Energy Usage (11th Solaris 2021)” organized by Niigata University, Tokyo, Japan during September 27-30, 2021

10. Ms. Reshma Dileep K (Dr. V. Ganapathy) attended the ESPResSo workshop on “Report on the Outcome from the European Commission funded project”, organized by Dyenamo on September 29, 2021

11. Mr. D. Nazeer Basha (Dr. Ravi Bathe) attended the Workshop on “Cyber-Physical Manufacturing and Inspection Systems” organized by IIT Madras, Chennai during October 04-09, 2021

12. Mr. C.Narendra (Dr.S. Sakthivel) attended a seminar on "Energy Yield Losses in PV Installations due to Soiling and Mitigation" organized by IEEE Electron Devices & Solid-State Circuits Society Bangladesh Chapter on October 13, 2021

13. Ms. P. K. Rajalakshmi Nair and Mr.Ch. Venugopal attended online workshop on “Establishment Rules – II” organized by Institute of Secretariat Training & Management’s (ISTM) during November 22-26, 2021

14. Ms. Aarti Gautam, (Dr. R. Subasri), Ms. S. Mamatha (Dr. Roy Johnson), Mr. P. Raju (Dr. Y. Srinivasa Rao), Mr. T. Nagaraju (Dr. Dibyendu Chakravarty) and Ms. Priyanka S.N. (Dr. S. B. Chandrasekhar) attended the virtual workshop on "Presentation Skills" organized by CSIR – Indian Institute of Toxicology Research on November 26, 2021

15. Ms. Priya Anish Mathews attended the "National Conference on Indian Independence Movement & the Role of Science" organized by CSIR-NPL during November 29-30, 2021

16. Mr. M. Tarun Babu (Dr. K. Suresh) attended a workshop on "Recent Advances in Modeling of Inelastic Response and Integrity Assessment of Metals" conducted by Indian Society for Applied Mechanics (ISAM 2022) during January 10-20, 2022

17. Mr. C.Narendra and K.K Phani Kumar (Dr. S. Sakthivel)attended "Indo-UK PV Soiling Workshop" organized by IIT Bombay, Mumbai during January 24-25, 2022

18. Dr. K. Suresh attended the Satellite online session of InPAC-2022 on "Application of High Energy X-rays in Materials Science: Role of High Energy 4th Generation Light Source" organized by RRCAT, Indore on March 21, 2022

Panel Discussion

Name	Technical Session Topic	Event Name	Date
Dr. R. Prakash	---	8th Meeting of Electric and Hybrid Vehicles Sectional Committee,TED-27	28 May 2021
Dr. T. Mohan	EV Battery Swapping System	Stakeholder Consultation Meeting for Light EV Battery Swapping Standards Development	01 July 2021
Dr. Srinivasan Anandan	---	Interoperability of Light EV Battery Swap Systems	14 August 2021
Dr. T. Mohan	---	Interoperability of Light EV Battery Swap Systems	14 August 2021
Dr. R. Prakash	Electric And Hybrid Vehicle	Safety and Procedural Requirements for Type Approval of Compressed Gaseous and Hydrogen Fuel Cells	21 December 2021
Dr. Pramod H Borse	Intelligent IoT sensors	World Sensor Congress 2022	10 March 2022
Dr. Srinivasan Anandan	Electro-technology in Mobility, Battery Chemistry	19th meeting of Electrotechnology in Mobility Sectional Committee, ETD 51	23 March 2022

Journal Publications (Calendar Year 2021)

1. A Sangeetha, L. Samyuktha, A. Kapley, Neha Hebalkar, R.K. Sharma, S.G. Uppin and K. Jamil, Evaluation of Biological Effects and Toxicity of Cetyltrimethylammonium Bromide Stabilized Silver Nanoparticles and Cetyltrimethylammonium Bromide Alone Following Intravenous Injection in Mice, Current Nanomedicine, Vol.11(1), p 70-80, 2021

2. A. Karati, T. Parida, J. Gupta, H.K. Adigilli, P.H. Borse and J. Joardar, Band-Gap Engineering in Novel Delafossite-Type Multicomponent Oxides for Photocatalytic Degradation of Methylene Blue, Materials Research Bulletin, Vol. 137, Article No. 111181, 2021

3. B. Jayachandran, B. Prasanth, R. Gopalan, T. Dasgupta and D. Sivaprahasam, Thermally Stable, Low Resistance Mg2Si0.4Sn0.6/Cu Thermoelectric Contacts Using SS 304 Interlayer by One Step Sintering, Materials Research Bulletin, Vol.136, Article No. 111147, 2021

4. S.Harish, D. Sivaprahasam, B. Jayachandran, R. Gopalan and G. Sundararajan, Performance of Bismuth Telluride Modules under Thermal Cycling in an Automotive Exhaust Thermoelectric Generator, Energy Conversion and Management, Vol.232, Article No. 113900, 2021

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3. A.H.V. Pavan, K. Soumya, B.R. Chandra, M. Swamy, R. Vijay and K. Singh, “Characterization and Mechanical Behaviour of Mechanically Milled and Hot Extruded Oxide Dispersion Strengthened Steel”, Proceedings of International Conference and Exposition on Mechanical, Material and Manufacturing Technology (ICE3MT2020) in Materials Today Proceedings, Vol. 38, p 2687-2694, 2021

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6. A chapter on “Highly Functionalized Nanostructured Titanium Oxide-Based Photocatalysts for Direct Photocatalytic Decomposition of NOx/VOCs” authored by K. Nanaji, M. Vijayakumar, A. Bharathi Sankar and Mani Karthik in the book on ‘Nanaostructured Materials for Environmental Applications’ (eds.) Subramanian Balakumar, Valérie Keller, M.V. Shankar, Springer Nature, p 521-544, 2021

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2. S. Sakthivel, S.R. Atchuta, M. ShivaPrasad, K. Phanikumar, and V. SaiKrishna, “ARCI new solar thermal components testing facility at Hyderabad to give further fillip to India's growing solar sector”, Ministry of Science and Technology website, July 07, 2021.

