

**ANNUAL
REPORT
2022-23**



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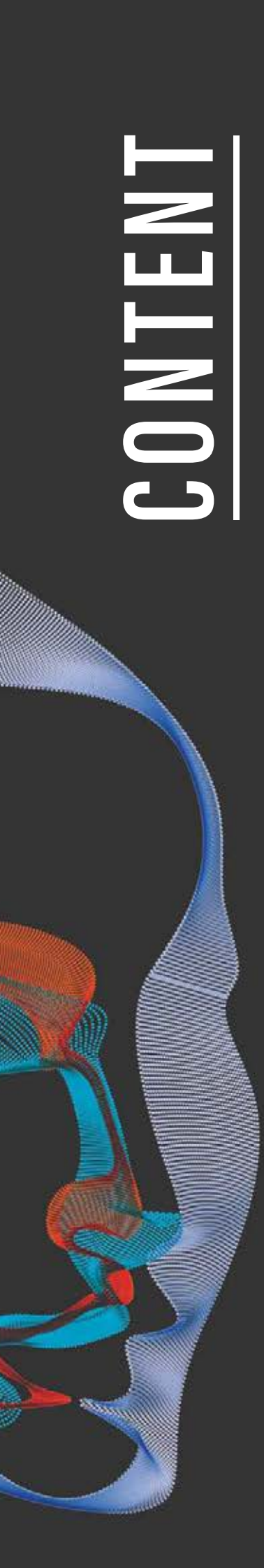


The Indo-German Science & Technology Centre (IGSTC) has been established to facilitate Indo-German R&D projects and networking through substantive interactions among Government, academia/research systems and industry to foster innovation for the overall economic and societal developments of both the countries.

IGSTC AIMS TO

- ▶ Play a proactive role in facilitating participation of industry in joint R&D+I projects.
- ▶ Provide/assist in mobilizing resources to carry out industrial R&D+I projects.
- ▶ Promote electronic exchange and dissemination of information on opportunities in bilateral science & technology cooperation. The Centre will also prepare/compile state-of-the-art reports on topics of interest with the help of highly qualified scientists and technologists from both the countries.
- ▶ Provide advice to institutes and industries from both the countries on the possibilities of Indo-German cooperation and help identify suitable partners.
- ▶ Facilitate and promote Indo-German collaboration in Science and Technology S&T through substantive interaction among Government, academia and industry
- ▶ Encourage Public-Private Partnerships (PPP) to foster elements of innovation and industrial application and cultivate a culture of cooperation between science and industry
- ▶ Nurture networking between young and mid-career scientists and technologists to develop a sense of mutual trust, leadership and entrepreneurship.
- ▶ Develop cooperation through the identification of scientists and scientific institutions of the two countries.
- ▶ Organize workshops, seminars, training programmes and other types of events on topics of mutual interest.

CONTENT



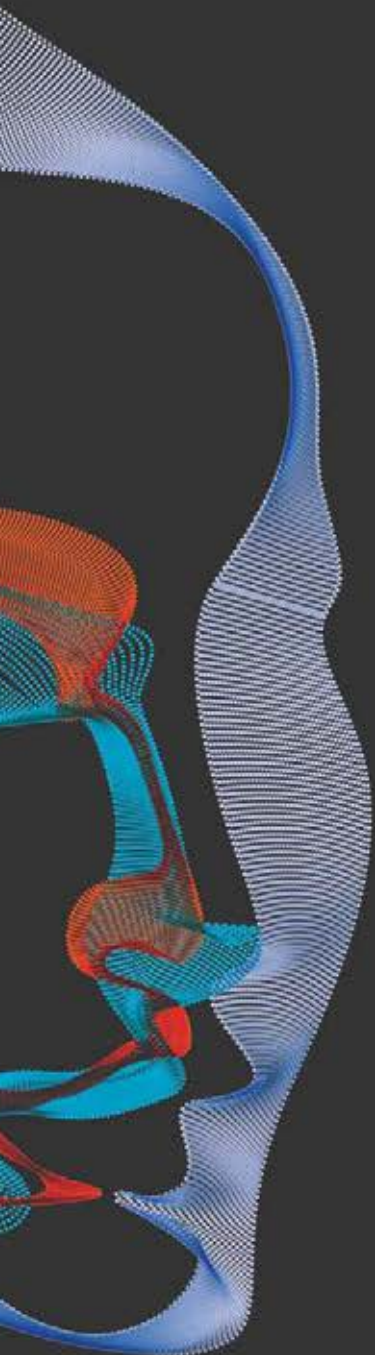
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THE YEAR 2022-23 AT A GLANCE

The Indo-German Science & Technology Centre (IGSTC), a joint initiative of the Department of Science & Technology (DST), Government of India and Federal Ministry of Education and Research (BMBF), Government of Germany is in its 14th year of establishment. Over the years, IGSTC has created a unique niche in creating a network of Indo-German collaborations through its various bilateral programs like 2+2 projects, scientific workshops, fellowships, support for women researchers. Through its various funding program, IGSTC catalyses innovation centric R&D projects by synergising the strength of research/academic institutions and public/ private industries from India and Germany.

The Year 2022-23 saw a great momentum for the newly launched programs of IGSTC Industrial Fellowship, Women in Science & Engineering Research (WISER), Paired Early Career Fellowship in Applied Research (PECFAR) and Small Immediate Need Grants (SING) targeting early, mid-career and women researchers. A brief of different activities is presented below.

India and Germany share a long history of cooperation in S&T research and innovation,

institutionalized under the framework of the Inter-Governmental Agreement on 'Cooperation in Scientific Research and Technological Development' since May 1974. The Joint Statement released after the successful visit of German Chancellor H. E. Olaf Scholz's to India on 25th February 2023 mentioned IGSTC as one of the key S & T cooperation between the two countries.

The statement recognized that academia-industry cooperation is the key to catalyse Indo-German strategic research and development partnerships. India and Germany welcome the progress achieved by the jointly funded Indo-German Science and Technology Centre (IGSTC), under which projects have been supported on national priority areas such as Advanced Manufacturing, Embedded System and ICT, Sustainable Energy/Environment, Biotechnology/Bioeconomy, Bio-Medical Technology/Water and Wastewater Technology and Smart Cities/e-Mobility.



Hon'ble Prime Minister Narendra Modi and H.E. German Chancellor Olaf Scholz
(Pic courtesy : Press information Bureau of India)

2+2 projects, the flagship program of IGSTC supports joint R&D&I projects of industrial relevance by means of "2+2 Mode of Partnership" i.e. involvement of at least one research/academic institute and one public/private industry from both the countries. Project proposals are expected to provide insights and exploitable research results leading to new technologies, products, processes, patents and/or services. To date, IGSTC's flagship programme namely the 2+2 scheme has supported 54 projects partnering research institutions, academia and industries creating a network of more than 216 organisations.

During the year 2022-23, IGSTC has provided funding support to 25 ongoing 2+2 projects in emerging areas of sustainable energy, advanced manufacturing, biomedical devices and technology, water & wastewater technologies, smart cities, bioeconomy. Currently, ongoing IGSTC Projects involve more than 100 project partners from academia and industry from India and Germany with total project investment (from BMBF and DST) of an estimated ₹ 147 Cr or € 18 million.

The bilateral workshop programme of IGSTC creates a platform for substantive interaction between scientists/researchers from academia and industry from both India & Germany to explore new avenues for Indo-German scientific collaborations. IGSTC supported 11 workshops in topics such as like

antibiotic resistance, water treatment, photovoltaics, aquaculture, marine farming, bio fabrication, ceramics, etc. The workshop networked more than 500 academicians, industry personnel, policy makers and early career researchers.

The IGSTC Industrial Fellowship programme, an unique fellowship provides exposure of PhD students/young researchers from India at a German industrial setup to promote applied research and technology development. Fellowships are offered annually at two levels, PhD Industrial Exposure Fellowship (PIEF) and Post-Doctoral Industrial Fellowship (PDIF). From Call 2022 of Industrial Fellowship 20 (10 PDIF and 10 PIEF) candidates were selected from various institutes of India. Currently, there are 40 fellows at different German organisations who have completed or near completion of their fellowships.

The fellowship has provided a distinct outlook and exposure to international research environment to the young researchers working at German industrial and applied R & D setup. The Industrial Fellowship programme has chartered a new path for PhD/Post-Docs to perform industrial research in Germany at an early stage of their career.



Call 2022 – Industrial Fellowship Awardees

The Women Involvement in Science and Engineering Research (WISER) programme provides an opportunity to women researchers from India and Germany to be a part of an ongoing R&D project of interest with acceptance from the host team. The first batch of WISER awardees were selected in the year 2022-23 – 10 Indians and 1 German. They will carry out projects in various fields

such as the microbiology, avionics, flood modelling, etc. WISER programme has created a pathway for women researchers in both countries to embark on international collaborations. The subsequent calls are having tremendous response and it hopes to improve the women representation in STEM in both the countries.



WISER 2022 awardees



Paired Early Career Fellowships in Applied Research (PECFAR) provides an opportunity to early-career scientists & engineers to explore Indian & German research landscape on various aspects, including entrepreneurship, collaborative research, innovation and sharing of lab facilities and infrastructure. In its inaugural call of 2022, 11 pairs from various parts of India and Germany were selected. These pairs of researchers will build networks in different areas of STEM such as autonomous mobilities, geothermal potential of India and Germany, computational modelling of materials, robotics, etc.

Small Immediate Need Grants (SING) supports proposals/initiatives that requires modest funding to kick start or has the potential to embark on good bilateral

Indo-German collaboration. Under this programme, 7 awardees have been selected. The grants have been provided for joint projects, industrial collaborations, travel support, etc.

The Indo-German Science and Technology Centre (IGSTC) has been increasing its outreach and visibility by conducting events in various tier-2 cities of India. IGSTC organized four successful outreach events in Coimbatore, Thiruvananthapuram, Guwahati and Lucknow. One virtual event in Germany was also organised. The events were attended by invitees from different academic and research institutions as well as industries. The outreach events have introduced around 500 participants across various spectrum of scientific community to IGSTC and its progress.



Group Photo at Coimbatore outreach event



Panel discussion at outreach event in Thiruvananthapuram

IGSTC has made it possible for researchers from India and Germany to work together on industrial projects. It has supported different levels of research collaboration, from early career to senior researchers. It has also

fostered a culture of innovation and excellence in both countries. IGSTC will continue to flag-bear the collaborations in S & T between Indian and Germany in the coming days, months and years.

GOVERNING BODY



Sanjeev Kumar Varshney

DST (Indian Co-Chair)



Vishvajit Sahay

DST



Neelima Gupta

Dr. Harisingh Gour Sagar University



Tata Narasinga Rao

ARCI



Sanjiv Rangrass

Zetwerk Manufacturing Pvt. Ltd.



Kathrin Meyer
BMBF (German Co-Chair)



Martin Goller
BMBF



Kaspar Meyer
German Embassy



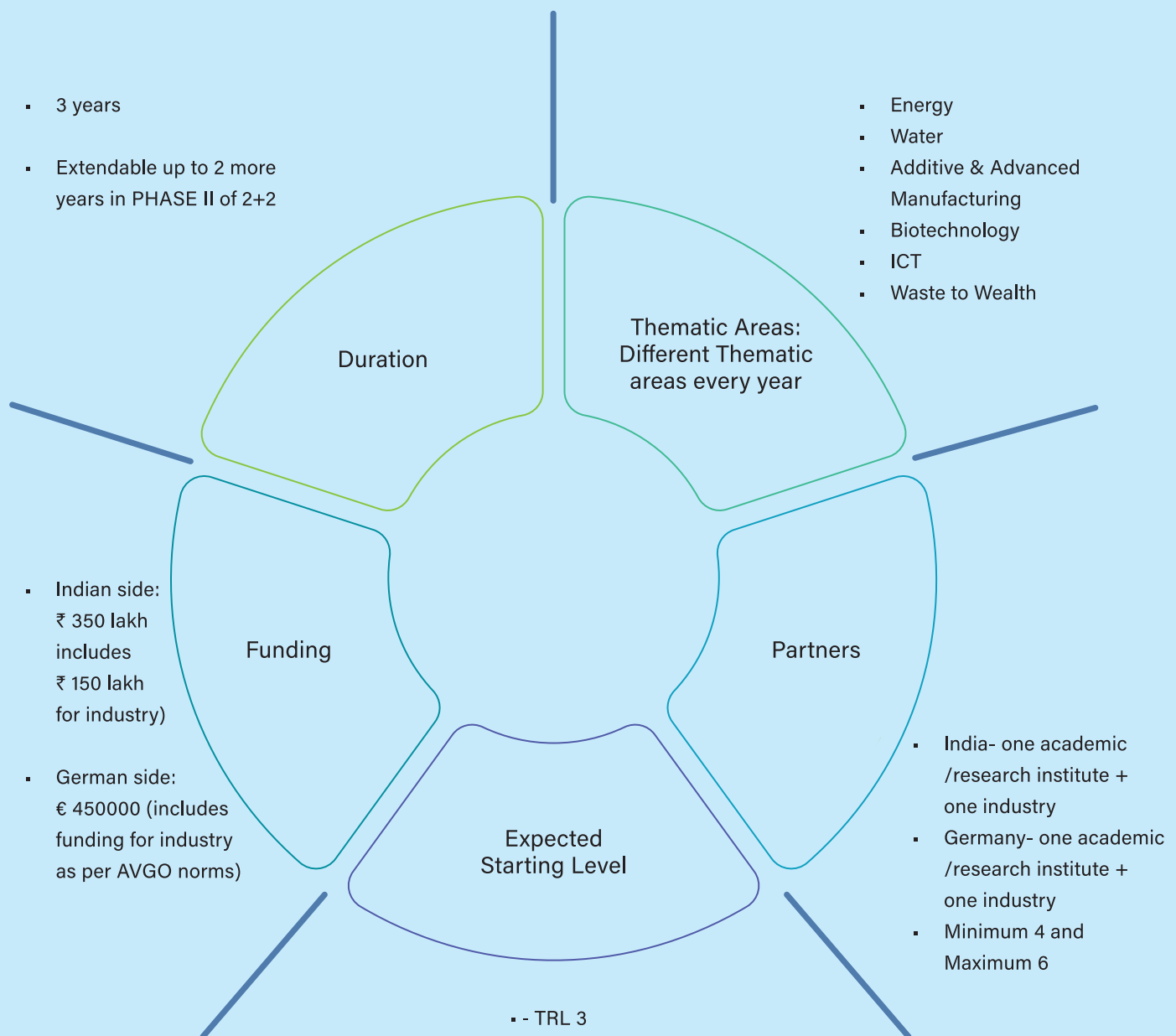
Andrea Frank
Stifterverband



Clas Neumann
SAP

2+2 Projects

IGSTC intends to catalyse innovation centric joint R&D+I projects of industrial relevance by means of "2+2 Mode of Partnership" with the participation of research/academic institution and public/private industry from both India and Germany. The project proposal is expected to produce insight and exploitable research results leading to new technologies, products and/or services.

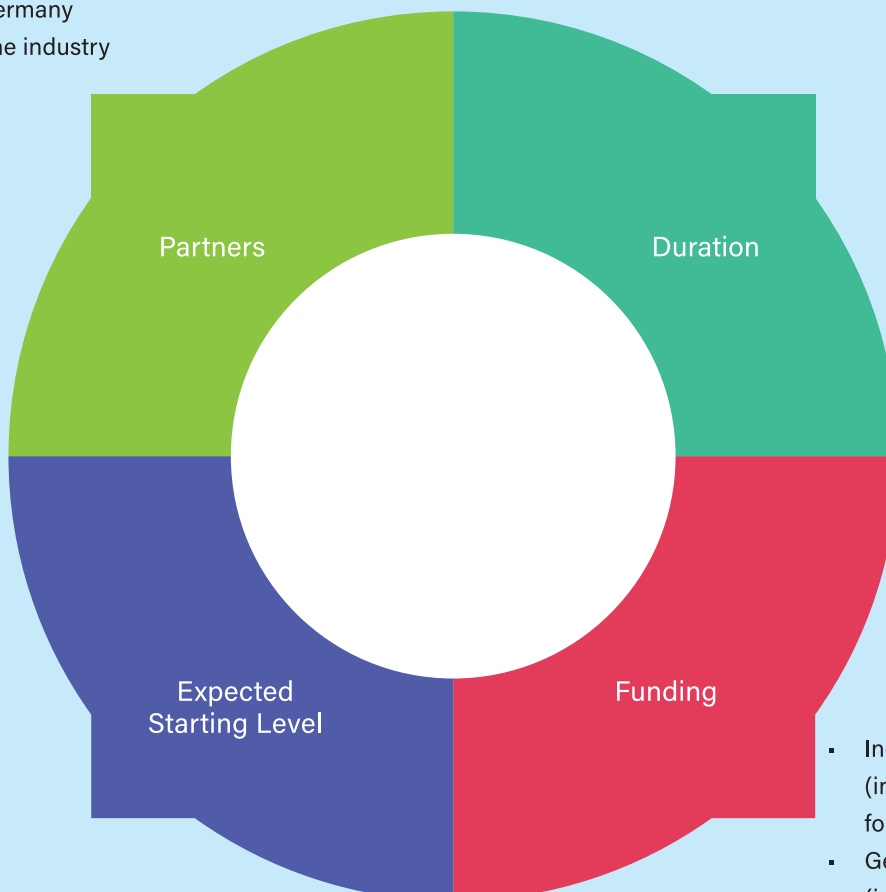


PHASE II of 2+2

It is an opportunity to selected 2+ 2 projects with promising results to apply for an extension up to two years with additional financial support to cover the gap between the validation in relevant environment and system qualification.

- One partner from bot India and Germany
- Minimum one industry

- 2 Years



- - TRL 5

- Indian side: ₹ 230 lakh (includes ₹ 100 lakh for industry)
- German side: € 30000 (includes funding for industry as per AVGO norms)

ADDITIVE MANUFACTURING





ADD-BITE

Development of patient-specific additively manufactured mandibular implants with biotechnology-inspired functional lattice structures

Project Brief

Commercially available Total Mandibular Joint (TMJ) replacement implants do not fit properly in Indian patients. Hence, patient specific anatomical TMJ implants seem to be a better alternative than the existing stock implants. Additionally, these commercial implants lack the hierarchical bony architecture. Therefore, it is hypothesized that an anatomical TMJ implant with additively manufactured bio-inspired functional lattice-structures will have improved biomechanical performance.

The aims of the manufacturing investigations are to specifically control the process parameters for powder bed fusion with a laser beam (PBF-LB) to adjust the morphology and topography of lattice structures, cryogenic cutting of the final contour and select and optimize the finishing processes such as stream finishing, centrifugal disc finishing or electropolishing.

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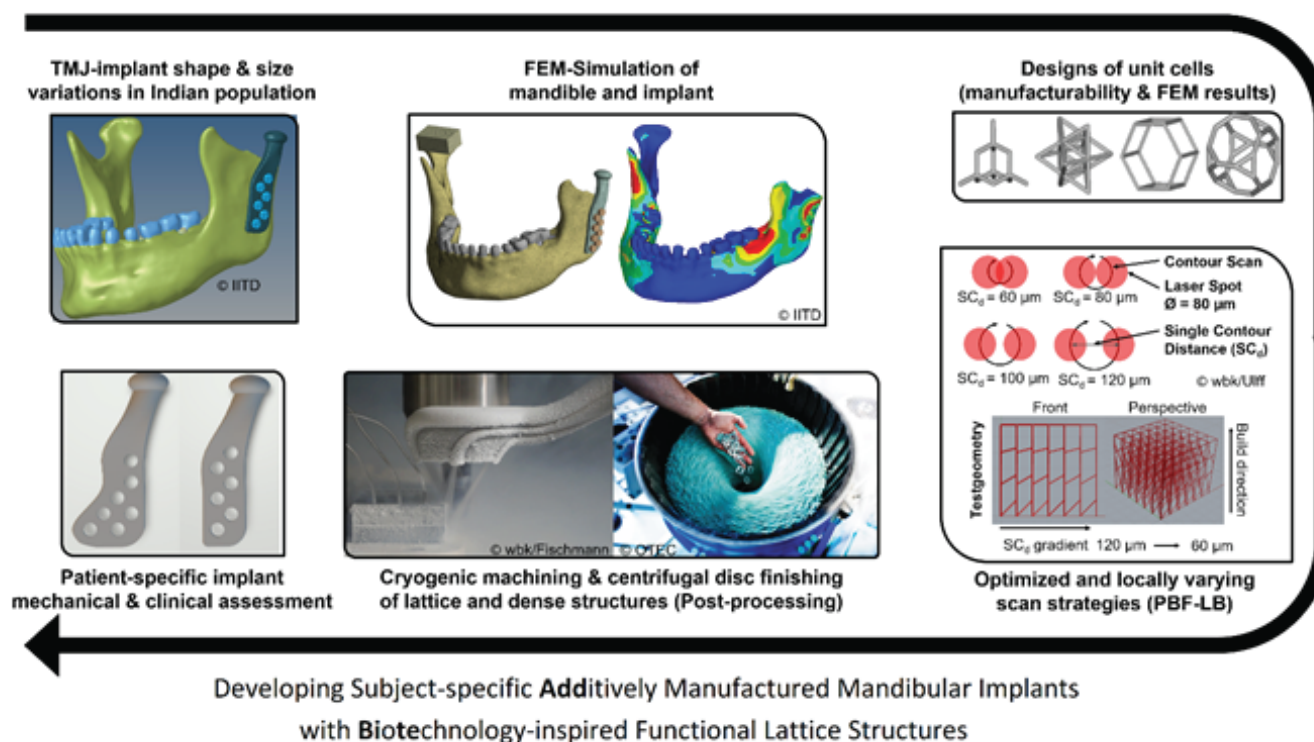
Progress made/achieved

All India Institute of Medical Sciences (AIIMS)

In Work Package 1 - (Analysis of patient data to know the size variation of patient individual TMJ Implants) at AIIMS, suitable patients with terminal Temporomandibular joint disease (TMJ) were identified and enrolled in the study. The patients without terminal TMJ disease were taken as control. Their CT scans were acquired, which were used to develop the virtual 3D mandible through biomedical image processing using MIMICS software. These virtual mandibles were sent to IITD team. Total stock temporomandibular joint (Biomet) for micro-CT were also given to IITD team. The CT scan data of 15 terminal TMJ disease patients has been utilised for 3D printing of the mandibles via 3D printer.

Indian Institute of Technology Delhi (IITD)

IITD team analysed the CT data for the mandibular shape and size variations (e.g. angularity, length of ramus, ramal width, gonion angle etc.). The ranges of these morphometric parameters have been compared with those of the Caucasian population and to understand differences in the shape and size variations. The received TMJ stock implants (Biomet) were scanned to develop the corresponding 3D virtual models. These 3D implant models were virtually placed on the reconstructed subject-specific 3D mandible to analyse the degree of misfit. Primarily, the mismatch between the ramal length and angulation of the mandible and the stock implant has been observed. IITD team has also explored various lattice cells and has established a numerical framework to estimate the homogenized mechanical behaviour of such lattices. The numerical framework corroborates well with the results of published articles. However, the IITD team is aiming to validate the numerical framework against the experimental data from wbk/KIT. The IITD team has also virtually developed the first set of lattice-structured TMJ implants.



Tata Steel

Tata Steel team has established the pipeline to fabricate the Ultra-High Molecular Weight Polyethylene (UHMWPE) fossa components and the implant sterilization procedure. Tata Steel team is ready to fabricate the UHMWPE fossa components, once the same are designed by the IITD team.

wbk Institute of Production Science, Karlsruhe Institute of Technology (wbk-KIT)

The wbk evaluated the minimum manufacturable strut and pore sizes to define the minimum size of a unit cell. For this purpose, a test geometry was designed for the evaluation of the process-related directionality and scan strategy adjustments. First results have shown that an adaptation via the contour diameter of the laser scan path is possible here and thus, depending on the strut inclination angle, the initial design could be adapted or a local reduction of the laser power reduces the oversize in case of overhanging struts. In addition, it could be shown for machining that the lattice design decisively determines the force curve over the cutting path and the volume fraction (volume proportion of material to the theoretical total volume), which is individual depending on the type. Therefore, a characteristic cutting path has already been created for some lattice types and decisive parameter variations in order to be able to predict optimal cutting conditions for less tool wear and better surface qualities.

OTEC

OTEC focused on the development of new electrolytes for electropolishing with floating ion exchangers, it was found that titanium

components can be processed by applying a pulsed voltage. The workpiece, in this case titanium including jaw implants, serves as the anode; the floating ion exchangers as functional partners surrounded by liquid medium. The cathode is formed by a fixed stainless steel container wall. The workpiece is rotated through the floating ion exchangers. By applying a positive voltage, a thin oxide layer is formed on the titanium surface, which is removed by applying a negative voltage. A rapid alternation of positive and negative voltage pulses causes then surface to dissolve. The dissolved Ti ions are absorbed by the ion exchanger, which saturate over time. Since these only touch the roughness peaks of the workpiece surface, these are predominantly removed (the material removal in the roughness valleys can be considered negligible here). In contrast to previously used electrolytes, this removal mechanism makes it possible to achieve significantly better high-gloss polished surfaces. Since the smoothing of the surface is influenced by the diameter of the ion exchangers, large roughness peaks or waviness can only be removed to a limited extent. Surface preparation is essential to achieve the smoothest possible surface. Only with smoothed and pre-polished surfaces with $Ra < 0.1 \mu m$ can high-gloss surfaces be achieved without rounding the workpieces too much. For this purpose, vibratory finishing seems to be a promising preparation method.

Throughout the period, a close coordination was maintained between all the three Indian partners (AIIMS, IITD and Tata Steel) through meetings between project investigators and researchers of all the three parties. A close coordination was also maintained with the German partners (wbk/KIT and OTEC) through regular meeting and sharing updates via a common repository.

