

INDO-GERMAN SCIENCE & TECHNOLOGY CENTRE





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AHT



Annual Report
2019-20







The Indo-German Science & Technology Centre (IGSTC) has been established to facilitate Indo-German R&D 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.

| 1 | Play a proactive role in facilitating participation of industry in joint R&D+I projects. |
|-------|---|
| 2 | Provide/assist in mobilizing resources to carry out industrial R&D+I projects. |
| 3 | 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. |
| 4 | Provide advice to institutes and industries from both the countries on the possibilities of Indo-German cooperation and help in the identification of suitable partners. |
| 5 | Facilitate and promote Indo-German collaboration in science and technology through substantive interaction among Government, academia and industry. |
| 6 | Encourage Public-Private Partnerships (PPP) to foster elements of innovation and industrial application and cultivate a culture of cooperation between science and industry. |
| 7 | Nurture networking between young and mid career scientists and technologists to develop a sense of mutual trust, leadership and entrepreneurship. |
| 8 | Develop cooperation through the identification of scientists and scientific institutions of the two countries. |
| 9 | Organize workshops, seminars, training programmes and other types of events on topics of mutual interest. |



Federal Ministry of Education and Research

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Mr Sanjeev Kumar Varshney, (second from right) Indian Co-Chair during the due-diligence meeting at IIT Madras

THE YEAR 2019-20 AT A GLANCE

IGSTC continues to accelerate the Indo-German research network through its programmes and schemes with a zeal and plays a pivotal role in facilitating the area of collaborative research supporting various Indian & German institutes and industries. The flagship scheme of 2+2 currently supports 20 projects in various areas of national priority for India and Germany. The revamped Open Workshop Call supported five workshops which were held in the period 2019-20 and few more are scheduled in the coming months to create platforms for productive interactions among scientists and policymakers of the two countries. The IGSTC-CONNECT Plus programme in association with Humboldt Foundation was launched to support short-term research stays in India and Germany which supported one fellow during this period

During 2019-20, IGSTC supported 20 joint projects in 2+2 mode in emerging areas of (i) sustainable energy (ii) advanced manufacturing (iii) biomedical devices and technology (iv) water & wastewater technologies (v) Smart Cities. Two new projects from Call 2018 in the overall thematic areas "Sustainable Production" and "Clean and Green Technologies" started in March 2020 (few more projects to start in the next couple of months). Currently, ongoing IGSTC projects involve 85 (eighty-five) project partners from academia and industry from India and Germany with a total project investment (both Indian and German) of estimated ₹ 120 Cr or € 15 million. There are eighteen (2+2) projects already completed. Approximately 600 scientists, researchers, engineers from both countries have been networked through this programme since its inception. Also, 250 research personnel at the level of post-doctoral, doctoral, masters and bachelors are working on these projects creating capacity building of significant high-quality research manpower.

IGSTC has given extension for three projects under Call 2014 for phase 2 funding which have shown promising results and reached a significant TRL. The aim in Phase 2 for these projects is to bring a product/service close to commercialisation. Sound4All, a project partnered by Path GmbH, TU Munich, IIT Delhi and AIIMS Delhi are in advanced stages of developing a prototype of affordable hearing aids. SIBAC project partnered by Narayana Nethralaya, Bangalore and Oculus Optikegrate GmbH is in the development of a software tool for predictive modeling of corneal deformation with air-puff applanation. The MIDARDI consortium partnered by BiFlow Systems GmbH, Manipal University, Achira Labs, Fraunhofer IZI & ENAS has been developing a microfluidic based lab-on-a-chip for rapid (<1hour) and accurate detection of different types of bacteria, their virulence/fitness factors and antibiotic resistant genes that may contribute to dominance of certain types in Diabetic Foot Ulcer settings.

This period witnessed changes in the Governing Body of IGSTC. Ms Kathrin Meyer has taken over as the new German Co-Chair of IGSTC. IGSTC welcomes the new Co-Chair of



Ms Kathrin Meyer (fourth from left) German Co-Chair's visit to IIT Delhi

A marquee workshop on "Research and innovation towards leapfrogging in frontier technologies (RILEAP)" was funded by IGSTC. It was coordinated by CSIR, India and Fraunhofer, Germany and convened at various Governing Body. IGSTC also expresses its gratitude to the departing Co-Chair Dr Lothar Mennicken for his pivotal guidance to IGSTC for the past several years.

places in India. It will result in several long-standing, concrete and mutually beneficial collaborations in the areas of Sustainable Buildings, Water, Advanced Production Technologies and Battery Technologies.



Four workshops under the Open workshop call of IGSTC in the areas of Scientometrics (GESIS-Leibniz Institute for the Social Sciences, Cologne), Groundwater Assessment (Anna University, Chennai), Solar Thermochemical Technologies (DLR, Cologne) and Computational Mathematics (IISc Bangalore) were organized in various parts of India & Germany. Around 250 Indian & German scientists, policy officers, young researchers were benefited from the above-said workshops. These workshops generate new associations and joint research projects

among scientists/ technologists between the two countries.

Indo-German Science & Technology Centre and Alexander von Humboldt Foundation (AvH) jointly launched the IGSTC-CONNECT Plus Programme in May 2018. The programme supported one fellow in this Financial Year. Few more fellowship awards are in the pipeline.

The Indian & German Co-Chairs also approved six projects of Call 2018 recommended by the Joint Scientific Committee.



Joint Scientific Committee of Call 2018

IGSTC continued administering DST-Max Planck Programme on behalf of DST. This programme has provided an excellent opportunity to Indian young scientists to partner with

global leaders at the Max Planck Institutes in Germany through a networked model of cooperation. During this period, IGSTC is implementing 7 Visiting Fellowships.

GOVERNING BODY



Sanjeev Kumar Varshney



B Anand



G Padmanabham



Sandeep Verma



Anjan Das



Philipp Von Ritter*







Gerold Heinrichs



Stephan Lanzinger*



Eberhard Abele TU



Clas Neumann



PROGRAMME ACTIVITIES 2+2 PROJECTS

2+2 PROJECTS CALLS

Salient Features of 2+2 Partnership

| Project proposal is expected | | | |
|------------------------------|--|--|--|
| to produce insight and | | | |
| exploitable research results | | | |
| leading to new technologies, | | | |
| products and/or services. | | | |

Funding is provided in the form of grants amounting up to ₹ 230 lakhs per project from Indian side and up to € 450000 from German side, for a period of up to three years.

Industry partners are expected to contribute 50% of their eligible cost.

Academic/research partners receive 100% of the eligible cost.

The proposal will be evaluated by a Joint Scientific Committee consisting of experts from both India and Germany.

PARTNERS

Min. 4 & Max. 6

- India 1 academic/research institute + 1 industry
- **Germany 1 academic/research** institute + 1 industry

THEMATIC AREAS

- Energy
- Water
- Manufacturing

FUNDING

- Indian side ₹230 lakhs
- **b** German side € 450000

DURATION

- **3** years
- Extendable up to
- 2 more years



MANUFACTURING

PPAM

Metal powder production for additive manufacturing



Saptarshi Basu

IISc Bangalore



IIT Kharaqour







Suman Chakraborty Suvankar Ganguly Tata Steel Ltd., Jamshedpur TU Darmstadt

Cameron Tropea Hans-Jürgen Odenthal SMS group GmbH



Project Summary

For Laser Powder Bed Fusion (LPBF), a fine metal powder is solidified into layers using a focused laser beam. The properties of the product depend strongly on the uniformity of size and consistency of the powder particles. This project addresses the production of steel powder 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 operations are used in combination to develop validated, predictive capabilities, and design guidelines for full-scale facilities. Scientifically, the challenge lies in modeling 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 facilities and one as an end-user. Improved quality, lower cost, and an expanded product design parameter space can be expected.

Progress made/achieved

Partner 1: IISc

During the reporting period, academic partner IISc has made contributions to the work packages 3 (Adaptation/ Development of Facility), 4(Shock-droplet Shock-tube interactions: Breakup Mechanisms) and 5 (Atomization model development).

Partner 2: IIT Kharagpur

During the reporting period partner IIT Kharagpur has made contributions to the work package 4. (numerical simulation of shock-droplet interaction and its perspective in close-coupled atomization)

Partner 3: Tata Steel

During the reporting period partner Tata Steel has made contributions to the work packages 10 and 11. (Development of test procedures and powder properties for quality assurance including benchmarks configurations)

Partner 4: TU Darmsdat (TUDa)

During the reporting period partner TUDa has made contributions to the work packages 1 (Dimensional analysis for research facility), 2 (Experiments in research facility), 5. (Atomization Model Development), 7 (Results comparison: Research facility and pilot plant), and 9 (Validation of numerical simulations and atomization model)

Partner 5: SMS Group

During the reporting period partner SMS group has contributed to work packages 1 (Dimensional analysis for research facility), 5(Atomization model development). 6(Implementation of atomizer model in code), 8 (Measurement of powder properties for validation), 9 (Validation of numerical simulations and atomization model) and 11(Experimental additive manufacturing: Sample property measurements).

The progress achieved during the first 15 months of the project PPAM has been very satisfactory. No significant obstacles or delays have been encountered. The main research achievements are summarized below in point form. Nevertheless, it is too early to make a statement about TRL, as many facilities have

Distribution of Stainless steel 17-4 PH particles under microscopic level.

just now been commissioned. This will be possible in the next report.

- A phase-field model coupled with a high Mach flow module has been used for simulating the droplet-shock interaction. The numerical model has been implemented in Comsol Multiphysics. The present numerical results depict good agreement with the results of Sembian et. al. (2016). In the numerical analysis, the Weber number, Mach number and the domain confinement ratio are found to have significant importance in the sheet-thinning behavior of the droplet as shown in Figure 1.
- The presence of shock waves in the gas flow field and the velocity contour in the numerical simulation of the close-coupled atomizer closely resembles the findings by Zeoli and Gu (2006) and Firmansyah et. al. (2014).
- Evidence for a strong two-way coupling between gas and liquid flow in the closed-coupled atomizer has been found (see Figure 2). As a result, it appears to be inappropriate to rely on conclusions drawn only from gas-only flow

investigations in order to predict the atomization performance.

Mass flow rate measurements suggest that no Mach disc forms during the atomization process (see Figure 2a). Consequently, different atomization mechanisms must be responsible for the wide distribution of particle sizes.

•

- By March 2020, approx. 95 charges have been carried out on the SMS production plant and three grades of metal powder (austenitic, bainitic, martensitic steel) have been produced. The typical PSD after sieving is 15 - 45 μ m. With the standard plant settings (melt superheating, nozzle diameter, atomizing pressure, atomizing temperature, GMR), the plant runs stably and produces high quality powder.
- A preliminary Euler-Lagrangian atomization model found in the literature has been implemented in OpenFOAM. The basic model predictions regarding the mass flow rate of water and the droplet diameter at variable atomization gas pressures tend to agree well with the TUDa water model measurements. However, a further modification of the atomization model is required.
- A droplet solidification model based on . classic homogeneous nucleation formation has been developed and is currently implemented in OpenFOAM.

 $t = 6 \times 10^{-4}$





Figure 1: Influence of selected parameters on the temporal evolution of the droplet.



(a) Liquid mass flow rate





Figure 2: Characteristic features of the multiphase flow.

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TRANSLEARN

Robot skill transfer from simulation to real world deployment in manufacturing industries and warehouses



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IIT Kanpu



Swagat Kumar Tata Consultancy Services (TCS) New Delhi



Torsten Kroger KIT Karlsruhe



Rainer Bischoff Kuka Deutschland GmbH Augsburg

Project Summary

Industry 4.0 will be driven by two basic technologies: AI and Robotics - and especially the combination of both - allowing robots to learn skills and tasks without explicitly programming them. Learning and optimizing complex and interactive robot manipulative skills through reinforcement learning algorithms is a multifaceted challenge and an unsolved problem. With the goals of (i) significantly reducing robot programming costs and (ii) reducing robot cycle times, the project plans to develop reinforcement learning algorithms running in massively parallelized, cloud-based physics engines. This system learns and optimizes task-specific robot and machine skills that can be transferred to and deployed on physical robots. Project plans to develop concrete demonstrations of novel solutions for real use cases stemming from the manufacturing industry and warehouse automation. The solutions will rely on robot learning in a cloud-based simulation environment as well as optimization during real-world execution.