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5. S. Sakthivel, S.R. Atchuta, M. ShivaPrasad, K. Phanikumar, and V. SaiKrishna, “ARCI sets up concentrated solar thermal-based test rig facility in Hyderabad”, Business Line, July 08, 2021.

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8. S. Anandan, R. Vijay, T.N. Rao, “Low-cost indigenous energy storage (Li-ion batteries & supercapacitor) materials from ARCI can make electric vehicles affordable” Newsletter & Magazine - NIT Warangal Alumni Association, September 2021.

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10. Sanjay Bhardwaj, “Demonstration and transfer of advanced materials technologies”, Proceedings of International Conference on Recent Innovations in Chemical and Biological Engineering (RICBE-2k21), Department of Chemical Engineering and Biosciences, Rajiv Gandhi University of Knowledge Technologies – A.P. (Nuzvid Campus) and Indian Institute of Chemical Engineers – Amaravati Regional Centre, Guntur, p.24, September 16-18, 2021

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14. Tata N. Rao, Kaliyan Hembram and B.V. Sarada , “Scientists develop self-disinfecting biodegradable face masks to combat COVID-19”, DST website, February 10, 2022

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Contributions to Professional Societies/ Bodies as Office Bearers / National Committees

Name	Contribution / Role
Dr. Tata Narasinga Rao	• Member, Scientific Advisory Committee (SAC) on Hydrocarbon of Ministry of Petroleum and Natural Gas • Member, Governing Body of Indo-German S&T Centre • Member, ETD (Electrotechnology in Mobility Sectional Committee) 51 Bureau of Indian Standards • Co-opted Member to Sub-Committee to prepare academic activities for the proposed National S&T Research University. • Member Governing Council of National Centre for Additive Manufacturing of Govt. of Telangana • Member, Research Advisory Board of Centre for Nano and Soft Matter Sciences (CeNS) • Member, Technical Jury, Indian Standards, Interoperability of Light Electric Vehicle Battery Swapping System • Member, University Research Advisory Council, SRM University-AP
Dr. R. Gopalan	• Executive Member, Rare Earth Association of India • Joint Secretary, Magnetics Society of India • Editorial Board Member, J. Materials Science and Engineering A&B • Member, Steering Committee on Energy Storage, TIFAC, New Delhi • Member Invitee – "The Consultative Group on Future Transportation System", PSA Office, Govt. of India • Advisory Committee Member, TIDCO Nanoscience & Technology, Tamilnadu Government • Member, Board of Studies, PSG College of Technology, Coimbatore • Member, Board of Research, Hindustan Institute of Science and Technology, Chennai • International Advisory Committee Member for Rare Earth Magnets, REPM • Member, Programme Advisory Committee (PAC), SERB • Board of Members, Automotive Solutions Portal for Industry Research & Education (ASPIRE), International Centre for Automotive Technology (ICAT) • Member Research Advisory Board (Under Ministry of Heavy Industry), ICAT • Executive Member, Indian Society for Analytical Scientists (ISAS) • Member Publication Committee, Indian National Academy of Engineering (INAE) • Member Invitee – Rare Earth Magnets, NITI AAYOG Govt. of India
Dr. R. Vijay	• Member of Board of Studies, School of Engineering Sciences and Technology (SEST), University of Hyderabad, associated with improvement of academic programs of the school • Member of Board of Studies, Dept. of Chemical Engineering, NIT Warangal for a period of 3 years from 2021 • Member. Committee of Department of Science and Technology, Govt. of India, for the preparation of Concept note and Detailed Project Report on Hydrogen Mission in India
Dr. Sanjay Bhardwaj	• Chairman, Indian Institute of Chemical Engineers, Hyderabad Regional Centre (IIChE – HRC) for 2021-22 • Chairman, Organizing Committee, IIChE – HRC Lecture Series (2021-22) initiated in December 2021
Dr. Malobika Karanjai	• Joint Secretary and Co-Convener, International Conference on Powder Metallurgy and 47th Annual Technical Meet PM-22 organized by PMAI during April 18-20, 2022 and contributed as Session Chair and Session Coordinator of Keynote lectures (April 19, 2022) as well as "Press and Sinter Session" (April 19-20, 2022)
Mr. K.V. Phani Prabhakar	• Joint Secretary, The Indian Institute of Welding, Hyderabad Branch
Dr. Srinivasan Anandan	• Member of Bureau of Indian Standard (BIS) in Electrotechnology in Mobility Sectional Committee, ETD 51
Dr. Gururaj Telasang	• Chair for membership drive (2021-23), MC member, SAEINDIA Hyderabad Division, Chennai section.
Dr. R. Balaji	• Member in "Adoption of Hydrogen Technologies in Upstream Sector" formed by Ministry of Petroleum and Natural gas, Govt. of India

Awards and Honours

1. Dr. B. V. Sarada was elected as the 'Fellow of Telangana Academy of Sciences (FTAS) for the year 2020" on February 08, 2022

2. Dr. Dibyendu Chakravarty, was elected as the 'Associate Fellow of Telangana Academy of Sciences for the year 2020' on February 06, 2022

3. Ms. Ramya Krishna B, SRF (Dr. R. Easwaramoorthi) was awarded 'AWSAR 2021' for the best popular science story in the National level PhD category.

4. Dr. R. Vijay received the 'Distinguished Researcher in Nanomaterials' award from Venus International Foundation (7th Venus International Science and Technology Awards – VISTA 2021).

5. The Lithium-ion battery (LIB) team ARCI, Chennai was awarded the 'National Project Excellence Award 2021', by Project Management Associates organization at New Delhi on August 23, 2021.