Publications

1. Gupta A, Dutta A, Mukherjee K, (2023) "Influence of Implant Materials on Fixation of Mandibular Subcondylar Fracture: An In Silica Assessment", Annual Meeting of Orthopaedic Research Society (ORS), Dallas, Texas US, Feb 10-14, 2023.
2. Singh G, Shah KJ, Gupta A, Dutta A, Mukherjee K, (2023) "Periprosthetic Bone Adaptation in Mandibular Subcondylar Fracture Fixation: A Numerical Investigation", Annual Meeting of Orthopaedic Research Society (ORS), Dallas, Texas US, Feb 10-14, 2023.
3. Ghosh R, Mukherjee K, (2022) "Stress distribution around a temporomandibular joint (TMJ) implant in a reconstructed mandible", International Conference on Biomaterials, Regenerative Medicine and Devices (Bio-Remedi 2022), Guwahati, India, Dec 14-18, 2022.
4. Ghosh R, Gupta A, Dutta A, Khandelwal G, Roychoudhury A, Mukherjee S, Chawla A, Mukherjee K, "Biomechanical evaluation of narrow TMJ implant", International symposium on Computer Methods in Biomechanics and Biomedical Engineering (CMBBE2023), Paris, France, 3- 5 May 2023.
5. Chandra G, Ghosh R, Khandelwal G, Roychoudhury A, Mukherjee, S, Chawla A, Mukherjee K, "Mandibular morphometry and TMJ ankylosis: from the perspective of Indian population", 28th congress of the European Society of Biomechanics, (ESB2023) Maastricht, Netherlands, July 9 -12, 2023.

Material and process development for additive manufacturing and post-processing of tools made of modified hot work tool steel

Project Brief

The Laser Powder Bed Fusion (LPBF) additive manufacturing process is suitable for tool making due to the small batch size and the ability to produce curved cooling channels that are not conventionally possible. When processing standard steel for hot work and plastic moulding tools H13 with LPBF, cracking must be prevented by using high preheating temperatures or by significantly limiting part size. To overcome these limitations, a modified hot work tool steel is being developed that can be processed at preheating temperatures of 200 °C or less to enable industrial use. For efficient parameter selection, software for LPBF process development will be adapted and used. For a high surface quality of the functional outer surface and the complex cooling channels, polishing with a polymer rheological abrasive in a semisolid to liquid medium is used. The process chain to produce a tool is demonstrated and the tool is implemented in a plant environment.

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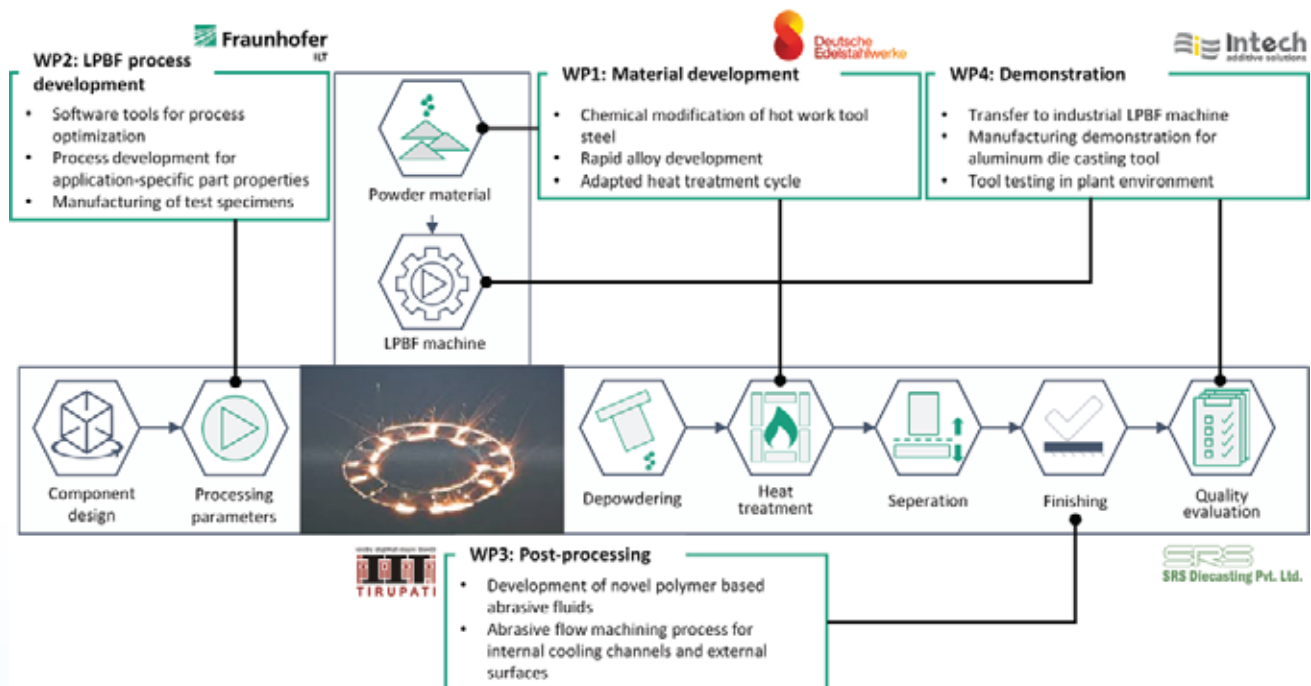
Progress made/achieved

Fraunhofer Institute for Laser Technology (ILT)

A design of experiment was prepared for the rapid alloy development of the initial material. The processability of the material will be investigated on a small processing chamber and the microstructure of the printed parts will be evaluated. The chemical composition of the initial material will be iteratively adjusted based on the results of the investigation.

Deutsche Edelstahlwerke Specialty Steel GmbH & Co. KG (DEW)

The base of the development is the common tool steel H13/1.2344. Thermodynamic and thermokinetic simulation are done and three candidates are identified. Laboratory heats of the new design alloys are produced and investigated. The production of powder of the most promising alloy is in preparation.





IIT Tirupati

Post processing of the AM features using polymer rheological abrasive medium: Different versions of medium by changing the compositions is under process. The finishing trials of the AM internal features (cylindrical workpieces) with medium size (20 mm) are tried. Deballing and finishing are achieved by polymer rheological abrasive medium. To study the better flowability and abrading ability, various medium characterizations are carried out. Flow and deformation of the medium done using rheological characterization and abrasive particle movement was observed using atomic force microscopy.

Intech

Demonstrated the AMOptoMet Software for parameter creation (DOE) for new materials. Initially few parameter sets are taken for different materials from AMOptoMet software and printed the coupons for optimization. The optimized specimens for different materials printed using AMOptoMet software are shared with IIT Tirupati for initial polishing trials.

Salient Research Achievements

Using simulation software Thermocalc and JMatPro the effect of manganese, carbon, chromium, molybdenum, and vanadium on the chemical equilibria and transformation temperatures are simulated. Lowering the martensite start temperature following measures are proposed.

- increase of manganese from 0.5 to 2.5 %,
- carbon remains at 0.39 %,
- increase of chromium from 5 to 8 %,
- increase of molybdenum from 1.3 to 1.8 %

Reducing the risk of stress induced precipitations, the use of vanadium is omitted.

Robust additive manufacturing of functional lightweight integrated customisable metallic structures

Project Brief

Light-weight high-performance components such as motor casing and battery enclosures require the assembly of multiple parts with complex geometry for the efficient design of electric vehicles. Design innovation to reduce the part counts without compromising the desired structural, thermal and mechanical performances is needed but limited by the ability of the traditional processes. The recourse is to produce parts with an innovative design by printing additional features on a cast or extruded part using wire-arc additive manufacturing (WAAM) thereby reducing part counts and the need for elaborate assembly processes. WAAM is a novel technique and involves rapid melting, deposition and solidification of materials to build geometric features layer-by-layer on a base. An understanding and precise control of the WAAM process are needed to produce a defect-free, structurally sound and dimensionally consistent component.

The present project aims at WAAM based printing of three-dimensional features on cast / extruded

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aluminium alloy parts to enhance their functionality. The work packages include the development of in-situ monitoring and process control systems, computer-based models to predict the structure, property, residual stress and distortion and defect generation and printing of parts with enhanced features as demonstrators. These demonstrators will be put under standard tests to check their performances for further commercialization and mass production. The tasks will be carried out by all the partners in a systematic manner to ensure the reproducibility of the developed technology and completion of the overall targets.

Progress made/achieved

- An inventory of parts, their corresponding manufacturing routes and overall fabrication procedures for state-of-the-art EV motor casings was carried out.
- A design analysis was done to build 3D functional features on an extruded part with the objective to reduce the inventory of part counts.
- Procurement process of earmarked WAAM facilities at both IITB and IITM is completed.
- An in-person kick-off meeting was conducted at IITB and Hindalco premises involving all six partners and senior personnel from IGSTC. It was learnt that activities for German partners were started after six months as compared to the Indian partners.
- Hindalco has agreed to deliver the substrates on which printing of 3D features will be attempted at IITB and IITM.
- Efforts are being made to develop printing parameters for building 3D features of automotive-grade aluminium alloys on selected EV substrates using WAAM-based 3D printing.
- An impact of process conditions on the dimensional consistency of printed features, defects such as porosity and cracking, and structural integrity are currently studied on the laboratory scale.
- Efforts are being made to develop computer based numerical models to understand the effect of power and speed on thermal cycles, feature profile, microstructure, residual stress and distortion evolution during printing.

ROBUST ADDITIVE MANUFACTURING OF FUNCTIONAL LIGHTWEIGHT INTEGRATED CUSTOMISABLE METALLIC STRUCTURES



Multi-Axis Multi-Material Wire Arc Additive Manufacturing

Project Brief

The powder-feed metal Additive Manufacturing (AM) systems can realize the Functionally Graded Materials (FGMs) but remain inefficient and challenging to control the localized material composition. Therefore, this project proposes a novel approach, "Multi-Axis Multi-Material Wire Arc Additive Manufacturing (MAMM WAAM)," to efficiently fabricate large-scale metallic objects of FGMs. The proposed system will be a robot-cell consisting of two multi-wire plasma welding torches attached to two 6-axis Robotic Arms mounted on the curved tracks. This system will produce large-scale FGMs objects of size up to 2m×2m×1m. Also, a Computer-Aided Process Planning (CAPP) software will be developed for efficiently operating the proposed system. New algorithms for (i) representing FGMs CAD models, (ii) build strategies, (iii) volumetric simulation, and (iv) collision detection will be developed for this CAPP software. The system will demonstrate its capabilities through industrial case studies.

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Progress made/achieved

IIT Guwahati

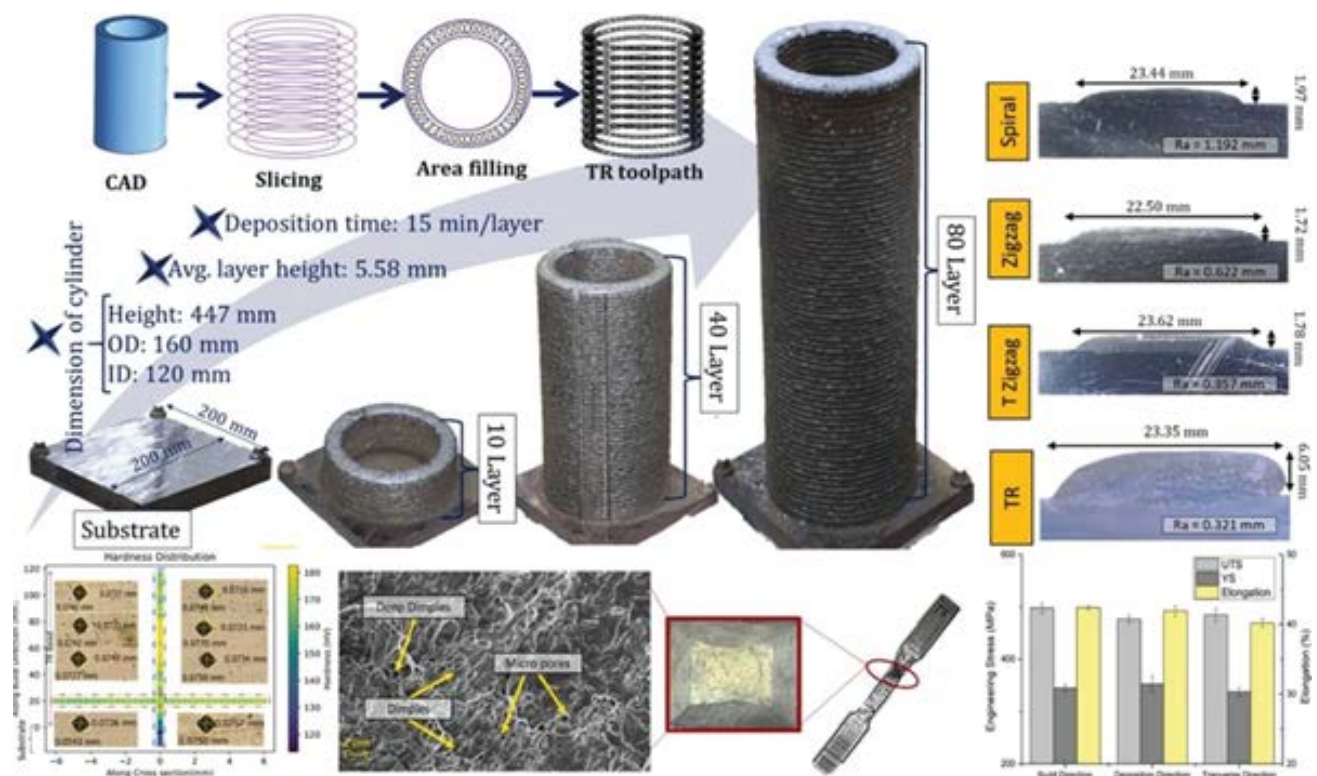
After discussion with the stakeholders, the Robot – cell has been designed and arrived at the following specifications of the robot cell:

- Robotic Arms: Two 6-axis robotic arms with 11-12 kg payload and 2.2-2.4-meter reach will be mounted on two parallel tracks.
- Controller: A dual arm controller will operate the 14 (6+1+6+1) axes and six analog switches (changing the wire speed and current).

- Linear Tracks: there will be two parallel tracks of 3.5-meter stroke length

It was decided to use linear tracks instead of the curved tracks due to CAM environment complexities. It has been concluded that the deliverables and capabilities of the robotic cell will not be compromised even if parallel tracks are used.

Appropriate toolpaths and build strategies can eliminate most Additive Manufacturing (/3D Printing) issues. In this project, the team proposed to explore toolpaths suitable for creating Functionally Graded Materials (FGMs), and the first toolpath to be tested is "Trochoidal (TR)" (famous for machining). The classical trochoidal-trajectory-based toolpath is employed to rapidly build up the structures of low-carbon steel (ER70S6) with comparable homogeneous mechanical properties of the built.



A cylindrical structure of ~500 mm height, 160 mm OD and ~35 Kg weight while testing the TR toolpath. It is one the largest metal parts ever fabricated by Metal 3D Printing in the India.

This toolpath came out to be a novel methodology to reach near the isotropic property in part fabricated by WAAM and the following summarized benefits:

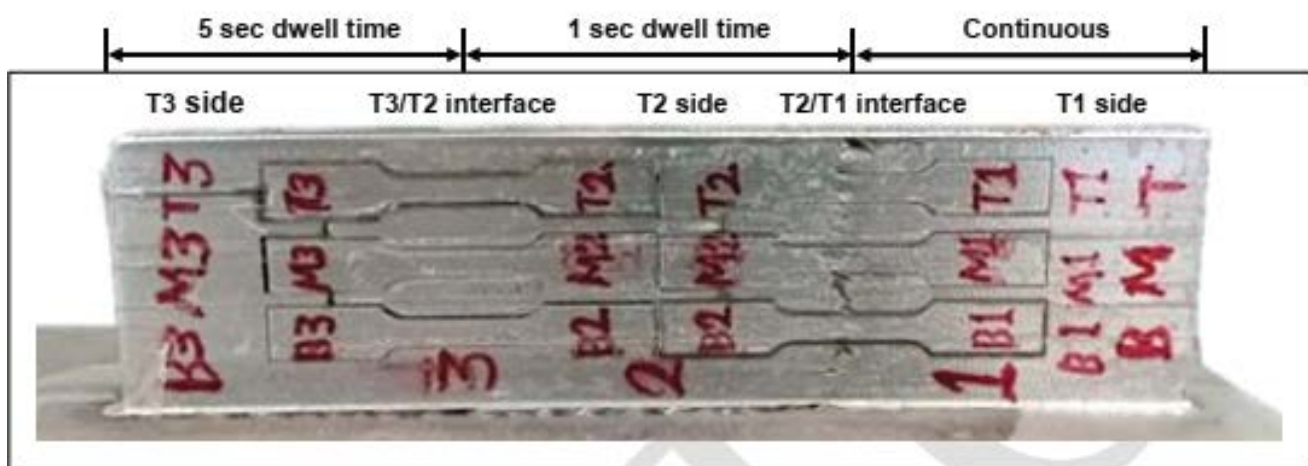
- The toolpath can deposit layers of $\varnothing 6$ mm height and $\varnothing 20$ mm width in a single pass, which is significantly higher than conventional toolpaths.
- It yields degenerate pearlites in the deposition of low-carbon steel.
- Refined equiaxed grains and nearly uniform mechanical properties are observed throughout the deposited part.

IIT Kanpur

IIT Kanpur is working on characterization and on the dynamics of robots.

Characterization related:

They had received drop on demand deposited mild steel wall (shown below) from IIT Guwahati prepared using WAAM for microstructural and mechanical characterization.



Wall of mild steel prepared using WAAM.

Ace Manufacturing Systems Ltd.

A MIG Welding based Wire Arc Additive Manufacturing System

- Experimented Arc DED (Make: Fronius MIG – CMT, Model: TSI – 400i) and studied the various aspects of Wire ARC-DED.
- Interfacing of MIG unit to CNC Machines to understand various process parameters

like voltage, current, feed rate of wire and axed feed rate required to achieve the desired job, programming from CNC controller.

- Visit to IIT Guwahati to discuss more on the project integration, tool path and other tests done by them, inputs required for present project.



Various 3D printed parts using the Arc Welding technology

RWTH Aachen

During this project RWTH Aachen will develop a multiwire plasma torch to create multi-material additive manufactured parts. Creating multi-material parts will enable the development of functionally graded structures. Two use cases have been determined: Creating a seawater resistant FGM which has a high strength and low cost and a FGM which fills the requirements of die and mold operations. These shall be tested in further experiments.

ModuleWorks

An algorithm to calculate the unsigned distance functions for two sets of triangles and a given point cloud was developed and implemented. The goal is to calculate the minimal distance of a tool point (part of the point cloud) to the inner- and outer-wall (given as triangles in the stl-format). The implementation (Q1 2023) works solidly and is computationally fast enough to present a viable industrial- used solution. It was successfully tested on the show submarine geometry.



Development of biodegradable alloys and AM processes for soft tissue anchors

Project Brief

Presently used metallic bioimplants are non-degradable and remain permanently inside the body necessitating secondary surgery for removal. To overcome such problems, biodegradable (BD) metallic implants (Fe-Mn, Mg, Zn) are being developed. Mg based alloys are recently being commercialized for dental, trauma and orthopedic applications. However, their usage is not extended to the applications which require longer period due to higher degradation rates and hydrogen evolution. These can be reduced by incorporating fine grain structure and coatings. Fe-Mn based alloys are recently gaining importance due to high specific strength and low cost. The challenge with Fe-Mn based alloys is lower degradation rates which can be addressed by miniaturizing. Presently, these BD implants are being developed by conventional techniques. Additive manufacturing (AM) is an advanced manufacturing technique that makes

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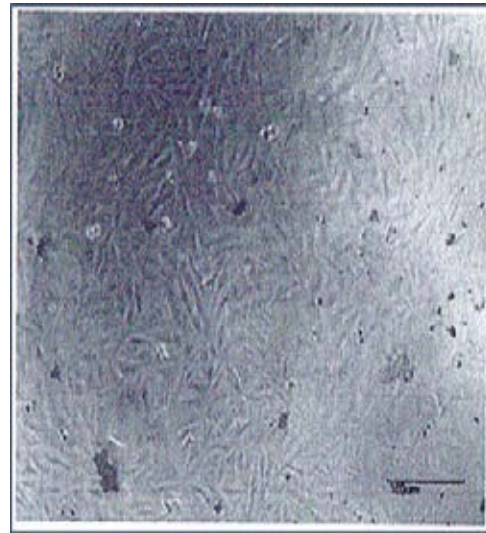
complex and custom made components with fine grained structure, controlled porosity and degradation rates. In addition, the challenges in fabrication of Mg based implants due to issues with forming and machinability can be overcome by AM. The reported studies on AM are preliminary. The use of soft tissue anchors (STA) as implants is projected to increase due to wider usage for fixing sports injuries as well as repairing wear and tear of tendons,

ligaments and cartilage. The proposed study envisages design of STAs, development of Mg and Fe-Mn alloy powders with suitable composition and demonstration of AM process for the manufacture of prototypes. The proposed work also involves characterization (microstructural, mechanical and biological) of AM built and surface modified coupons as well as components.

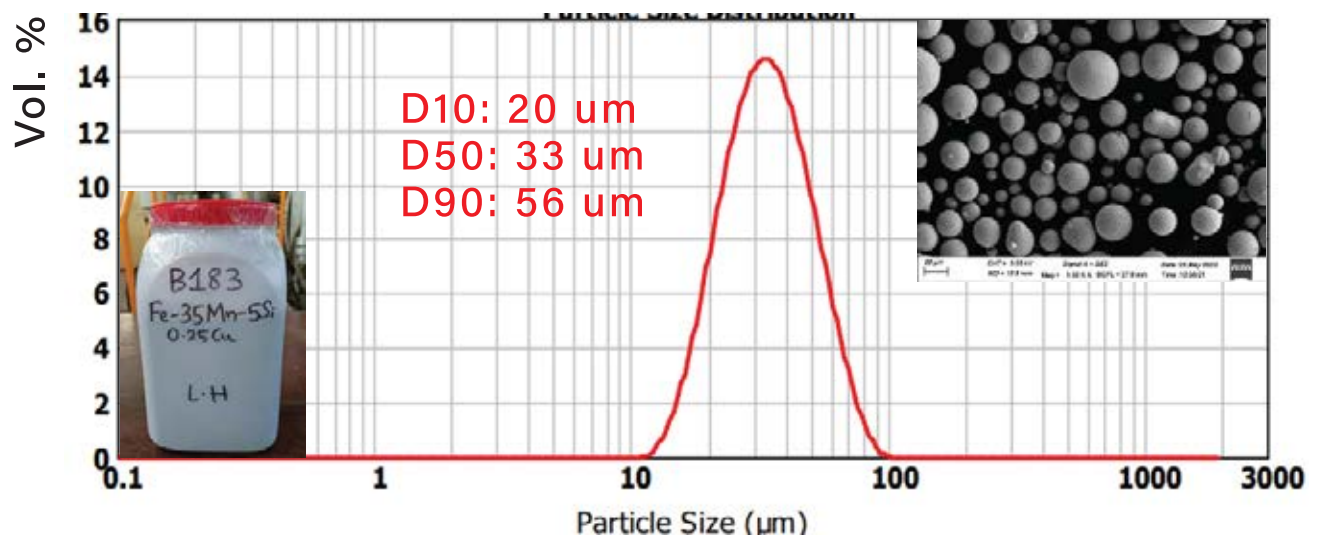
Fe - Mn based BD ALLOYS



Fe-Mn based alloy ingot made by Vacuum Induction Melting (VIM)



Alloy exhibited non-cytotoxicity



Powder size distribution made by Inert Gas Atomization (IGA), insets are the powder and their FESEM image confirmed spherical morphology, with suitable size distribution for additive manufacturing

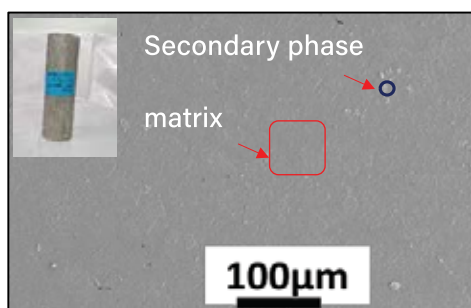


AM coupons made
by Powder Bed Fusion (PBF)

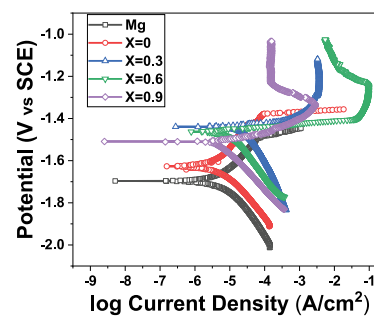


Optical micrographs
of the coupon shows defect free

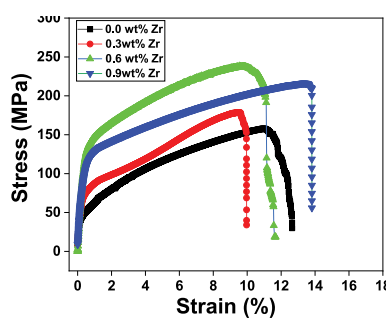
Mg - Zn based BD ALLOYS



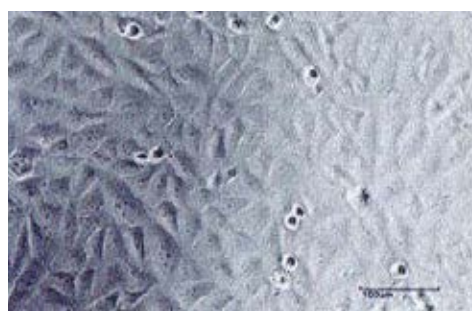
FESEM image of Mg-Zn based alloy and inset is
the ingot made by Vacuum Induction Melting (VIM)



Degradation studies of the alloys in Hank's solution
obtained degradation rate as low as 0.04 mm/y



Tensile properties of the alloys,
found UTS as high as 238 MPa



Alloy found to be non-cytotoxic
in mammal cell

AGRITECH AND BIOECONOMY





SIMON

Non-enzymatic microfluidic electrochemical multiplex sensor for cost-effective soil testing

Project Brief

Fertilizers and pesticides can exhibit moderate to lethal levels of toxicity in humans. Although they are used in farm-fields to boost agricultural productivity, these chemicals move up through the food chain, which leads to biomagnification. Most of the reported methods for the detection of fertilizer and pesticides in the soil are expensive, have a short shelf life, and are difficult to realize as a device outside laboratories. By combining the complementary expertise of the Indian and the German partners, our project aims to address this unmet challenge by developing an efficient multiplexed device for the detection of nitrate ion (NO_3^-) (a major fertilizer-based soil/ground water contaminant in India and Germany) and organophosphates (a class of pesticides) in soil samples. The device will comprise a microfluidic platform integrated with printed electrodes based on analyte-sensitive ink formulations and will facilitate the regular screening of NO_3^- and organophosphates to monitor the quality

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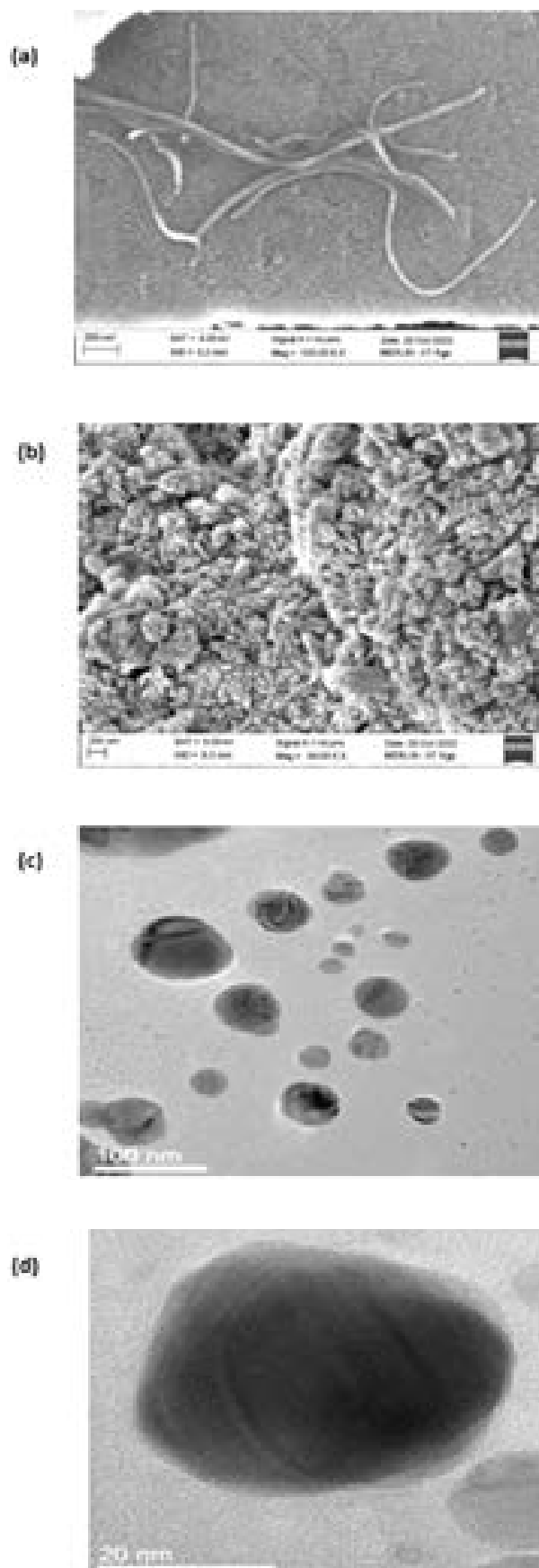
Joachim Wiest
cellasys GmbH

of soil samples. Envisioned for commercial marketing, the device will be an important step towards sustainable agriculture, which will significantly improve the livelihood of rural farming communities in the countries and help in safeguarding water resources from pollution. Additionally, through the development of a user-friendly soil testing device in this project, awareness on environmental protection will be enhanced.