Progress made/achieved

Partner IITK

Regarding D0 (Specification of demonstrator scenarios and criteria for evaluation), the requirements for vision-based grasping and assembly applications in manufacturing and

warehouse automation have been identified. Segregating waste of different categories of items (metallic, wooden, etc.) from a moving convevor belt was selected as a promising use case. A UR10 robot manipulator with a mobile base is planned for this task.

Concerning D2 (System parameters of robots and tasks), a physics-based simulation environment with multibody contact modelling and realistic rendering for deep reinforcement learning is developed in collaboration with TCS. The simulation environment is based on existing state-of-the-art physics simulators like PyBullet and NVIDIA Flex. It will be used to learn motor skills and to develop vision-based algorithms for object detection, segmentation and grasp planning.

Partner TCS

With respect to D5 (RL based algorithms for hand-eye coordination and visual servoing), a reinforcement learning algorithm has been developed for hand-eye coordination using simulated data. Additionally, a technique to transfer an RL agent for hand-eye coordination from simulation to a real domain has been propose.

Partner KIT

While working on DO, KIT has identified dynamic movements for industrial tasks to be a major challenge for robot learning due to the safety concerns during exploration. To address this issue, two additional milestones E3 (Learning of time-optimal and cost-optimized robot trajectories developed



and evaluated) and E4 (Learning of online adaptations based on sensory feedback developed and evaluated) were defined. While E3 indicates that learning offline generation of time-optimal trajectories has been successfully accomplished, E4 proved that incorporating sensory feedback enables effective learning of online adaptations.

With respect to deliverable D3 (Noise models for robust learning in simulation), KIT has developed a method to incorporate noise models for robust learning based on Monte Carlo tree search which is especially suitable for tasks that require high action precision. For deliverable D6 (Transfer learning from simulation to the real world), KIT has shown successful sim-to-real transfer for a balancing policy based on the technique developed within milestone E4 and for a water pouring policy.

The consortium has published eleven papers by now, with three of them being accepted at the IEEE flagship conferences ICRA and IROS.

The TransLearn kick-off meeting was held in New-Delhi, India in October 2019

Partner KUKA

The aim of deliverable DO was the definition of one or more demonstrator use cases, in which the project developments can be demonstrated and evaluated. Possible scenarios have been discussed and agreed upon: KUKA will pursue the use case "end-of-line test for connectors". Control of an omnidirectional load-carrying mobile platform will be evaluated as an additional use case.

For deliverable D2, KUKA has worked on interfaces and a framework for collecting data from robotic applications. With the implemented structures, data collection for training data and the identification of parameters for the simulation systems can be carried out. Based on the data KUKA has also implemented a system identification pipeline determining system parameters for a given simulation based on commands executed both on a real robot and on a simulated counterpart.

Salient Research Achievements

- Publication of a newly developed model-free method to learn time-optimal and cost-optimized robot trajectories within a wide range of starting points and endpoints.
- Development of a model-free method to learn online adaptations of robot trajectories based on their effects on the environment (under review).
- Successful usage of operational space control combined with system identification to train a robust policy without the need for dynamics randomization (under review).
- Successful demonstration of sim-to-real transfer for a peg-in-hole task and a balancing task with a KUKA iiwa robot.

Publications

Ravi Prakash, Laxmidhar Behera, J Sarangapani: Dynamic Trajectory Generation and a Robust Controller to Intercept a Moving Ball in a Game Setting, IEEE Transactions on Control Systems Technology, 2019 Aiswarya Menon, Ravi Prakash and Laxmidhar Behera: Adaptive Critic Based Optimal Kinematic Control for a Robot Manipulator, International Conference on Robotics and Automation (ICRA), Montreal, 2019

Jonas Kiemel, Peiren Yang. Pascal Meißner. Torsten Kröger: PaintRL: Coverage Path Planning for Industrial Spray Painting with Reinforcement Learning, Workshop on Closing the Reality Gap in Sim2real Transfer for Robotic Manipulation at RSS 2019, Freiburg

Jonas Kiemel, Pascal Meißner, Torsten Kröger: TrueRMA: Learning Fast and Smooth Robot Trajectories with Recursive Midpoint Adaptations in Cartesian Space, IEEE International Conference on Robotics Automation (ICRA), 2020

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





T.P.D. Rajan CSIR-National Institute for Interdisciplinary Science and Technology (NIIST) Trivandrum H. Sundaramurthy Fenfe Metallurgicals Bangalore

Project Summary

The increased demand for lightweight materials with high specific strength, stiffness and better tribological properties have accelerated the development, diversification and use of metal-matrix composites (MMCs). The objectives of the present investigation are development of processing method for Carbon (C) fibre reinforced Auminium (Al) MMCs by liquid metal infiltration process. Preforms of high modulus continuous C-fibre will be produced by advanced textile technologies like 3D-weaving in a near-net shape form based on the expertise of ITA der RWTH Aachen University, and the squeeze infiltration processing of Auminium composite will be carried out in the CSIR-NIIST. The Indian Industrial partner. Fenfe Metallurgicals will develop and supply 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 will provide the conceptual and detailed part design based on the textile and infiltration process as well as the structural analysis. The developed near-net-shape component will be evaluated and on successful development the industrial partners will manufacture the components for Indian and German OEMs.



Thomas Gries RWTH Aachen University Aachen



Farbod Nezami CIKONI GmbH Stuttgart

Progress made/Achieved

Partner 1: Institut für Textiltechnik (ITA) der RWTH Aachen University

Milestone No.1: Fabrication of continuous Carbon fibre preforms for specimens:

The objectives of the milestone have been reached. In particular, the following results have been achieved:

- Suitable Carbon fibre has been chosen as a compromise between cost, modulus, and processability for 3D-weaving.
- Tenax®-E HTS45 E23 12K fibres with a defined twist has been purchased and the most relevant parameters for 3D-architecture have been listed.
- Based on this data, a Design of Experiment (DoE) has been carried out.
- Twelve different multilayer-patterns have been designed with a CAD/CAM software as well as a reference 2D-pattern.
- To ensure easy transferability to the industry from the very beginning, the fabrics were produced on an industrial scale 3D-weaving loom at Lindauer Dornier GmbH.
- In addition to the 3D-patterns, simple 2D-patterns have been designed and manufactured in order to investigate the influence of different fibres and more parameters on a multiscale approach (e.g. a mock-leno-fabric with very open pores).



Carbon fibre 2D "mock-leno" preform woven at ITA RWTH Aachen University

Partner 2: CIKONI GmbH

Process simulation for the interaction of squeeze infiltration and textile fabric: This work package is still ongoing. The results will be achieved according to the project plan by the project month 18. The following results have been achieved so far:

- A simulation method to determine the permeability of the fabrics was selected.
- The Finite Element (FE) model of a unit cell was developed to represent the mesoscopic structure of the textile used at the manufacturing process.
- Boundary condition and parameter studies were carried out to simulate the infiltration of the fluid medium.
- The simulative assumption of permeability of the textile architecture was carried out. However, there are some deviations from the experimental results (based on values in literature). Therefore, further calibration of the FE model will be carried out.

Partner 3: CSIR - National Institute for Interdisciplinary Science and Technology (NIIST)

Surface treatment process for continuous carbon fibre and its preform: The objectives of the milestone have been reached. Based on the de-sizing method developed together with ITA, the following results have been achieved:

- The surface treatment to the PAN-based carbon fibre fabric is carried out by Copper based coating to enhance the wettability and degradation of the carbon fibre during the infiltration process. The coated carbon fabrics are stacked to form the preform for the infiltration with liquid aluminium melt.
- The die for the infiltration is designed and fabricated using the tool steel.
- The squeeze infiltration processing of carbon fibre fabric preform is initiated to optimize the process parameters.



Figure shows the morphology of Cu electroplated Carbon fibre for an input current of 0.5 A and 1 hr plating time

Partner 4: FenFe Metallurgicals, Bangalore, India

Development and casting of matrix Aluminium alloy: The objectives of the milestone have been reached. The following work has been carried out:

- Al alloys have been selected according to the process and material demands in close cooperation with CSIR-NIIST.
- Melting, casting and process optimization of the designated Aluminium alloys have been carried out.
- The Aluminium ingots for the matrix to be used for the squeeze infiltration of Aluminium alloy have been supplied to CSIR-NIIST.



Dr H. Sundara Murthy, Fenfe Metallurgicals together with the German project team (Mr. Philipp Huber Dr. Amool Raina) and colleagues from ITA (Mr. Yanick Schlesinger and Ms. Gözdem Dittel) in the foundry

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Salient Research Achievements

In the first year of the project, the basics were achieved for in-depth investigation and understanding to be carried out in the second project year. The steps surface treatment, fabric production, matrix casting, and squeeze infiltration have been established independently. In the following project year, these sub-steps will be combined and characteristic values for this novel material will be collected. Together with these results, the accompanying modeling and simulation will then form the basis for commercialization in the third year.

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STEEL4LTC

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



Koteswararao

V. Rajulapati University of Hyderabad







Robert Brandt Universität Siegen



Steffen Klapprott

Partner 2 - JSW Steels Salem Works (JSW)

JSW has supported the project by means of providing hot rolled SAE 9254 spring steel to the consortium.

Partner 3 - University of Seigen (USI)

USI have been working to meet the first deliverable of the project, i.e. experimental based hypothesis of LTC controlling mechanism. USI is expected to deliver the deliverable #1 (Experimental based hypothesis of LTC controlling mechanism) by May 2020 with



Downsizing and lightweight design of all automotive components especially in the chassis area is underway. Higher stress acts on spring material due to its lightweight design. The springs being used currently may not withstand very high stresses. Hence, there is a pressing need for the development of advanced spring steels with a combination of the higher tensile strength (>2000 MPa), adequate ductility, improved low temperature creep resistance, and better high cycle fatigue properties. This could be achieved by suitable alloying strategies, fabrication technologies, and heat treatments. This consortium is aimed at developing an advanced spring steel grade with the improved mechanical properties through 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 mechanical properties in comparison to the current state of the art materials will be determined by comprehensive microstructural characterizations. Detailed experiments will be conducted, and a phenomenological description will be developed to understand the improved low temperature properties based on the creep 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).

Progress made/achieved

Partner 1 - University of Hyderabad (UoH)

University of Hyderabad (UoH) is supporting Universität Siegen (USI) to deliver the first deliverable of the project. UoH made nanoindentation tests to obtain activation volume of low temperature creep (LTC) in order to strengthen the USI's new experimental based hypothesis on low temperature creep mechanism in spring steels, i.e. load partitioning. UoH also has carried out basic microstructural and phase examination of the steel supplied by JSW Steels Salem Works (JSW) using optical microscopy and scanning electron microscopy techniques. Microhardness measurements were also made. Detailed investigations on tensile and compressive behavior of SAE9254 steel are in progress.

(a) Scanning electron micrograph of longitudinal surface of SAE9254 steel showing complete

support of UoH. The work done related to deliverable #1 is formulated as a manuscript to submit to a peer reviewed scientific journal.

Partner 4 - Muhr and Bender KG (MUB)

MUB has reworked the sample material, provided by JSW into straight bars. This was done at "Mubea Automotive Components India Private Limited" in Pirangut. The sample material is despatched to USI and UoH for material investigations as described.

pearlite structure (b) Inset reveals the details of interlamellar spacing.

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Project Summary

Salient Research Achievements

The LTC investigations were carried out by USI, revealed that LTC of high strength martensitic steels obey logarithmic creep law. Subsequently, USI was involved in reviewing the existing LTC mechanism models, i.e. strain hardening theory and exhaustion creep model, followed by benchmarking them based on the experimental data. It is realized that both the theories were inadequate to fully justify the experimental observations. Moreover, none of these theories seamlessly reveal the nature of the LTC controlling mechanism. USI therefore applied a concept of inhomogeneous plastic deformation leading to a load partitioning between the components of a martensitic

structure. The parameters of the logarithmic creep law are discussed in terms of the new proposed approach showing up that "micro-plasticity" is a valid hypothesis for the LTC controlling mechanism. This work is in relevance to the deliverable #1" of the project. The observed microstructural investigations are also supporting the newly proposed hypothesis. The optical microscopy investigations revealed the presence of stripes along the rolled direction as shown in figure below. These stripes are reported in the literature as segregation of alloying elements, e.g. Cr.