6. Ms. Aarti Gautam (Dr. R Subasri) was awarded the 'Best paper award' by CORCON 2021 NACE International Conference & Expo on Corrosion at Mumbai on November 20, 2021.

7. Mr. K. K. Phani Kumar (Dr. S. Sakthivel) received the 'Best oral presentation award' for the paper on 'Nanocomposite based Solar Selective Absorber Coatings with High Thermal Stability and Wide Angular Solar Absorptance' at the Virtual conference on 'Recent Advances and Innovations in Solar Energy (RAISE – 2021)' held during December 02-04, 2021.

8. Dr. Sanjay Bhardwaj received IIT Bombay - Chapter 'Service Award 2021' in recognition of outstanding contributions to the Hyderabad IIT Bombay Alumni Chapter and to the progress of the Institute, at IIT Bombay on December 26, 2021

9. Dr. Sanjay Bhardwaj received 'Annual Trophy of Best Regional Centre Award 2021' , as Chairman of Indian Institute of Chemical Engineers – Hyderabad Regional Centre (IIChE – HRC) , in the CHEMCON 2021 Conference and 74th Annual Session of IIChE held at CSIR – Institute of Minerals and Materials Technology, Bhubaneswar during December 26-30, 2021

10. Mr. N.Chundi, SRF, (Dr. S.Sakthivel) received the 'Second prize for oral presentation' on "Development of ambient condition curable highly weather stable anti-soiling coating for photovoltaic modules and other applications", organized as part of National Science Day celebrations at ARCI during February 2022

11. Ms. Reshma Dileep .K, SRF, (Dr. V. Ganapathy & Dr. T. N. Rao) was awarded 'Consolation prize for oral presentation' on "Alternative Cathode Materials for Perovskite Solar Cells" organized as part a of National Science Day celebrations at ARCI during February 2022

12. Mr. K. K. Phani Kumar (Dr. S. Sakthivel) received the 'Best poster presentation award' for the paper on "Novel spinel nanoparticles based Absorber coated receiver tubes for Concentrated Solar Thermal Industrial Applications" at the 'National Conference of 12th Bangalore Indian Nano 2020' held during March 07-09, 2022.

13. Dr. V.V.N. Phani Kumar, won the 'Best poster award' for the paper on "Investigation of micron sized lithium Iron Phosphates cathode using aqueous binder for Li-ion batteries" at the 'National Conference on Energy Technologies (NCET)' held at IIT Madras, Chennai during April 29-30, 2022.

14. Ms. P. Samhita (Dr. B.V. Sarada) was awarded the 'Second and Consolation prizes' at the 'International Sci-Art Image Competition' organized by the Indian National Young Academy of Sciences (INYAS) organization.

15. Dr. Malobika Karanjai was selected as Guest Editor for Materials Today Proceedings and Guest Editor for Advanced Powder Technology Journal.

Personnel (as on March 31, 2022)

Director
Dr. G. Padmanabham (upto 03/06/2021)

Director (Additional Charge)
Dr. Tata Narasinga Rao (w.e.f. 04/06/2021)

Regional Director
Dr. Raghavan Gopalan

Associate Director
Dr. Roy Johnson

Distinguished ARCI Chair
Prof. P. Rama Rao

Distinguished Emeritus Scientist
Prof. G. Sundararajan

Scientists

D. Srinivasa Rao, Scientist 'G'
Dr. G. Ravi Chandra, Scientist 'G'
Dr. Pawan Kumar Jain, Scientist 'G'
Dr. R. Vijay, Scientist 'G'
Dr. R. Subasri, Scientist 'G'
V. Balaji Rao, Scientist 'G'
Dr. L. Rama Krishna, Scientist 'G'
Dr. Bhaskar Prasad Saha, Scientist 'G'
Dr. Pramod H. Borse, Scientist 'F'
Dr. Y. Srinivasa Rao, Scientist 'F'
Dr. Sanjay Bhardwaj, Scientist 'F'
Dr. S. Sakthivel, Scientist 'F'
Dr. N. Ravi, Scientist 'F'
Dr. I. Ganesh, Scientist 'F'
Dr. Joydip Joardar, Scientist 'F'
Dr. Malobika Karanjai, Scientist 'F'
Dr. Ravi N. Bathe, Scientist 'F'
Dr. G. Siva Kumar, Scientist 'F'
Dr. R. Prakash, Scientist 'F'
Dr. S. M. Shariff, Scientist 'F'
Dr. D. Siva Prahasam, Scientist 'F'
Dr. B. V. Sarada, Scientist 'F'
K. V. Phani Prabhakar, Scientist 'F'
Dr. T. Mohan, Senior Scientist *
Dr. Neha Y. Hebalkar, Scientist 'F'
Dr. S. B. Chandrasekhar, Scientist 'F'
Dr. P. Sudharshan Phani, Scientist 'F'
Dr. Nitin P. Wasekar, Scientist 'F'
Dr. Dibyendu Chakravarty, Scientist 'F'
Dr. K. Suresh, Scientist 'E'
Dr. Sanjay R. Dhage, Scientist 'E'
Dr. Kaliyan Hembram, Scientist 'E'
Dr. K. Murugan, Scientist 'E'
Dr. Dulal Chandra Jana, Scientist 'E'
Dr. K. Ramya, Senior Scientist *
Dr. Srinivasan Anandan, Scientist 'E'
Ms. S. Nirmala, Scientist 'E'
Dr. P. Suresh Babu, Scientist 'E'
Dr. Krishna Valleti, Scientist 'E'
Dr. M. Buchi Suresh, Scientist 'E'
Manish Tak, Scientist 'E'
Dr. Papiya Biswas, Scientist 'E'
Dr. Gururaj Telasang, Scientist 'E'
Dr. R. Easwaramoorthi, Scientist 'E'
Dr. R. Senthil Kumar, Scientist 'E'
Dr. S. Kumar, Scientist 'E'
Ms. Priya Anish Mathews, Scientist 'E'
Dr. Prasenjit Barick, Scientist 'E'
Dr. Naveen Manhar Chavan, Scientist 'E'
M. Ramakrishna, Scientist 'E'
Dr. Balaji Padya, Scientist 'E'
S. Sudhakara Sarma, Scientist 'E'
R. Vijaya Chandar, Scientist 'E'
Dr. Pandu Ramavath, Scientist 'E'
Arun Seetharaman, Scientist 'E'
Ms. J. Revathi, Scientist 'D'
Dr. M. B. Sahana, Senior Scientist *
Dr. D. Prabhu, Scientist 'D'
Dr. R. Balaji, Senior Scientist *
Dr. Raman Vedarajan, Scientist *
Dr. Shiv Prakash Singh, Scientist *
Dr. V. Ganapathy, Scientist *
Dr. Bijoy Kumar Das, Scientist *
Dr. Srikanti Kavita, Scientist *
Shri S. Ramakrishnan, Scientist *
Shri Vallabharao Rikka, Scientist *
Dr. L. Venkatesh, Scientist 'C' (upto 02/07/2021)
Ms. K. Divya, Scientist 'C'
Dr. K. Nanaji, Scientist *
Dr. Ravi Gautam, Scientist * (upto 31/03/2022)
Dr. A. Srinivas Rao, Scientist *
Dr. V. V. N. Phani Kumar, Scientist *
Dr. J.A. Prithi, Scientist *
Amit Das, Scientist 'B