Progress made/achieved

IIT Kharagpur

The pilot testing for NO_3^- and organophosphate sensing and development of ink formulation for synthesized electrode materials are ongoing. The modified electrode PEDOT: PSS/ Gold nanoparticles will be used with thiolated aptamers for detection of the four organophosphates namely glyphosate, malathion, chlorpyrifos, and phorate. Among which Glyphosate detection is currently ongoing and other 3 organophosphate detection are yet to be accomplished. The organophosphate detection scheme was modified from the proposed methylene blue tagged aptamer to thiolated aptamer for better results. The real-soil sample analysis from water extract for NO_3^- sensing was performed in NO_3^- spiked samples and the percentage recovery of the spiked NO_3^- concentrations were calculated.



SEM images of (a) FWCNT/ITO (b) Cu-NC /ITO and TEM images of (c) Cu-NCs (d) a single Cu-NC particle

TU Munich

The design and fabrication of printed microelectrode arrays was conducted. To facilitate the fabrication process and allow faster design iterations an alternative fabrication strategy based on laser ablation was also developed and will be used within the project. Electrode arrays were fabricated using inkjet printing. In comparison, the ablation process turned out to be significantly faster and more reliable and will be used for

the fabrication of the project's devices. A sputtering process was used to deposit conductive base electrode materials (e.g. gold) onto polyimide substrates. After laser patterning of the feedlines and electrodes, a parylene process was employed to insulate the feedline structures towards solution. The electrode sites were opened using an aluminium mask process with laser ablation and etching of the parylene via oxygen plasma.



Interaction with farmers and spreading awareness about nitrate-based fertilizers, herbicides and pesticides in Midnapur region of West Bengal, India



Exchange Visits: 10/10/2022-14/10/2022; Bernhard Wolfrum, Joachim Wiest, and Marta Nikic visited IIT Kharagpur from Germany side to discuss the project progress and exchange the knowledge of the project

Circular urban cultivation systems with re-useable textile growing substrates

Project Brief

Urban agriculture is integral part of sustainable city development for providing ecosystem services like air quality regulation, cooling, appealing appearance and food production. Urban agriculture moved as trend into urban environments in form of vertical farming, rooftop and community gardening. Besides space, soil as cultivation substrate is scarce. Textile is light-weight and adaptive compared to other substrates and thus very suitable for soilless urban cultivation systems. The proposed project aims at the development of a re-useable textile cultivation substrate following a plant performance-based approach. In addition to plant and system specific properties, the dimensional stability of the textile will be taken into account during the development to allow for re-usability of the substrate through cleaning. Thermo-mechanical and a biological cleaning process will be developed and evaluated. Subsequently, existing urban farming systems will be

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technically adapted to the textile substrate to improve resource-use efficiency and include an appropriate substrate cleaning process. In combination with a market analysis and target group segmentation (community gardening; urban farming for self-sufficiency; professional indoor, greenhouse and vertical farming) the value proposition and the financial feasibility will be translated into novel business models to support the market growth of urban farming. Circular, light-weight and resource-efficient urban farming with re-usable substrate may inspire urban inhabitants, trigger sustainable consumer behaviour and lead to a societal transition towards bioeconomy.

**Progress
made/achieved**

Amity University Kolkata (AUK)

Sowing and germination of Italian basil seeds on the arrived substrates arranged in three different arrangements - Rolled, stacked and rolled with topping at the Nutrient Film Technique (NFT) system. Morphological data was collected according to the universal BBCH scale and graphically interpreted. The substrates were subjected to physical cleaning for further use in the system. Tomato seeds were sowed on textile substrate A, B and C in rolled arrangement for Dutch Bucket system. Morphological data was collected according to the universal BBCH scale and graphically interpreted.



Italian basil growing on Novel textile substrate at AUK

During the process of optimizing plant growth in a laboratory hydroponics system, a new microbial biostimulant was created by extracting root endophytes from naturally occurring mangrove species thriving in saline environments. Subsequently, a range of tests were conducted including biochemical and molecular identification, analysis of plant growth promotion traits, competitive assessments, morphometric analysis, and the selection of four bacterial strains. This microbial biostimulant aims to improve plant performance under salt stress, contributing to the sustainable advancement of agriculture.

Bidhan Chandra Krishi Viswavidyalaya, Kalyani

A test run was performed by growing basil in the Nutrient Film Technique (Vertical) NFT system using rock wool and clay ball as substrates while maintaining the parameters like pH, EC, Temperature and TDS. After a successful test run, the rock wool and clay balls were replaced with the three types of novel textile substrates sent by the German partners.

Italian basil and tomato plants were grown in five different arrangements (Rolled, stacked, rolled with topping, folded and multiple rolls). Following a full basil crop cycle, the used

textile substrates were cleaned and prepared for reuse with the next batch of substrates sent by the German partners in January 2023.

Plant growth was slower in aquaponics than hydroponics, due to imbalance ratio of fish and plant number. Fish seeds were released for possible rectification. Water was circulated from the fish tank to aquaponics NFT pipes through mechanical and biological filters. Fishes like Koi (*Cyprinus carpio*), Tilapia (*Oreochromis niloticus*) were grown in the fish tank.



Polyhouse at BCKV

Harimitti Agro Pvt Ltd. Kolkata (HMA)

HMA interacted with urban dwellers and acquainted them with the hydroponic units. They found out certain challenges in respect to sunlight, making of shades, space, cost, monitoring etc. for developing hydroponics unit at home scale in West Bengal and for commercial unit, the cost of regular maintenance of controlled environment is very high. HMA aimed in growing crops in open condition and make it a commercially viable option. HMA observed the growth of the plants in the substrate is more than the Rockwool and the substrates were also easy to handle. HMA is working on making cost effective model in comparison with the existing substrate and adaptation of various vegetable crops in hydroponics system in tropical Indian climatic condition under open environment throughout the year. Next batch of 3 new textile substrate has arrived and all three Indian partners are on the verge of adapting them in their respective systems.



Open house Hydroponics at HMA

University of Hohenheim (UHOH) & German Institutes of Textile and Fiber Research (DITF)

Cultivation experiments in hydroponic NFT system set ups were carried out at UHOH (greenhouse) and DITF (technical hall) with textile substrate samples in net pots compared to rockwool as a reference. Different crops were tested (Pak Choi, Basil, Sage, Rocket, Pea, Beet root). Seven different spacer textile in different arrangements in the net pots were screened & tested. The influence of the textiles on the flow properties in the NFT system and the water retention properties in running system were investigated. Further experiments were done with a selection of three textile structures with distinct differences in rise height and water holding capacity. Root growth was investigated and compared to rockwool. The three tested textile structures are as suitable as or better than rockwool for root development in BBCH scale 1-10. The yields of the tested crops grown in textile substrate were as high as grown in rockwool or higher. The arrangement of the spacer textile in the net pot has no effect. Cleaned and reused textile showed normal performance in cultivation experiments. Textile-technical characterization experiments were done as well as application-specific characterizations.



Pak Choi (L) & Basil (R) cultivated on textile substrates in NFT system in a greenhouse at UHOH



Terrabioptic garden systems with textile substrate as drainage layer in a greenhouse at UHOH

Eschler Textile GmbH (ETF)

Based on the cultivation experiments a new textile structure was developed, designed and produced by ETF. The new textile substrate was produced in different variations and sent to all project partners for further experiments concerning cultivation, cleaning and recycling. First cleaning tests were done with the used textile substrate from the cultivation experiments. Together a concept for the cleaning experiments and their evaluation was elaborated. Respected setups for cleaning trials are in preparation. The terrabioptic setups were installed with textile structures that replaced gravel in the draining area. Draining properties, as well as pressure stability, were tested in laboratory setups. Cultivation and composting experiments are ongoing.



Wrap knitting machine that produces textile substrate at ETF

Publications/Papers

- Poster-Presentation at 26th ICABR conference in Bologna from 5th to 8th July 2022: 'Re-useable textile substrates for sustainable soilless crop cultivation in urban agriculture'
- Bastian Winkler, Jędrzej Cichocki, Bilitis Vanicela, Christoph Riethmueller, Michael Walz, Sanjit Debnath, Anwesha Chatterjee, Proma Ghosh, Vasu Vijayaragavan, Suhrid Chandra, Harshata Pal, Abstract accepted (on 28th March 2022).

General Public Interactions

- Visit to 'IPM Essen 2023 - The world's leading trade fair for horticulture' (Essen, Germany) on 26.01.2023 for networking and exchanging with professionals in the horticulture and greenhouse sector.
- Visit to India's first urban farming trade fair SUFex (Smart Urban Farming Expo), Delhi: (Date:24.03.2023-25.03.2023) for networking and exchange with professionals in the sustainable and urban cultivation domain.

SENSVERT

Development and evaluation of automated sensors for a highly efficient nutrition management system in indoor vertical farming.

Project Brief

Indoor Vertical farming can make an important contribution to feed the growing global population (estimated to be 9.6 bn by 2050) especially in regions where the climatic conditions have significant restrictions on crop production. In Indoor farming the crops are cultivated in vertical stacked layers with the help of soilless, hydroponic or aeroponic growing system. Vertical farms can be established in towns, cities, desert and degraded lands for growing vegetables and fruits with a high economically and nutritious value inside protected structures with precision agricultural methods [Kalantari et al, 2017]. Nutritional management through fertigation is the basic requirement in vertical farming as the plants are grown in inert media. Major and micronutrient management is the major task for successful vertical farming. Sensors are required for precise measurement, control and supply of nutrition to the plants. There is urgent need of detection of NPK, Ca,

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Mg, EC and pH for fertigation management. These sensors should act automatically and connected to fertigation unit through IoT for close loop system. Conventional methods of fertigation management in horticultural production rely on EC and pH measurements, offering no possibility to detect and react to changes in ion ratios deviating from the optimum. Ion-specific fertigation management promises to increase nutrient use efficiency and to decrease the environmental impact of horticultural production by minimizing nutrient loss in the drainage fraction.

The goal of the SENSVERT project is the development of an ion selective sensor platform for the precise and continuous measurement of NO_3^- , K^+ , PO_4^- , Ca^{2+} and Mg^{2+} ions in nutrient solutions equipped with an IoT interface, allowing for practical and user-friendly live monitoring of ion ratios in nutrient solutions. The integration of the sensor platform with a stock solution dosing system will make an automated efficient ion specific fertigation management system for Vertical farming.

Progress made/ achieved

The current Technology Readiness Level of the project is 6 as the actual prototype of Greenhouse vertical farm with automation has been designed and installed.



Greenhouse Hydroponics Vertical Farming System
at CPCT IARI PUSA DELHI



Prototype of the Fertigation Unit with Controller and user interface (Left), sensor array (middle) and injection unit (right)



Visit of Indian partners at HSWT (18.6.23) from left to right: Markus Abel (HSWT), Sabine Wittmann (HSWT), Dr. Murtaza Hasan (ICAR), Dr. Markus Reinke (HSWT, vice president), Prof. Heike Mempel (HSWT), Shivendra Singh (Barton Breeze), Mohamed Bourouah (Hahn schickard), Fabian Daum (SMB-Brückner)

ICAR-Indian Agricultural Research Institute (IARI)

Sensor platform development, integration of environmental sensors and development of Greenhouse Vertical Farm has been completed. Experiments related to nutrient uptake study and close loop fertigation model development for Greenhouse Vertical farming have been carried out both in HSWT GERMANY and IARI & Barton Breeze. Development and standardization of sensor values and complete IoT system for fertigation are also in process.

Hochschule Weihenstephan-Triesdorf (HWST)

The Ion-Selective Electrodes (ISEs) were tested with known concentration solutions to assess accuracy and precision. However, their

performance deteriorated over time, particularly the Ca^{2+} Electrodes, which exhibited reduced sensitivity beyond 100 ppm concentrations after about four weeks of daily use. This degradation posed a challenge to accurate measurement. Alternatively, NO_3^- and K^+ ISEs were explored which gave accurate measurements for higher concentrations with better sensitivity over extended periods. But there was a decline in the sensitivity of K^+ electrodes within six months. The measurement error fell below 4% for NO_3^- and K^+ ions when measured closer to the calibration points. In contrast, Ca^{2+} measurements mismatched actual concentrations at higher levels due to electrode response deterioration during its service life. For accurate measurements in a nutrient solution with varying ion ratios, selecting calibration points near the expected concentration range is vital. The NO_3^- , K^+ , and Ca^{2+} ISEs had been in use for approximately 8, 7, and 10 months respectively at the time of measuring.

Hahn-Schickard Institute

The Hahn-Schickard Institute is gradually progressing in the signal acquisition and processing of ISE. The first prototype circuit board for processing ISE-raw signals was sent to HSWT in April and the second version to be sent to ICAR and B&B for integration into fertigation setups. An alternative ISE signal solution is being tested in a fertigation controller by SMB-Brueckner due to address the complications in integrating the data transfer protocol in the first sensor board with the PLC controller.

Concurrently, a microfluidic sampling system for automated calibration and sample delivery has been developed. It includes calibration solution containers, rinse channels, a flow cell for measurements. Integration into HSWT and ICAR fertigation controllers is planned for May. The system was first designed in CAD software, ensuring accurate placement of components and cost-effective implementation.

Sondermaschinenbau Bruckner GmbH (SMB-Brueckner)

SMB-Brueckner has provided a prototype of an ion-specific fertigation controller to HSWT equipped with EC, dissolved O₂ and temperature sensors. It features provisions for the integration of ISE and pH probe signals, with an interface for sensor calibration and measurement-dependent dosing of individual stock solutions. The extension unit for signal processing has been designed and tested by SMB-Brueckner. It is due to be integrated into the fertigation controller already installed at the test beds at HSWT on the 24.04.2023.

Barton Breeze Pvt Ltd

Barton Breeze in consultation with IARI and HSWT has been actively involved in vertical farm development, nutrient uptake study and fertigation model development.

Publications/Papers

- Murtaza Hasan, Indra Mani, Naved Sabir, A K Singh, M C Singh, Love Kumar, Vinayak Paradkar and Kishor Gavhane (2022) Smart Urban Farming Technology, TBICN: 270/2022
- Design and Development of Automatic Nutrient Sensors for Efficient Water and Nutrient Management in Vertical Farming Systems (Paper accepted in Acta Horticulturae (IHC 2022), International Symposium on Advances in Vertical Farming)
- Identification of variations in nutrient uptake ratios of Pak Choi (*Brassica rapa*) as an indicator for the potential of ion-specific nutrient management (Paper accepted in Acta Horticulturae (IHC 2022), International Symposium on Advances in Vertical Farming)

Public engagement Activities

- Visit of German Delegation Co-Chair of IGSTC Governing Body Dr Kathrin Meyer with IGSTC delegates at ICAR-IARI, New Delhi at IGSTC Project site on 13th May 2022



German Parliamentary Delegation led by Prof Heige Reinhold Braun, German National Parliament Member and his team visit to IARI and SENSVERT project site on 14th Feb 2023.

AutoNutri

On-site multi-ion monitoring system for on-line nutrient-laden water control in vertical hydroponic systems to minimize environmental impact

Project Brief

One of the most critical objectives of this project is to ensure that the system is compatible with crops that are commercially important in terms of growth, nutrient consumption, vital metabolite production and its content. With respect to this, consortium have selected Lettuce (*Lactuca sativa* var. *crispa* 'Lollo Rossa'), Brahmi (*Bacopa monnieri*), Thyme (*Thymus bulgaria*), Stevia (*Stevia rebaudiana*) & Basil (*Ocimum basilicum*) as model crops for this project. In the initial phase, three out of the five model plants (Basil, Lettuce and Brahmi) were cultivated hydroponically in the selected Nutrient Film Technique (NFT) system at our indoor facility. Throughout the study, the selected hydroponic system was monitored in terms of temperature, climatic parameters, nutrient elements, pH and EC to study their nutrient requirements and absorption patterns at each growing stage.

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Fraunhofer Institute for Microengineering
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Oliver Stegen

RM Geraetebau
Oliver Stegen

Progress made/achieved

The proposed equipment has been procured and installed at the HiM facility to determine relevant ions concentration and to evaluate nutrient absorption patterns in five model plants and further validate the AutoNutri prototype. Standard operating procedures have been developed for various equipments for elemental nutrient analysis of nutrient solution samples to validate the ion selective monitor system. HiMedia laboratories provided commercially available hydroponic nutrient formulations to F-IMM for sensor array and testing purposes. Subsequently, F-IMM is currently working on the development of a multi-ion monitoring system that uses solid-contact liquid-membrane ion-selective electrode based sensors to directly detect major ions for crop growth. Five (5) most relevant ion types and corresponding concentration ranges were identified, to be measured within hydroponic systems: ammonium, nitrate, phosphate, calcium and potassium. For the corresponding ion types commercially available ionophores were identified and purchased, except for Potassium for which ionophore solutions were made at IMM, serving as a basis for the manufacturing of miniaturized ion selective electrodes (ISE). With all ionophores ISE's were manufactured and tested, initially with aqueous solutions containing only the corresponding ion type in the relevant concentration range. For that, a lab demonstrator was set up, including electronics with shielding against EMI, as well as microfluidic chips made of polycarbonate. During the project the chip design was improved, to compensate air bubble formation above the ISE's. The corresponding

microfluidic chips have been fabricated by 3D printing with an epoxy resin. The best results were achieved with potassium and ammonium ISE's, the slope of the concentration dependent potentiometry curves showed a Nernstian behaviour with values close to the theoretical limit of 59mV. The reproducibility of these electrodes was good. The Phosphate ISE's require a pH value of 7.4 for correct operation which does not correspond with the typical value for hydroponic solutions of 6-7. The corresponding ISE's showed a bad reproducibility as well as a non-nernstian behaviour. Further investigations with an adapted pH value are required. With the lab demonstrator also more cost-efficient peristaltic pumps have been tested which shall be applied in the demonstrator, instead of expensive syringe pumps. During these tests, with higher flow rates and pressures, a strong noise appeared on the sensor signal, caused by the movement of small air bubbles at the surface of the ISE's. This can be avoided by switching off the pump during the measurement. After a short relaxation time the sensor signal stabilizes on a constant level with low noise. The transfer of the laboratory demonstrator into a prototype to be tested in India, has been discussed within a meeting with the German industrial partner RM Geraetebau. A state-of-the-art outdoor hydroponic farm of around 40,000 sq. ft. and an indoor hydroponic lab facility of around 380.3 sq. ft. has been set up at Igatpuri (120Km from Mumbai) and Ghatkopar (Mumbai) respectively. Five model plants will be grown in soil to study their growth requirements in soil. By comparing the growth patterns and nutrient absorption rates in soil-grown plants with those grown hydroponically, the researchers can identify the differences and determine the applicability of AutoNutri in traditional farming.

Milestones Achieved

Institute of Chemical Technology ICT

ICT has prepared SOPs for ICP-MS and chemical methods. The ICP-MS has been procured and its installation at HiM facility is underway. Standard analysis procedure for the detection of nutrient concentration has also been determined.

HiMedia Laboratories Pvt. Ltd.

HiMedia is currently in negotiations with different parties for the procurement of an Automated plant reading station. They are monitoring hydroponic and soil systems as well as evaluating commercial plants.

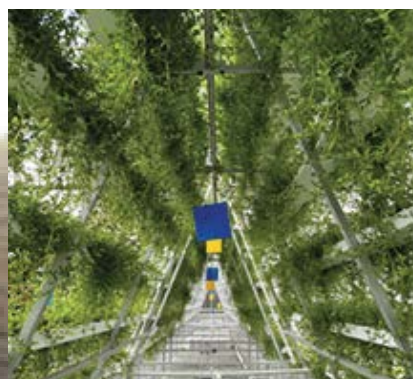
Fraunhofer Institute for Microengineering and Microsystems

Fraunhofer IMM is working on designing and testing microfluidic chip prototypes as well as developing and testing an ion-selective-electrode sensor array with nutrient solutions. For ions nitrate, calcium and phosphate further improvement has to be made.

RM Geraetebau Oliver Stegen discussed technical details of the transfer of the laboratory demonstrator into a prototype to be tested in India within a meeting with the German research partner F-IMM.

Salient Research Achievements

1. Four key nutrients such as N, P, K, & Ca are selected for the proposed ion-selective monitoring and regulation purpose (5 ions: Ammonium, Nitrate, Phosphate, Calcium and Potassium).
2. Standard operating procedures have been developed for various equipment, including the ICP-MS, chemical methods, and fibre analyser to ensure accuracy and consistency.
3. Testing equipment are set up at HiM facility for elemental nutrient analysis.
4. To validate the monitoring system, hydroponic systems have been set up at both indoor and outdoor facilities at HiM for evaluating all five model crops (Lettuce (*Lactuca sativa* var. Crispa 'Lollo Rossa') Brahmi (*Bacopa monnieri*), Thyme (*Thymus vulgaris*), Stevia (*Stevia rebaudiana*) & Basil (*Ocimum basilicum*).
5. All five model plants are growing and successfully maintained at HiM facility.
6. The climatic and nutrient requirements of three out of the five model plants grown in hydroponic systems were studied and evaluated at different stages to support the development of the ion-selective management system.
7. Characterization of all 5 ions has been done by F-IMM but further improvement is required for ions nitrate, calcium and phosphate. The TRL is 3 for the Development of Lab demonstrator.



Outdoor Hydroponic Farm set up-Igatpuri (120Km from Mumbai)

SUSTAINABLE ENVIRONMENT



Development and validation of a cost-effective hybrid electric drive solution for small two-wheelers for reducing CO₂ emission

Project Brief

The objective of this project is to develop a cost-effective hybrid two-wheeler fulfilling the requirements of reduced CO₂ and other emissions and improved fuel economy. IIT Madras and RWTH Aachen will develop and integrate simulation models of the engine and the vehicle along with the electric drive for sizing the important components and will arrive at suitable topology and control strategies. The hybrid electrical drive control units and the battery management system will be developed by VEMAC GmbH, Germany. TVS Motor Ltd., India will do the design, component procurement and integration on test bed and vehicle. The proposed hybrid control strategies will be experimentally evaluated and fine-tuned in the laboratory in IIT Madras on a special test rig. Integration on the two-wheeler, calibration for performance and evaluation on the test bench and outdoor test track will also be done by TVS Motors. One prototype vehicle will be evaluated in Germany for fine tuning the control logic. Finally, the potential for reduction of fuel consumption and CO₂ emissions will be evaluated against a targeted value of 25% in the chassis dynamometer in TVS Motors.

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Progress made/achieved

IIT Madras (IITM)

Develop and validate an engine simulation model; Develop a CVT model, integrate with the engine (performance and emissions) and preliminary vehicle model and validate; Integrate the models and implement different hybrid topologies and combinations of subsystem components in the mode.

The conventional vehicle powertrain including the engine and the CVT (Continuously Variable Transmission) was modelled and validated with test measurements. A steady state engine test bench has been created using the engine provided by TVSM with necessary instrumentation for performance, combustion and emissions. The engine was tested at 70 different steady state speed-load

points to characterize the same. The Three Way Catalytic (TWC) converter efficiency was calculated by measuring the emissions at engine-out and tail pipe locations at about 30 steady state points. Maps of these measurements were used for the simulation model. A transient engine-out emission model was developed based on Artificial Neural Network (ANN). Training the ANN model requires transient emission data. Hence, a few slow transient emission measurements were done in steady state test bench in IITM. For validation of the entire powertrain model and measuring the CVT efficiency, steady and transient tests were conducted on the vehicle on a chassis dynamometer at TVSM. The vehicle was specially instrumented for this measurement. With the transient vehicle test measurement, the entire conventional powertrain model was validated. The developed engine and CVT models were presented and handed over to RWTH to perform drive-cycle simulations and compare all the four hybrid powertrain topologies chosen at the end of first phase of the project.