The presence of stripes (inhomogeneities) along the rolling direction in Bechet-Beaujard etched surface



Captured during the first network meeting held at Mubea Weißensee, Germany. Participants (left to right): Mr. Remalli (USI), Prof. Brandt (USI), Mr. Heßland (MUB), Prof. Rajulapati (UoH), Dr. Sambandam (JSW), Mr. Klapprott (MUB).

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SMART & WISE

Smart and reliable water and wastewater infrastructure systems for our future cities in India and Germany



B S Murthy

IIT Madras



Ashok Natrajan

Tamil Nadu Water

Chennai



Theo Schmitt

Heidrun Steinmetz

TU Kaiserslautern





Martina Scheer Ingenieurbuero Scheer Oberstdorf

Gerald Angermair tandler.com GmbH Buch am Erlbach

Project Summary

The Indian project partners (IIT Madras and Tamil Nadu Water investment Company Limited), as well as the German partners (University of Kaiserslautern, Engineering Office Scheer and tandler.com) are working on the overall project goal to support the implementation of reliable and sustainable water and wastewater infrastructure systems (WIS) with added value in terms of smart cities. The targets of the project are to develop planning methods and tools to successfully face current and future challenges on the three linked levels of conventional, advanced, and smart water and wastewater infrastructure systems. E.g. automated planning based on mathematical optimisation to improve conventional sewerage system planning with incomplete planning database. Research on advanced level involves the integration of decentralised and resource-oriented approaches as well as improved water pollution control. Smart WIS research provides interfaces for WIS integration in smart city planning. The methods and tools will be sampled in pilot

areas in India (e.g. Coimbatore) and Germany. Research results will be disseminated through training programs and utilization in planning services for local planners and decision-makers.

Progress made/achieved

Development of planning & decision-making approaches for evaluation criteria, interfaces between WIS and smart city planning

In 2019, the development process to generate planning and decision-making approaches was started. First of all, existing evaluation criteria are summarized by the German partners. These have been checked by the Indian project partners for their applicability in India. A preliminary list of criteria has been identified for evaluating the water infrastructure at conventional, wise and smart levels. A draft report on evaluation criteria has been prepared.

The team decided to use the knowledge gained in the course of the project to develop flowcharts for a systematic guidance on water infrastructure planning. These flowcharts provide a base for the development of several tools (as in a tool-box) which helps in planning. These tools could be in the form of (i) excel computation sheets; (ii) computer programs for finding answers to specific optimization problems, (iii) incorporation of several changes to existing K++ software and (iv) manuals that provide guidelines.

In the first step six flow charts are being developed that provide the planner with systematic guidance on water infrastructure planning. These flow charts include (i) an analysis of necessity, (ii) a feasibility



Field trip in the sewerage system of Kaiserslautern in September 2019

Pilot Studies

Indian industrial partner has made arrangements for one of their employees to work from Coimbatore to facilitate data collection. It has facilitated the collection of secondary data available for (i) a new 24x7 water supply project that is planned; (ii) the existing underground sewerage system for the city, (iii) the status of the stormwater drainage system and (iv) a water balance study that was carried out as part of the smart city project that is being implemented. After several rounds of discussions with the Commissioner of Coimbatore Corporation and his colleagues, assessment, (iii) a pre-design stage and (iv) a design stage. The flowcharts systematically show the linkage between the individual sectors. Therefore, the project focuses on the integrated planning of water supply, urban drainage and wastewater treatment, and points out ways to close the local urban water balance. At this moment the team is working on detailed flowcharts of 5 topics: "Water Supply and Water Reuse", "Stormwater Management", "Sewerage Systems", "Heavy Rain and Flood Protection", and "Resource orientated Wastewater Treatment".

the pilot area for implementation was changed from our original plans and a new pilot area has been chosen. Data for this new pilot area has been collected by the Indian Industry partner already. This data is now being processed by IITM for proper geo-referencing and to fit into the format of K++ software. The data has also been vetted by all the project partners for the consistency and the data gaps. IITM is outsourcing an agency to do the surveying and collecting the missing data. The agency has been identified and IITM is in the process of releasing the work-order for this purpose.



Indian Pilot Area in Coimbatore

Salient Research Achievements

A master data requirement list has been created by Tandler, IB Scheer, and TWIC. This list was then compared with the available data in Germany and India and was adjusted as per our needs. Although we had started data collection for the originally planned pilot area, we had to restart this work because we had to change the pilot area as per the request of the City of Coimbatore. 80% of data collection for this new pilot area is now completed by TWIC. All the project partners identified the data gaps. Missing data is being collected by IITM through outsourcing. Data is also being converted to the format required by K++ software.

•

A flow chart has been developed by IITM with inputs from all the project partners for planning the retrofitting of an existing conventional water supply scheme which is either unable to deliver the services to

the present conditions or need to be retrofitted to cater to the future demands. It considers the situation where the demand cannot be met by existing water sources (surface and subsurface), and the gap between the demand and availability of water is closed by reusing the tertiary treated wastewater for non-potable purposes. The tertiary treated wastewater is available from decentralized sewage treatment plants (STPs) and is supplied through a dual piping system.

A flow chart has been developed by University of Kaiserslautern with inputs from all the project partners for macro-level (overall) planning of a greenfield water supply scheme which considers different water sources i.e., surface reservoirs, groundwater pumping and tertiary treated wastewater from decentralized sewage treatment plants (STPs), spatially distributed in the project area.



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Project meeting at University Kaiserslautern in September 2019 - visit in the laboratory

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ECO-WET

Efficient coupling of water and energy technologies for smart sustainable cities









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Project Summary

Smart cities are envisioned to efficiently use two most critical resources: water and energy. Advanced techniques are being developed to conserve water. Similarly, renewable energy resources and smart devices are being implemented to meet the increasing electricity demand of the large population.

In reality, water management and energy efficiency are complementary to each other. On one hand, electricity from the renewable sources can be used to run water pumps or other components of the water treatment system while on the other hand, during the oversupply of electricity from renewable energy sources, water pumps can be made operational to create a balance of energy demand-supply in the electrical distribution network.

Coupling of cross-commodity infrastructure and integration of energy storage is a challenge for smart cities. With respect to ICT this project addresses the challenge to bring intelligence closer to the device, which leads to distributed design. In such a system, highly integrated components from different sectors interact with each other to use available resources more efficiently and increase the overall performance.

The main goal of the project is the energy-efficient management of electricity and water by complementing both critical resources (energy and water infrastructures) in the smart sustainable cities. The core scientific research is to enhance the overall efficiency by coupling of these most essential infrastructures, through advanced ICT and intelligent computational framework.

Progress made/achieved

Fortiss GmbH

- Designed appropriate software and system architecture for the testbed system;
- Identified the requirements and use cases for the testbed and the battery system control;
- Prepared software architecture and communication design report and contributed for the report on the use case specification and requirements;
- Interfacing with 4DIAC for real-time controlling of the battery system and other hardware.

IITGN

- Developed optimization framework for optimal integration of distributed energy resources and battery management in a simulation environment;
- Developed forecasted on-site solar PV generation algorithm for improved optimization and decision making;
- Procured and deployed the hardware layer to set up the testbed (STP and WTP) at GIFT city;
- Preliminary software layer integration -Integrated the forecast-optimization code with iEMS software;

• Integrate software-hardware layer at testbed location and demonstrate proof of concept (POC) of efficient energy management at use-case levels.

Sonnen GmbH

- Provided necessary Software details for real-time controlling of the battery system;
- Executed detailed use case simulation for validation of hardware dimensions and possible additional use cases to be considered;
- Developed testbed at Sonnen headquarter, Germany, for hard- and software testing of use cases;
- Designing and assembling the battery switching boxes for the respective use case, Installation of the battery switching boxes at STP

GIFT City

- Understanding of existing infrastructure to incorporate Battery Storage and Solar PV System;
- Site survey to proceed with battery installation and integration;
- Prepared use-case specification and requirements report;
- Installation and Commissioning of received sonnen batteries and its associated hardware at testbed locations namely WTP and STP;
- Providing online remote connectivity to batteries and troubleshooting with sonnen (German counterpart) for seamless communication;



- Installation of sonnen power meter and energy meter with online modbus connectivity for load forecasting;
- Installation of sonnen battery switching box and its ancillaries; Designing of Solar PV System for testbed at WTP and STP;
- Preparation of technical specifications and tender document for Supply, Installation, Testing and Commissioning for the following works/ usecases
 - o 15 kWp Solar PV each at STP and WTP
 - o Lightingale server upgradation for Streetlight
 - o Atmospheric Water Generator at WTP
 - o Capacitive Deionization System at STP
 - o Free Residual Chlorine Sensor in Water Supply Pipeline

MMMUT

- Understanding existing electrical infrastructure for power quality improvement;
- Investigation of various harmonic estimation methods;
- Work on Exact Model Order Estimation algorithm is complete;
- Work on ESPRIT algorithm for harmonic estimation is complete.

Started working on IEMS based tool development of the algorithm for deployment at workstation with the help of Fortiss GmbH.



Linear programming framework using Python ze operating cost 's max buy and sell power limi - Grid's min buy and sell power limit ry's max and min SOC erv's max and min charge/ discharge p

Optimal BESS charge,

IDC-Water

Integrated diagnostics of contaminants in water supply and management system





J Maniula

Debiprosad Roy Mahapatra IISc Bangalore

Bigtec Labs P. Ltd., Bangalore

Project Summary

The project proposes to develop a system for monitoring water quality in terms of specific bacterial cell/DNA and pharmaceutical residues. The system will consist of the following components: (1) an in-line water collection and enrichment sample compartment. (2) a system of microfluidic cartridges for bacteria cell capture, culture, amplification, and detection in a short period of time, (3) a system of micro-fluidic cartridges for capture and detection of pharmaceutical residues in a short period of time, (4) an integrated board that hosts all the compartments 1-3, reagent supply units, detection units and performs automated diagnostic tasks and a similar counterpart with micro-PCR for off-line diagnostics, (5) a software framework to operate the integrated system, analyze the data collected over time and provide an appropriate early warning. The system will be designed in such a way that it can be installed in the water pipelines in the water treatment plant settings and in building infrastructure settings for remote monitoring. Target specification for detection of the pathogen would be less than 100 cells in 1 CFU/ml and nanomolar concentration of target DNA detection within an hour. Targets for the detection of pharmaceuticals will be a concentration of 100 ng/L and within a measurement time cycle of 10 minutes.

Salient Research Achievements

Software Layer - Forecasting-Optimization Framework:

The software Forecasting-Optimization framework will be the heart of the project where a day ahead forecasting module will forecast solar PV output power, electricity price, and load demand. It will always be used as an as input to the optimization framework to obtain the optimal battery energy storage system (BESS) charging and discharging references. The forecast-optimization framework will be implemented at each use cases levels at both STP and WTP. The basic flow of the forecasting-optimization framework is shown in the below figure. The proposed energy management algorithm was developed and can be readily applied for solving the energy management problem at use-case levels. The algorithm is developed in such a way that it can be extended for solving energy management of any additional use-cases identified during future course. The entire forecast-optimization framework is developed in Python programming language as to implement it in Raspberry Pi with ease.

Publications

Sachinkumar Suthar, Nitish Kumar and Naran M. Pindoriya, "Cost-Effective Energy Management of Grid-Connected PV and BESS: A Case Study", IEEE PES ISGT ASIA 2019, Chengdu, China, 21-24 May 2019.

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Progress made/achieved

Salient Research achievements

- A detailed product requirement specification 1. document has been developed including national and international standards and recommendations, and technology gap analysis have been carried out jointly by all partners.
- 2. As an alternative and more cost-efficient approach, immunoaffinity extraction via antibodies immobilized on magnetic beads has been conceived and tested. Binding of diclofenac to magnetic beads coated with monoclonal anti-diclofenac antibodies was established. Appropriate elution conditions could be figured out. Miniaturization for the use in a mesofluidic device still needs to be developed (sifin).
- BioTez, a company located in Berlin-Buch 3. was commissioned to produce from the two anti-DCF antibody candidates immunoaffinity columns (IAC), i.e. gel-based immunoextraction columns, to extract and preconcentrate diclofenac from an aqueous sample. Concentration analysis (feed solution vs. extract) was performed at BAM (Dr. Andreas Lehmann). Both antibodies are functional, yet, antibody F01G21 showed much higher recoveries. With a specific gel loading of 2 mg/ml recoveries at the higher concentrations tested were quantitative, a 10-fold lower antibody loading decreased the recovery

to be too low. It was found that methanol (without any addition of 2% HOAC) has sufficient eluting power to release the bound DCF.