* On Contract Basis

Technical Officers

Debajyoti Sen, Technical Officer 'E'
K. R. C. Somaraju, Technical Officer 'E'
Ms. A. Jyothirmayi, Technical Officer 'E' - (upto 30/06/2021)
Ms. V. Uma, Technical Officer 'D'
G. Venkata Ramana Reddy, - Technical Officer 'D'
V. C. Sajeev, Technical Officer 'D'
P. Rama Krishna Reddy, - Technical Officer 'D'
V. Mahender, Technical Officer 'D'
K. Srinivasa Rao, Technical Officer 'D'
Ch. Sambasiva Rao, Technical Officer 'C'
D. Sreenivas Reddy, Technical Officer 'C'
C. Karunakar, Technical Officer 'C'
M. Srinivas, Technical Officer 'C'
Ms. B. V. Shalini, Technical Officer 'C'
N. Venkata Rao, Technical Officer 'C'
M. Srihari, Technical Officer 'C'
J. Nagabhushana Chary, Technical Officer 'C'
A. Raja Shekhar Reddy, Technical Officer 'C'
L. Babu, Technical Officer 'C' *
A. R. Srinivas, Technical Officer 'C'
E. Anbu Rasu, Technical Officer 'C'
S. Sankar Ganesh, Technical Officer 'C'
K. Naresh Kumar, Technical Officer 'B'
M. Ilaiyaraja, Technical Officer 'B'
P. V. V. Srinivas, Technical Officer 'B'
K. Ramesh Reddy, Technical Officer 'B'
Ms. N. Aruna, Technical Officer 'B'
R. Anbarasu, Technical Officer 'B'
M. R. Renju, Technical Officer 'B'

* On Contract Basis

Technicians

D. Krishna Sagar, Technician 'E'
K. V. B. Vasantha Rayudu, Technician 'E'
G. Venkata Rao, Technician 'E'
E. Konda, Technician 'E'
A. Sathyanarayana, Technician 'E'
B. Venkanna, Technician 'E'
G. Venkat Reddy, Technician 'E'
P. Anjaiah, Technician 'E'
A. Ramesh, Technician 'D'
D. Kutumba Rao, Technician 'D'
B. Subramanyeswara Rao, Technician 'D'
Kona Vigneswara Rao, Technician 'D'
A. JayaKumaran Thampi, Technician 'D'
B. Hemanth Kumar, Technician 'D'
A. Janga Reddy, Technician 'D'
A. Jagan, Technician 'D'
Sushanta Mukhopadhyay, Technician 'D'
M. Satyanand, Technician 'D'
P. Suri Babu, Technician 'D'
G. Anjan Babu, Technician 'C'
Shaik Ahmed, Technician 'C'
K. Ashok, Technician 'C'
E. Yadagiri, Technician 'C'
I. Prabhu, Technician 'C'
Ch. Jangaiah, Technician 'C'
S. Narsing Rao, Technician 'B'
Mothe Lingaiah, Technician 'B'
Aan Singh, Technician 'B'
A. Praveen Kumar, Technician 'D'
K. Satyanarayana Reddy, Technician 'D'
D. P. Surya Prakash Rao, Technician 'D'
Kurra Venkata Ramana, Technician 'D'
Govinda Kumar, Technician 'D'
Gaje Singh, Technician 'A'
Kadiri Sai Charan, Technician 'A'
Sushant Nayak, Technician 'A'
Desetti Bala Surya Krishna, Technician 'A'
Gedela Janaki Rao, Technician 'A'
Rasikanta Maharana, Technician 'A'
Vemula Prashanth, Technician 'A'

Technical Assistant

J. Shyam Rao, Technical Assistant 'A'
Gugulothu Murthy, Technical Assistant 'A'

Senior Staff Officer To Director

P. Nagendra Rao

Senior Stores & Purchase Officer

N. Srinivas

Senior Finance & Accounts Officer

G. M. Rajkumar

Administrative & Personnel Officer

A. Srinivas

Finance & Accounts Officer (Projects)

Anirban Bhattacharjee

Communications and Public Relations Officer

N. Aparna Rao

Security, Fire & Safety Officer

D. Ramesh

Officers

Y. Krishna Sarma, Officer 'C'
Poduri Venugopal, Officer 'B'
Ms. P. Kamal Vaishali, Officer 'B'
Pothuri Venkata Ramana, Officer 'B'
G. Gopal Rao, Officer 'B'
P. Dharma Rao, Officer 'A'
B. Laxman, Officer 'A'
Ravi Singh, Officer 'A'
Ms. Rajalakshmi Nair, Officer 'A'