TVS Jupiter two-wheeler with Hybrid Electric Drive

Vehicle Chassis Dyno experiments and Simulation of the Hybrid Topologies

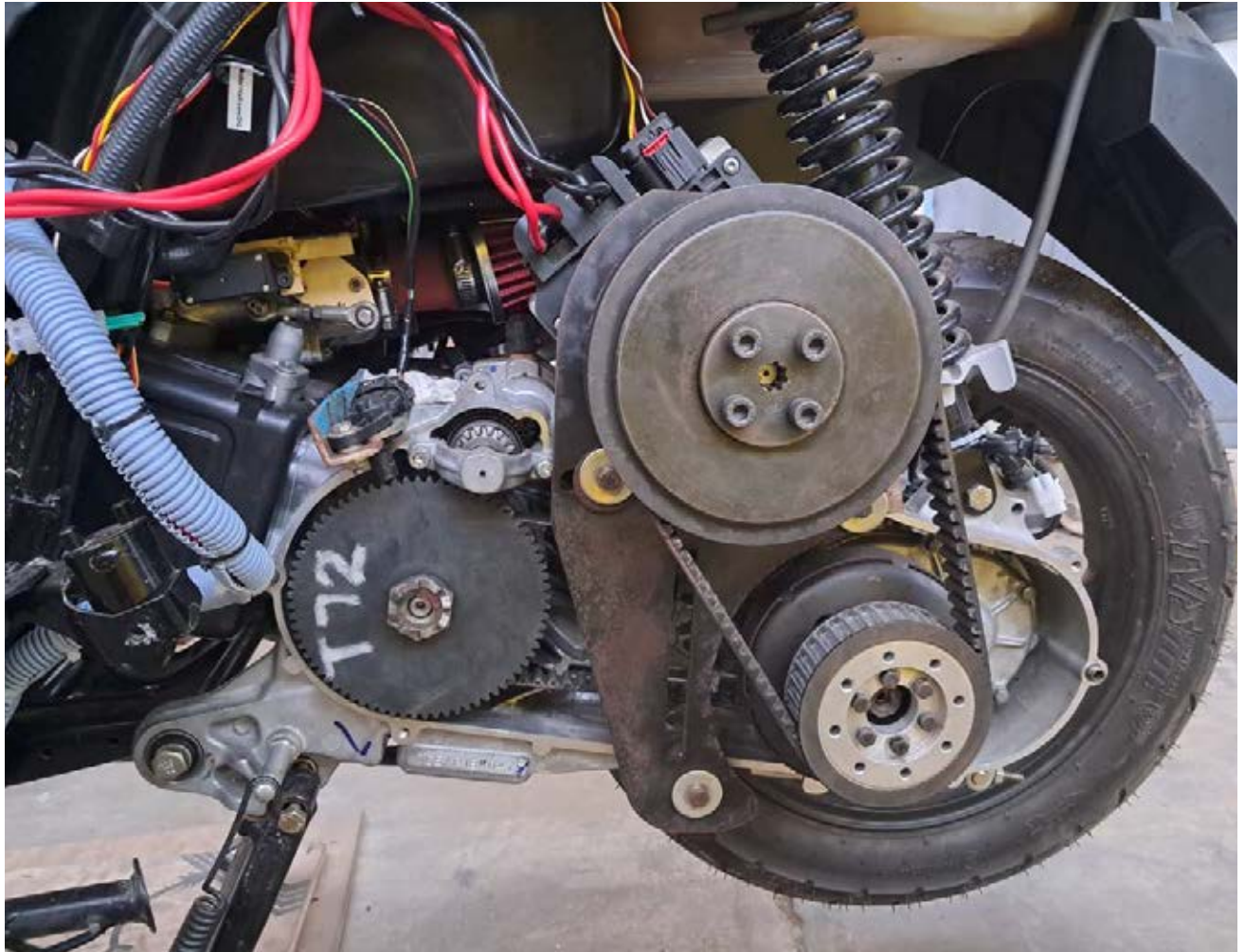
After the conventional powertrain model was validated, three different powertrain topologies were simulated to check the working of the model in different hybrid powertrain topologies. The results were also presented to all the partners for their suggestions.

Battery Pack and Simulator

It has been proposed to use Lead acid batteries for the evaluation of the hybrid drive in test bench due to safety concerns in the test rig. A battery pack with four lead acid batteries has been developed. This was tested for its OCV vs SOC, Internal resistance vs SOC at different charging/discharging rates. In addition to these steady curves, transient behavior of the battery was also tested during step charging and discharging cycles. These experiments were done to characterize the existing lead-acid battery and also to validate the methodology of testing and model development of Li-ion battery. On the test bed the lead acid batteries will be used but a simulation model will enable the performance of the equivalent Li-ion battery to be simultaneously captured.

Conceptualization and simulation of a Two Speed Drive for Hybrid Electric Direct Drive (HEDD) layout

From simulations, it is evident that 2-speed HEDD topology is superior to 1-speed in terms of grade-ability, acceleration and fuel economy. And it was also observed the need of a shifting mechanism which is both speed and torque sensitive. The gearbox has to be mechanically automated to replace the CVT without losing the fun-to-ride aspect of the scooter. Hence, a shifting mechanism which is speed and torque sensitive is conceptualized and simulated using multi-body dynamics simulation tool for its validation. Currently a gear drive (planetary gear train, belt/chain drive, etc.) which can fit in the two-wheeler powertrain is being analyzed.



Model of the hybrid drive being developed

TVS Motor Company, Hosur (TVSM)

TVSM supported IITM team in conducting test for verification of the CVT model and collection of emission test data. TVSM is supporting the 5th milestone with respect to the feasibility of component integration & development. Work related to the 7th milestone is under progress.

The lithium-ion batteries needed for the initial development and also two 5 kW motors have been provided for the work. The needed engines have also been provided for

modification into the HEDD drive layout and also for the transient evaluation.

Several discussions on the comparison of the different layouts and also the development of the parts of the HEDD layout have taken place. The parts list for manufacturing has been confirmed and the drawings are being checked so that they can be fabricated and provided to IITM. Simultaneously discussions are also on with RWTH to obtain the parts list from them for fabrication.

RWTH Aachen University, Aachen (RWTH)

Integrate the models and implement different hybrid topologies and combinations of subsystem components in the model

The component models developed by the different partners were combined utilizing HERCET framework to a hybrid topology simulation for a hybrid concept, which can be compared to the conventional drive train. The simulation model for the ePGS drive train is ongoing and almost finished. The first results are promising, but a detailed analysis needs to be done within the next weeks.

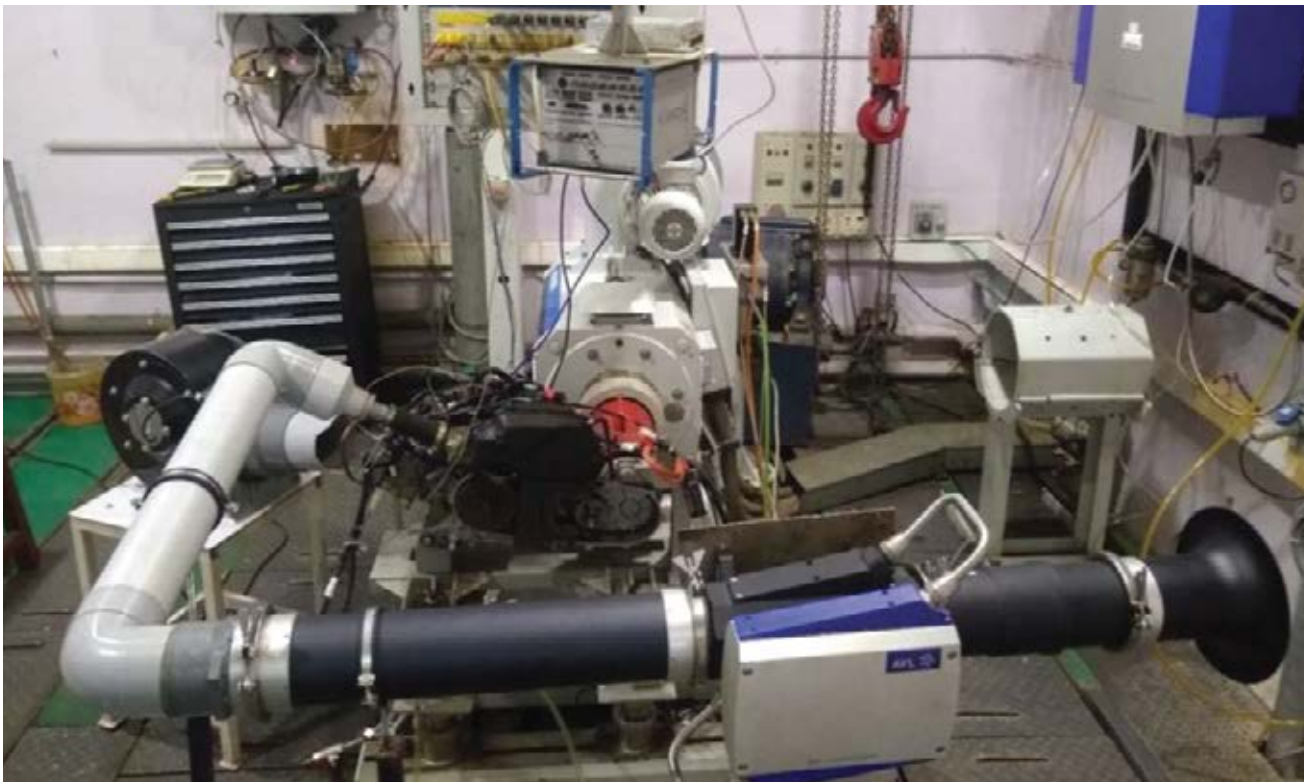
Simulation work has been carried out to determine the maximum power needed for the electric machine. The hybrid layout has been prepared and initial discussions with TVSM have been conducted for the fabrication.

VEMAC GmbH & Co. KG

The Vehicle Control Unit hardware and the software Version 1 have been developed successfully and also tested on a hybrid Go Kart in RWTH. The developed VCU has been provided to IITM and will now be tested in various stages before being inducted into the drive. Discussions are also on in connection with on the controller working and integration.

Publications

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Engine under evaluation on the transient test bed

ElectroH₂O

Effect-based monitoring demonstrates efficiency of electrically - driven water treatment processes to remove salts and micropollutants from process water

Project Brief

The project aims to improve the process of water treatment in industries to reduce harmful toxicological effects in receiving environments. One promising technology to address the problems of desalination and dye removal is Capacitive Deionization (CDI). Compared to reverse osmosis, flow CDI can deal with highly concentrated brines and suffers less from organic fouling. Micropollutants will be removed by a synergetic combination of CDI and Advanced Oxidation Processes. The novel treatment technologies will be scaled-up and piloted in the textile industry. The findings will enable replication and transfer to other key industries. Water quality and treatment efficiency will be monitored by emerging effect-based methods (EBM), which are complementary to chemical target analyses. The advantage of EBM is that they provide a holistic indication of toxicological effects from complex mixtures typical of process waters, which covers

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unknown oxidation by-products and synergistic effects. A bioassay test battery will be developed and transferred from Germany to India.

EffectroH₂O targets the United Nations Environment Programme Sustainable Development Goals 6 to "Ensure availability and sustainable management of water and sanitation for all" by contributing to the reduction of water consumption in water-scarce regions such as India.

The technologies will be studied at a lab scale and subsequently scaled up and piloted in the textile industry: M/s Rohini Textiles ETP and Kunnakalpalayam CETP. The findings will enable replication and transfer to other key industries. The major pollutants present in textile effluent are recalcitrant organics, dyes, salts, and other toxicants. Advanced Oxidation Processes (AOP) for wastewater treatment experiments were performed. It included several bench-scale experiments, reactor studies, and pilot-scale treatment system evaluations to test the effectiveness of the electroperoxone process for treating dye bath effluent and synthetic wastewater. Based on the study results, various strategies for textile wastewater treatment are suggested, and the effects of different dyes and cathodes on the AOP process were investigated. Capacitive Deionization (CDI), a technology that removes ions from water using a low-voltage electrical field, was studied. In this study, the performance of fixed electrode capacitive deionization (Fixed CDI) in various capacity and pilot scale systems using synthetic wastewater was tested. Additionally, the effects of flow rate in the pilot system and experiments with flow capacitive deionization setup were also performed, and a new Flow CDI system was fabricated. Studies will be conducted by varying operating conditions of the skid-mounted pilot system in the Rohini textiles and Kunnakalpalayam CETP.

Progress made/achieved

IIT Madras

Test combined Fixed CDI + AO reactor for removal and advanced oxidation of micropollutants with specified synthetic waters and industrial water samples at bench scale, i.e. investigating the order of treatment and the influence of electrode materials are complete. Flow CDI with synthetic wastes were also simultaneously tested. Small-scale CDI pilot testing with some operating parameters is completed. The pilot system (300 litres) for AOP is ready for implementation. A series of treatment systems with AOP and large-scale CDI will be tested on-site at Tirupur by in the next two months (June 2023).



Test site at Tiruppur

RWTH Aachen

The CDI system at RWTH Aachen was tested on tap water and synthetic wastewater with concentrations of 4g/L and 6g/L to evaluate its efficiency. The CDI system had four steps, including purification, concentrate, pre-purify, and post-purify. The CDI system achieved a recovery of 62.50% pure water when

optimized with a flow rate of 180 LPH pure and 108 LPH reject flow, resulting in conductivity of pure water of 1.86 mS/cm. Overall, the small-scale pilot CDI system demonstrated efficient salinity removal, and the operational parameters can be adjusted to optimize the system for different feed water and flow rate conditions. Optimal process conditions were used as initial conditions for FlowCDI experiments. However, the experimental setup had to be improved and optimized (Two-Cell Approach). Synthetic textile waste waters have been successfully desalinated and decolorized in the One-Cell Approach. However, the membrane stability issues could only be resolved by transferring the system to a two-cell approach. The current TRL is 4/5. Further optimization regarding long-term operation of the process and desalination degree for the coupled Two-Cell Approach is required.



Test site at Tiruppur

Goethe-University & iBacon GmbH

The optimization of the test methods to the given environmental conditions in specific endpoints (e.g. high salt concentrations; TAP 2.3) also especially for evaluation the treatment Technology in Lab Scale of treated synthetic mixture (salt mixture) to tested adapted the EBM; the chemical and biological analysis of original textile wastewater samples to identify toxic drivers (TAP 2.5). The establishment of a textile-related Database for specific target analytic of textile wastewater and periodization of toxic Substances.

In addition, the project partners dealt with the dissemination and publication of the project and processes of the project-specific homepage (www.efectro.org), the presentation of the results at the international and national conference SETAC (Europe and GLB), poster presentation in CHAINS event conducted by IIT Madras for industry research collaboration and completion of a project description and short review for publication in an interdisciplinary scientific journal.



Project Team at RWTH Aachen

CO₂ and Biomass as feedstock for the production of fuels and chemical intermediates

Project Brief

Catalytic processes that are ecologically & economically advantageous form the base of sustainable value chains in the industry. However, fossil resources are currently used as the primary raw materials in the production of fuels and in the chemical industries. In the CO₂BioFeed project, a consortium of academic institutions and industry partners from India and Germany are collaborating to use Carbon dioxide (CO₂) and biomass as sustainable feedstock to produce high value chemical intermediates such as epoxides and acrylates.

CO₂ plays an important role as a soft oxidizing agent for the epoxidation of short-chain alkenes and other highly valuable follow-up products. It can be also used as a carboxylating agent to produce acrylic/methacrylic acid. Carbon monoxide (CO), obtained as a renewable by-product can be utilized in other industry-relevant production processes.

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Furthermore, a key process in the industrial value chain to produce a basic chemical containing only carbon from sustainable sources will be compared via a Life Cycle Assessment (LCA). The main goal of the project is to scale-up the process to industrial scopes, confirm the performance of the newly developed catalysts under industrial conditions and assess the cost benefits and environmental impact of the processes.

Progress made/achieved

Indian Association for the Cultivation of Science (IACS)/IIT(ISM), Dhanbad/ Reliance Industries Ltd. (RIL)

The work on carboxylation and epoxidation of propylene and ethylene has further progressed in India. Functional MOFs (Cr-MIL-101, Fe-MIL-101) and functionalized mesoporous silicas (Fe-SBA15, CeO₂-SBA15, ZrO₂-SBA15, Pd-SBA15) have been synthesized through solvothermal crystallization in autoclave at refluxing conditions. These highly porous support materials were impregnated with reactive Ag nanoparticles (NPs) through wet impregnation. In addition, metal organic materials (Pd-NHC, Ag-DVB, Ru-CTF) have been prepared and were sent to Germany for evaluating ethylene carboxylation and epoxidation using CO₂.

IIT (ISM) Dhanbad and IACS, Kolkata developed and characterized mesoporous TaPO₄ catalyst for synthesizing acrolein and glycerol carbonate from glycerol. As acrolein and glycerol carbonate are value-added chemicals, the design of catalysts for production from glycerol, which can be obtained from biomass, is an important finding. The process for the production of acrolein has been optimized. At IIT (ISM) Dhanbad a high pressure and high temperature online autoclave reactor has been procured, installed and trial reactions are in progress to check safety issues (Figure 3). Online GC-MS has been installed on March 5, 2022 and is operational now.



Online high-pressure and high temperature autoclave reactor integrated with GC at IIT (ISM) Dhanbad

Reliance Industries Ltd. (RIL) developed various mixed metal oxide and supported metal oxide catalysts. The performance evaluations for various carboxylation and glycerol conversions are being evaluated at IACS Kolkata. Further, RIL's high pressure fixed bed reactor is ready for performance evaluation. Online GC installations are completed in March 2023 (Figure 4). The data generated serves as input for process simulation. RIL, RWE and RUB joined in discussing and contributing to the safety concept necessary for any test runs on the pilot plant scale.

Ruhr-Universität Bochum (RUB)

Process simulation is 75% completed. Furthermore, CO₂-activation and adsorption of atomic oxygen on the catalyst surface, was explored with a RUB-made ceria and indium oxide catalysts to derive process simulation data and identify the process window for operating the high-temperature mini-plant. For further process validation and development an on-line gas chromatograph was received based on project funding and integrated for analytical purposes into an existing setup at RUB together with the experimental Berty-Reactor by Parr Germany, which can be operated at 200 bar and 300 °C. Several catalysts from the Indian project partners were received and were tested in various stages with regard to both characterisation and process development.

Process simulation was initiated and CO₂-activation & adsorption of atomic oxygen on the catalyst surface were explored with RUB made ceria and indium oxide catalysts to derive process simulation data and identify the process window for operating the high-temperature mini plant. For further process validation and development, an online gas chromatograph was received and integrated for analytical purposes together with the experimental Berty-Reactor into an existing setup at RUB.



Main module of the new RWE pilot plant, status as of February 2023

Novel catalysts based on redox-active multi metal oxides with supported metallic silver have been developed and characterised by IR, BET, SEM-EDX, XRD and XPS measurements (IIT/RUB). Evaluation results (RUB) show that the materials are capable to transfer oxygen to alkenes. Also, successful reoxidation of the oxides with CO₂ has been proven with concomitant formation of CO. Optimization for steering selectivity of oxygen transfer to alkenes is in progress (IIT/RUB). Furthermore, the silver doped molybdenum tellurium and vanadium mixed oxide produced in oxygen limited oxidation experiments with propene, mainly acrolein and acetone, but also propene oxide at 400-500 °C. Narrowing the process window and shifting the selectivity towards the propene oxide are underway. Additional safety measures are being implemented for conversion of ethene to ethylene oxide (RUB).

RWE Power A bifunctional catalyst combining the RWGS activity and CC coupling propensity of Fe with a base (K₂O/Al₂O₃) in spatially separated functions shows excellent performance in the one-step conversion of CO₂ to alkenes (RUB). Integral and differential kinetics was investigated in a fixed-bed (supplied by Parr). The reaction will be piloted in the new pilot-plant facilities that become available in Q3/2023 (RWE).

Parr Germany. The combined knowledge of the consortium in the areas of catalyst and process development was used to construct a Mini-Plant fitting our purpose and was engineered by Parr into a novel high-temperature Berty-Reactor.

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DEMO-Multi-WAP

Demonstration of Multi-WAP results leading to novel, validated multiplexed, label-free fiberoptic biosensor array system for waterborne pathogen detection

Project Brief

The aim of DEMO-Multi-WAP (Phase 2), is to bring to the market a device and ready-to-use test kits ('plug & play' cartridges) for waterborne pathogens detection (TRL6-7). The platform is a multiplexed, rapid, label-free, and real-time method for continuous monitoring multiple waterborne pathogens present in water samples at low cost and high sensitivity (>90%). Apart from relying on existing antibodies at LIONEX, our aim was to further investigate and produce stable biofunctionalized plasma-treated and silanized fibers with different biomarkers to boost additional applications of the platform. A commercial product is the clear end focus of the partners. The German and Indian partners have succeeded in fulfilling most of their milestones, despite the difficulties posed by the COVID-19 crisis. In addition to environmental

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monitoring, the proposed fibreoptic array biosensor (FAB) technology has a strong potential in clinical diagnostics and biomolecular interactions, which are important for pharmaceutical industry.

At IIT Madras, the platform point of care version with a manual loading of fragile probes, a more rugged, user-friendly cartridge-based ArFAB with an automated process for cartridge-holding and sample incubation was developed and documented. Significant changes were in the design of the ArFAB were made to realize the current version. A few more fine tunings are necessary before arriving at TRL8. The market research was carried out by ChemBioSens to identify potential domains of application of ArFAB technology including waterborne pathogen detection as well as food borne pathogen detection. At IOT, functionalizing stability was shown on 5 separate FOP batches using Ar gas of different purity. Averaged value for absorbance at 495 nm for FITC- derivatized FOP is $0,285 \pm 0,038$. The concept of low-cost set-up with using two commercially available LED of correspondent emission wavelength (cyan 490-495 nm and orange 600-610 nm) was developed. Test runs of the built reactor prototype show good discharge uniformity and thermal stability of the reactor. All these can decrease expenses in industrial application of the technology. A new semi-final draft Failure Mode and Effects Analysis (FMEA) in compliance with DIN EN ISO 14971 was prepared. Drafts of PDP-related files are nearly finalized. Since the platform can later be used also for clinical diagnostics by replacing the biomarker, LIONEX began

drafting a Performance-Evaluation-Plan document that is 100% compliant with the new IVDR requirements which must be implemented before 2026. LIONEX selected and produced further batches of arrays' biomarkers. The optimization of antibodies immobilization was done at LIONEX in the label free protocol on OCTET robotic platform using different buffers and concentrations. This protocol will be used as a comparison with the DEMO Multi-WAP platform. To fasten the Demonstration of ArFAB for simultaneous detection of multiple pathogens, several antibodies, and antigens (16 Abs/Ags) were sent to IITM. In the last annual meeting of the 2+2 project partners which took place at LIONEX in Braunschweig, the plans for the coming months, especially for performance studies and future applications, were discussed.

Based on all these results, the technology developed is currently at TRL 6-7, and project consortia are striving for TRL 8-9 by the end of 2025. This high TRL level is also reflected in the fact that the consortium is entirely made up of SMEs, high- tech research organizations, most of which already have a long-standing collaboration and experience in such areas.

Finally, it's worth pointing out that the technology that was developed in this project is quite generic in the sense that by changing the antibodies, different assays can be run on the same hardware, e.g., monitoring of infectious/cancer markers in urine.

Progress made/achieved

- Automated fiber bending machine – A more robust and replicable machine was developed with capacity to bend silica optical fibers to fabricate as many as 50 U-bent fiber optic sensor probes in an hour. A complete documentation for replication of the machine is now available for the transfer of technology (ToT)
 - Fiber probe polishing machine – A customized bare fiber polishing machine with three polishing sheets (5, 3 and 0.5 μm grit on three independent discs) for the polishing fiber distal ends of the U-bent probes for an efficient optical coupling was developed and documented.
 - Fiber probe cartridge – A cartridge to conveniently hold the U-bent fiber sensor probe during the bio/chemical process and testing was designed, fabricated and tested. This cartridge is designed work in both disposable and reusable forms and tremendously improves the user-friendliness in handling.
 - Array Fiber optic absorbance biosensor (ArFAB) – Subsequent to the PoC version with a manual loading of fragile probes, a more rugged, user-friendly cartridge-based ArFAB with an automated process for cartridge-holding and sample incubation was developed and documented. Significant changes were in the design of the ArFAB were made to realize the current version. A few more fine-tunings are necessary before arriving at TRL8.
- Three different designs of reactor for simultaneous plasma-treatment and silanization of 8 U- bent probes, mounted into a cartridge, were developed. After models building and testing the conveyor-type reactor was selected for further development and a working prototype was built.
- Functionalizing stability was shown on 5 separate FOP batches using Ar gas of different purity. Averaged value for absorbance at 495 nm for FITC-derivatized FOP is $0,285 \pm 0,038$.
 - The concept of low-cost set-up with using two commercially available LED of correspondent emission wavelength (cyan 490-495 nm and orange 600-610 nm) was developed.



Fabricated 8 channel Array Biosensor Prototype before and after loading the fiber probe cartridges

- Test runs of the built reactor prototype show good discharge uniformity and thermal stability of the reactor.
- Treatment parameters were optimized both for plasma-pretreatment part and for gas- phase silanization part.
- Middle-cost HV generator (Information Unlimited, USA) was mounted into dielectric compartment and equipped with safety switch to work with the standard research plasma-box.
- Using of technical-purity argon gas (Ar 4.6) as a plasma-forming gas and as silanization reagent carrier shows suitable results comparing to high-purity argon gas (Ar 6.0). It can decrease expenses in industrial application of the technology.
- The market research was carried out by ChemBioSens to identify potential domains of application of ArFAB technology including waterborne pathogen detection and food borne pathogen detection, where several of the relevant industries were contacted for firsthand information and requirements. Waterborne pathogen detection is of interest to government agencies only, where the volumes are not big enough for a sustainable business model. On the other hand, the market assessment study food borne pathogen detection has a good market especially in the meat industry with focus on exports. The ArFAB will be finetuned to suit the requirements of food borne pathogen detection.
- A new semi-final draft Failure Mode and Effects Analysis (FMEA) in compliance with DIN EN ISO 14971 was prepared.
- Drafts of PDP-related files are semi-finalized.
- Labels and instructions will be provided to the user with all information essential for the safe and reliable use of the product in accordance with DIN EN ISO 18113-1 and DIN EN ISO 18113-2. All these labels and symbols shall be applied to all pilot batches.
- Since the platform can be used for clinical diagnostics by replacing the biomarker, LIONEX began drafting a Performance-Evaluation-Plan document that is 100% compliant with the new IVDR requirements.
- LIONEX selected further batches of the final arrays' biomarkers. Further batches of quality-controlled anti-LAM, anti-E. coli, anti-FimH and anti-fliC antibodies were produced.
- The optimization of antibodies immobilization was done at LIONEX in the label free protocol on octet platform using different buffers and concentration. This protocol will be used as a comparison with the DEMO Multi-WAP platform.
- More batches were produced of M. bovis and M. tuberculosis LAM and lipoglycans.
- Started developing new and novel methods for LAM purification and QC using unique platform. Several batches of quality-controlled anti-LAM antibodies were produced, with KD around 10⁻⁸ – 10⁻⁹.
- To fasten the Demonstration of ArFAB for simultaneous detection of multiple pathogens and the performance studies at Indian Institute of Technology Madras (IIT) before the final performance evaluation study. Several antibodies and antigens (16 Abs/Ags) were sent to IITM.