- An alternative approach to enrichment 4. via an immunoaffinity column pursued in (III) performing compound capture/ release via antibodies immobilized on magnetic beads (size ca. 1 Qm) was extended. Transporting the beads to the detection zone (for fluorometric or electrochemical detection) this approach combines the steps of enrichment and immunodetection. For immobilization of the antibodies on magnetic beads a chemical approach of cross-linking amino-functionalized (commercial) beads with amino groups in lysine residues of the antibodies by glutaraldehyde was chosen. Other, non-commercial beads with improved features will be tested in due time (BAM).
- 5. A pre-filtration unit was designed and tested to eliminate larger size contaminants and to send a controlled quality of sample without unwanted inhibition into the cartridge (IISc), and simultaneously monitor the general condition of the sample in terms of pH, total dissolved solid, temperature and turbidity (IISc).
- 6. An integrated board for the product prototype (Fig. 3) has been designed and various integrated tests are in progress (IISc) as shown in Figure 1. In this integrated board or platform, a modular approach has been adopted to integrate various components to operate the two different systems of cartridges (VII, VIII) as explained in Figs. 4 and 5.
- 7. The water sample from the pre-filtration unit is sent to an automated meso-fluidic bioreactor cartridge designed for cell culture/enrichment (IISc). There will be a rack of these cartridges in the integrated product according to the test schedule for field application requirements. Specific bacterial growths were identified in-loop and the inference was drawn using data analytic technique regarding the specificity of bacteria (IISc), which will be further implemented into a software algorithm. The developed technology has achieved success in terms of quick detection time of less than an hour for

detecting accurately a concentration of 100 cells from 1 CFU/20 ml of original sample in the cartridge (IISc). Batch operation in software-controlled manner has been planned for further testing and validation toward fully in-line remote monitoring with the respective system of cartridges.

- 8. Optical spectroscopy technique with optical fibers to the detection unit was established and tested for detection of cell growth in the cartridge, as part of a preliminary laboratory test and basic technology feasibility study (IISc). It was established that reduction in sample volume in the detection zone to micro-fluidic like condition can significantly eliminate the culture lag phase and increase in cell count with high sensitivity is possible to detect earlier than what is existing standard. In the integrated board, the technique is further refined with LED-photodiode based optical detection unit for a specific wavelength as identified from laboratory test results.
- 9. The cell/DNA detection zone of the cartridge is also incorporated with a printed micro-electrode with which the electrochemical impedance-based detection scheme has been established (IISc). Calibration curve for electrochemical impedance-based detection of cells have been established and detection better than 100 cells after culture from 1CFU/ 20ml of original sample has been achieved so far with a the culture volume being 20ml in each cartridge.
- 10. Various product development milestones have been followed and product design. fabrication, unit testing have been carried out (IISc). More tests will be required. The unit test results around the cartridge operation is being reviewed jointly by IISc and Bigtec for the Cell/DNA cartridge performance and arriving at product specifications.
- 11. Laboratory test results for pathogen strain-specific detection of DNA strands were successfully carried out for E. Coli and Salmonella at the starting of the project (IISc). DNA detection from the cultured cells in the same cartridge's detection zone has been designed and the tests are yet to be initiated (IISc).



Figure: Proposed water quality monitoring system components and workflow involving an integrated product for cartridge based in-line deployable/portable tests for pathogens and pharmaceutical residues in water and a micro-PCR device for portable or laboratory test of collected samples. There are two types of cartridges that can be deployed in the in-line installed platform, one is for pathogen Cell/DNA enrichment/culture and detection, and the other is for immunoassay-based detection of harmful pharmaceutical residues. The portable real-time micro-PCR device already developed by the Indian Industry partner Bigtec Labs and available in the market works as a part of the monitoring system with its cartridge specifically being developed in the project for water born pathogen detection.

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BIO-CUINGE

Biotechnology for the recovery Germanium, Indium and Copper from industrial Copper dust waste





T R Sreekrishnan Dummy Text

Project Summary

S K Ziauddin Ahammad IIT Delhi





G Venkat Saravanan Lakshmi Life Sciences Coimbatore



Katrin Pollmann Helmholtz Zentrum Dresden Rossendorf Dresden



Cu mineral from Cu smelter dust with the help of biosorptive biocomposites. This project brings the (bio)leaching and reactor operations expertise of IIT Delhi together with the design and production of biosorptives biocomposites of HZDR along with mine waste remediation know-how of GEOS with product characterization and life cycle assessment of LLS. Further, this project fits the "waste to wealth", smart city campaign of India and recovery of critical elements for Germany.

Progress made/achieved

Partner 1 (IIT Delhi) & Partner 2 (LLS)

- Waste material collection from Hindustan Zinc Limited (HZL) and Hindustan Copper Limited (HCL) along with the sample prepared by Lakshmi Life Sciences(LLS)
- Chemical leaching of samples in 5 types of leaching reagents (Ultrapure water, HCI. HNO3. H2SO4. and NaOH)
- Elemental and mineralogical characterizations of the samples using ICP-MS, SEM-EDX and XRD.



Schematic drawing of the biopanning process



SEM micrograph of Copper dust



SEM micrograph of Ore

Publications

Jain, R.; Fan, S.; Kaden, P.; Tsushima, S.; Foerstendorf, H.; Barthen, R.; Lehmann, F.; Pollmann, "Recovery of gallium from wafer fabrication industry wastewaters by Desferrioxamine B and E using reversed-phase chromatography approach", Water Research 158(2019), DOI: 10.1016/j.watres.2019.04.005

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dusts. Further, the large volume of the produced Cu dust waste is a challenge for Cu smelters. This project proposes to develop environment-friendly and commercially viable technology for the recovery of In and Ge while decreasing the volume of Cu dust waste. The preferential project encompasses (bio)leaching of Ge and In from Cu smelter dust waste by optimizing various parameters followed by selective sorption. This project is very novel as it will apply the highly selective and sensitive siderophores and peptide-based biosorptive biocomposites to recover In3+, and Ge4+ from the leachate. This approach will also be applied to the waste from Cu metal powder and mold manufacturing for the recovery of Cu. The project, for the first time, will attempt selective flotation for recovery of

Germanium (Ge) and Indium (In) are the

important elements for the high-tech industry

and their future supply is not assured. Copper

(Cu) dust waste from smelters contains Ge

and In, however, there is no existing

technology for their recovery from these

Partner 3 (HZDR)

- Receiving of additional 4 different samples from Indian copper industry (D1) and 5 different samples from Indian Zinc industry
- DFT calculations for In and Ga complexation by deferrioxamine E (DFOE) and deferrioxamine B (DFOB), the calculation for Ge is planned, Ge complexation has been experimentally demonstrated by HPLC analyses (D5)
- Selectively iron, germanium, and indium binding phage clones were identified and enriched after extensive biopanning procedures.
- Most promising phage clones were identified by binding experiments using mini-libraries
- 18 Selected phage clones with argininearginine and his-his-gly or his-gly were tested regarding their Cu2+ binding behavior, further experiments are ongoing.

Partner 4 (GEOS)

- Literature search on possible processing options for Ge-containing ores and materials potentially applicable to the current project work;
- Preparation of sample materials from Hindustan Copper Limited (HCL) and Hindustan Zinc Limited (HZL) for partners (HZDR & IITD) and characterization of the samples through external service provider (ALS labs);
- Experimental testing of the approaches with the available sample materials which includes acidic and alkaline digestion and leaching test series with Cu-containing sample material from HCL and Zn-containing sample material from HZL.



MULTI-WAP

Multiplexed, label-free fiber optic biosensor array system for waterborne pathogen detection





Cochin

V V Raghavendra Sai

V I Bishor ubio Biotechnology Systems Pvt Ltd



Claus-Peter Klages TU Braunschweig Braunschweig



Mahavir Singh Lionex GmbH Braunschweig

Project Summary

The main concept of the first stage of Multi-WAP project was miniaturisation and development of amultiplexed, rapid, accurate, label-free, and real-time method for detection of multiple waterborne (faecal) pathogens in water resources prevalent in Indian conditions at low cost and high sensitivity (>90%). The analytical/diagnostic platform which is developed is an optical absorbance biosensor with the prerequisite of having the ability to perform online measurements. In the last period of MultiWAP project, a U-bent fiberoptic probe fabrication facility for small scale production is set-up.

Optoelectronic instrumentation and a custom-built software are realized for the development of the array sensor. Highly stable UV and visible high-power LED devices are developed. In addition, a point of-care device and a smart fiber optic refractometer are being developed for biosensing and chemical sensing applications. A process sequence for the amino-silanization of U-bent silica fiber optic sensors is being developed, consisting of an atmospheric-pressure plasma pre-treatment in an Ar-H2O gas mixture, and immediate

vapor-phase silanization in a flowing gas stream of Ar, saturated with APTMS at room temperature. Both processes were run in the same process chamber, a low-cost dielectric barrier discharge reactor made from guartz plates. In an immunoassay-based comparison, virtually the same results are achieved with the new vapor-phase procedure on the one hand. and the standard wet-chemical sequence etching in piranha solution and silanization in solution - on the other. In repeat experiments it turned out, however, that the new process is still lacking reliability so that additional studies will be required to guarantee process safety and subsequently address the task of designing a prototype for industrial production.

In the last project period, joint experiments were performed specially on the validation of the prototype platform at the laboratories of LIONEX GmbH and TU Braunschweig. The main objective of these experiments was to test the device with 2-7 bacterial pathogens using the developed multi-channel array system. The functionalization of vapor phase silanization has been performed and was found to have a significant response compared to wet phase silanization. The

device has been validated and has a warm-up time of 3 hours. The assay had a significant absorbance change when the cells were dropped cast directly on to the U-bent surface of the sensor. The absorbance response was not significant during dip type assay and the speculated reasons could be. i) the cells were not in the vicinity of evanescent field, ii) the cells were not bound to the probe surface. For better results certain changes in the device can be implemented like continuous shaking of sample platform casing to protect the external light entering the sensor. In addition, the production of the quality-controlled biomarkers for the real arrays was successfully done. All produced antibodies expressed an excellent affinity with KD 10-7- 10-10 M. In addition to that LIONEX will continue the work of selecting further batches of the final arrays biomarkers and biofunctionalized plasma-treated and silanized fibers in collaboration with IOT.



Figure: SEM imaging of probes after incubation with M. smegmatis

Progress made/achieved

One of the significant achievements is the development of the automated fiber bending machine to fabricate U-fiber optic probes with high consistency in the probe geometry and hence the reproducible sensitivity. Currently, about 50 U-bent fiber optic probes are Based on the results of Multi-WAP, the consortium is confident to mention that the platform progressed from TLR1/2 to proof-of-concept TRL-4 technology which is currently operational in their labs. The consortium agrees that the future steps will focus on bringing to the market a device and ready-to-use test kits ('plug & play' cartridges) for waterborne pathogens detection. As evidenced by the success of the Multi-WAP project, there is a clear unmet need to move our technology from TRL 4 (current status) to TRL 6-7. 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%). The project partners will be able to realize this by building upon a highly sensitive array sensor system concept which has been validated for different biomarkers.

> produced in a day. While the fiber bending takes only 1 minute, the pre and post processing including decladding and polishing of the distal ends for efficient optical coupling involves manual process and consumes a significant time and effort.



Fiber optic array biosensor developed in-house with sensor platform for detection of waterborne pathogens

The other achievement is the development of the fiber optic array biosensor with an UV LED and UV-sensitive CMOS detector with UV-active fiber bundles for light propagation between the U-bent probes and the light source/detector. The issues with the previously conceived design for the precise alignment of the probe ends with that of fibers in bundles (due to machining limitations) were overcome by using the ceramic ferrules (<5-micron concentricity) at the fiber ends and mating sleeves to align the two ferrules].

- Based on all these results, the project technology is currently at TRL 4.
- Another significant indirect outcome of this project is incorporation of ChemBioSens Pvt. Ltd., a start-up company as a spin-off of the technology development activities at the Biosensors Laboratory at IIT Madras enabled by the project funding. ChemBioSens Pvt. Ltd. Was incorporated on 23/10/2018 at IIT Madras Incubation Cell. Due to the need for customized light sources, photodetectors and relevant software that required expensive solutions from elsewhere, the responsibility of development of stable light sources with power LEDs and photodetectors was

taken up by the start-up and successfully supported the fiber optic array biosensor work.