Assistants

Ms. K. Madhura Vani, Assistant 'B'
Narendra Kumar Bhakta, Assistant 'B'
Ramavathu Ranga Naik, Assistant 'B'
J. Bansilal, Junior Assistant (MACP)
Boorgu Venkatesham, Assistant 'A'
Pokalkar Sai Kishore, Assistant 'A'
Sudheendra, Assistant 'A'
Pagadala Siva Prasad Reddy, Assistant 'A'
Ch. Venugopal, Assistant 'A'
Edunuri Ramesh, Assistant 'A'
A.Balraj, Assistant 'A'
K. Prashanth, Assistant 'A'
P. Prasad Babu, Assistant 'A'
Thati Thoti T Koteswar Rao, Assistant 'A'
Pakanati Ashoka Reddy, Assistant 'A'
Nalamasa Sampathkumar, Assistant 'A'
Ramavath Sunil Naik, Assistant 'A'

Junior Translation Officer (Hindi)

Dr. Rambha Singh

Drivers

Md. Sadiq, Driver 'C' (MACP) (upto 31/03/2022)
T. Satyanarayana, Driver 'B' (MACP)
M. A. Fazal Hussain, Driver 'B' (MACP)
P. Ashok, Driver 'B' (MACP)

Lab Assistants

Roop Singh, Lab Assistant 'D' (upto 30/09/2021)
Hussain Ali Khan, Lab Assistant 'D' (upto 27/04/2021)
Ms. Sakina Hussain, Lab Assistant 'A' (w.e.f 29/03/2022)

Consultants

Dr. V. Chandrasekharan
Dr. U. V. Varadaraju
P. Sampath Kumar

Project Scientists in TRC Project

Dr. Mani Karthik, Project Scientist 'E'
Dr. Manjusha Battabyal, Project Scientist 'D'
Dr. Prashant Misra, Project Scientist 'C'
Kumari Konda, Project Scientist 'B'
Dr. K. Harigopi, Project Scientist 'B' (upto 10/05/2021)
P. Sai Karthik, Project Scientist 'B'
Puppala Laxman Mani Kanta, Project Scientist 'B'
G. Vijaya Ragavan, Project Scientist 'B'
Muni Bhaskar Siva Kumar, Project Scientist 'B'
Mahender Peddi, Project Scientist 'B'
Bheesetti Gowreeswari, Project Scientist 'B'
V. Tarun Kumar, Project Scientist 'B'
P. Vijaya Durga, Project Scientist 'B'
Minati Tiadi, Project Scientist 'B'
S. Ganesh, Project Scientist 'B'

Project Technical Assistant in TRC Project

R. Vasudevan
N. Kannadasan
Debendra Nath Kar
Shaik Nagur Baba
Golu Kumar Jha (upto 24/02/2022)
Krishna Kumar Pathak (upto 21/03/2022)
K. Velmurgan
K. Shanmugam
T. P. Sarangan
A. Sivaraj
D. Vigneshwaran
N. Ramesh
Nenavath Raju
K. Sudalaiyandi
M. Nandhagopal

*TRC : Technical Research Centre on 'Alternate Energy Materials and Systems

Financial Report

Independent Auditors' Report

To
Governing Council Members of International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad.

Date: 21/09/2022

Report on the Financial Statements

We have audited the accompanying financial statements of International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) ("the Society"), which comprise the consolidated Balance Sheet as at March 31, 2022, the Consolidated Income and Expenditure Account and Consolidated Receipts and Payments Account for the year then ended and a summary of Consolidated significant accounting policies and other explanatory notes and Standalone Balance Sheet, Standalone Income and Expenditure Account, Standalone Receipts and Payments Account and Standalone significant accounting policies and other explanatory notes of the following funds :

i) Operational Fund | ii) Technology Demonstration and Transfer Fund | iii) Sponsored Projects Fund

Management's Responsibility for the Financial Statements

Governing Body of the Society is responsible for preparation of these financial statements of the Society in accordance with the Generally Accepted Accounting Principles in India (GAAP) and the significant accounting policies stated in financial statements. This responsibility also includes maintenance of adequate accounting records for safeguarding the assets of the society and for preventing and detecting frauds and other irregularities; selection and application of appropriate accounting policies; making judgments estimates that are reasonable and prudent; and design, implementation and maintenance of adequate internal financial controls, that were operating effectively for ensuring the accuracy and completeness of the accounting records, relevant to the preparation and presentation of the financial statements, that are free from the material misstatement, whether due to fraud or error.

Auditors' Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our examination in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the examination to obtain reasonable assurance about whether financial statements are free from material misstatements.

Examination of financial statements involves performing procedures to obtain audit evidence about the amount of disclosures in the financial statements. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the society's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of the accounting policies used and the reasonableness of the accounting estimates made by the Management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the aforesaid financial statements of the Society for the year ended March 31, 2022 are prepared in all material aspects, in accordance with Generally Accepted Accounting Principles in India (GAAP) and the significant accounting policies stated in Note 24 to the Financial Statements Other Matters:

a) In our opinion, proper books of accounts as required by the law have been by kept the society so far as it appears from our examination of those books.

b) The Statement of Affairs, the Income and Expenditure Account, and Receipts and Payments account dealt with by this report are in agreement with the books of accounts.

For ANANT RAO & MALLIK
Chartered Accountants
FRN : 006266S
Sd/-
V ANANT RAO
Partner
M No. 022644

Schedule - 24 Background Information & Significant Accounting Policies

1 Operation Fund of ARC – International (OP Fund of ARCI) is the main fund of International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI/ Society).