ADVANCED MANUFACTURING





Metal powder production for additive manufacturing

Project Brief

For manufacturing of objects using laser powder bed fusion (LPBF), a fine metal powder is solidified in layers using a focused laser beam. The properties of the product strongly depend on the uniformity of size and consistency of the powder particles. PPAM addresses the production of steel powder for LPBF using close-coupled atomization and strives to better understand and model the process to achieve a uniform size and porosity of the powder particles. Generic experiments, numerical simulations and pilot plant operation are used in combination to develop validated, predictive capabilities and design guidelines for full-scale facilities. Scientifically, the challenge lies in modelling the complex liquid metal atomization involving extreme process conditions and material properties. The results will be of immediate competitive benefit to the collaborating companies, one as a manufacturer of such powder production facilities and one as an end-user. Improved quality, lower cost and an expanded product design parameter space can be expected.

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IIT Kharagpur



Suvankar Ganguly

Tata Steel Ltd



Cameron Tropea

Technische Universität
Darmstadt (TUDa)



Hans-Jürgen Odenthal

SMS Group GmbH

The main objectives of the research include

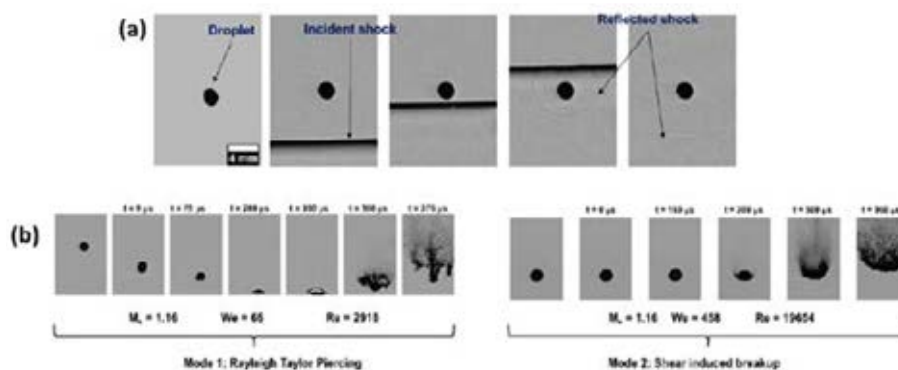
- Improved understanding of atomization nozzle design and operating parameter influence on particle size distribution and powder properties
- Development of validated, physics-based, semi-empirical models, allowing predictive numerical simulations of the deformation, atomization and solidification stages for powder production. Increase TRL of predictive capabilities from 2 to 6.
- Realization of improved nozzle designs and operation in production facilities.
- Realization of narrow powder size distribution with close-coupled atomization
- Characterization of improved mechanical properties of laser powder bed fusion manufactured components with powder of decreased polydispersity
- Achievement of lower powder production costs

**Progress
made/achieved**

IISc Bangalore

Shock-droplet interactions (Breakup Mechanism)

The global observation of the shock-droplet interaction phenomenon is shown below. The whole phenomenon of interaction can be divided into two stages. Stage I corresponds to the initial interaction where different types of interaction waves, such as reflected waves, transmitted waves, refracted waves, and Mach stems are formed, which locally change the flow and fluid properties around the droplet. During this stage, the droplet remains unaffected by the changes around its periphery. Stage II of interaction includes droplet breakup dynamics, where the droplet starts to deform in shape due to aerodynamic forces acting on its surface. The continuous deformation of the droplet then results in its rupture. Based on the governing dimensionless numbers, two modes of droplet breakup were obtained. Rayleigh-Taylor instability based breakup mode was observed for smaller droplet sizes, while for larger droplets, shear-induced stripping of tiny droplets were observed from the mother droplet periphery.



Stages of shock droplet interaction: a) Stage 1: initial shock interaction, and b) Stage 2: droplet breakup dynamics

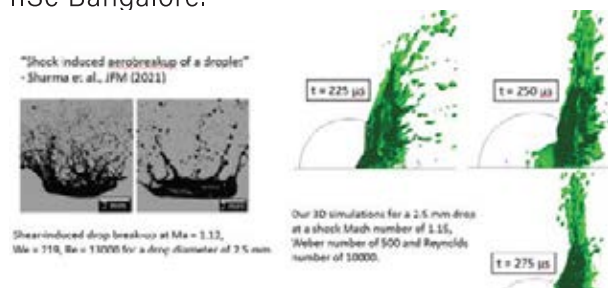
IIT Kharagpur

2D simulations of droplet-shock interaction

IIT Kharagpur carried out a model validation study between their numerical results and the experimental results performed at IISc Bangalore and have qualitatively validated their numerical calculations. For higher Weber number, K-H instabilities are initiated near the pole on the windward side which travel towards the equator and form ligaments. The rupture of these ligaments due to the high shear gives rise to the ultimate shear-induced breakup of the drop at the high value of Weber number.

3D simulations of droplet-shock interaction.

To consider the effect of third dimension of the domain in the analysis and incorporate the 3D nature of the flow field in the analysis, they have again performed 3D numerical simulations and compared the results with the work performed at TUDa and SMS Group. The figure shows excellent matching between the numerical and the experimental results of IISc Bangalore.

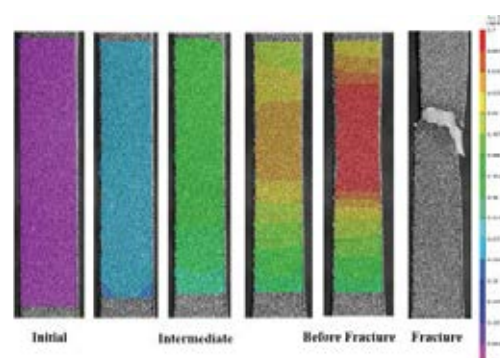


Comparison between numerical (IIT Kgp) and experimental (partner IISc) results.

Tata Steel Ltd.

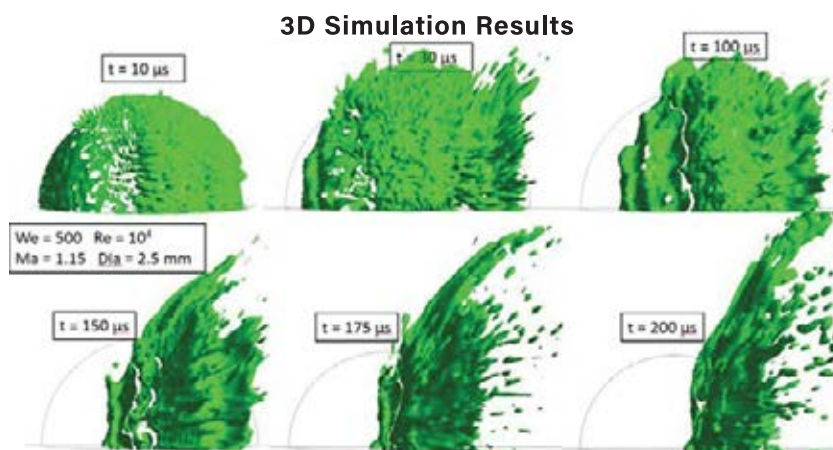
Experimental additive manufacturing: Sample property measurements

ASTM based sub-standard sized dog-bone specimen was considered for testing. The specimen (10 numbers) was then fabricated by employing the finished metal powder supplied by the SMS group. The printing was done through the Selective Laser Melting (SLM) process, which forms the product by selectively melting the successive layers of the powder with the interaction of the laser beam. Primarily, the metal substrate is preheated, and the part is printed three- dimensionally by layer-on-layer method. A solid-state LASER source is directed on to powder bed for localised melting of powder. To prevent oxidation during the 3-D printing process, the chamber is filled with inert gas which maintains the oxygen levels $< 0.1\%$. Once, final layer of printing is accomplished the build structure is cooled for a short period.



Distribution during the elongation of dog-bone specimen at different time instants.

3D Simulation Results



Droplet breakup features seen in case of a 3D simulation for a high value of Weber number

TU Darmstadt (TUDa)

Following the analysis of the data sets obtained from atomization runs performed at the powder production plant operated by the partner SMS in Mönchengladbach, TUDa has provided the partner SMS with an extensive data set containing particle size and velocity data obtained at the research facility for a water spray by means of the phase Doppler measurement technique. This data covers a wide range of set points of operation, that is, gas stagnation pressures and liquid mass flow rates. Furthermore, the data includes global particle size distributions, which have been calculated from local particle size distributions obtained at different spatial position in the spray. The data set summarizes the sensitivities of the atomization result to changes in the set point of operation, the physical properties of the working liquid and the geometric design of the atomizer unit, which have been observed for the atomization of water.

SMS Group GmbH

Implementation of the atomization model in code

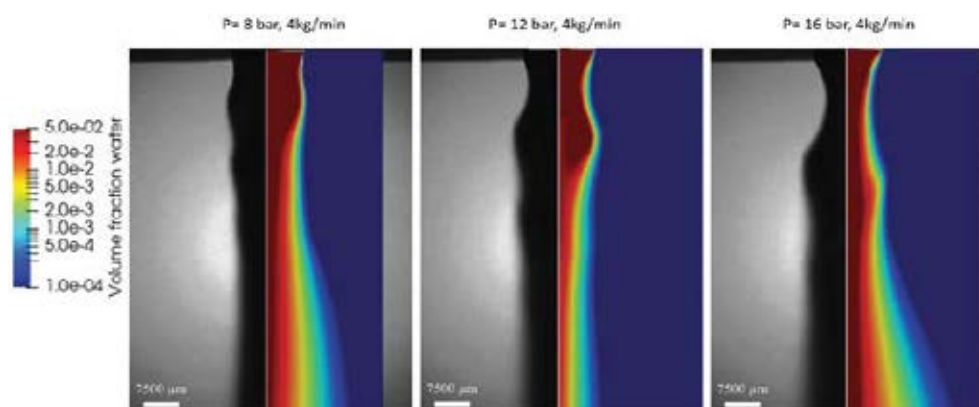
In the last reporting period, a secondary breakup model was developed by our partner

TUDa. It is a novel model that distinguishes between supersonic and subsonic droplet breakup. In this report, this model is referred to as DARTS model. The part of the model that describes the droplet breakup in the subsonic region is called ART model. The model was implemented in OpenFOAM in a way that allows to select all secondary breakup models as the subsonic part of DARTS model.

Salient Research Achievements

In the shock-droplet interaction experiments, the following objectives have been achieved:

- Design, fabrication, installation, and testing of the shock tube setup have been completed.
- Experimental data pertaining to the shock-droplet interaction has been obtained and analysed for water and galinstan.
- The mechanisms responsible for the droplet breakup have been described as a function of the non-dimensional flow numbers characterizing the flow.
- Experimental data has been obtained and analysed for the daughter droplets resulting from the shock-droplet interaction.
- Design, fabrication, and installation of



Volume fraction of water calculated with a Schmidt Number of $S_{ct} = 2$ compared with shadowgraphs for an air pressure of 8, 12 and 16 bar and a water flow rate of 4 kg/min.

supersonic flow wind tunnel setup has been completed.

In the metal powder property assessment and its strength testing, the following objectives have been achieved:

- The particle size distribution, surface morphology and composition of metal powder supplied by the SMS group has been determined and validated with provided data.
- Tensile test results obtained at TATA steel have been found to match fairly well with the results of the SMS group.

In the laboratory facility, the following achievements have been made:

- The phase Doppler particle analyzer has been set up for measuring particularly small particles exposed to a supersonic flow.
- Particle size and velocity measurements have been successfully performed for varying set points of operation.
- A comprehensive software package has been developed and implemented, which is capable of analyzing and statistically assessing phase Doppler data.
- The influence of the set point of operation, the physical properties of the working liquid and the geometric design of the atomizer unit on the atomization result has been investigated and documented.
- Visualization of the atomization process has been used to identify and described mechanisms responsible for primary and secondary atomization.

In atomization model development, following objectives have been achieved:

- Dimensionless quantities describing the interaction of a liquid volume and a supersonic gas flow have been derived.
- The liquid dynamic viscosity has been shown to not have an influence on the atomization result.
- A characteristic length scale for the particle size produced by the close-coupled atomizer has been derived and successfully compared to phase Doppler measurements.

- The main mechanism responsible for the atomization has been identified to be the interaction between the liquid and the shear layer of the supersonic gas flow.

Publications

Sharma, S.; Rao, S.J.; Chandra, N.K.; Kumar, A.; Basu, S.; Tropea, C.: Depth from defocus technique applied to unsteady shock-drop secondary atomization, Experiments in Fluids, 2023

Apell, N.; Tropea, C.; Roisman, I. V.; Hussong, J.: Application of the Phase Doppler Measurement Technique for the Characterization of Supersonic Gas Atomization, LXLASER 2022: 20th International Symposium on Applications of Laser and Imaging Techniques to Fluid Mechanics, Lisbon, 11 – 14 July 2022

Apell, N.; Roisman, I. V.; Tropea, C.; Hussong, J.: Modeling of the Characteristic Size of Drops in a Spray Produced by the Supersonic Gas Atomization Process, ILASS Europe 2022: 31st European Conference on Liquid Atomization and Spray Systems, Tel Aviv (virtual), 6 – 8 September 2022

Wilkens, Y.; Brune, T.; Odenthal, H.-J.; Vogl, N.: Production of high-grade metal powder for additive manufacturing by using the powder atomization plant of SMS group, World PM2022 Congress & Exhibition, Lyon (France), 9 – 13 October 2022

PhD / Master thesis supervised

Mirschinka, D. (2022): Experimental investigation of primary mechanisms in supersonic gas atomization. Master thesis. Technische Universität Darmstadt, Darmstadt, Germany. Institute for Fluid Mechanics and Aerodynamics

Sharma, S. (2023): Secondary atomisation of a droplet in diverse interaction settings. Ph.D. thesis. Department of Mechanical Engineering, Indian Institute of Science, Bangalore, India

High strength spring steels with reduced low temperature creep for light weight designs

Project Brief

Downsizing and light weight design of all automotive components especially in chassis area is underway. Higher stress acts on spring material due to its lightweight design. The springs which are currently used may not be able withstand the high stress. Hence, there is a need for the development of advanced spring steels with a combination of higher tensile strength (>2000 MPa), adequate ductility, improved low temperature creep resistance and better high cycle fatigue properties. This can be achieved by suitable alloying strategies, fabrication technologies and heat treatments. This consortium aims to develop an advanced spring steel grade with the improved mechanical properties by lab scale, pilot scale and industrial scale melting by continuous optimization of process parameters, fabrication technologies and heat treatments. The underlying micromechanics of plasticity leading to better

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Steffen Klapprott
Muhr und Bender KG
(MUB)

mechanical properties in comparison to current state of the art materials will be determined by comprehensive microstructural characterization. Detailed experiments will be conducted and a phenomenological description will be developed to understand the improved low temperature creep properties based on the micro mechanisms deduced. The role of residual stresses in imparting better low temperature creep properties and high cycle fatigue life will also be investigated. Springs will be manufactured out of the developed steel with optimized chemical composition and field tests will be conducted. This development of a new spring steel grade will be achieved by close interaction between a steel maker (JSW), academic institutes (UoH and USI) and the spring manufacturer (MUB).

University of Hyderabad (UoH)

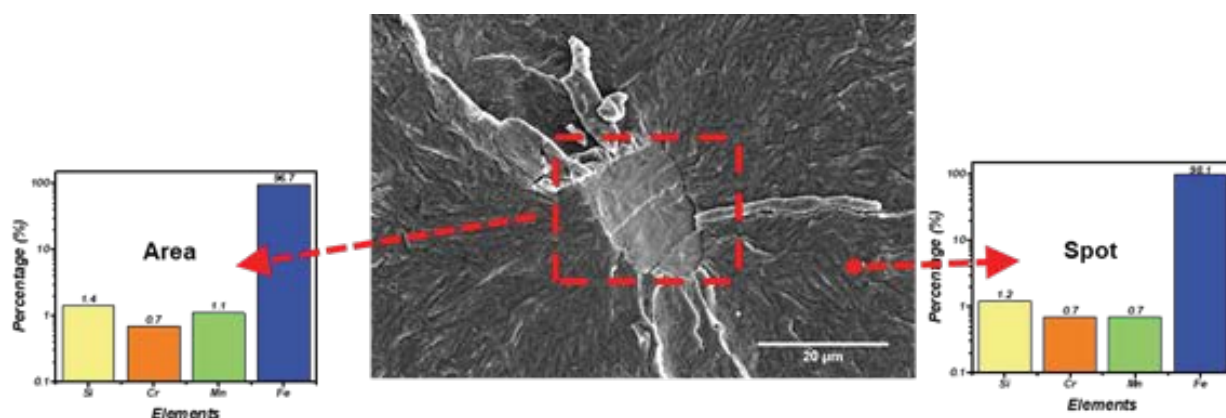
Experimental evidence of the suggested steel grade and heat treatment

The consortium proposed the pilot scale melting of 3 compositions (i.e., by adding 0.04, 0.06 and 0.15 Nb, by wt. % to SAE 9254)

to reduce the volume fraction of like retained austenite (RA) in high strength steels (HSS) vis-a-vis improving the tensile and Low temperature creep (LTC) resistance. UoH has carried out the microstructural and phase characterization studies with the consortium to finalize the composition with reduced RA. The RA content and prior austenite grain size (PAGS) were evaluated for the samples.

To gain a better understanding of the microstructure, tensile deformation, LTC behavior, and HCF behavior of newly developed alloy steel.

UoH also completed high-cycle fatigue (HCF) testing of ITW SAE 9254 at two different load ratios at various percentages of its yield strength (YS) and understood the HCF behavior. The samples at different stress ratios exhibited varied fatigue limits owing to the varying amplitude stresses. A few fractured samples showed fish-eye cracking due to alloy segregation, as confirmed by EDS.



Fish eye cracking originating from PAGB and their respective EDS analyses

JSW Steels Salem (JSW)

Profound proposal of steel grade and heat treatment

JSW Steel Ltd. has completed the pilot melting of new steel grade SAE 9254 with Nb (0.06 and 0.15 Nb, by wt.%). The steel ingots are forged to size 30-35 mm rods for quenching and tempering (QT). HT condition of austenization at 950 °C for 30 min and tempering at 350 °C for 30 min were carried out. The UTS of >2100 MPa and RoA of >30% were achieved in the QT condition of new steel of SAE 9254 containing Nb 0.15%. The samples are forwarded to UoH for further material characterization and fatigue studies.

Universität Siegen (USI)

Substantiation of hypothesis by extensive mechanical testing and microstructural characterization

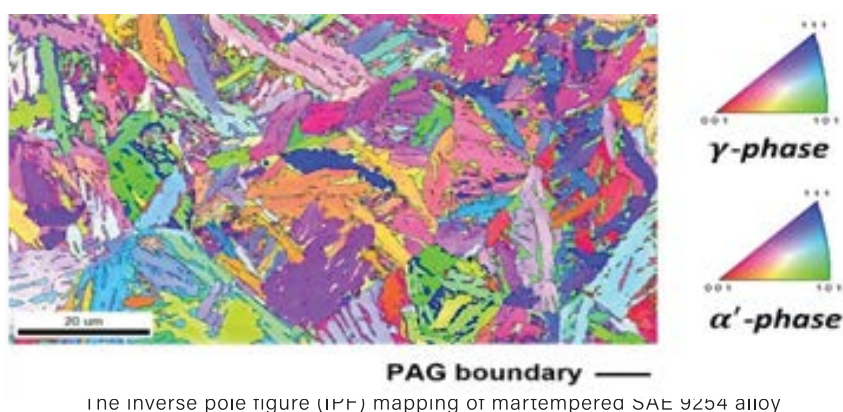
Although the LTC results of IQT SAE 9254 are favorable to propose a hypothesis that metastable RA in HSS is responsible for LTC, it is challenging to provide experimental evidence since IQT SAE 9254 have low RA content. Hence, USI seek the expertise of UoH to increase the RA content of SAE 9254 to 30 % through Martempering technology. The microstructure of martempered SAE 9254 is investigated with the aid of SEM-EBSD.

Mubea Fahrwerksfedern GmbH (MUB)

Profound proposal of steel grade and heat treatment

Since metastable RA in HSS seems to be the sole contributor to LTC. MUB is focused on optimizing the in-house heat treatment technology parameters to tailor the austenite the RA quantity, size, and morphology in HSS with the support of USI.

MUB has recently received a newly developed steel grade (SAE 9254 + 0.12 Nb, wt. %) from JSW, which has shown good drawability during the wire drawing process. The wire was then subjected to inductive heat treatment to achieve a desired UTS of >2000 MPa and a RoA of 40%. Ongoing efforts are being made to optimize the heat treatment vis-a-vis metallographic examination and determination of the mechanical properties. Once the optimization is completed, MUB will proceed for component production (axle springs) followed by material and component testing to evaluate the performance of the newly developed steel grade.



Salient Research Achievements

Steel4LTC consortium has defined the alloying strategy, fabrication and heat treatment technology within the tight limits imparted by our industrial partners. Owing to the fact that the consortium is targeted to produce a new steel grade for lightweight spring applications, the alloying strategy was defined to vary only C, Si, Cr, Mn, V and Al contents. Fabrication technology is set according to the industrial partners. Heat treatment technology limited to quench & tempering (QT) process either by means of furnace or inductive. Thus, the consortium achieved the milestone #1.

SAE 9254 (0.53 C, 1.32 Si, 0.71 Cr, 0.69 Mn) steel grade was considered to optimize the heat treatment parameters to achieve milestone #2, i.e. ultimate tensile strength (UTS) in the range of 2000-2200 MPa with reduction of area (RoA) higher than 20%. Experiments performed by academic partners revealed that a UTS of more than 2100 MPa with an RoA of 30% can be achieved by the furnace QT process.

According to the recommendation of the German industrial partner MUB, the consortium set the target for RoA to be persistently higher than 30% for UTS in the range of 2000-2200 MPa. Furthermore, the steel grade must have high resistance to the low temperature creep (LTC), i.e. time dependent deformation at RT-80°C. Since these two criteria can't be met by SAE 9254

steel grade, the alloying and heat treatment strategy requires the necessary adjustments, i.e. strength mainly contributed by precipitation hardening, solid solution strengthening mechanisms. In this aspect, the knowledge gained on the impact of heat treatment parameters on the mechanical properties and the microstructural features (a part of work done relevant to the milestone #3) can be applied to develop the new steel grade with required mechanical properties. LTC rate controlling mechanism in spring steel is formulated as localized plasticity along with phase transformations in soft phase like retained austenite (RA).

Thus, the creep resistance of new steel grade is expected to be improved by wisely choosing the alloying elements that lowers the retained austenite quantity. The alloying elements Si, Mn and Ni act as austenite stabilizers and subsequently result in a higher austenite quantity. By refining the grain sizes, the alloying element Nb promotes higher quantity in the case of austenite localization exclusively on the grain boundaries. So, new steel grade with improved LTC resistance can be developed by strategic variation of the above discussed alloying element quantities.

Publications

N. Remalli et al., "On the low temperature creep controlling mechanism in a high strength spring steel", **Journal of Materials Research and Technology** 21 (2022) 2309-2315.



2nd network meeting at University of Siegen, Germany held on 13th July, 2022.



Project partners with the Materials Processing and Deformation Science Laboratory team at the School of Engineering Sciences and Technology (SEST), University of Hyderabad.

Modular lightweight wastewater treatment units made with TRC for rural and periurban dwellings

Project Brief

Wastewater treatment (WT) is an essential prerequisite for a healthy society. Still 90 % of the worldwide used water enters the environment untreated. Most rural and periurban regions of developing countries have no access to a wastewater treatment plant (WTP), because current mid/big size WTPs require large power supply and space. Currently septic tanks or soak pits are used in many regions that could be replaced with modular and lightweight WT units, which are easy to transport and handle in hard-to-reach locations. The realization of these required systems is possible through the development of high-strength and lightweight materials. By using of durable materials the operating and maintenance costs can be kept as low as possible, which is an important decision criterion concerning the orders. The aim of this project is the realization of an innovative lightweight, modular WTP made with textile reinforced concrete (TRC). The advantage of a modular WTP design lies in a decentralized production facility, whereby all the

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necessary plant components have to be delivered to the construction site and assembled. Within the project a design suitable for the innovative material will be developed. Furthermore, the textile reinforcement and concrete matrix will be developed according to the application. These fundamental developments are followed by designing, dimensioning, numerical simulation using finite element analysis and testing structural components and realization of a demonstrator in form of a complete WTP including proof of bearing capacity and function control on site. In addition, from an economic point of view a suitable production and transportation process, as well as a business case for efficient sale and distribution are developed.

**Progress
made/achieved**

IIT Madras

A concrete matrix for Textile Reinforced Concrete (TRC) was developed, considering the need for larger aggregate sizes suitable for TRC, the availability of materials in India, and cost. The effect of addition of binders and aggregates like fly ash, ground granulated blast furnace slag, quartz sand, and crushed sand on their mechanical and durability properties were evaluated throughout material testing. The tensile capacities of pristine textiles from ITA were also assessed. Additionally, uncoated ITA textiles were coated with SBR and locally sourced epoxy, mimicking ITA's coating, to explore the potential of in-house coating and reduce the need for shipping coated textiles. TRC composites were made with the

fine-grained matrix and ITA textiles (3 layers) were cast and tested. The test results were shared for incorporation in numerical models. To enhance durability, coatings for both the matrix and composites were subjected to acidic attack tests. In a significant step, full-scale rectangular and circular demonstrators were cast in laboratory facilities, marking the initial realization of both versions. To finalize installation locations, site visits were carried out in collaboration with partners.