- Highly promising results were obtained in the recent research period showing that the concept of plasma-based gas-phase pretreatment and subsequent vapor-phase silanization of U-bent silica fiber optic sensors is in principle able to substitute the state-of-the-art wet-chemical process. However, process stability and reproducibility are still unsatisfying, and more experiments are needed in order to achieve Technology Readiness Level 7-8 and to design an upscaled version of the reactor. Several possibilities to reduce production costs have been identified and should be investigated (adapted power generator, photometric check of surface functionalization.)
- ubio performed an independent validation of different sets of the final arrays' antibodies from LIONEX.
- LIONEX continued the production of the quality-controlled biomarkers for the real arrays. Further batches of qualitycontrolled anti-LAM antibodies against Mycobacterium avium complex were produced, with KD around 10-8 - 10-9 LAM. The model E. coli antibodies were successfully produced. These both

antibodies will be used as model analyte for Multi-WAP prototype. New anti-FimH and anti-fliC polyclonal Abs were produced against Salmonella enterica surface biomarkers, with KD 10-7 M and 10-8 M respectively. New polyclonal Abs were produced with high affinity against Campylobacter jejuni biomarker (KD 10-7 M). New anti-Blc polyclonal Abs were



Publications

- 1. Plasmonic biosensors for bacterial endotoxin detection on biomimetic C-18 supported fiber optic probes; Hariharan Manoharan, Prasanta Kalita, Shalini Gupta, V.V.R. Sai; Biosensors and Bioelectronics, Volume 129, 2019, pp 79- 86.
- 2. Graphene oxide coated U-bent plastic optical fiber based chemical sensor for organic solvents. Divagar, M., Gowri, A., John, S., & Sai, V. V. R.;Sensors and Actuators B: Chemical, 2018, 262, 1006-1012.
- 3. Fiber optic sensor for continuous liquid level monitoring; Allwyn S Rajamani, Divagar M, V V R Sai; Sensors & Actuators A Physical, 2019
- 4. Controlled In Situ Seed-Mediated Growth of Gold and Silver Nanoparticles on an Optical Fiber Platform for Plasmonic Sensing Applications, H Manoharan, KC Dharanibalaji, VVR Sai - Plasmonics, 2019
- 5. Plasmonic biosensors for bacterial endotoxin detection on biomimetic C-18 supported fiber optic probes, H Manoharan, P Kalita, S Gupta, VVR Sai Biosensors and Bioelectronics, 2019

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vvrsai@iitm.ac.in manu@iitm.ac.in bishor@ubio.in c-p.klages@tu-braunschweig.de info@lionex.de produced to be used for detection of Vibrio cholerae, with KD and affinity less than 10-8 M.

LIONEX will continue the work of selecting further batches of the final arrays' biomarkers and biofunctionalized plasma-treated and silanized fibers in collaboration with IOT.

FEC-ONLINE

Online-indication of pathogen-like pollution in water by fecal pigment (FP) analysis





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Wido Schmidt DVGW Technologiezentrum Wasser Dresden



Christian Moldaenke bbe Moldaenke Schwentinental

Project Summary

A promising alternative for time consuming measurements of pathogens in water is the detection of fecal pigments (FP) as indicator compounds by 2D fluorescence. Pigment analysis is of high efficiency and used for early warning against cyanotoxins in water since a long time. However, while algae pigments can be measured directly, the fecal pigments are of lower fluorescence effect and therefore the sensitivity as well as selectivity of the measurement has to be improved. The project follows the strategy of selective pre-concentration of the analytes, a method which is online practicable and widely used for trace detection of organic contaminants, e.g. using LC-MSMS. Because of the broad peaks of fluorescence, a new calibration software based on multivariate approach is urgent.

The general project outcome is the onlinedetection of pathogen-like pollution in water. In detail, the outcome of the project is described a follow:

- Understanding of the indicator function of FP against pathogen water pollution based on systematic measurements: The FPs have a significant indicator function against pathogenic water pollution
- Design of a new analytical unit consisting of: automatic sample preparation which is coupled with a brand new 2D fluorescence sensor. For this device the option of Zn-addition is favored.

Design of a software package for analysis of the spectra. An intelligent software is the key

instrument for using and applying the indicator function of FPs.

• Testing and recommendation for general application of this approach in practice using the new bbe device.

Potential users of the new technique could be: drinking and wastewater treating companies as well as companies of food production

Progress made/achieved

The measurement of faecal pigment fluorescence via 2D fluorescence spectroscopy in the range of 275 to 505 nm (excitation) and 500 to 600 nm (emission) was systematically investigated within the framework of the project in order to find out the indicator function of this fluorescence against faecal contamination of waters of different origin.

Faecal pigments (FP) based on a porphyrin structure show a comparatively clear fluorescence in an area of the fluorescence matrix (EEM) that is not influenced by the fluorescence of other water constituents. Therefore, these pigments are suitable for a fast indication of fecal impurities in aquatic environments.

A decisive question, however, is the sensitivity and reproducibility of these analyses. Further questions are related to the correlation of pigment fluorescence with microbiological findings and above all to the field suitability of the measuring method. Should all these aspects be solved advantageously, the fast fluorescence measurement on site would be

excellently suited for an indication of pathogenic germs in water.

In order to solve these questions, a systematic investigation program was carried out with all partners integrated in the project.

This was preceded by an extended literature search. As a result of the review and evaluation of current research work, it can be stated that the spectrum of fecal pigment structures is very extensive. The precursors of the porphyrinborne pigments do not fluoresce, but the end products excreted by the living organisms do.

The main components are urobilin and stercobilin. In contrast to urobilin, stercobilin is more stable and would therefore be suitable as an indicator of fecal impurities in the aqueous phase.

However, the native fluorescence intensity of the FP is too low for a sensitive indication of pathogenic germs. For this reason, samplepreparing agents had to be developed to increase sensitivity. Various options, including solid phase enrichment (SPE), were tested.

The results showed that complexation of the FP with transition metals leads to a significant increase in sensitivity of the fluorescence. The addition of zinc acetate in stoichiometric excess proved to be the method of choice. The pH value plays an important role in this reaction. The optimum pH range is > 10. This requires the addition of pH buffers. A commercially available glycine buffer proved to be suitable. It should be noted that zinc carbonate can precipitate in the alkaline range. This can particularly affect waters with increased carbonate hardness, since the solubility of zinc carbonate in water is only approx. 10 mg/L. As a rule, however, the fluorescence measurement is not adversely affected by this effect.

The conditions for the fluorescence measurement of FP have been optimized. The method of choice was 50 mg/L zinc acetate. A standard



Figure: EEM signature of (a) Raw water with zinc acetate (10mM) in EtOH 10% of pH 10.3 and (b) Raw water with Zn and Ca acetate (10mM) in EtOH 10% of pH 10.3

operating procedure is given in the annex to the report.

The sensitivity of the measurements can be significantly increased by the use of mathematical models (PARAFAC). Above all, this approach can eliminate background fluorescence (humic substances). The measurements thus become safer and more accurate overall. Ultimately, the fluorescence measurements were verified using a chromatographic method with mass spectrometric detection.

Due to the fact that no high-purity standards are available for the FP. a calibration with the offered products had to be carried out. A stercobilin standard is usually contaminated with urobilin and another unknown component. The concentration was therefore correctly indicated as the sum of these three components in the form of stercobilin equivalents.

The analytical determination limits for the fluorescence method (laboratory instrument, stercobilin) are in the two-digit ng/L range, for the mass spectrometric method in the lower single-digit ng/L range. For the optimized method with 50 mg/L zinc acetate, the detection limit for stercobilin is 28 ng/L and the determination limit 77 ng/L.

The concentration of stercobilin or its equivalents in untreated wastewater may be several hundred Qg/L. In addition, urobilin is also detected, but in lower concentrations. Stercobilin therefore acts as an indicator of faecal contamination of the water.

The elimination of FP with 3 log stages is to be expected in the effluent of German sewage treatment plants. Therefore, the elimination is almost complete (99.8 %).

In flowing waters (e.g. in rivers), the concentration of FP in Germany is a few to 3 digit ng/L. In India, the values are significantly higher.

The monitoring program at different surface waters and a sewage plant effluent shows the very good correlation (Pearson) of the faecal pigment fluorescence to enterococci, E. coli and coliform bacteria with a coefficient of determination of 0.75 to 0.86. The limit of determination for the faecal pigments corresponds to a bacterial concentration of 2000 coliforms.

Thus, there is a meaningful correlation between the number of enterococci. E-coli and coliform bacteria and the concentration of FP as well as FP fluorescence in untreated effluents. effluents from wastewater treatment plants and in rivers.



Figure: Time-resolved fluorescence measurements of SB and UB in its native state and after Complex formation in water medium ($\lambda ex = 450 \text{ nm}$, $\lambda em = 500 \text{ nm}$ (FP), $\lambda em = 511 \text{ nm}$ (FP-Zn))

The company bbe Moldaenke has developed and manufactured two prototypes of field sensors. The two tested prototypes show their suitability in principle, whereby in the case of the first prototype the effect of scattered light is still too high. With the latest prototype, a correct estimate of the number of bacteria can be made within eight minutes.

Due to the photodiodes built into the sensor for detection, no fluorescence matrix is generated, only a point measurement. However, the sensitivity of a native fluorescence measurement with the sensor corresponds approximately to that of a laboratory device with CCD technology.

The scattered light causes measurement problems. This fact has to be further optimized in future.

As a result of a simulation, it is suggested to improve the sensor by using only one excitation wavelength in the range of 475 -492 nm instead of two excitation wavelengths

and one emission wavelength, but two emission wavelengths. The first emission wavelength should be in the range of FP fluorescence (around 520 nm), the second emission wavelength in a longer wavelength range where only humic matter occurs (around 580 nm).

With the development of the near-series prototype 3, fecal impurities can also be measured wherever there is no suitable laboratory for microbiological investigations in the vicinity, which opens up great application potential in developing countries and crisis regions. The detection of harmful concentrations of E. coli in Indian drinking water would be possible in case of higher contamination.

In summary, it can be determined that the sensor at hand is able to generate faecal impurities in the aquatic environment promptly in the form of field measurements. The measurement method is robust and

sufficiently selective. The disadvantages for the current state of development are the sensitivity and the limited possibilities to eliminate undesired matrix effects in the lower concentration range.

For this reason, the basic principle of the measurement procedure must be reconsidered in order to transfer the procedure to routine operation.

Ultimately, it must be decided whether the principle of punctual EEM with excitation by LEDs and signal detection by photomultipliers is suitable or whether the development must go in the direction of "mini spectral



Salient Research Achievements

- 1. Definition of optimal conditions for fluorescence spectroscopy for rapid detection of faecal pigments in waters of different origin.
- 2. Development of one of the LC-MS reference methods for the analysis of FP in real water.
- 3. Monitoring programs in Germany and India.
- 4Determination of the relationship between the concentration of fecal germs and 4 FP in aqueous samples.
- 5. Test of the sensor prototypes developed by bbe for field measurement of FP using fluorescence.
- 6. Definition of Standard Operational Procedures (SOP) for application in practice.

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fluorimeters", whereby at least the matrix effects can be eliminated well.

Since there have been decisive and significant advances in recent years in the field of miniaturization of analytical instruments using optical methods, this path would be very promising. However, this would mean further development work.

The Indian & German partners of this project agree to intensively advance the further application and development of the approach pursued in this project. They expect a high market potential for this technology.

Graphical presentation of the faecal pigment detection protocol.

CANDECT

Cluster-composite nanofibre membranes for rapid, ultra-trace detection of waterborne contaminants







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Project Summary

Elevated arsenic (As) concentrations in water are faced by about 200 million people worldwide and have become one of the biggest challenges in the context of water purification. Long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions. Contamination of drinking water by As is one of the major concerns for India as well as Germany. Prevention of further exposure to arsenic by the provision of safe water supply for drinking, food preparation, and irrigation of crops to the affected communities is important. Monitoring of As contaminated water is an important aspect in implementation of arsenic removal technologies in the affected areas. The development of suitable sensor technologies using advanced materials that could be integrated to hand-operated pumps or decentralised water supplies is the subject of this proposal. The consortium of IITM, INR, KIT, and FAD are working towards a solution in the form of affordable technology which can be implemented in the form of luminescence based arsenic sensor system with atomically precise quantum nanoclusters.