Grants received from Department of Science and Technology (DST), Ministry of Science and Technology, Government of India (GOI) are recognized in the financial statements of OP Fund of ARCI as Income of the Society if these grants are for meeting operational expenses of the Society and as part of Corpus, if utilized for the purposes of capital expenses. These Grants are allocated by GOI in the form of annual budgets under Plan Funds to DST. DST draws the funds from GOI and forwards the same to ARCI. The funds released by DST are in the form of Grants in Aid.

Other Funds of the Society are Technology Development & Transfer Fund (TDT) and Sponsored Project Fund (SP Funds).

2 Basis of preparation of financial statements:
Financial statements of OP Fund of ARCI, Hyderabad, have been prepared on historical cost convention and on accrual basis unless otherwise stated.

Significant Accounting Polices:
(A) Grants:
Grants are recognized on receipt basis.
Grants received from DST and earmarked for special / specific projects are grouped under Sponsored Project Fund.

(B) Reserves & Surpluses:
Fifty percent of Net Surplus / Deficit in Technology Demonstration & Transfer Fund (TDT Fund) is transferred to OP Fund of ARCI and is recognized under Reserves and Surplus. Balance Fifty percent is retained in TDT Fund

3 Fixed Assets:
Fixed assets are stated at cost. Cost includes duties, taxes, freight, insurance etc attributable to acquisition and installation of asset.
Depreciation and Amortization :
Depreciation on fixed assets (except Lease Hold building) is provided on written down value method as per rates stated in Income Tax Rules, 1962.

Non - Refundable advance towards Lease Hold Building is amortized over lease period.

4 Interest Income:
Interest income from bank balances/deposit is recognized on time proportionate basis.

5 Research and Development (R&D) Expenditure:
R&D expenditure including cost of raw materials, consumables, other inputs and services etc. is charged off as revenue expenditure. Raw materials, consumables, stores spares and other inputs are procured on need basis and issued to indenting departments soon after they are received. Hence values of closing stock of these materials is not recognized in the accounts.

6 Foreign Exchange Transactions:
Foreign exchange transactions during the year are recorded at the exchange rate prevailing on the date of transactions.

7 Retirement Benefits:
Contributions of Society's share of Provident Fund and New Pension Scheme (Defined Contribution Plans) are charged to Income and Expenditure Account as per applicable rules/statutes.

Provision towards gratuity and leave encashment (Defined benefit Plan) is made on actuarial valuation carried out by Life Insurance Corporation of India. The Society has covered its gratuity and leave encashment liability with Life Insurance Corporation of India (LIC) and contributions are made to LIC on yearly basis as per the actuarial reports shared to the Society by LIC.

8 Margin Money Deposits:

Society places one hundred percent of its funds as Margin Money Deposits with Banks towards Letters of Credit issued to the vendors of the Society. These are grouped under Loans and Advances- Advances Recoverable in Cash/Kind.

For M/s. Anant Rao & Mallik
Chartered Accountants
Firm Registration No 006266S
Sd/-
V.Anant Rao
Partner
Membership No. 022644
Hyderabad

G.M. Raj Kumar
Senior Finance & Accounts Officer

D. Srinivasa Rao
OSD (Admin, Finance & Stores)

Dr. Tata Narasinga Rao
Director
(Additional Charge)

INTERNATIONAL ADVANCED RESEARCH CENTRE FOR POWDER METALLURGY AND NEW MATERIALS (ARC-International) BALAPUR POST. HYDERABAD ARCI (OPERATIONAL) FUND

Schedule – 25 Notes to the Accounts

1 Department of Science and Technology (DST) sanctioned and released during the year Rs.56,34,00,000/ towards revenue and Rs:17,60,00,000/- as capital grant-in-aid under Plan (Previous year Rs.50,06,00,000 and Rs.11,10,00,000/- towards revenue and capital respectively under Plan grant-in-aid). Under Non-Plan, Grant-in-aid sanctioned was nil.

2 Capital Work in Progress
Rs. 1,36,33,826/- as at March 31,2022 as stated in Schedule 8 to the financial statements – pending capitalization for more than three years. Management identified certain deficiencies while installing these equipments. The process of resolving the deficiencies is going on. In the opinion of the management of the Society, all these capital works are capable of being used for the purpose for which these assets once these deficiencies. The management, at present, is of the opinion that these capital works do neither require any impairment nor provisioning.

3 The figures of previous year have been regrouped/reclassified wherever necessary.

For M/s. Anant Rao & Mallik
Chartered Accountants
Firm Registration No 006266S
Sd/-
V. Anant Rao
Partner
Membership No. 022644
Hyderabad

G.M. Raj Kumar
Senior Finance & Accounts Officer

D. Srinivasa Rao
OSD (Admin, Finance& Stores)

Dr. Tata Narasinga Rao
Director
(Additional Charge)

Name of Entity: International Advanced Research Centre for Powder Metallurgy and New Materials (ARC-INTERNATIONAL) HYDERABAD

ARC INTERNATIONAL FUND (OPERATIONAL) BALANCE SHEET AS AT 31-3-2022

(Amount in Rs)

GRANTS - IN - AID: FUND AND LIABILITIES	Schedule	Current Year	Previous Year
GRANTS - IN - AID	1	1,38,64,19,850.75	1,36,58,57,698.10
RESERVES AND SURPLUS	2	0.00	0.00
EARMARKED/ENDOWMENT FUNDS	3	0.00	0.00
SECURED LOANS AND BORROWINGS	4	0.00	0.00
UNSECURED LOANS AND BORROWINGS	5	0.00	0.00
DEFERRED CREDIT LIABILITIES	6	0.00	0.00
CURRENT LIABILITIES AND PROVISIONS	7	39,78,52,308.75	38,05,01,007.06
TOTAL		1,78,42,72,159.50	1,74,63,58,705.16