CSIR-Structural Engineering & Research Centre (SERC)

Structural analysis, design and finite element modelling of baffle TRC WRP unit have been extensively carried out. Based on the studies, 40 mm thick TRC panels with 3 layers of textile reinforcement was recommended for the constructions. A novel fabrication technique has been devised to create both rectangular and circular/cylindrical TRC WTP modular units. The method has been successfully scaled up to fabricate full-scale dimensions of the TRC WTP modular unit. To achieve the full height of the TRC WTP unit, a specialized jointing method for stacking TRC segments was conceived. Prototype TRC WTP rectangular units underwent rigorous experimental investigations, capturing response behaviours such as cracking, ultimate load, and complete failure. Additionally, investigations were carried out to determine joint efficiency and leak-proof characteristics. To further advance the understanding and qualification for on-site implementation, full-scale demonstrators of both rectangular and circular TRC unit variants have been meticulously fabricated.

Raina Industries

For the development of a transport concept, the limiting factors (including availability, size and maximum load weights) of the means of transport were defined. The maximum dimensions for transportation were derived from the design of the equipment, this includes the lengths as well as the weight dimensions. The necessary requirements for the production process were derived from the limitations of transport and the processing properties of textile concrete. Trials were carried out for the placement of textiles and creating small mock curvilinear samples replicating the wall thickness of the STP Plants. Two business models were developed, one targeting customers close by, the other targeting customers in further distance.

RWTH Aachen University

Based on the mechanical and economic properties of high-performance fibre materials and resulting textile properties, a preselection has been conducted. This led to the elimination of rovings with finesses below 1200 tex and above 4800 tex as well as the elimination of carbon fibres. In accordance with the progress of the development of the concrete matrix, the grid opening of the textile reinforcement was adjusted. Based on this, tensile tests and flexural stiffness tests were carried out with two coating systems (styrene-butadiene-rubber and epoxy resin).

A first quantity of textile was sent in coated condition to the Indian partners to perform composite and textile comparative tests. After feedback from the partners, it was further sent for structural component tests. Further coating materials are tested to improve

understanding regarding the effects of varying environmental conditions on material behavior. 350 m² of textile reinforcement were shipped to the Indian industrial partner for fabrication of the demonstrator.

Betonwerk Hentzschel GmbH (HENTZSCHEL)

Based on typical small sewage treatment plants made of (steel) concrete, a cylindrical design of small sewage treatment plants made of textile concrete was derived. The production process was discussed with the Indian industrial partner Raina Ind. The transport and installation process as well as the resulting requirements for the tank were defined for the classic small wastewater treatment plant. The sizing of the plant was predicated on the projected wastewater volume. Comprehensive guidelines and strategies were formulated for implementing functional testing in discussion with the partners.

Publications/ Papers

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sustainable water management First International Conference on Circular Economy for Sustainable Water Management Online Format, 23.03.2022-25.03.2022

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- Dittel, G.; Heins, K.; Raina, M. Clean Water: modular, lightweight waste water treatment plants made of textile reinforced concrete for rural and peri-urban residential buildings. IGSTC Partners Meet, 14-15 June 2022, Frankfurt/Main
- Kira Heins Sichere Abwasserbehandlung in Schwellenländern Kleinkläranlagen aus Textilbeton für Indien BFT Jahrbuch, Beton Bauteile 2022, Bauverlag BV GmbH, 2022. Will be further published in German and English in BFT 5/22
- Gopinath, S., Shankar, S., Ahmed, A.K.F. et al. A Macro Modelling Based FEA Methodology for Realization of Textile Reinforced Concrete Rectangular and Cylindrical Shaped Tanks. J. Inst. Eng. India Ser. A 103, 961–973 (2022) <https://doi.org/10.1007/s40030-022-00645-1>

General Public Interactions

Roll-to-roll printed electronic labels for temperature, humidity and tampering detections

Project Brief

The project aims to establish a test production line for printed electronic labels by roll-to-roll gravure printing. The label shall comprise a first coil (to receive 13.56 MHz from a smartphone), a rectifier (to convert AC to DC), a ring oscillator (to generate 1-1000 Hz, ~10 mA), a resistive sensor (to control the output frequency of the ring oscillator) and a second coil (to generate a magnetic field to be detected by the Hall sensor of the smartphone). The resistive sensor can detect a change in temperature or humidity or damage to the label. The proposed label has huge market potential in the field of anti-counterfeiting, food packaging and biomedicine cold storage logistics. A proof-of-concept label has been successfully tested by the consortium partners using standard electronic components (TRL-4). The consortium brings experts in circuit design, functional inks, organic transistors and roll-to-roll gravure printing to one platform to guarantee the success of the project.

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Dresden (TUD)



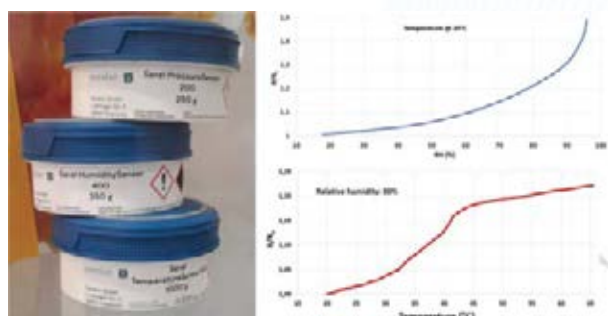
Moazzam Ali

Saralon GmbH
Chemnitz (SAR)

Progress made/achieved

Saralon GmbH (SAR)

SAR has developed screen printable resistive inks for temperature and humidity detection. In addition, they have also developed highly conductive silver ink which can be used to print low resistance NFC antenna. The SAR team has also developed a low-cost Cu based screen printable ink that can be used to print other circuits.



SAR developed and optimized temperature sensor and humidity sensor inks, which has been commercialized and is currently being sold through their website:

<https://www.saralon.com/en/inks/>. The inks are screen printable and also suitable for gravure printing. The screen-printed sensors show an increase in resistance with increasing temperature or humidity. No ionic conductivity is involved, resistance can be measured using DC current. With printed moisture sensor, SAR printed a device that can communicate with a smartphone using an NFC chip.

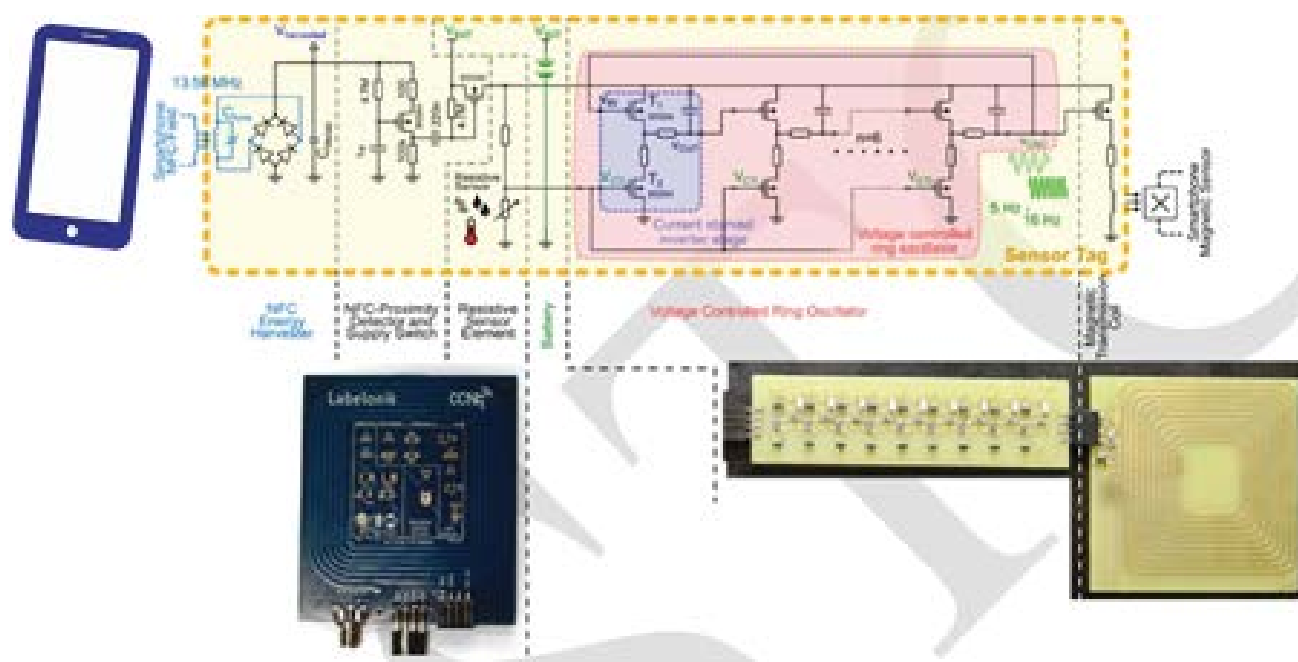
TU Dresden (TUD)



NFC readable humidity sensor from Saralon GmbH

TUD has optimized and tested the circuit design for NFC powered chip. The chip operates at 13.56 MHz and can trigger the magnetic FM transmitter for readout. The circuit design is prepared for migration to printed organic electronics.

The TU Dresden team designed the electronic circuit for a fully passive label. The harvesting coil and rectifier tuned to 13.56 MHz is capable of harnessing $\sim 800 \mu\text{W}$ power at 3.75 V from the smartphone NFC. The circuit design incorporates a resistive sensor element, that responds to a change in temperature/humidity and modulates the control voltage (V_c) for the ring oscillator. Depending on the V_c , the ring oscillator oscillates at frequencies ranging from 0.01-10 kHz. The resultant magnetic field is detected by the smartphone Hall sensor. TU Dresden team also designed a mobile application to read out the magnetic FM signal.



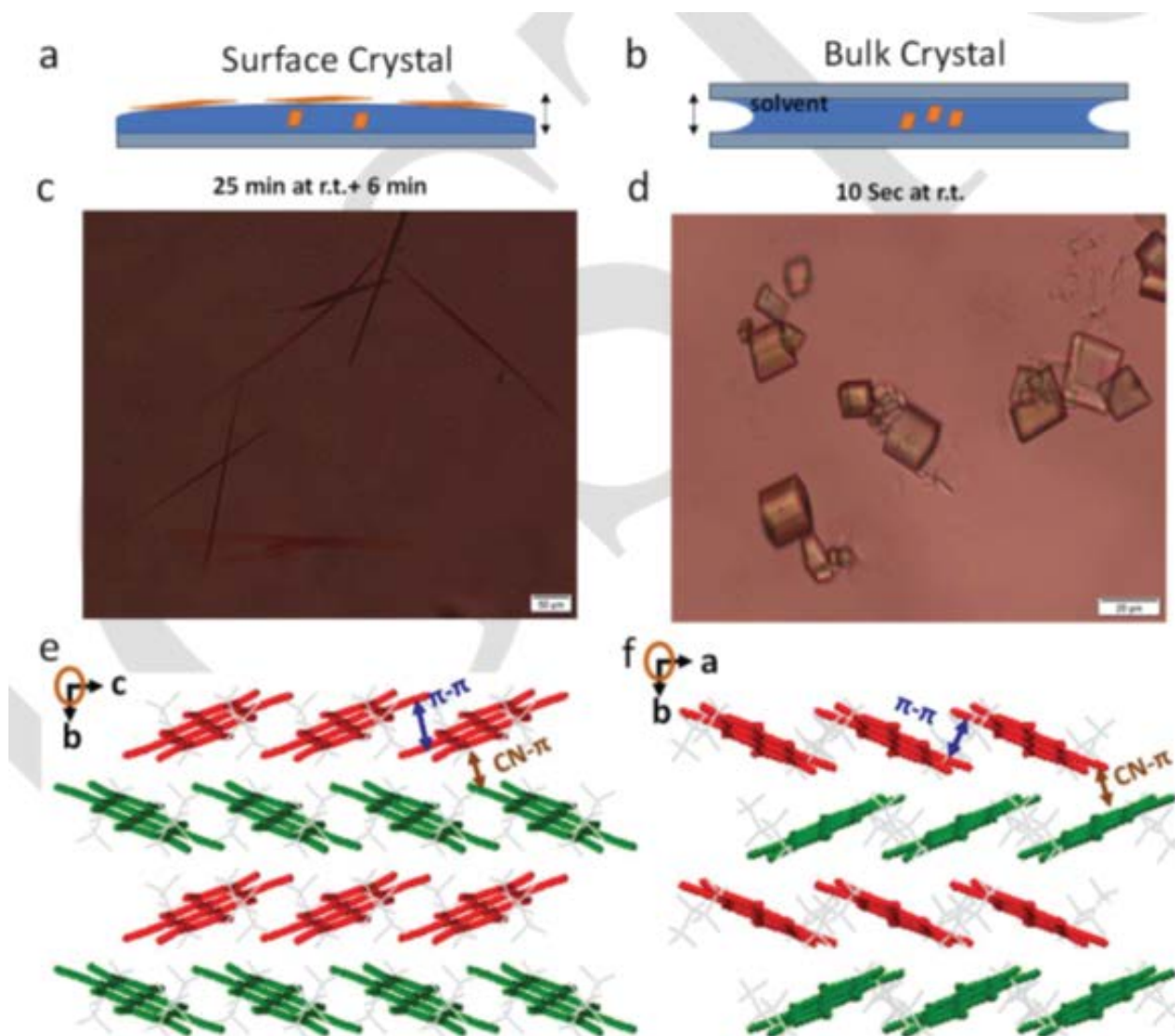
Measurement setup at two different label-to-reader distances to determine the power harvestable from NFC-reader (green PCB).

IISER Kolkata

The group at IISER Kolkata have developed a library of naphthalene and perylene diimide based OFET materials that can be processed from a variety of different solvents and conditions. Prototype devices based on a pair of these molecules have shown promising performance in terms of very high electron mobilities, ultralow threshold voltages, high ON/OFF current ratios, and exceptional ambient stabilities. They have also developed a series of molecules that show non-volatile resistive memory with very high ON/OFF ratios.

A compact label design limits on the number of transistors, which must express high carrier mobility and exceptional ambient stability. The IISER Kolkata team developed

naphthalene diimide based n-type organic semiconductors that live up to the challenge. Spin-coated field-effect transistors made from these molecular semiconductors show a very high electron mobility of $2.4 \text{ cm}^2/\text{V.s}$, an ON-OFF current ratio $\sim 10^8$, a negligible threshold voltage, and an exceptional ambient stability for over a month. The team filed an Indian patent on the developed materials.



(a,b) Surface - and bulk-nucleation experiments. The thickness liquid film of both surface and bulk experiment is approximately 50 μm . (c,d) Comparison of surface (needle shape) and bulk (block shape) nucleated crystals. Surface crystal (e) and bulk crystal (f) showing significant π -stacking in single crystal structure along a and c-axis respectively.

Holographic Security Marking Systems Pvt. Ltd. (HSMS)

HSMS have started its 8-colour gravure machine and undertook some printing trials of moisture sensor inks. The inks were supplied by SRL. Initial trials were promising but there is variability in resistance. With the new tooling that is being developed more consistent readings with the new trials are expected.

Publications

T. Pal, D. Chaudhuri, Chiral and Morphological Anisotropy of Supramolecular Polymers Shaped by a Singularity in Solvent Composition, *J. Am. Chem. Soc.*, 145, 2532-2543, 2023.

NearNetMAC

Design and development of near-net-shape manufacturing process for lightweight high strength aluminum composite and engineering components by squeeze infiltration technique for automotive and aerospace applications

Project Summary

The overall objective of the project is the development of Carbonfibre-Aluminium-Composites (C-Al MMCs) and the associated design tools. To achieve this goal, various individual developments are necessary, which influence each other and require the interdisciplinary cooperation of the partners. This project has five main objectives:

1. Process development and demonstration of Al-C-composite manufacturing using squeeze infiltration technique.
2. Process development and system integration of near-net-shape preforms for metal matrix composite manufacturing using 2D/3D-weaving or 2D/3D-braiding processes.
3. Development of design and analysis techniques using advanced numerical simulation techniques.

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4. Setup lab scale and plan for pilot scale demonstrations for selected automotive and aerospace components like connecting rods and heat sinks.
5. Development of a business plan for full scale commercialisation of MMCs based products developed as a part of this project.

Progress made/achieved

There are four partners working together in the project. The research partners involved in the project are the Institut für Textiltechnik (ITA) of RWTH Aachen University and the National Institute for Interdisciplinary Science and Technology (NIIST), Trivandrum, India and the industrial partners CIKONI GmbH, Stuttgart, Germany and Fenfe Metallurgical, Bangalore, India. The responsibilities in the strongly interdisciplinary project are distributed among the partners according to their competencies.

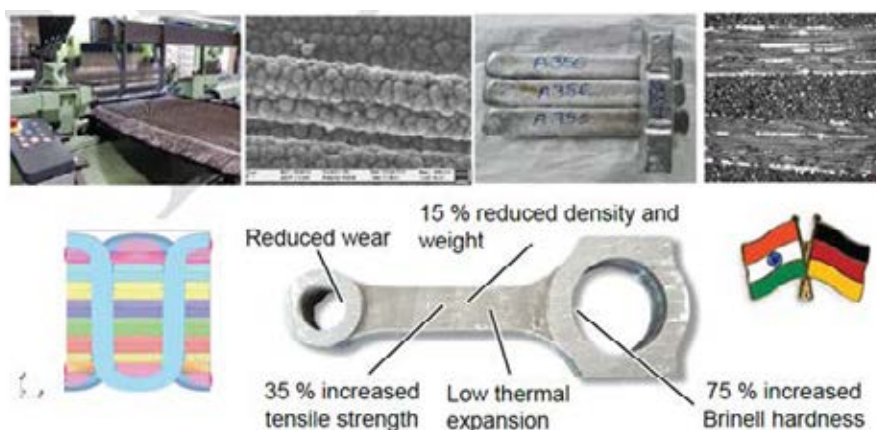
Preforms of high modulus continuous C-fibre are produced by advanced textile technologies like 3D-weaving in a near-net-shape form based on the expertise of ITA of RWTH Aachen University, Germany. The surface treatment squeeze infiltration processing of aluminium composite is carried out at CSIR-NIIST, India. The Indian Industrial partner Fenfe

Metallurgicals develops and supplies the suitable Al-alloy for the infiltration and industrial scale processing and evaluation of connecting rod and heat sink components. The German industrial partner CIKONI GmbH provides the conceptual and detailed part design based on the textile and infiltration process as well as the structural analysis.

The objectives of the project as a whole and of the individual sub-projects of the partners were achieved. Within the project, a complete value chain for the design and production of near-net- shape Al-C-MMCs and components made of this material was developed. In addition to the processes required to produce 3D fabrics from C-fibres, de-sizing, subsequent metallic coating and squeeze infiltration, the necessary design tools for infiltration and component simulation were also developed. The entire process chain was tested and validated using an automotive demonstrator. Individual aspects of the process were tested using additional demonstrators.

The following results were achieved:

1. The process chain for the production of 2D and 3D reinforcements for Al-C-MMCs was developed.
2. The textile production was developed on a laboratory scale and transferred to industrial equipment at Lindauer DORNIER GmbH (TRL 6).
3. Desizing and subsequent coating with Cu or Ni have been developed and tested on a laboratory scale. Suitable, uniform and thin coatings can be achieved with different processes (TRL 4-5).



Process chain and Component made of Carbon Fibre Reinforced Aluminium developed in the IGSTC project NearNetMAC

4. A process for the squeeze infiltration of C-Al-MMC has been developed and applied to multiple carbon fibres and preforms under laboratory conditions. (TRL 4- 5).
5. Therefore, the necessary aluminium alloys have been developed and casted. Process analysis and optimization (e.g. preheating of the preform, die design, infiltration pressure, melt pouring temperature and infiltration time) has been carried out.
6. A simulation-methode for the squeeze-infiltration-textile interaction has been developed using Representative Unit Cells (RUC). The infiltration can be predicted by considering temperature-dependent changes in the most important physical properties of the infiltrated aluminium melt.
7. The results of the simulation depend on the simulation parameters, which have to be recalibrated after each change in the boundary conditions. For this reason, the simulative representation of the manufacturing process is not yet interpretable in industrial applications and there is a need for further research. (TRL 2-3)
8. Material data for the textile reinforcements and C-Al-MMCs have been measured and Material data sheets have been created.
9. Material data sheets for the developed 3D-woven reinforcements were created based on polymeric matrix. Models for in- and out-of-plane shear, compression, tension, impact and compression-after-impact behaviour were derived from the experiments to model the relationships and predict properties.
10. Experimental data for the physical properties (e.g. hardness, thermal expansion and conductivity, density) as well as mechanical properties (tensile behaviour) of the C-Al- MMCs have been created.
11. A multiscale modelling and simulation method for the analysis and design of near-net- shape C-Al-MMC has been developed and evaluated. The method uses Micro- (Fibre Bundles), Meso- (RUC of the Textile Structure) and Macroscale (Component) to efficiently predict the component performance.
12. The simulation has been validated using the material properties of the 3D-CFRP and then transferred to the Al-matrix.
13. Three demonstrators were designed, developed and manufactured. A connecting rod was woven and impregnated with Al-matrix. An engine component was developed as an example for an aerospace application and woven on a much larger scale to test the complex weave patterns. As a third component, a flat heat sink was manufactured with pitch-based C-fibres and Al-matrix to demonstrate further functional advantages of the material.
14. The connecting rod was used to demonstrate the advantages over existing aluminium components. Both in the simulation and in the mechanical tests carried out, the following properties could be demonstrated: Reduced wear, lower thermal expansion, 15 % reduced density and weight, 35 % increased tensile strength and 75 % increased Brinell hardness.
15. For the preparation of a business case, process cost calculation with data collection from literature and interviews with experts along the process chain was carried out. Based on a SWOT analysis, different strategies for a market launch were developed.

Salient Research Achievements

Within the project, a complete value chain for the design and production of near-net-shape Al-C-MMCs and components made of this material was developed. In addition to the processes required to produce 3D fabrics from C-fibres, desizing, subsequent metallic coating and squeeze infiltration, the necessary design tools for infiltration and component simulation were also developed. The entire process chain was tested and validated using an automotive demonstrator. For the preparation of a business case, process cost calculation with data collection from literature and interviews with experts along the process chain was carried out. Based on a SWOT analysis, different strategies for a market launch was developed.

PYRASOL

Smart Cities integrated energy supply, carbon sequestration and urban organic waste treatment through combined solar sludge drying and pyrolysis

Project Summary

Collection, treatment, and disposal systems of urban wastes in Indian Smart Cities as well as in other urban centers have to be managed and organized with an integrated and interactive approach. Through this PYRASOL project, simple and robust processing technologies for urban organic waste will be combined in a synergetic manner and further developed to improve sanitation and welfare, supply regenerative energy, convert waste into products and reduce the carbon footprint of Smart Cities by an innovative organic waste drying system using the solar natural chimney effect followed by a highly efficient single-chamber pyrolysis. The project aims to offer an innovative approach to transforming urban organic waste into biochar and energy in urban areas. Thus, the optimum process and operation parameters of the solar

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dryer will be determined and the pyrolysis process with a unique condensing boiler system will be developed and investigated. This is supplemented through a comprehensive evaluation of the value-added chain from urban organic waste into biochar and energy and the application of biochar for land reclamation (long-term fertilizer, heavy metal adsorbent, etc.). As the generated biochar and heat are consequently utilized as the process chain, this project contributes to the Zero Waste Approaches of Smart Cities in India. To this end, fruitful cooperation of experienced researchers and engineers from India and Germany were forged and targeted exchange and training schedules are elaborated.

**Progress
made/achieved**

CSIR-Central Leather Research Institute (CLRI)

Spatial planning and mapping of the pilot plant

The planning and layout mapping of pyrolysis equipment and its accessories has been completed. In addition, the installation of the pilot-scale pretreatment and monitoring system for pyrolysis unit is also completed. The supply of the pretreatment and monitoring equipment is in the final stage and the installation of all equipment was completed. The pyrolysis pilot plant has been finally installed

Ramky

The construction of updraft solar dryer and for procurement of weather monitoring systems is in process. A detailed design has been done with the help of CLRI and ISAH and structural design has been finalised.

ISAH, Leibniz Universität Hannover

Pyrolysis process scale up analysis

The process scaling effects - mass and heat transport, changes in the turbostratic carbon structure, aromaticity and process thermodynamics and GHG emissions - were investigated at thermogravimetric, lab-, pilot- and industrial-scale reactor (Biomacron). The objectives were to elucidate the changes in scaling effects with respect to the uncompressed weight of the input feedstock. This scaling investigation aids in extending the results from PYRASOL to the general pyrolysis community for realizing scalable the lab-to-field implementations.

Development LCA model of the complete system

An LCA model of the PYRASOL process is created with the help of the life cycle assessment software Umberto® LCA+ in order to be able to evaluate the system ecologically. The software Umberto LCA+ enables life cycle assessments, material flow analyses and cost structures to be realized and visually processed in a single model (Sankey diagram, network plan view). Umberto LCA+ also offers the user a choice of databases (Ecoinvent, GaBi, EstiMol), which allow to obtain ISO standardized (ISO 14044, ISO 14064 and ISO 14025)

results. Umberto LCA+ is also characterized by an application-oriented programming and input structure, which makes it easy for the user to run intuitively. For the subsequent theoretical model calculation, input material characteristics data and corresponding Umberto databank for Indian conditions are used. Three designated substrates (FOW, SS, AD) and their characteristics data are considered to create the model. The model is run through the sets of theoretical data and the specific substrates characteristics data. The LCA model will be validated using the pilot plant results once it is in operation. Then a complete picture of the life cycle environmental impacts and carbon footprints of the PYRASOL processes can be drawn as an important indicator of sustainability of the project. In addition, different Techniques for the heat usage are investigated, such as heat exchanger, absorption chilling, Stirling engine, floor heating and ORC-process.

Publications

- Nair R.R., Mondal M.M. and Weichgrebe D. (2022) Biochar from co-pyrolysis of urban organic wastes—investigation of carbon sink potential using ATR-FTIR and TGA. *Biomass Conv. Bioref.* 12, 4729–4743. <https://doi.org/10.1007/s13399-020-01000-9>
- Nair, R.R., Mondal M.M., Srinivasan, S.V., Weichgrebe, D. (2022) Biochar Synthesis from Mineral- and Ash-Rich Waste Biomass, Part 1: Investigation of Thermal Decomposition Mechanism during Slow Pyrolysis. *Materials* 2022, 15, 4130. <https://doi.org/10.3390/ma15124130>

Biomacon GmbH

Installation instructions including a video animation guides

Biomacon has provided detailed installation instructions to ensure proper movement and installation of the pyrolysis reactor at the project site. Due to the Covid-19 restrictions, Biomacon created and provided an explanatory video animation training that explains the process and the installation requirements. Moreover, several video meetings were conducted by Biomacon GmbH during the reporting period to support and ensure proper installation of the pyrolysis unit in the project site in Chennai.