Nanoclusters consist of a well-defined metal core that is protected by ligand shells such as thiols, phosphines, etc. Some of the metal nanoclusters (like gold (Au), silver (Ag), and so on) are known to be luminescent in nature. But their applicability in the field of sensors is often limited due to their instability in various conditions. In this project, atomically precise

clusters with specific interactions with inorganic and organic contaminants developed by IIT Madras will be incorporated in electrospun fibres for the detection of heavy metal ions in water at ultra-trace levels and porous substrates. This technology can be developed further into a sensor device for arsenic in drinking water. After numerous trial and error attempts with many cluster systems, a system of Lipoic acid (LA) protected Ag clusters used with Tris(2carboxyethyl)phosphine (TCEP) has been demonstrated for sensing arsenic at sub-ppm concentrations and the team is working on further improvement in the sensor performance. The current stage of work involves the study of the interfering ions (various cations and anions) present in field water which can affect the sensor performance and to devise an effective methodology for their elimination.

INR has evaluated the available designs for luminescence-based sensing using mobile attachment and the necessary approach for its implementation in the present project has been identified. INR has developed a backbone of the device for smartphone-based readout for a proposed fiber mat sensor which can be used for the measurement of arsenic in contaminated water. Apart from that, water samples from various sites in West Bengal, India were collected and analyzed using ICPMS to know the current level of arsenic contamination.

Progress made/achieved

Partner 1: IIT Madras

- Studies have shown that the response of Ag29@DPPP to As(III) in water was inconsistent due to the solubility issues. Hence repeatability could not be achieved.
- 2. Incorporation of the new phosphine ligands in the Ag29 clusters were found to be degrading clusters. Hence efforts towards new cluster system development were started.
- A system of Ag29(L)12 TCEP was developed which can be used for sensing As(III) in water as lipoic acid protected clusters are water soluble.
- 4. Linear response to As(III) in subppm regime was observed and it was repeatable.
- 5. Ag29(L)12 TCEP system also showed a response to As(V).
- Consistency in the results was tested using Fluorescence Spectroscopy and visual verifications (by exposing samples to the Ultraviolet light).
- 7. Interference from various anions and cations that are likely to be present in groundwater was studied.
- 8. Development of suitable methodology to eliminate interfering ions in the sensing medium is under progress.
- 9. NMR Spectroscopy and Fluorescence Lifetime measurements have been performed to understand the sensing mechanism.
- Synthesis of other water-soluble clusters with better properties such as enhanced luminescence and preferred stability are in progress for improvements in the developed As sensor.
- 11. Sensor performance to be tested with field water samples from As-affected places.

Partner 2: KIT Karlsruhe

- The proper characterizations on the nanoclusters were delayed due to the extensive cluster chemistry development at IIT Madras. However, the time was well spent to develop other relevant aspects;
- 2. Detection of both As(III) and As(V) were challenging in presence of other contaminants including salts and organic wastes. The new analysis procedure has been taken care of this issue and is fully functional now.
- 3. The validation of the coupling of the Field Flow Fractionation (FFF) with the ICP-MS and the LC-OCD is under way. With this set up, the detection of As is possible in organic matter. Currently, sensitivity calibration of FFF is going on to get the proper operational parameters before exposing it to real organic samples with As traces.
- 4. Extensive work has been carried out on the nanofiltration of As(V), As(III) with variable salt concentration and organic matter. Two publications are in preparation out of the additional work carried out at KIT beyond the scope of the proposal while IIT Madras was deployed in chemical formation of nanoclusters. Methods are in place for the characterization of sensor mats in real conditions (with organic matter)
- 5. The nanofiber spinning with clusters is due to take place at IAMT(KIT) as soon as the chemistry and the clusters are available. In the meantime, a nanofiber fabrication system was further optimized and a former project with IIT Madras continued to produce fibers with incorporated cyclodextrin. Three publications will result, and this system is now ready to receive instructions and clusters to produce sensor mats.

6. Overall, the year has been extremely productive at IAMT(KIT) and the completion of the project should be

possible, while an extension of the project towards As removal would be a very logical next step, if possible.



Optical image of Ag29(L)12-TCEP system to As(III/V) at ppm level concentrations under visible and UV light.

Partner 3: Inno Nano Research

- Designs available for luminescence-based 1. sensing and readout using mobile attachment were evaluated and necessary approach for the implementation in the present project was identified.
- 2. Various electronic hardware components necessary for the building of mobile attachment were identified. Exact LED excitation source and filters necessary for the attachment will be dependent on the luminescent cluster-nanofiber composites; so final design and integration of components will be decided after completion of the work on sensing element.
- 3. Various components for filter-based excitation and readout methodology were integrated with smartphone. An android app was developed for sensor

readout using smartphone camera.

- 4. Water samples from various sites of West Bengal India were collected and analyzed using ICPMS to detect Arsenic contamination.
- 5. Water samples from various sites in Nalgonda District, Telangana, India were collected and analyzed using Fluoride ion selective electrode to detect Fluoride contamination.
- Water samples from various sites in 6. Nallampatti, Erode, India were collected and analyzed using GC-MS to detect Pesticide contamination.

Partner 4: Fader Umwelttechnik (FAD)

The main points of action will be

Identification of real waters in Germany 1. that contain As



(C) TCEP-As (500 ppb), (D) TCEP-As (1000 ppb)

2. Extension of the capabilities of analysis to other contaminants, those of highest priority being Cr and PFC (due to the contaminant concern in Germany as well as globally)

Salient Research Achievements

Fluorescence spectroscopic measurements and visual observations were conducted with Ag29(LA)12 - TCEP system to observe its consistent response for As (III/V). Interference from various anions and cations that are likely to be present in groundwater was studied. Suitable methodology development to eliminate interfering ions in the sensing medium is in progress. NMR spectroscopy and fluorescence lifetime measurements have been done to understand the sensing mechanism. Synthesis of other water-soluble clusters with better properties like higher luminescence and better stability are in progress for improvements in the developed As sensor. Real-time sensor performance is yet to be tested with field water samples from As-affected places.

Design for sensor holder was made. Prototype was 3D printed. Exact LED excitation source and filters necessary for the attachment will be dependent on the luminescent cluster-nanofiber composite; so final design and integration of components will be decided after completion of the work on sensing element.

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Stacked NMR spectra showing interaction of TCEP with arsenite (A) TCEP, (B) TCEP-As (100 ppb)

3. If possible, at IIT Madras end the clusters and sensor mat sensitivity to such contaminants could be expanded (F and steroid hormones being analytes that can be analysed to very low levels at IAMT(KIT) already)

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WATERCHIP

DNA Biochip for on-site water pathogen detection including viability and antibiotic resistance testing















Bernd Giese Food GmbH Jena Analytik-Consulting (Food) Jena



Project Summary

The project aims at the development and test of a multiplexed chip by adopting an already developed a robust and low-cost platform for on-site water pathogen detection. Genetic markers associated with at least a dozen waterborne pathogens, indicators, and antibiotic resistant bacteria will be included on the chip including viability testing to be validated with appropriate sensitivity and specificity. The proposed project has three objectives: 1) Provision of waterborne pathogens chips and detection systems, 2) Integration of live vs. dead (viability) protocol on the chip, and 3) field validation, deployment, support, and feedback.

During the project, a new platform was developed, the Waterchip[™], which has a broader application potential related to the original GeneZ Plus Plattform, and therefore

could be used more universally. For the new platform novel universal chips were designed and produced. For the bioassay, a panel of target water contaminants and ARGs were selected (E. coli, Shigella spp., Legionella pneumophila, Cryptosporidium parvum, Giardia intestinalis). After an extensive optimization process, all protocols for LAMP-based pathogen detection were established and partially validated with real water contaminants. The LAMP-based amplification has been enhanced with on-site colorimetric detection based on a gold nanoparticle assay. The development of a parallelized assay based on a plasmonic microarray is an extension of the initial proposal. Here a successful preparation of this microarray and its usability for pathogen detection could be demonstrated

Progress made/achieved

Partner 1/AU

AU was primarily related to the development of the bioassay and the elaboration for the pathogen and ARG panel for the platform. The AU has implemented WP1, (2), 3, 4 and 6.

In WP 4, several working steps were realized: i) Procurement of chemicals and consumables ii) Primer designing and synthesis for isothermal amplification iii) Establishment of direct LAMP assay (without DNA extraction).

A set of primers for LAMP for the certain selected target organism with specific markers was designed through PrimerExplorer V5 (https://primerexplorer.jp/e/): E.coli (eaeA, stx2), Shigella spp. (ipaH), Legionella pneumophila (dotA, lepB), Cryptosporidium parvum (Hsp70, gp60), Giardia intestinalis (beta-giardin)

Scheme of the work flow in the project

Partner 2/ABC

ABC was focused on the development of the Gene-Z and later on the Waterchip[™] platform. In these WPs the new design of the device, the layout of the cartridges and the software (App) were developed.

The team of ABC accomplished later the following tasks activities:

- Production of Gene-Z as well as cartridges;
- · Development of adapted cartridges for viability tests.

For a wider field of application, a new device was developed in the last project year, the WaterchipTM. This is as compact and suitable for on-site verification, as the original device. In addition, other diagnostic assays can be performed by replacing the disposable chip.

The associated App for control, reading, and processing of Gene-Z and later the WaterchipTM on an Android system for the waterchip (WaterChip App) is ready and is integrated with the novel developed WaterchipTM device (hardware). As originally proposed, the App consists of the following functionalities: 1) analyze WaterChip, 2) view Water Chip Results, 3) share WaterChip Data, 4) Sample ID/Targets/Genes, and 5) Live vs Dead Status. In addition, more functionality related to antibiotic resistance genes, connectivity to the database, and GPS are also added. Two functionalities- indication of live/dead and request for analysis are being added.

Partner 3/IPHT

The Leibniz-IPHT team was focused on the development of the LAMP-based assay with viability test and an additionally plasmonic nanoarray-based multiplex detection platform. The work packages were adapted after modification and coordination with the project partners.

On the basis of the Indian partners data the staff of the IPHT realized extensive studies for







Waterchip[™] disposable chip with 7x7 detection window produced by ABC

LAMP. Several dyes were tested with model microorganisms, such as methylene blue, neutral red, propidium iodide, Calcein-AM, and the SYTO82 orange fluorescent nucleic acid stain (Invitrogen) as recommended by the partners. The viability assay was tested without the platform. For the LAMP assay, a model assay of water-borne pathogen Legionella pneumophila was established. For the point-of-care compatible optical detection, a hydroxynaphtol blue (HNB) in the visible range was tested by the Blue-LAMP method.

Partner 4/Synlab (Food)

The partner Synlab (Food) aimed to establish a novel ARG detection which included the primer design, the elaboration and the optimization of amplification protocols (WP 1). In continuation of the project the validation of the assays without (WP 5) and with the platform (WP 6) was performed. The adaptation and the optimization of the isothermal amplification LAMP were realized in cooperation with the IPHT and according to the scheme of the Indian partners. The validation was realized using integrated real-samples.

A set of primers for LAMP were designed and two examples for ARGs were tested with real surface water. A model system was selected, and the LAMP protocol was established and optimized.