ASSETS	Schedule	Current Year	Previous Year
FIXED ASSETS	8	1,09,61,75,006.98	1,21,33,39,856.81
INVESTMENTS - FROM EARMARKED /ENDOWMENT FUND	9	0.00	0.00
INVESTMENTS - OTHERS	10	0.00	0.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	68,80,97,152.52	53,30,18,848.35
TOTAL		1,78,42,72,159.50	1,74,63,58,705.16
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As per our report of even date
for M/s V.Anant Rao & Mallick
Chartered Accountants
Firm Registration No. 006266S

Sd/-
V.Anant Rao
Partner
Membership No. 022644
Date: 21/09/22
Place: Hyderabad

G.M.Raj Kumar
Senior Finance & Accounts Officer

D.Srinivasa Rao
OSD(Admin, Finance & Stores)

Dr. Tata Nasinga Rao
Director (Additional Charge)

Name of Entity: International Advanced Research Centre for Powder Metallurgy and New Materials (ARC-INTERNATIONAL) HYDERABAD

INCOME AND EXPENDITURE ACCOUNT OF ARC INTERNATIONAL FUND (OPERATIONAL) FOR THE YEAR ENDED 31-3-2022

(Amount in Rs)

INCOME	Schedule	Current Year	Previous Year
Income from Sales/Services	12	0.00	0.00
Grants/Subsidies	13	56,34,00,000.00	50,06,00,000.00
Fees/Subscriptions	14	0.00	0.00
Income From Investments (Income on Investment from earmarked/endowment Funds).	15	0.00	0.00
Income from Royalty, publications etc	16	0.00	0.00
Interest Earned	17	3,66,99,940.00	56,62,605.00
Other Income	18	4,10,70,439.37	3,69,81,816.45
Increase/(decrease) in-stock of finished goods and work - in - progress	19	0.00	0.00
TOTAL (A)		64,11,70,379.37	54,32,44,421.45
EXPENDITURE	**Schedule**	**Current Year**	**Previous Year**
Establishment Expenses	20	38,53,83,047.47	38,35,83,395.21
Other Expenses	21	23,71,09,887.59	16,98,98,612.52
Expenditure on Grants/Subsidies	22	8,44,860.00	1,37,700.00
Interest	23	3,11,05,954.00	46,94,641.00
Depreciation (Net Total at the year-end -Corresponding to Schedule 8)		18,57,34,376.13	18,67,87,540.00
TOTAL (B)		84,01,78,125.19	74,51,01,888.73
Balance being excess of Expenditure over Income (B-A)		19,90,07,745.82	20,18,57,467.28
Transfer to Special Reserve [Specify each]			
Transfer to /From General Reserve			
BALANCE being Excess of Expenditure over Income T/F to- GRANTS IN AID		19,90,07,745.82	20,18,57,467.28
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As per our report of even date
for M/s V.Anant Rao & Mallick
Chartered Accountants
Firm Registration No. 006266S

Sd/-
V.Anant Rao
Partner
Membership No. 022644
Date: 21/09/22
Place: Hyderabad

G.M. Raj Kumar
Senior Finance & Accounts Officer

D. Srinivasa Rao
OSD (Admin, Finance & Stores)

Dr. Tata Nasinga Rao
Director (Additional Charge)

Name of Entity: International Advanced Research Centre for Powder Metallurgy and New Materials (ARC-INTERNATIONAL) HYDERABAD

RECEIPTS AND PAYMENTS OF ARC INTERNATIONAL FUND (OPERATIONAL) FOR THE YEAR ENDED 31-3-2022

(Amount in Rs)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
I. Opening Balances			**I. Revenue Expenses**		
a) Cash in hand	32,692.00	30,126.00	a) Establishment Expenses	36,48,71,558.00	37,28,58,710.00
b) Bank Balances			b) Other Expenses	23,10,96,533.49	16,77,51,528.32
i) In Current accounts					
ii) In Deposit accounts	5,70,00,000.00	1,00,00,000.00			
iii) Savings accounts	3,42,53,657.01	1,17,26,553.17			
Total Opening Balances	**9,12,86,349.01**	**2,17,56,679.17**	**Total Expenses**	**59,59,68,091.49**	**54,06,10,238.32**
II. Grants Received			**II. Payments made against various projects**		
a) From Government of India	73,94,00,000.00	61,16,00,000.00	Payments made against various projects	0.00	0.00
b) From State Government					
c) From other sources [details]					
Total Grants Received	**73,94,00,000.00**	**61,16,00,000.00**	**Total of Payments Against Projects**	**0.00**	**0.00**
III. Income on Investments From			**III. Investments and deposits made**		
a) Earmarked/Endowment funds	0.00	0.00	a) Out of Earmarked/Endowment funds	0.00	0.00
b) Own Funds (other investments)			b) Out of Own Funds (investments-others)	0.00	0.00
Total Income on Investment	**0.00**	**0.00**	**Total : Investments and Deposits**	**0.00**	**0.00**
IV. Interest Received			**IV. Expenditure on Fixed Assets & Capital Work - in- Progress**		
a) On Bank Deposits	3,29,98,169.00	45,65,873.00			
b) Interest from Sponsored Projects	0.00	0.00			
c) Loans, Advances to staff etc.	0.00	1,44,591.00	**Total of Fixed Assets**	**4,68,34,647.25**	**5,02,73,075.80**
Total Interest Received	**3,29,98,169.00**	**47,10,464.00**			
V. Other Income	**7,11,29,288.00**	**5,78,83,420.06**	**V. Refund of surplus money/ loans**		
			a)To Government of India	0.00	0.00
			b)To State Governments	0.00	0.00
			c) To other providers of funds	0.00	0.00
				0.00	**0.00**

(Amount -Rs)