WORKSHOPS

IGSTC bilateral workshops are platforms for substantive interaction between scientists/ researchers from academia and industry from India & Germany to explore new avenues for Indo-German scientific collaborations. These workshops play an important role in connecting relevant stakeholders for future collaborations.

Challenging Antibiotic Resistance: Perspectives on novel tools and diagnostics for efficient management (CARPE DIEM)

The workshop on “Challenging Antibiotic Resistance: Perspectives on novel tools and diagnostics for efficient management” was held on 16-17 May 2022 at Harnack Haus, Berlin with a special focus on the Indian and German perspectives. The workshop was coordinated by Prof K. Satyamoorthy, Manipal University, Dr Timo Jäger, German Center for Infection Research, Braunschweig and Dr Ralf Sudbrak, Global AMR R&D Hub.

According to World Health Organisation, one of the major challenges facing human populations in the current century is antimicrobial resistance (AMR) since it directly impacts the economy, security and public health systems worldwide. Recent reports suggest that AMR would contribute to substantial economic loss and increased morbidity and mortality unless some effective measures are taken to overcome this silent pandemic. This is especially true in developing countries like India due to the high burden of infectious diseases. The workshop was hence planned to deliberate and develop strategies and, foster industry-academic partnerships between various interested stakeholders to tackle this scourge of AMR. In addition, a strong

emphasis was laid on strengthening networking, surveillance methods, policy decisions and cross-sectoral collaboration, especially in the field of diagnosis and developing new antimicrobials or novel strategies to overcome AMR.

Dr. Madhan Rajachandran, Director, IGSTC congratulated the organisers for planning a workshop on an important issue that has much relevance to both countries. He suggested that this workshop could be a foundation stone for future programs on similar topics.

He was happy that several distinguished participants in the field who will give talks and requested all the participants to make use of the opportunity available to industry partners, academicians and especially early career researchers and others to utilize the various funding opportunities available to them. Dr. Ludwig Kammeshedit, German Aerospace Centre – International Bureau elaborated on various unilateral, bilateral and other multilateral funding opportunities available to German and Indian scientists; and encouraged further discussions on the important topic.

A total of 23 researchers from leading academic and industry organisations (Fraunhofer Institute for Cell Therapy and Immunology, Charite – Universitätsmedizin Berlin, CSIR-CCMB, Indian Institute of Science, Achira Labs, etc.) from India & Germany participated in this exciting and interactive workshop. The talks were categorized into five major themes with

speakers from both India and Germany discussing their points of view. The themes were (1) Advances in antibiotic research and development, (2) Public Health consequences of antimicrobial resistance, (3) Commercial landscape for antibiotics, (4) Innovative diagnostic solutions and (5) Omics of pathogen detection and function.



Participants at the workshop

One of the major recommendations from the workshop was the need to establish a multidisciplinary task force to influence global policymakers and stakeholders to sensitize the gravity of AMR burden; assess reasons for impending catastrophe due to ones inability to manage AMR and promote innovation and establish international cooperation with

support and funding to manage country-specific AMR issues. Interactions during the workshop have led to a) familiarization of each other's area of translation, b) identification of common areas of collaboration and c) evolving novel translatable concepts for execution.

Agricultural management practice effects on soil and plant-associated bacterial communities and their resistome (AMPSEAP)

Indo-German workshop on “Agricultural management practice effects on soil and plant-associated bacterial communities and their resistome” was coordinated by Dr K. Annapurna, ICAR-Indian Agricultural Research Institute and Prof Kornelia Smalla, Julius Kuehn Institute. The workshop was held at Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam from 20 to 22 June 2022.

Agricultural management practices such as irrigation with wastewater, use of organic fertilizers, pesticides or biological control measures might affect bacterial communities associated with plants or soil.

The increasing demands for minimally processed produce were recently related to foodborne disease outbreaks and were reported as reservoirs of bacterial pathogens and transferable antibiotic resistances. Besides, surface contamination, the possible internalization of bacteria carrying pathogenicity or resistance genes into edible parts of plants were previously reported.

Heavy metal and pesticide contamination in produce is another concern. The workshop

aimed to discuss the current state of knowledge concerning the effects of agricultural management practices on plant and soil-associated bacterial communities with a focus on human pathogens and transferable antibiotic resistances.

The workshop participants from the two countries; India and Germany deliberated on developing a quantitative risk assessment, the realization of the importance of Anti-Microbial Resistance (AMR) in One Health, and drafting guidelines for the regulation of wastewater reuse, application of organic fertilizers or inoculants for agricultural purposes.

The workshop started with two plenary talks delivered by Prof Kornelia Smalla (German Coordinator) and Dr. K. Annapurna (Indian Collaborator). The workshop was divided into four sections: Antibiotic Resistance Genes (ARGs) in plant environment, Impact of agricultural management on ARG – One Health, ARG in diverse environments, AG Human Pathogens on Crop plants and plant infect project.

A total of 30 Indian and German Scientists participated from various organisations like ICAR-Indian Agricultural Research Institute, IIT Delhi, National Centre for Cell Science, Pune, Julius Kuehn Institute, German Federal Institute for Risk Assessment (BfR), University of Bonn, etc.



Participants at the workshop

The workshop deliberations brought out the emerging threat of AMR in agriculture, showcasing the persistence of manure-driven ARB, and their ARGs in soil for a few weeks and up to years and importantly the existence of horizontal gene transfer taking place in regularity in native soil bacterial isolates. The fact that aquaculture, poultry, sewage water, riverine, and raw vegetables/soil act as rich reservoirs of ARGs and human pathogens are also a cause for concern as and strategies

must be developed for mitigating the resistome from such environments.

These are important and interesting areas for collaborative research where scientists from both the countries can complement their knowledge and skills. The in-depth and lively deliberations and interactions in the workshop generated a better understanding of this interesting area directly concerned with "One Health".



Participants during the technical session

The take-home message for the workshop participants has been to focus their research on survey, transmission pathways, mitigation

strategies, isolations and risk assessment studies.

Securing sustainable treatment for drinking water production and water recycling with focus on anionic contaminants (SuWaReC)

The workshop “Securing sustainable treatment for drinking water production and water recycling with focus on anionic contaminants” was held at TU Hamburg from 20 to 2 July 2022. It was coordinated by Dr Bhaskar Jyoti Dekka, IIT Roorkee and Prof Mathias Ernst, TU Hamburg.

A total of 34 Indian and German researchers from Academic organisations, and industries, along with reputed policy makers participated in the workshop.

Discharge of anionic contaminants into the nearby water bodies causes a significant threat to our biosphere. Limitations of existing remediation technologies further multifold the threat level. In the workshop, in-depth research findings on detection, quantification and especially remediation approaches were discussed not only by academic researchers but also by industry representatives/research engineers. Apart from the conventional adsorption technology, hybrid and advanced membrane-based technologies were canvassed with respect to the removal of contaminants. Further, the case studies from different parts of India and Germany strengthened the workshop broadly. Participation by relevant industries from both countries were well connected with scientific communities along with the exchange of knowledge. Overall, the workshop provided a platform to establish academic-industry collaboration among the participants from both countries.



Participants at the workshop



The workshop was notable for many innovative ideas and critical insight into the dynamic relationship between development and water conservation that underlies sustainable development. In the workshop, participants from both countries discussed various domains of environmental science

and engineering, whilst garnering insights on conventional and low-cost remediation techniques for water pollutants to achieve goals of sustainable water recycling. The workshop enabled new chapters of in-depth Indo-German academic cum industrial collaboration.



Co-ordinators Prof Mathias Ernst and Dr Bhaskar Jyoti Deka inaugurating the workshop.

Indo-German joint workshop on sustainable stress management: Aquatic plants vs. Terrestrial plants (IGW-SSWAT)

The Indo-German joint workshop on "Sustainable stress management: aquatic plants vs. terrestrial plants" was organised from 25-27 July 2022 at Friedrich Schiller University of Jena. The workshop was coordinated by Dr. K. Sowjanya Sree, Central University of Kerala and Prof. Ralf Oelmüller, Friedrich Schiller University of Jena.

The introduction of aquatic plants such as duckweeds into agricultural concepts for the future has opened novel research and application in the fields.

Aquatic plants take up the nutrients from water for their growth and utilize space that otherwise is not used for agriculture.

However, compared to land plants lesser is known about biotic and abiotic stresses these plants are exposed to and how they respond or adapt to them. Therefore, the workshop gave insights into how comparative analyses of these crops might contribute to a faster introduction of aquatic plants into agricultural applications.

The goal of the workshop was to bring together scientists from both fields and to discuss strategies on how terrestrial and aquatic plants can be integrated into a concept that better the agriculture of the future. A total of 41 researchers from leading universities, and industries participated in the workshop. The scientific sessions at the IGW-SSMAT focused on stress management strategies in both terrestrial and aquatic plants and the comparisons between the two. The scientific presentations were strategically categorized into six sessions - Abiotic stress management in terrestrial plants, Stress management in terrestrial plants: functional omics, Biotic stress management in terrestrial plants, Role of microbes in stress management in plants, Stress management in aquatic plants, Sustainable cropping systems.



Participants at the workshop



Several scientific presentations at the workshop found a good bilateral coherence between the research work being carried on in their groups and with others during the workshop.

The topics of bilateral interests included the role of brassinosteroids and the

corresponding signalling components under drought and salinity stress, biotechnological applications of duckweeds under stress conditions, comparison of MADS-BOX domains in terrestrial and aquatic plants, and role of endophytes in stress management in terrestrial and aquatic plants.



Inauguration of the workshop

Marine Farming - opportunity towards entrepreneurship, self-employment and sustainable rural development (Mari-Sustain)

The Indo-German bilateral workshop "Mari-Sustain: Marine farming - opportunity towards entrepreneurship, self-employment and sustainable rural development" was held from 23-25 August 2022 at Leibniz Centre for Tropical Marine Research (ZMT). The workshop was coordinated by Dr. Lata Gawade, Goa University and Dr. Andreas

Kunzmann, Leibniz-Centre for Tropical Marine Research (ZMT), Bremen.

The aim of this workshop, next to mutual exchange, was to look for possible collaborative projects between Indian and German institutes and the aquaculture industries. There is a huge demand for seafood, particularly bivalves and seaweeds in the global market as well as in India. The workshop investigated alternatives for Integrated Multi-Trophic Aquaculture (IMTA) including mussel/oyster production to meet the market demands.

Apart from the sustainable production of seafood, this workshop could be a step towards the generation of employment and community entrepreneurship developmental model.



Official photo of participants on 24.08.22 in the ZMT building

The workshop was held with 15 Indian and 15 German participants. The focus was on novel and more sustainable techniques for aquaculture practices like, green mussel cultivation, oyster farming, seaweed cultivation, and multiplication of such projects

at a commercial scale using advanced techniques. This also included the potential for co-culture and/or Integrated Multitrophic Aquaculture (IMTA). The avoidance or further use of by-products from processing, in the sense of Circular Economy, was also of interest.



Photo taken during the ice-breaker session on the 23.08.22 in the evening.

Apart from ZMT aquaria facilities (MAREE, Marine Experimental Ecology), the participants also visited the aquaria facilities of Zentrum für Aquakulturforschung (ZAF), at the AWI in Bremerhaven and the former fish market in Bremerhaven, where fish processing facilities are installed.

In the networking sessions, the workshop identified mainly six scientific fields of major interest for the participants: Seaweed culture, mussel and oyster culture with self-organized women groups in Goa and Kerala, hatcheries to provide supply with fry, IMTA and intensive farming setups, feeding and microbial activity.



Participants in networking session

Overall, the workshop was quite successful, and it will result in a white paper on the key identified areas of Marine farming.

Similar/Dissimilar materials welding of automotive & aerospace sectors (WSM 2022)

The three-day Indo-German Joint Scientific Workshop on "Similar/Dissimilar Materials Welding of Automotive & Aerospace Sectors (WSM 2022)" was hosted by Vellore Institute of Technology (VIT) in collaboration with Forschungszentrum Jülich, Germany. The workshop was conducted from 22-24 September 2022 and was attended by nearly 100 participants from both India and Germany.

The workshop offered an inordinate opportunity for experts from Germany and India to discuss the present state and future trajectories of such materials. This workshop also aimed to examine the difficulties encountered in the welding processes of superalloys, special steels, composites, and polymers that are extensively utilized in

automotive, aerospace, and related industries. The workshop also discussed the novel and latest technologies characterizing weld joints. Furthermore, the participants were given a unique chance to learn about ongoing research in metal joining for various applications. The workshop witnessed an attendance of nearly 100 participants from India and Germany.

The bilateral workshop commenced with an inauguration ceremony led by Mr. Madhan, Director, IGSTC. Dr. G. Madhusudhan Reddy, Director, DMRL also graced the occasion as the Guest of Honour and delivered a speech to the attendees.

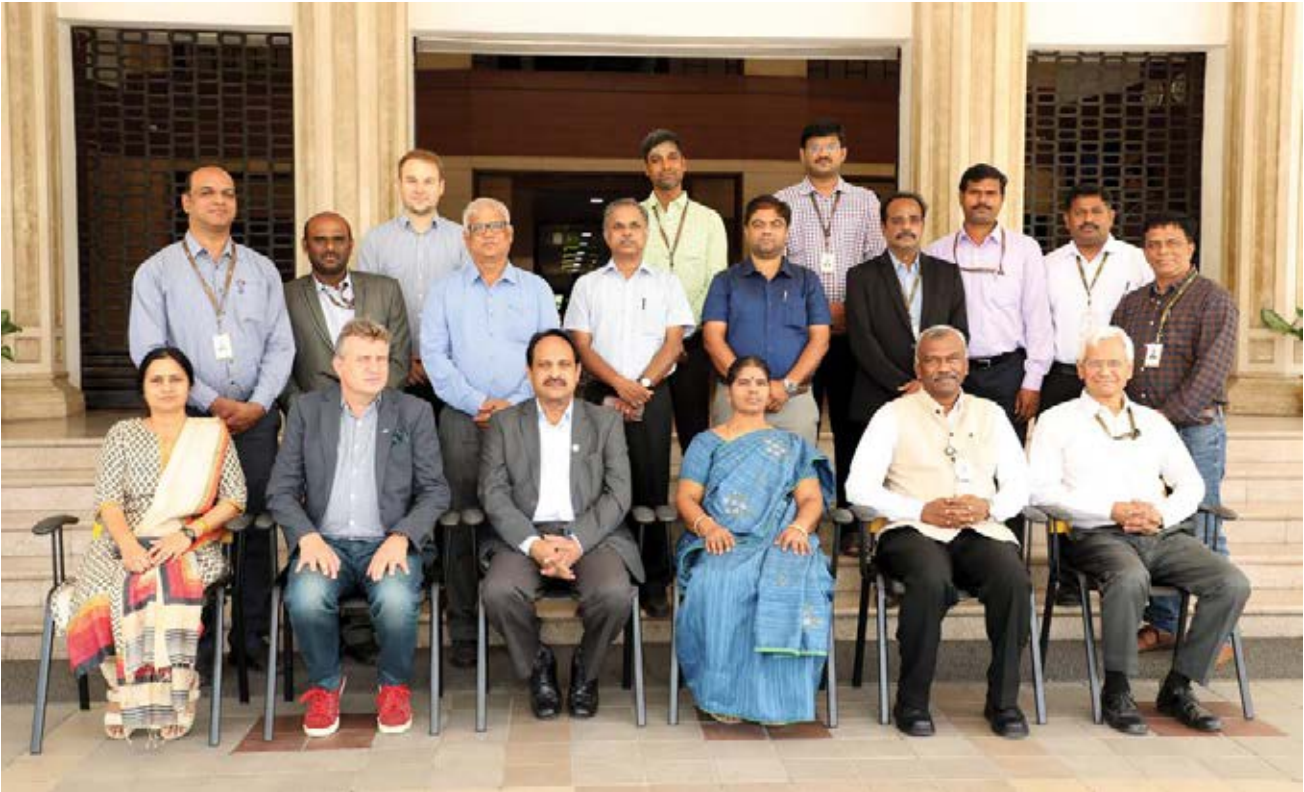
Many eminent speakers delivered talks during this two-day workshop from various leading organisations like Jade University of Applied Sciences; Karlsruhe Institute of Technology; FZ Julich GmbH from Germany and IGCAR, Kalpakam, Larsen & Toubro, Mumbai; ARCI, Hyderabad; IIST, Thiruvananthapuram; DRDO, Bengaluru, CSIR-NML Jamshedpur and ISRO, Thiruvananthapuram from India.



Director IGSTC
Shri R. Madhan delivering Inaugural Address



Director DMRL
Dr. G. Madhusudhan Reddy, delivering Keynote address



Group Photo with Speakers

The workshop provided good insight into the applications of welding in various industries. Various welding processes widely used to join automobile and aerospace applications were discussed in depth. In addition, the role of additive manufacturing in developing aerospace/automotive components to

overcome the challenges in the welding process was also focussed upon. The academicians, industrial experts, and scientists from India and Germany delivered a technological development around similar and dissimilar welding.

Biomaterials and implants for dental, cranio-maxillofacial reconstruction and bone regeneration (BIODENT)

As the life expectancy of humans is increasing there is a special need for medical support to the aging population which is more susceptible to accidental bone fractures and musculoskeletal disorders however, providing solutions to such bone-related medical conditions is much more than an engineering challenge. Synthetic biomaterials (designed specifically for the anatomy of the patient) should not only match the properties of the natural bones but must also be accepted by the body. This requires scientists to discover the appropriate materials, biologists to understand biocompatibility, and medical doctors to validate through clinical trials for effective translational research. Keeping the above directives in mind and building upon the learnings of the previous workshop, "Strategies for improved bone replacement materials and orthopedic implants: design – manufacturing – technologies, 2014", an IGSTC-sponsored symposium "Design and manufacturing of biomaterials and implants for dental, cranio-maxillofacial reconstruction and bone regeneration" was held during February 13-15, 2023, at Institute of Biomaterials, University of Erlangen-Nuremberg, Germany. The workshop was coordinated by Prof. Bikramjit

Basu, IISc Bangalore and Prof. Aldo Boccacini, University of Erlangen. This symposium involved the active participation of clinicians, scientists, and industry representatives. The objective of the symposium was to integrate state-of-the-art manufacturing technologies with the scientific understanding of biomaterials and implants and their transition to clinical trials. The symposium also incentivized Indo-German joint research venture and collaboration among the participants to scale up the production and commercialization of the undergoing innovations in the respective labs. In line with the objective of the symposium, the proceedings were distributed over 3 days and categorized under 11 technical sessions, each of which consisted of 3-4 speakers with a total of 35 presentations. The Indian delegation had representatives from academia, medical schools, hospitals, and industries: from IISc (Bangalore), IIT Kanpur, IIT BHU, KGMU, Ramaiah University, Jaslok Hospital, and Ceramat Pvt. Ltd (a Tata Steel Enterprise). The German contingent consisted of speakers from universities and hospitals spread over Germany such as Dresden, Erlangen-Nuremberg, Frankfurt, Heidelberg, Cologne, Würzburg, Mainz, Potsdam, Bremen, and Berlin.

The long-lasting impression of this workshop has been to connect us with collaborative partners for true translational research. All the participants acknowledged the dire need of developing biomaterials, complying with their clinical validations, and recognizing the opportunities for interdisciplinary research.



Participants at the workshop

Indo-German workshop on Biofabrication: Emerging biomaterials, machines & digital tools (IGBMDT 2023)

The Indo-German Workshop on Biofabrication: Emerging biomaterials, machines & digital tools (IGBMDT 2023) was jointly organised by SASTRA Deemed University and Ruhr University Bochum, Germany on February 22, 23 & 24, 2023. IGBMDT 2023 was aimed to bring together renowned scientists, scholars, start-ups, industries, and technology business incubators who work on 3D bioprinting to discuss strategies on biofabrication and to get hands-on training & demonstration on key identified areas in the field.

IGBMDT 2023 was inaugurated by Madam. Michaela Kuchler, Consul General of the

Federal Republic of Germany to Tamil Nadu, Telangana, Andhra Pradesh and Puducherry. Madam Michaela Kuchler advised young scientists from India and Germany to take inspiration from exemplary scientists whose pathbreaking research had resulted in novel products for human welfare.

This workshop brought 12 experts from Germany and 11 Indian Scientists to discuss emerging technologies in the realm of 3D printing for efficient structural and functional regeneration of organs. The panel included scientists from TU Dresden, the University of Cologne, the University of Freiburg, Reutlingen University, Fraunhofer Institute of Laser Technology, Aachen, University of Wuerzburg, TU Darmstadt, TU Munich, Ruhr University Bochum, Fibrothelium, Aachen, IIT Delhi, Wipro 3D, Cellink, DSS Imagetech, Next Big Innovation Labs, CTARS and SASTRA. The Workshop also enabled new collaborations for joint research projects on biofabrication that can create viable solutions in healthcare and regenerative medicine.



Group photo of the participants

Water conserved organic food production through climate smart carbon neutral aquaculture (Aquasmart)

The Indo-German Workshop 2022-23 on "AQUASMART: Water-conserved organic food production through climate-smart, carbon-neutral aquaculture" was organized by the Kerala University of Fisheries and Ocean Studies in association with Ludwig-Maximilians University Munich, Germany. The workshop received funding support from the Indo-German Science and Technology Center, New Delhi. The event took place in Kochi from March 2 - 4, 2023, and aimed to bring together experts from various fields to explore sustainable aquaculture and elucidate its role in climate-smart, water-resilient food production systems.

The workshop focused on a wide range of topics, including sustainable aquaculture practices, stakeholder responsibilities, the transition from current aquaculture practices to future smart production methods, energy and water conservation in food production, environmental protection, competition for space and user conflicts, biosecurity, food safety, antibiotic residues, seafood contamination, green technologies, alternative energy sources, organic food production, and social aspects related to aquaculture. The workshop was highly successful, attracting researchers and entrepreneurs from

India and Germany. A total of 12 German participants and 17 Indian participants came together under the thematic title of "Clean and Green Technology." One aquaculture technocrat from Ecuador gave a special presentation as a guest faculty.

The event featured 36 presentations, two panel discussions, and a field trip, covering topics such as energy and water conservation, technological costs of production, the impact of high-water footprints, food safety, and food security issues.

The workshop yielded several key recommendations, including the importance of collaboration in scientific and feasibility studies, the integration of knowledge transfer to farming communities for more sustainable production practices, support for achieving Net Zero in Aquaculture, and the joint development of low-tech, cost-effective Integrated Multi-Trophic Aquaculture (IMTA) systems using local species. The participants also emphasized the need to rethink the sustainability of mass production, focusing on local production for local needs. They highlighted the significance of tailored production systems for families or villages and stressed the importance of collaboration and networking involving students and academicians to strengthen aquaculture health, biosecurity and the overall advancement of the field.

The workshop was coordinated by Prof Dinesh Kaippilly from the Kerala University of Fisheries and Ocean Studies and Prof. Dušan Palić from Ludwig-Maximilians University

Munich. The inaugural ceremony was attended by Mr. R. Madhan, the Director of the Indo-German Science and Technology Center, along with Prof. Rosalind George, the Vice-Chancellor of KUFOS and Prof. Manoj Kumar, then Registrar of KUFOS. The inauguration took place at the KUFOS campus, while the technical sessions were held at Hotel Casino, Willington Island, Cochin, and Hotel Trident, WI, Cochin.

The workshop participants proposed various collaborative activities, including faculty and scientific staff exchanges, sharing of documentary resources, twinning programs for undergraduate and postgraduate students,

sponsorship of international workshops and seminars, joint technical-assisted activities and research programs, the establishment of academic chairs to strengthen cultural and scientific relations between KUFOS and LMU, and the encouragement of technical collaboration between the two institutions.

Overall, the Indo-German Workshop on "AQUASMART" provided an invaluable platform for knowledge exchange, fostering collaborations, and advancing sustainable practices in aquaculture for water-conserved organic food production with a climate-smart and carbon-neutral perspective.



Participants at Aquasmart workshop at KUFOS, Cochin



Precursor Derived Ceramics: Innovations and translational research (PDC-IT)

Embarking on an enthralling journey into the future of advanced ceramics, the three-day workshop on "Precursor Derived Ceramics: Innovations and translational research" delved into the fascinating world of materials for extreme environments. The workshop was organised from 8 – 11 March 2023 at IIT Madras. The workshop, organized under the aegis of the Indo-German Science and Technology Centre and partnered by Department of metallurgical and materials engineering, IIT Madras and the University of Bayreuth, Germany, provided an invaluable platform for experts from diverse fields to explore the boundless possibilities of precursor derived ceramics. Throughout the event, renowned experts showcased groundbreaking advancements in the synthesis, characterization, and applications of precursor derived ceramics. From soaring the skies to exploring the depths, these remarkable materials find applications in various realms. In the aerospace industry, they empower aircraft engines and heat shields to withstand scorching temperatures, ensuring safer and more efficient flights. Meanwhile, in the energy sector, precursor derived ceramics drive progress, enhancing gas turbines' performance and powering solar cells, harnessing the sun's energy for a greener tomorrow. Researchers presented

cutting-edge synthesis methods and processing techniques, elevating precursor derived ceramics to a whole new level of performance and functionality. The use of advanced characterization techniques unveiled the secrets of these materials, providing a deep understanding of their structure and properties. Additionally, computational modeling and simulation opened up possibilities for predicting the properties and performance of precursor derived ceramics, accelerating the pace of innovation. The workshop was not just theoretical; it served as a platform for startups and established industries to showcase ingenious products and technologies, fostering collaboration between academia and industry. A captivating panel discussion emphasized improving the manufacturing readiness level of precursor derived ceramics, identifying the challenges and opportunities in scaling up production. Standardized protocols, advanced characterization techniques, and new manufacturing methods emerged as key takeaways. Moreover, the workshop celebrated the exceptional contributions of women in the field of ceramic science on International Women's Day, serving as an inspiration to all. Researchers unveiled their latest findings, envisioning a future where precursor derived ceramics hold even greater promise. New precursor materials with enhanced reactivity and stability, complex ceramic structures with precise control over their morphology and composition, and additive manufacturing techniques like 3D printing are set to revolutionize the industry. The integration of precursor derived ceramics

with other materials creates hybrid composites with superior properties, paving the way for innovation in various fields. The workshop yielded invaluable recommendations, emphasizing increased collaboration, further research, standardized characterization techniques, and exploring novel applications in biomedical engineering and nanotechnology. The workshop was coordinated by Prof Ravi Kumar, IIT Madras and Prof. Gunter Motz, University of Bayreuth, Germany. The inaugural ceremony was attended by Mr. R. Madhan, the Director, Indo-German Science and Technology Center, along with Prof. V Kamakoti, Director, IIT Madras and Mr. N Ananthaseshan, Managing

Director, Carborundum Universal Ltd.