Salient Research Achievements

- A set of primers for LAMP for pathogens were designed: E.coli, Shigella spp., Legionella pneumophila, Cryptosporidium parvum, Giardia intestinalis.
- Model system for LAMP (blue-LAMP) in table cycler for validation were established •
- LAMP detection with on-site colorimetric assay were developed
- \bullet Plasmonic microarray for multiplex assays was developed
- WaterchipTM platform was established
- Chips were developed to WaterchipTM platform •
- Software (App) were developed

Publications

- Reuter, C. et al. 2-LED-QSpectrophotometer for Rapid On-Site Detection of Pathogens Using Noble- Metal Nanoparticle- Based Colorimetric Assays. Applied Sciences 10, 2658 (2020).
- Reuter, C. DNA-based Detection of Human Pathogen Water Contaminants, poster at the International Symposium Molecular Plasmonics 2019, May 2019 Jena
- David Zopf, Angelina Pittner, Cornelia Arnold, Stephan Kastner, Andre Dathe, Matthias Thiele, Jacqueline Jatschka, Thomas Schneider, Ondrej Stranik, Andrea Csaki, and Wolfgang Fritzsche: Plasmonic nanoparticles for molecular detection, META 2019, LISBON - PORTUGAL, July 23 - 26, 2019

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Chip for LAMP assays on Waterchip™ platform with elastic and stiff resin



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METNETWORK

Nanostructured hybrid transparent network electrodes for large area visibly transparent solar cells









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Project Summary

Sciences (CeNS), Bangalore

Semitransparent solar cells could exhibit enormous applications from a window panel to the automobile roof top solutions. By definition, they require semitransparent active layers and transparent electrodes. The current recipes for the realization of a large area technology suffer from process limitations related to the deposition of transparent conducting electrodes (TCE) with sufficient transparency and low resistivity. Other issues are related to the electrode stability, up-scaling to the large areas, and flexible substrates. There is also a big demand to replace the expensive indium tin oxide as TCE. Additionally, there is a need to develop printing compatible TCEs which can be applied to any type of surface without the further necessity of welding or soldering. Project partners have demonstrated that micrometer cracks formed in a polymer film can be used as a template to deposit metals and by the lift-off of the polymer template, hybrid metal network TCEs with high transmission and low resistivity can be developed.

The main objectives of the project are

- to examine the feasibility of printing methods to develop large area TCE metal network.
- to synthesize the metal network TCE on • flexible substrates such as PET, PEN or paper.

- to test the feasibility of alternative metalation method based on the solution processing techniques and/or incorporating graphene.
- to integrate these TCEs in large-area solar cells suitable for the window applications.

The uniqueness of this approach is its simplicity and the suitability for any kind of metals and their precursors. Since we can control the metal fill factor and the structural width of the metal network by tuning the width of cracks in the polymer film, the conductivity and transmittance of such TCEs can be tuned. In collaboration with the industry partners, the chemistry and the process will be adapted to fulfill the objectives. The proposed work will provide viable solutions to the pertinent issues related to fabrication of ITO-free TCEs. The application of these electrodes is extendable to other applications such as thermal heaters, sensors, and electrochromic or thermochromic devices. This innovative concept of nanostructured hybrid TCE is a big step towards smart window applications suitable for building integrated photovoltaics.

Progress made/achieved

- WP1: Screening materials and feasibility test towards large area TCEs with metal network (both sublimation and wet chemistry).
- WP2: Fabrication of large area hybrid TCEs with metal mesh and graphene.
- WP3: Optimization of semi-transparent organic/hybrid photoactive materials to integrate with hybrid TCEs.
- WP4: Fabrication of large area (>10cm2) TCEs using printing methods.
- WP5: Fabrication and optimization of large-area semi-transparent solar cells with hybrid TCEs.
- WP6: Towards integration of smart windows and other applications.

Centre for Nano and Soft Matter Sciences (CeNS)

CeNS mainly optimized different large coating methods for large area templates (up to 30x30 cm2) such as screen printing, spray coating and roll-to-roll (R2R) printing (on a laboratory scale). CeNS and Tata Steel also studied the formation of twisted multilayer graphene on a polycrystalline Ni-foil by a modified CVD process.

Tata Steel Ltd (Tata Steel)

Tata steel along with CeNS developed a process to grow Reduced Graphene Oxide (RGO) film on a transparent substrate with metal network to achieve conductivity in non-metallic void regions and to protect the metal from environmental degradation through the barrier layer of RGO also moving toward techno commercial feasibility with the use of affordable metal copper. Team demonstrated the growth of semiconducting

Salient Research Achievements

Rollable demonstrator, having LED's controlled by capacitive touch buttons, to emphasize metal network TCE properties: flexibility, electrical conductance and optical transmittance.

and transparent RGO film on guartz substrates with barrier property. However, this process could not be extended to flexible polymer or glass substrates because of the process requirement of substrate heating up to 7500C. Tata steel focused on understanding RGO formation through natural precursor using a homemade cluster deposition setup and tried growing RGO at lower substrate temperature but could not achieve promising results.

University of Bayreuth (UBT)

UBT optimized hybrid-TCEs for perovskite solar cells. All the optimized procedures were transferred to Papierfabrik Louisenthal (PL) to realize large area printed TCEs on PET substrate. UBT also screened the different filler materials such as metal oxides and AZO in combination with the Au-mesh and Cu-mesh to understand the efficacy of such hybrids TCEs with improving charge collection as a function of island sizes and thickness. The TCEs were incorporated in perovskite solar cells. The PCE of perovskite solar cells fabricated on Cu/AZO hybrid-TCEs was equivalent (PCE = 7.4 %) to the ones prepared on Au/AZO hybrid-TCEs (8.2%).

Papierfabrik Louisenthal GmbH (PL)

PL developed the fabrication of metal network TCEs on PET foil on industrial scale in good quality and without any defects. The metal network TCEs are based on either cupper or aluminium and have an optical transmission of 82% and a sheet resistance down to 10 Ohm / sq. Furthermore, PL fabricated 70 nm high metal network TCEs on lab-scale based on copper and gold on a 125 Qm2 laminates support foil and delivered them to UBT for integration into solar cells.



STRUCTURAL PROPERTIES



Optical microscope image of 400 nm aluminium mesh



Scanning electron microscope image of 600 nm copper mesh



Any desired combination of SmartMesh with fully metallised or non-metallised areas is possible without any additional process steps and allows for simple electrical connection of the metal mesh.

ELECTRICAL PROPERTIES





Rollable transparents demonstrator with touch button and LEDs

MECHANICAL PROPERTIES

Smartmesh®is highly flexible and

shows excellent bending stability.

OPTICAI PROPERTIES

High optical transmittance in the VIS and NIR range



Figure Properties of the Metal Network fabricated at PL, developed under the name SmartMesh[®], Pictures are taken from the actual data sheet.

Publications

Hunger, C. (2019, March). SmartMesh® - Industrial scale production of transparent metal mesh electrodes for printed electronics. Presentation helded at the LOPEC 2019 Conference. Munich.

Hunger, C. (2019, July). SmartMesh® - Transparente Metallnetzwerkelektroden für gedruckte Elektronik. Presentation helded at the Printed Electronics Conference at FAPS. Nuremberg.

Patents filed/published

WO 2018229561 - A process for producing graphene based transparent conductive electrode and the product thereof



Figure Presentation of the Demonstrator - heated glove compartment lid - on the OES booth at the LOPEC exhibition in March 2019 at Munich. The compartment lid was realized by laminating a metal network TCE produced at PL under the leather as heating film. A thermal camera was looking at the compartment lid and the monitor was showing the real time temperature profile. The compartment lid had a temperature up to 60°C and was running during all three exhibition days. The demonstrator was realized by PL under the KEX consortium in cooperation with the companies Lohman Tapes and BMW group.

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Hunger, C. (2019, November). SmartMesh® - A transparent metal mesh electrode for printed electronics fabricated on industrial scale. Presentation helded at the Proflex 2019 Conference. Dresden.

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RESERVES

Cluster-composite nanofibre membranes for rapid, ultra-trace detection of waterborne contaminants





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Project Summary

The project "RESERVES" is intended to find a solution for the organic wastes generated from wholesale vegetable markets and slaughterhouses in urban cities. The project aims to demonstrate the feasibility of biogas production and energy output during co-digestion of vegetable, fruit & flower market waste (VFF) and slaughterhouse waste (SHW) in India. Sampling and variations of the market's waste generation in terms of composition and biogas potential were studied and published in an international journal in which major wastes generated from wholesale koyambedu market complex have been evaluated. Based on the waste composition studies, with vegetable wholesale market waste, lab-scale batch and continuous studies have been carried out to identify the optimum ratio for co-digestion and organic loading rate (OLR) respectively. Also, a pilot plant has been installed and commissioned along with the bio-extruder, manufactured by Lehmann-UMT GmbH and the study is being conducted on the premises of CLRI, Chennai, and operated by Indian and German partners jointly. Since July 2019, the plant has been commissioned and is being operational until February 2020. Analysis of potential pathogen removal has been conducted for the extruder pre-treatment. The life cycle assessment studies and concept for utilisation of biogas have also been carried out.

Progress made/achieved

Milestones achieved

- 1. Pilot plant ready for continuous operation onsite;
- Appropriate technique and concept for the refinement of digestate for field application and by-product development;
- Appropriate technique for the efficient biogas upgrading and sustainable concept for reliable energy supply by RESERVES;
- 4. Evaluated results for sustainable assessment with LCA, energy and material flow as well as CO2 balance;
- Comparative study on the effect of shredding and bio-extrusion of Koyambedu vegetable market waste on biogas yield;
- 6. Periodic survey of vegetable, fruit and flower waste from Koyambedu market;
- 7. Comparative study of dry and wet anaerobic digestion of banana peduncle;
- 8. Process design and detailed engineering of pilot plant;
- 9. GIS mapping of organic waste Bio-reserves in Chennai city;
- Continuous reactor studies with vegetable and slaughterhouse waste with different loading rates in lab-scale;

 Characterization and elemental analysis of slaughterhouse and other organic waste generated from urban areas;



GIS mapping of bio-reserves in Chennai city

12. Training of qualified staffs for operation and concepts for vocational training.

Pilot Plant

In this milestone, a pilot plant has been installed and commissioned along with the bio-extruder supplied by Lehmann-UMT GmbH, during June 2019 after several trial runs in the premises of CLRI. However, the initial feeding was started from May 2019 as a part stabilisation and commissioning of the plant. The continuous operation of the pilot plant and feeding was started from July 2019 and the plant was initially fed with 200-300 kg/day. After two months, the plant was fed with a waste capacity of 500 kg/day from wastes of vegetable and slaughterhouse wastes in the ratio of 3:1. During the pilot plant operation, average specific biogas production of 0.54 m3/kg oDM was obtained.

The pilot plant is currently at a Technology Readiness Level (TRL) of 6. The construction of the pilot plant has been completed as per the developed designs.

The pilot plant was operated from July 2019 at a mesophilic temperature of 37°C with mixed proportions of vegetable, fruit, flower markets, and slaughterhouse wastes. The plant was operated for about 238 days in which 36,959 kgs of waste were feed. During operation, the pH of the digestor was observed in the range 6.5-7.6 which is in the optimal range for the Anaerobic Digestion process. The digester is equipped with two agitators for uniform mixing which mix the reactor for 15 min per hour. This ensures uniform distribution of the substrate inside the digester. During the operational period, the VFA and alkalinity of the digestate ranged between 500 to 700 mg/l and 1800 to 2000 mg/l respectively. Hence, the Volatile Fatty Acids (VFA) to alkalinity ratio is in the range 0.28 to 0.35 which is optimum for the stabilised digester. In addition, VFA and total ammonium nitrogen concentrations were found to be below 1000 mg/L, below the inhibitory concentrations

(VFA below 1800 mg/L and ammonium nitrogen below 1500 mg/L), which also ensures the stability of the reactor. During the operation period, about 36,959 kg of waste was fed and the specific biogas yield of the pilot plant was found to be 0.54 m3 of biogas for per kg of oDM added. The analysis of the digestate, has been carried, but the soil applications of the digestate as fertiliser is yet to be carried out.

The collected biogas has methane content in the range of 45 to 52.7 % and H2S concentration in the range 4159 to 5850 ppm has been observed. The raw biogas has been stored in the balloon. As part of biogas purification studies, the scrubbing system composed of iron fillings and activated alumina has installed which ensures the H2S concentration to below 40 ppm. The biogas utilization concepts have been evaluated for different applications, however other innovative methods of purification are vet to be evaluated.

The residual digestate produced every day with a high water content of 95%-97% is dewatered using a screw press supplied by Indian Industrial partner, Ramky. The liquid and solid fractions of digestate resulting from the digester were characterized. During the characterization of the digestate, it was observed that the nitrogen, phosphorus, and potassium content of the solid portion of digestate are 1.00%, 0.55% and 0.69% respectively. The nitrogen, phosphorus and potassium concentrations in the liquid analysis were found to be 0.03%, 0.002%, and 0.06% respectively. The total bacterial count in liquid and solid samples were found to be 6 and 8 (x106 CFU/g) respectively. the experiments are initiated and yet to be completed on utilisation of digestate as organic fertiliser on field application are in progress .