RECEIPTS	Current Year	Previous Year	PAYMENTS	Current Year	Previous Year
VI. Amount Borrowed	**0.00**	**0.00**	**VI. Finance charges (Interest)**	**0.00**	**0.00**
VII. Any other receipts [Give details]			**VII) Other Payments (Specify)**		
1) EMD & Security Deposits	0.00	0.00	1) Interest-DST	3,58,00,595.00	87,03,670.00
2) Sales of Fixed Assets	0.00	0.00	2) Security Deposit-Supplier	11,83,420.00	1,00,000.00
3) Advances to Suppliers-Buildings	0.00	0.00	3) Earnest Money Deposit-Supplier	75,000.00	52,93,500.00
4) Tax Deduction at Source & GST Deductionstt	79,961.00	4,23,194.90	4) TDS	0.00	1,06,925.00
			5) GST-IGST	98,405.00	0.00
Total Any other receipts	**79,961.00**	**4,23,194.90**	**Total Other Payments**	**3,71,57,420.00**	**1,42,04,095.00**
			VIII) Closing Balances		
			a) Cash in hand	13,896.00	32,692.00
			b) Bank Balances		
			i) In Current accounts	0.00	0.00
			ii) In Deposit accounts	15,00,00,000.00	5,70,00,000.00
			iii) In Savings accounts	10,49,19,712.27	3,42,53,657.01
			Total Closing Balances	**25,49,33,608.27**	**9,12,86,349.01**
Grand Total	**93,48,93,767.01**	**69,63,73,758.13**	**Grand Total**	**93,48,93,767.01**	**69,63,73,758.13**

As per our report of even date
for M/s V.Anant Rao & Mallick
Chartered Accountants
Firm Registration No. 006266S

Sd/-
V.Anant Rao
Partner
Membership No. 022644
Date: 21/09/22
Place: Hyderabad

G.M.Raj Kumar
Senior Finance & Accounts Officer

D.Srinivasa Rao
OSD (Admin, Finance & Stores)

Dr.Tata Natsinga Rao
Director (Additional Charge)

Our Collaborators

Foreign

1. Applied Materials, USA
2. Belarusian State University of Informatics & Radio Electronics
3. Corning Incorporated, USA
4. DesignTech Systems Limited
5. Deakin University, Australia
6. Fraunhofer Institutions, Germany
7. Industrial Materials Institute of National Research Council of Canada (NRC-IMI), Canada
8. Institute for Problems of Materials Science (IPMS), Ukraine
9. International Centre for Electron Beam Technologies, kraine
10. MPA Industrie, France
11. Nanomechanics, USA
12. SLM Solutions Singapore Pvt. Ltd.
13. The Boeing Company, USA
14. Zoz GmbH, Germany

Indian

1. Allox Minerals Pvt. Ltd.
2. Ansgar Hinduja Cleantech Pvt. Ltd.
3. Andhra University
4. Andhra Pradesh Mineral Development Corporation Ltd.
5. Advik Hi-tech Pvt. Ltd.
6. Ashok Leyland Limited
7. ABB Global Industries and Services Private Limited
8. Bharat Electronics Limited
9. Bharat Heavy Electricals Limited
10. Bhabha Atomic Research Centre
11. Croda India Company Pvt. Ltd.
12. Defence Research and Development Organization
13. Desmania Innovation Labs LLP
14. Deki Electronics Ltd.
15. Daksha Online Services Pvt. Ltd.
16. Elixir Technologies
17. Epsilon Advanced Materials Pvt. Ltd.
18. Elite Carbon Creations
19. GE India Industrial Pvt. Ltd.
20. Greentech Systems
21. Gujarat Fluorochemicals Ltd.
22. Hindustan Aeronautics Limited
23. HBL Power Systems
24. Hyderabad Eye Research Foundation
25. Hindustan Petroleum Corporation Limited
26. HSIL Limited, AGI Glaspac
27. High Energy Batteries
28. Indian Institute of Chemical Technology
29. Indian Airforce
30. Indian Space Research Organization
31. Indira Gandhi Centre for Atomic Research
32. Indian Institute of Technology-Bombay
33. Indian Institute of Technology-Madras
34. Indian Institute of Technology-Kanpur
35. Indian Institute of Technology-Kharagpur
36. Indian Institute of Technology-Hyderabad
37. Indian Oil Corporation Limited
38. KAHO Solar Limited
39. Las Engineers and Consultants Pvt. Ltd.
40. Log 9 Materials Scientific Pvt. Ltd.
41. Lodestar Innovations Pvt. Ltd
42. Larsen and Toubro Limited
43. Lava International
44. Lifeline Circuits Private Limited
45. Mahindra and Mahindra
46. Mishra Dhathu Private Limited
47. Metalsa India Private Limited
48. Manideep Technocoats
49. National Institute of Technology-Warangal
50. National Institute of Technology-Thiruchirapalli
51. National Institute of Technology- Nagpur
52. National Engineering Industries Ltd.
53. National Research and Development Corporation
54. Neogen Chemicals Ltd.
55. NAION Pvt. Ltd.
56. Nsure Reliable Power Solutions Pvt. Ltd.
57. Nesbo Enterprises Pvt. Ltd.
58. Osmania University
59. Phasetron Engineers India (P) Limited
60. Prayogik Technologies Pvt. Ltd.
61. Positive Ion Technologies Pvt. Ltd
62. Prayogik Energy Pvt. Ltd.
63. Resil Chemicals Pvt. Ltd.
64. Robo6 Controls & Automation Pvt. Ltd.
65. Redilens Optics Pvt. Ltd.
66. RR Soura Shakti
67. Sri Chitra Tirunal Institute for Medical Sciences and Technology
68. Sai Surface Coating Technologies
69. Simplified Technologies
70. Sakthiselvam Enterprises Pvt. Ltd.
71. Star Exports
72. SBL Speciality Coatings
73. Sri Bioaesthetics Pvt. Ltd.
74. Tata Steel Limited
75. TVS Lucas
76. Technip India Limited
77. Tata Motors Ltd.
78. University of Hyderabad
79. United Technologies Corporation India Pvt. Ltd. (UTCIPL)

Editorial Board

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