The commitment to advancing the manufacturing readiness level of precursor-derived ceramics will bring these materials to the forefront of commercial applications. The Indo-German Workshop on Precursor-Derived Ceramics saw more than 50 participants, 40 invited talks that sparked innovation and collaboration, providing a platform for knowledge exchange among scientists, researchers, entrepreneurs, and industry partners. The event fostered interdisciplinary dialogue, promoting the exchange of knowledge, and paving the path toward a future where precursor derived ceramics revolutionize various industries.



Inauguration ceremony



Participants at the workshop

Indo-German Workshop on developments in established and emerging photovoltaic technologies (DEEPT-2023)

The Indo-German Workshop on “Developments in Established and Emerging Photovoltaic Technologies (DEEPT) – 2023” was successfully held during 13-15 March 2023 at SRM Institute of Science & Technology (IST), Kattankulathur. The workshop brought together scientists and industrialists from India and Germany, facilitating an exchange of ideas and solutions in the field of photovoltaic technologies.

The workshop was coordinated by Dr Malar Piraviperumal from the Department of Physics and Nanotechnology, SRM IST, Chennai, India, and Prof. Sanjay Mathur, Director of the Institute of Inorganic Chemistry, University of Cologne, Germany. It showcased the implementation of new knowledge and material technologies in photovoltaics.

The scientific program spanned over three days and featured lectures and discussions by renowned Indian and German scientists. Topics covered a wide range of aspects, including established silicon PVs, emerging materials like hybrid perovskites, and tandem technologies that integrate new materials with existing solutions.

A significant focus of DEEPT - 2023 was on exploring materials circularity in energy transitions, highlighting both challenges and opportunities in PV module recycling. The workshop also highlighted the importance of international collaboration in emerging technologies to address the United Nations Sustainable Development Goals (UN-SDGs).

Industry partners and national laboratories made valuable contributions to the workshop, presenting innovative approaches to greener materials and the development of new products. The exchange of information on current status and emerging trends fostered a deeper understanding on technological potential.

DEEPT - 2023 served as a platform for networking and fruitful discussions among Indian and German participants. It paved the way for potential research collaborations and advancements in photovoltaic technologies, contributing to the global energy transition.



Group photo of the participants

IGSTC Industrial Fellowships Call 2022





IGSTC Industrial Fellowships

IGSTC awards Industrial Fellowships to encourage young Indian researchers towards applied research in an Industrial setup in Germany. This programme is aimed at encouraging PhD students/researchers in S&T with an appreciable track record and having aptitude for applied research and technology development. This fellowship provides exposure to young researchers from India at German Industrial ecosystems and applied research institutions offering fellowships at two levels - Ph.D. Industrial Exposure Fellowship and Post-Doctoral Industrial Fellowship. The Industrial Fellowships are provided with financial support for subsistence, travel-related, and insurance costs. A total of 10 (ten)

researchers from leading academic and research institutions spread across India have been awarded Post-Doctoral Industrial Fellowships (PDIF), and 10 (ten) have been awarded Ph.D. Industrial Exposure Fellowships (PIEF) under the IGSTC Industrial Fellowship Call 2022. This is the second batch of IGSTC Industrial fellows. The awardees were felicitated and awarded certificates by Mr. S.K. Varshney, Adviser & Head, International Cooperation, Department of Science and Technology, Govt. of India and Indian Co-Chair, IGSTC, and H.E. Stephan Grabherr, Charge'd Affairs, German Embassy in an event on 10th August 2022. They both motivated the young industrial fellows who will be departing shortly for pursuing their research journey in Germany and strongly encouraged the fellowship awardees to experience German culture and facilities in applied research.



Industrial Fellowship Awardees 2022

Post-Doctoral Industrial Fellowship (PDIF) Awardees 2022



Dr. E Anusha

ARCI Hyderabad/NIT Warangal

HOST

Fraunhofer Institute for Machine Tools and Forming Technology IWU

Area of Work

Laser assisted forming of automotive steel blanks



Dr. Swathi E

IIT Madras

HOST

Fraunhofer Institute for Machine Tools and Forming Technology IWU

Area of Work

Laser assisted forming of automotive steel blanks



Dr. Mukesh Kumar

CSIR-Central Scientific Instruments Organisation (CSIO), Chandigarh

HOST

Senercon GmbH

Area of Work

Non-Intrusive Load Monitoring (NILM) system based device development with feature mapping and feature expansion technique using DL technique for accurate status and energy estimation of individual appliances connected in buildings



Dr. Gayathri Harihara Subramanian

IISc Bangalore

HOST

accu:rate GmbH

Area of Work

Pedestrian and crowd modelling - Simulating crowds in public places by incorporating group behaviour and psychological parameters



Dr. Vishnu Chauhan

Inter-University Accelerator Centre (IUAC)
& Indraprastha University, New Delhi

HOST

Facility for Antiproton and Ion Research (FAIR) GmbH

Area of Work

Influence of SHI irradiation on high performance metal-insulator-metal capacitor fabricated by oxides for memory applications



Dr. Ankitkumar Kansara

CSIR-Centre Salt & Marine Chemicals Research
Institute (CSMCRI), Bhavnagar

HOST

Fraunhofer Institute for Ceramic Technologies and Systems IKTS

Area of Work

Development of ultrahydrophobic metal-organic framework membranes for the separation of aromatic hydrocarbons by organic solvent nanofiltration



Dr. Sindu B S

CSIR-Structural Engineering Research Centre (SERC),
Chennai

HOST

Fraunhofer Institute for Algorithms and Scientific
Computing SCAI

Area of Work

Machine learning supported approach for synthesis of
novel epoxy polymers towards sustainable fiber
reinforced polymers



Dr. Sarita Devi

CSIR- Central Scientific Instruments Organisation
(CSIO), Chandigarh

HOST

Federal Institute for Materials Research and
Testing (BAM)

Area of Work

Tailored metal-organic framework-integrated
microfluidic device for immunosensing of
waterborne pathogen

PhD Industrial Exposure Fellowship (PIEF) Awardees 2022



Ms. Kavita Kiran Prasad

IIT Bombay

HOST

Wiferion GmbH

Area of Work

Wireless Battery charging systems for electric vehicles
in autonomous driverless transport systems, mobile
robots, and industrial trucks



Ms. Ruchika

CSIR-Institute of Himalayan Bioresource Technology (IHBT), Palampur

HOST

LIONEX GmbH

Area of Work

Development of novel rapid tests for differential diagnosis of bacterial and viral infections



Mr. Ramakanth Dakuri

IIT Roorkee

HOST

Envopap Deutschland

Area of Work

Paper-based active barrier coatings for improved shelf life and quality of food products



Mr. Rakesh Kumar Dhritlahre

CSIR- Institute of Himalayan Bioresource Technology (IHBT), Palampur

HOST

DendroPharm GmbH

Area of Work

IDCC conjugated dendritic polyglycerol-N-isopropylacrylamide thermoresponsive nanogel for safe and efficient transdermal drug delivery



Ms. Akhila Konala

IIT Roorkee

HOST

Envopap Deustchland

Area of Work

Development of high barrier coatings for sustainable packaging material



Ms. Ekta Singh Shrinet

IIT Bombay

HOST

Fraunhofer Institute for Solar Energy Systems ISE

Area of Work

Battery thermal management system of high energy density batteries



Ms. Reshma Dileep K

ARCI Hyderabad/IIT Bombay

HOST

HySPRINT Innovation

Area of Work

Photovoltaics-Scaling up of carbon based perovskite solar cells



Mr. Ayush Tara

University of Jammu

HOST

HySPRINT Innovation

Area of Work

Fabrication and characterization of lead free, tin based FASnI₃ perovskite solar cell with ZnOS as electron transport layer



Mr. Mritunjay M. Hiremath

IIT Bombay

HOST

Carl Zeiss AG

Area of Work

Developing a mathematical framework to quantify damage in fiber composites based on microstructural characterization



Mr. Kuchipudi Naga Venkata Sai Teja

CSIR-Central Building Research Institute (CBRI), Roorkee

HOST

Fraunhofer Institute for Non-destructive Testing IZFP

Area of Work

Detection and imaging of vertical surface breaking cracks in concrete using multi-wave techniques

Women Involvement in Science and Engineering Research (WISER)

-First Batch of Awardees

IGSTC had launched the Women Involvement in Science and Engineering research (WISER) programme on 24th November 2021. WISER aims to promote women researchers in Science, Technology, Engineering and Mathematics (STEM) to create avenues for networking, interaction and long-term research collaboration. Through this scheme, women researchers/entrepreneurs holding a regular position in academic/research institutions/industrial research organisations in India/Germany may apply to be a part of an ongoing R&D project of interest with acceptance from the host team.

WISER is open to all the areas of STEM and the tenure is for a period of 3 years or till completion of the project whichever is earlier and will cover one visit per year for short stay up to 1 month.

The financial assistance under this scheme for Indian awardee is upto ₹ 39 lakhs for 3 years and for German awardee it is € 48000 for 3 years.

IGSTC has received a tremendous response in applications and after a diligent evaluation, 10 awardees from India and 1 from Germany has been shortlisted. The following are the brief profiles of 11 successful candidates for WISER.



Dr. Gayathri Pananghat

IISER Pune

HOST

Max Planck Institute
for Terrestrial Microbiology, Marburg

AREA OF WORK

Structural and biochemical characterization of protein complexes in myxococcus xanthus polarity regulation



Dr. Shrutidhara Sarma

IIT Jodhpur

HOST

TU Braunschweig

AREA OF WORK

Towards development of ultrasensitive strain measurement system using laminated nanocomposites. (TESSLA)



Dr. Manju Nanda

CSIR-National Aerospace Laboratories, Bangalore

HOST

German Aerospace Centre (DLR) , Braunschweig

AREA OF WORK

Design, develop and propose a regulatory framework for model-based safety assessment towards software health management



Prof. Dipti Gupta

IIT Bombay

HOST

Karlsruhe Institute of Technology (KIT), Karlsruhe

AREA OF WORK

An integrated liquid/electrolyte gated transistor (EGT) technology platform for rapid, detection of cancer-associated extracellular vesicles



Dr. Poulomi Ganguli

IISER Pune

HOST

GFZ German Research Centre for Geosciences, Potsdam

AREA OF WORK

CRA floods: compound risk assessment of heat-stress induced pluvial floods



Prof. Meenu Saileshkumar Saraf

Gujarat University, Ahmedabad

HOST

Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures, Braunschweig

AREA OF WORK

Nutrient dynamics and functional aspects of microbial diversity in saline soils



Dr. Thanammal Ravichandran

Kumaraguru College of Liberal Arts and Science, Coimbatore

HOST

University of Hohenheim, Stuttgart

AREA OF WORK

Potential of digital innovations and its institutional dimensions to enhance dairy productivity in developing countries



Dr. Janani Srree Murallidharan

IIT Bombay

HOST

TU Darmstadt

AREA OF WORK

Computational modeling of boiling heat transfers



Prof. Radha Chaube

Banaras Hindu University, Varanasi

HOST

GFZ German Research Centre for Geosciences, Potsdam

AREA OF WORK

Ludwig-Maximilians-University, Munich



Dr. Rajamalli Pachai Gounder

IISc Bangalore

HOST

Kurt-Schwabe-Institut für Mess- und Sensortechnik Meinsberg e.V, Waldheim

AREA OF WORK

Design and synthesis of multi-resonance thermally activated delayed fluorescence emitter for optogenetics and imaging applications



Ms. Rahel Krause

RWTH Aachen University

HOST

IIT Delhi

AREA OF WORK

Heat transmission through multilayered clothing under extreme heat and fire conditions

WISER Award Ceremony

IGSTC organised the WISER award ceremony on 18th October 2022 to felicitate all the awardees. The event was graced by H.E. Dr Philipp Ackermann, German Ambassador to India & Bhutan, Prof. Santishree Dhulipudi Pandit, Vice Chancellor, Jawaharlal Nehru University and Mr. S.K. Varshney, Adviser & Head, International Division, DST & IGSTC Co-Chair, GB.

Dr. Ackermann appreciated the women researchers' efforts in niche science & technology areas and said that their contribution would strengthen Indo-German collaborations in S&T. "Initiation of a programme like WISER would motivate women researchers to excel and take up leadership positions in Science & Technology," said Prof. Pandit. The event was well attended by representatives from DST, German embassy, CEFIPRA, TDB, DAAD, and other funding agencies. The German awardee was felicitated on 21st September 2022 with the certificate in Aachen, Germany in the presence of members of IGSTC secretariat and German project office.



Indian WISER awardees



Dignitaries for the WISER award ceremony

Paired Early Career Fellowship in Applied Research (PECFAR)

-First Batch of Awardees

Paired Early Career Fellowship in Applied Research (PECFAR), a new initiative to facilitate research and networking among early career researchers from India & Germany through a short-term exchange visit up to 2 months was launched on 1st February 2022. PECFAR provides grants for research stay & networking including monthly fellowship along with international travel support & medical/travel insurance cost for the visit to the host country.

In the first Call, IGSTC awarded the fellowship to 11 pairs of Early Career researchers from various academic institutions in India & Germany. It is envisaged that such engagements through networking would further establish long-term bilateral collaborations and provide an opportunity to explore the Indian and German research

landscape for potential collaborations in future.

IGSTC organised a virtual Award Felicitation Ceremony on 15th November 2022. Mr. S.K. Varshney, Adviser & Head, International Cooperation, Department of Science and Technology (DST), Govt. of India & Indian Co-Chair, IGSTC GB and Ms. Kathrin Meyer, Head of the Division Cooperation with Asia and Oceania, Federal Ministry of Education and Research (BMBF), Govt. of Germany & German Co-Chair, IGSTC GB addressed the Awardees and inspired them to take the opportunity to visit India and Germany for exploring various S&T aspects. Each pair of Indian and German Awardees pitched their views on the programme and expressed how such opportunities will strengthen their future research endeavors.



PECFAR Award Felicitation Ceremony (virtual) on 15th November 2022

A brief profile of the selected Pairs of PECFAR awardees from India and Germany are detailed below:

PAIR 1: IISc Bangalore & TU Munich

Tarun Rambha

Assistant Professor, IISc Bangalore

AREA OF WORK

Smart transportation using Autonomous Mobility-on-Demand (AMoD) and public transit (PT) systems.

Maximilian Schiffer

Assistant Professor, TU Munich

AREA OF WORK

Smart transportation using Autonomous Mobility-on-Demand (AMoD) and public transit (PT) systems.

PAIR 2**IIT(ISM) Dhanbad & TU Munich**

Surabhi Jain

Post-Doctoral Researcher, IISc Bangalore

AREA OF WORK

Investigation of mechanical behaviour of biochemically stabilized tailings to mitigate the failure of tailing storage facilities.

Ana Paula Ribera

Diploma Engineer, TU Munich

AREA OF WORK

Investigation of mechanical behaviour of biochemically stabilized tailings to mitigate the failure of tailing storage facilities.

PAIR 3**IIT Gandhinagar & Helmholtz Institute Freiberg**

Pankaj Khanna

Assistant Professor, IIT Gandhinagar

AREA OF WORK

To develop outcropping reservoir analogues to unlock the geothermal potential of India.

Samuel Thomas Thiele

Post-Doctoral Researcher, Helmholtz Institute Freiberg

AREA OF WORK

To develop outcropping reservoir analogues to unlock the geothermal potential of India.

PAIR 4

IIT Bombay & RWTH Aachen University



Ankit Jain

Assistant Professor, IIT Bombay

AREA OF WORK

Understanding thermal transport properties of materials for thermoelectric applications and computational discovery of catalyst for thermochemical reactions.



Abhishek Khetan

Junior Professor, RWTH Aachen University

AREA OF WORK

Computational modelling and simulations for discovery of highly soluble battery molecules and highly active catalyst

PAIR 5

IISc Bangalore & Paderborn University



Sai Gautam Gopalakrishnan

Assistant Professor, IISc Bangalore

AREA OF WORK

Theoretical and experimental development of Ca-ion intercalation of electrodes using multi-scale theory.



Hans-Georg Steinruck

Assistant Professor, Paderborn University

AREA OF WORK

Theoretical and experimental development of Ca-ion intercalation of electrodes using multi-scale theory.

PAIR 6**Central University of Punjab
& RWTH University Hospital****Uma Shanker**

Assistant Professor, Central University of Punjab

AREA OF WORK

Translational liver research to study hepatic disorders research including Non-alcoholic steatohepatitis (NASH), viral hepatitis, liver cirrhosis and liver failure

**Amit Khurana**

Doctoral Researcher, RWTH University Hospital

AREA OF WORK

Study on gut-microbiome during the pathogenesis of acute-on-chronic liver failure

PAIR 7**CSIR-CMERI, Durgapur & TU Munich****Saikat Kumar Shome**

Principal Scientist, CSIR-CMERI, Durgapur

AREA OF WORK

Data-driven control strategies for 3D musculoskeletal model of the human hand

**Amartya Ganguly**

Senior Scientist, TU Munich

AREA OF WORK

Data-driven control strategies for 3D musculoskeletal model of the human hand

PAIR 8

IIT Delhi & TU Munich

Tanmoy Chakraborty

Associate Professor, IIT Delhi

AREA OF WORK

Combating Offensive Speech on Social Media: Roles of Language Usages, User Behavior, and Network Structure



Debarghya Ghoshdastidar

W2 Professor, TU Munich

AREA OF WORK

Development a formal framework for attack-defence mechanisms in community detection, inspired by recent advances in adversarial learning



PAIR 9

IIT Mandi & TU Berlin

Prateek Saxena

Assistant Professor, IIT Mandi

AREA OF WORK

Sustainability and effectiveness of the Laser Powder Bed Fusion (LPBF) based Additive Manufacturing process to design lightweight structures



Christian Lahoda

Research Engineer, TU Berlin

AREA OF WORK

Preparation of the feedstock and the identification of suitable process parameters for the qualification of recycling granulate for the additive process



PAIR 10

NIT Rourkela & PTB, Braunschweig

Bukke Kiran Naik

Assistant Professor, NIT Rourkela

AREA OF WORK

Framework on safety standards for commercializing low temperature thermochemical energy storage device in residential buildings



Sumit Agarwal

Project Manager and Scientist, PTB, Braunschweig

AREA OF WORK

Thermochemical energy storage system for building applications



The background is a dark, textured space filled with small, distant light points. A prominent, glowing blue arc curves from the upper right towards the center. In the lower right, there are several bright, orange-yellow light trails that appear to be moving or pulsing. The overall effect is one of cosmic or futuristic energy.

Small Immediate Need Grants (SING) Awardees



IGSTC introduced the initiative Small Immediate Need Grants (SING) on 27th December 2021, to support proposals that require modest funding with quick turnaround decisions and have the potential to embark on good bilateral Indo-German collaboration.

SING supports the proposal with at least one of the following objectives:

- Joint initiatives/ideas that have a scope to ignite and open avenues for long term connect/technology development/new areas of collaboration.

- Joint activity towards innovation, rapid prototyping, technology demonstration or industrial R&D.
- Individual proposals that have a high potential of involving industrial sectors.
- Utilizing scientific events to share intellectual thoughts/ideas that can explore avenues for bilateral cooperation.

Below are the brief details of the awardees under the SING program:



Dr Rajesh Kumar

Associate Professor, Department of Physics
Indian Institute of Technology Indore

TITLE

Developing electrochromic electrodes and devices using novel materials

HOST

Dr Nadja-Carola Bigall, Institute for Physical Chemistry and Electrochemistry, Leibniz Universität Hannover



Dr Hem Chandra Jha

Associate Professor, Department
of Biosciences & Biomedical Engineering
Indian Institute of Technology Indore

TITLE

Unrevealing the role of peroxisome in epstein barr virus mediated infections

HOST

Prof. Srikanth Karnati, Institute of Anatomy and Cell Biology, University of Würzburg



Dr Chinmay Khare

Founder & Director, Wissenkraft Labs, Pune

TITLE

To establish of mutual synergies and initiate collaborative research between Wissenkraft Labs and Department of Surgical Research, BG University Hospital, Bochum

HOST

Dr Marina Breisch, Head of Surgical Research, BG University Hospital, Bochum



Dr William Kaal

Group Leader, Fraunhofer-Institute for Structural Durability and System Reliability (LBF)

TITLE

Development of adaptive torsional vibration isolators (ATVI) using magneto-rheological elastomer

HOST

Dr Bharathi Priya C, Principal Scientist, CSIR-Structural Engineering Research Centre (SERC)



Dr C N Shyam Kumar

Assistant Professor, National Institute of Technology (NIT), Calicut

TITLE

Fabrication and testing of low-cost in-situ micro tensile tester for scanning electron microscopy

HOST

Prof Christian Kubel, Karlsruhe Institute of Technology



Ms Mayookha V P

UGC SRF, Department of Biochemistry
CSIR- Central Food Technological Research
Institute, Mysuru

TITLE

Towards a crystallization process for the separation of long chain fatty acid triglyceride species from virgin coconut oil.

HOST

Prof. Dr.-Ing. Andreas Seidel-Morgenstern,
Director, Max Planck Institute for Dynamics
of Complex Technical Systems, Magdeburg



Ms Kanchan Samadhiya

Research Scholar
Indian Institute of Technology Indore

TITLE

Biohydrogen: A Carbon neutral energy vectors from purple non-sulfur bacteria

HOST

Prof Regina Nogueira, Professur Wasser-und
Abwasserbiologie, Leibniz University, Hannover



IGSTC-CONNECT Plus

Alexander Von Humboldt (AvH) foundation and the Department of Science & Technology (DST) organizes Indo-German Frontiers of Engineering Symposia (INDOGFOE) which are a series of interdisciplinary, binational conferences. Funding support on the Indian side is provided by the Department of Science & Technology, Government of India and on the German side by the Federal Ministry of Education and Research (BMBF).

The activity brings together outstanding, early-career German and Indian engineers and natural scientists from industries, universities, and other research institutions to introduce their areas of research and technical work, thereby facilitating an interdisciplinary transfer of knowledge and methodology that aims to lead to the development of cooperative networks of young scientists from both countries.

To encourage long-term collaboration among participants of INDOGFOE, the AvH Follow-up Programme CONNECT allocates residence allowances for working visits of participants in INDOGFOE partner countries for up to a total of 30 days per conference. To further support working visits for successful CONNECT applicants from India and Germany, this Letter of Intent (LoI) designates and appoints IGSTC to implement, administer and manage the IGSTC-CONNECT Plus Programme. Under this programme, IGSTC will support international travel expenses for successful Indian and German CONNECT participants, thus promoting the scientific exchange and networking.

Following are the brief details of the IGSTC-CONNECT Plus awardees:



Dr Shree Prakash Tiwari

Indian Institute of Technology Jodhpur

TITLE

Exploration of Multifunctional Flexible Transistors for Photo-Sensing Applications

HOST

Prof Daniel Neumaier, Department of Electrical, Information and Media Engineering, University of Wuppertal



Dr Sonu Gandhi

DBT-National Institute of Animal Biotechnology (NIAB)

TITLE

Evaluation of fibrous fleece entrapped with mesenchymal stem cells in wound healing applications

HOST

Prof Sofia Dembski, Fraunhofer Institute for Silicate Research, Würzburg



Prof Daniel Neumaier

Department of Electrical, Information and Media Engineering, University of Wuppertal

TITLE

Printed negative capacitance field-effect transistors (nc-FETs) based on 2D-TMD semiconductors

HOST

Prof Subho Dasgupta, Indian Institute of Science Bangalore



Prof Subho Dasgupta

Indian Institute of Science Bangalore

TITLE

Printed negative capacitance field-effect transistors (nc-FETs) based on 2D-TMD semiconductors

HOST

Prof Daniel Neumaier, Department of Electrical, Information and Media Engineering, University of Wuppertal

Outreach

The Indo-German Science and Technology Centre (IGSTC) has been increasing its outreach and visibility by conducting events in various tier-2 cities of India. IGSTC organized four successful outreach events in Coimbatore, Thiruvananthapuram, Guwahati and Lucknow. The events were attended by invitees from different academic and research institutions as well as industries. The one-day interactive events included detailed sessions on IGSTC activities, descriptive sessions for applications, presenting success stories, an address from visiting dignitaries and a panel discussion. The panel discussion which

featured panellists from academia, research, industry, and the German consulate, focused on the relevance of international science and technology cooperation in today's context and connecting industry, academia, and research. It generated an excellent response from the audience and was a great experience for all involved. The events were well received and much appreciated by the participants. There were great opportunities for the IGSTC to connect with stakeholders and highlight the centre's mission of fostering collaboration between India and Germany in the field of science and technology.



Panel discussion at Coimbatore event on 26th September 2022



Participants at Coimbatore event on 26th September 2022



Panel discussion at Thiruvananthapuram event on 22nd November 2022



Participants at Thiruvananthapuram event on 22nd November 2022



Panel discussion at Guwahati event on 30th January 2023



Participants at Guwahati event on 30th January 2023

Virtual Outreach Event

IGSTC German project office organised a Virtual Outreach Event on 27th October 2022 to publicize IGSTC programmes to a larger audience in Germany. Mr Madhan, Director, IGSTC welcomed all the participants and gave a brief introduction on IGSTC. Dr Ulrike Wolters, BMBF congratulated IGSTC for acting as the nerve centre for Indo-German S&T Cooperation. Dr Madhusudan Reddy Nandineni, Science Counsellor, Embassy of India, Berlin congratulated India & Germany for completing 70 years of diplomatic relations and encouraged researchers, academicians & industrialists to initiate

cooperation in the priority areas of Green and Sustainable technology, Renewable energy and Agro-economic as discussed in the Intergovernmental Committee (IGC) held in Berlin, May 2022. The event also witnessed success stories from 2+2 project: PPAM and Indo-German workshop on sustainable stress management: aquatic plants vs. terrestrial plants, followed by the introduction of the newly launched IGSTC programmes: WISER, PECFAR and SING by Ms Doerte Merk, German Project Office, IGSTC. The event was well attended by representatives from scientific community in India & Germany.





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