Aerial view of the pilot plant



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PYRASOL

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







Santosh Kumar Ramky Enviro Engineers Chennai



Dirk Weichgrebe Leibniz Universität Hannove



Ulrich Suer Biomacon GmbH Rehburg



Trays with raw samples and sensors inside the lab-scale drying chamber

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 high efficient single-chamber pyrolysis. The project aims to offer an innovative approach to transform urban organic waste into biochar and energy in urban areas. Thus, the optimum process and operation parameters of the solar dryer will be determined and 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 a targeted exchange and training schedules are elaborated.

Progress made/achieved

Partner 1: CLRI

Identification of optimal ratios of fibrous organic waste (FOW) and municipal sewage sludge (MSS) for drying, including determination of the influence of the presence of fibers in the sludge regarding drying characteristics.

This work package was started at the beginning of the project and partly ended up within this reporting period. For finding out the optimal ratios of FOW and MSS, an intensive laboratory analysis of substrates was carried out to characterise the substrates and its blends/ mixtures. Firstly, ultimate, proximate, and fibre analyses are carried out to characterise the individual substrates and projected for the different mixtures. Later on, heavy metals and nutrient contents are analysed and projected for the mixtures as well. Secondly, an extensive study using thermogravimetry analysis (TGA) was

completed. These experiments provided the baseline information of the various mixing ratios of FOW (Banana Peduncle) and MSS (sewage sludge from STP) before the start of the lab-scale drying and pyrolysis tests.

Partner 2: Ramky

Solar Drying - Process design and detail planning of pilot plant, guideline, and manual for operation and maintenance

For attaining this objective, Ramky (Indian Industrial partner) has participated in project kick-off and review meetings along with the academic and industrial partners in India and Germany. The design of solar updraft dryer (SUD) with chimney effect has been completed to arrive at the dimensions and materials, based on the substrate characteristics, lab-scale drying experiments and meteorological conditions at the proposed site in consultation with ISAH and CLRI. Based on this design, detailed planning for the installation of the SUD is prepared which includes detailed engineering, bill of quantities, market availability of the materials, selection of installation ground, a tentative time frame for the construction, and so on.

Partner 3: ISAH, Leibniz Universität

Identification and guantification of heating value, "cracking" temperature and biomass conversion degree

Heating value or calorific value of the dried substrates are estimated individually as well as for different proportions/ blends. Two methods are used for estimating calorific value which is based on the ultimate and proximate analysis results of the substrates. Overall, the calorific values according to the ultimate method are between 12.88 - 19.95 MJ/kg DM and for the proximate method between 15.82 -17.23 MJ/kg DM. The significantly higher value for FOW (19.59 MJ/kg DM) of the ultimate method can be explained by the highest amount of carbon content and the very low ash content. The nitrogen value of the FOW (28.5%), which also differs greatly from that of MSS and Anaerobic Digestate (AD) at 2.7% and 2.6%, respectively.

For estimating biomass conversion ratio, lab-scale pyrolysis was carried out at 500°C for samples with 25 g per mixture with varying heating rate and holding period. Based on this lab scale investigation, the biomass to biochar conversion percentage is in the range between 40.32% and 59% were obtained. The highest biochar yield of 59% at a mixing ratio of 4:5:1 (MSS: FOW: AD) is occurred at a heating rate of 10°C/min and holding time of 60 min. The work packages to attain the above-mentioned objectives/milestones were carried out jointly by both German and Indian academic partners.



Partner 4: Biomacon GmbH

Pyrolysis - Process design and detail planning of pilot plant, guideline, and manual for operation and maintenance

A C63-F pyrolysis machine is already manufactured in Rehburg-Loccum, fitted in a container and started shipment to CLRI, Chennai from the factory. The shipment of the pyrolysis unit is expected to reach Chennai by

May /June 2020. Several constructive changes were made to simplify the on-site operation of the machine . For example, the changes relate to increasing the entry cell wheel lock to prevent clogging at entry. Furthermore, from other project experiences, instead of flexible discharge screw conveyor, linear augers are provided to reduce the noise level in the particular area.



Biomacon Pyrolysis reactor within the container for the project Pilot Plant

Publications

Weichgrebe D., Mondal M.M., Nair R.R. (2019) Biochar production through combined solar drying and single chamber pyrolysis. ECI conference on Bio-char II: Production, Characterization and Applications, 15 - 20, Sep 2019, Italy.

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SELBA

Advanced lithium Ion transporting Solid Electrolytes for Solid-State Lithium Batteries



Electrochemica

Research Institute Chennai



S. Sampath Indian Institute of Science Bangalore

Amara Raja Batteries Limited, Tirupati

Project Summary

The development of safe and cost-effective high energy density all-solid-state lithium batteries can realize the dream of sustainable road transport system. Mainly two reasons are driving research on such systems. First, the state-of-the-art lithium-ion batteries (LIBs) with liquid electrolytes (LEs) pose safety and reliability issues due to their flammability and instability under harsh conditions. Second, the use of Li metal as an anode is not possible at the moment which limits the energy density of the batteries. In this regard, solid electrolytes (SEs) exhibit several advantages: SEs suppress Li dendrite formation, non-flammable and enable high power density for all-solid-state batteries (ASSBs). Despite their obvious advantages, the use of SSBs is currently delayed by the limited availability of stable and high performant Li+ transporting SEs.





M. Venkateswarlu Maximilian Fichtner Karlsruhe Institute of Technology



Andreas Hintennach Daimler AG

The proposed research in SELBA directly addresses these key challenges via two routes. In one approach, the surface of selected Li+ transporting SEs will be modified suitably to attain increased interfacial stability and to reduce the grain boundary resistance. In a second approach, novel Li-containing and glassy fluoride compounds with high stability will be screened, and selected systems will be developed for enhanced Li+ conductivity and integration in solid-state battery cells.

Progress made/achieved

Partner 1: CECRI, India

- CECRI stabilised the Cubic phase of garnet Solid electrolyte in powder form with conductivity in the range of 10-4 S/cm.
- The porosity in the cathode films will be issue for the fabrication of solid state



batteries as it result in huge interfacial resisitamnce. This issue is overcome by use of nano crystalline based NMC 111 cathode materials and their processing protocols to obtain high density cathode coated film. The nanomaterials based electrodes would result in high compaction and therefore achieve high dense electrodes.

- Another objective achieved is the reduction of interfacial resistance at the cathode electrolyte interface, which is done with interfacial engineering of the electrode material by a suitable buffer layer coating, in this case Al2O3 is magnetron sputtered over cathode film.
- Optimization of cathode caoting and interface layer and their characterisation.
- Performance studies on the fabricated high dense cathode material using coin cell.
- Working on scale up procedure and synthesise of flexible thin film out of dense LLZO powder for pouch cell fabrication.

Partner 2: IISc , India

- The LLZO powder obtained from CECRI has been made in to pellets and used in symmetric configuration to understand the Li/LLZO interface. The results are being analyzed.
- The interface engineering using exfoliated carbon-based film is being carried out.
- Ionic liquids, hitherto unreported for solid electrolyte interfacial modification has been synthesized.
- Characterization of the ionic liquid is in progress.

Partner 3: Amar Raja India

- Insertion based electrode active material LiNi0.33Mn0.33Co0.33O3 NMC synthesis and optimised cathode processing protocols.
- To understand the fabrication process, prototype Li-ion cell of pouch type are fabricated with graphite and NMC respectively as anode and cathode.
- Liquid electrolyte is used as an electrolyte and tested at ambient temperature. The lab scale test results are very encouraging.
- The work on solid electrolyte scale up to few tens of grams are in progress.

Partner 4 & 5: Karlsruhe Institute of Technology & Daimler AG

- To develop new types of solid electrolytes with very high stability, compatibility with the electrode materials, low electronic and high ionic conductivity.
- Pursued an approach to synthesize and develop novel fluoride-based ceramic materials with garnet structure. This was achieved in the first instance.
- X ray patterns clearly indicate the formation of the garnet and the systems have a very high electro-chemical stability,
- The first measurements have shown an ionic conductivity which is still low and not competitive for practical applications.
- The activity is now directed to an optimization and variation of the current system. The intention is to keep the electrochemical stability and, at the same time, improve the ionic conductivity.

Microscopic observation



FESEM Images of AI²O³ sputtered NMC-111 coated film (a); Elemental mapping on the coated film (b).

Salient Research Achievements

To achieve the project goal of developing all solid state batteries, project partners made a significant progress during the first year of the project. Insertion based electrode active material LiNi0.33Mn0.33Co0.33O2 to obtain high dense cathode films is synthesied. Parameters optimised and standardised to meet the bench mark performance charecteristics. The nanomaterials based NMC cathode material procced films demonstrated a capacity of 156 mAh/g at 0.1C has retained more than 25 cycling. The performance of the cathode films were evalauted in a coin cell with LiPF6 based non aqueous liquid elctrolyte.

The high conducting solid elctrolyte garnet powders are synthesised by modified solid state synthesis method. We have optimized protocols to stabilise the cubic phase of garnet Solid electrolyte in pure form with high density and excellent ionic conductivity. Solid electrolyte garnet LLZO are structurally modified by doping with certain elements to arrive at the new compositions, Li7-3xMxLa3Zr2O12 where M= (Ga.Ge. Fe). Li7La3Zr2-x MxO12 where M= (Ta, Nb, W) and

Elemental mapping

Li7La3-xMxZr2O12 M=(Sr. Y. Ce) and their solid solutions to achieve the goal of high conductivity similar to liquid electrolytes. The dense pellets obtained with the above solid electrolytes by sinytering at high temperature shows good conductivity in the range of 10-6 to 10-4 S/cm at room temperature.

In order to tackle the issue of higher internal resistance at the electrode and electrolyte interface alumina is coated on LiNi0.33Mn0.33Co0.33O3 NMC by magnetron sputtering method. The alumina coated on NMC, provides a structural integrity and facilitates ion pathways throughout the charge and discharge process, which results in significant improvement of the electrochemical performance. We have developed composite electrode and electrolyte to improve electrochemical performance. The Composite cathode is also made by blending NMC cathode and conductive carbon with 5-15 % LLZO powder and tape casted using doctor bladetechnique.

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Figure 1.0: Key components developed under SELBA project for fabricating Solid State Li-ion batteries.

LABELONIK

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





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Rohitt D Mistry Holographic Security Marking Systems (HSMS) Mumbai

Impedance

Voltage vs. capacity plot Discharge capacity vs. cycle no.





Fig. 2.0: The electrochemical impedance spectrum with liquid electrolyte (a) Voltage-Capacity profile (b) Capacity vs cycle number plot (c) for the Li-half cell with Al2O3 sputtered NMC-111 cathode film.

Project Summary

The project aims to establish a test production line for printed electronic labels by roll-to-roll gravure printing. The label comprises 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 magnetic field to be detected by the Hall sensor of the smartphone. The resistive sensor can detect a change in temperature or humidity or a damage in 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 of circuit design, functional inks, organic transistors, and roll-to-roll gravure printing at one platform to guarantee the success of the project.

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NDO-GERMAN SCIENCE & TECHNOLOGY CENTRE 80



Frank Ellinger Technische Universität (TUD) Dresden



Moazzam Ali Saralon GmbH (SAR) Chemnitz



Figure 1. A LABELONIK label on a package communicating with a smartphone.

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Progress made/achieved

Partner 1: SAR

SAR has printed a humidity sensor on PET substrate, as shown in Figure 2. This printed humidity sensor requires two inks 1) Silver conducting ink and 2) humidity sensitive resistive ink.

SAR has also printed a temperature sensor on PET substrate, as shown in Figure 3. This printed temperature sensor requires two inks 1) Silver conducting ink and 2) temperature sensitive resistive ink. The temperature sensor shows a sudden increase in resistance at ~500C

Partner 2: TUD

Milestone MS2 - 1st Generation Label Prototype

Circuit simulations of the ring oscillator and integrated label for MS2 have been completed and the android app as well as its development environment have been set up, based on free and open-source software packages. The verification in hardware of the designed circuits has not yet been completed.

Partner 3: IISER

Deliverable D2: First n-type semiconducting rylene diimide synthesized



Figure 2. Printed humidity sensor on PET.



Figure 3. Printed temperature sensor on PET.

IISER has synthesized a pair of organic n-type semiconducting molecules, NDIFBr2 and NDIFCN2. Both molecules are based on naphthalene diimide (NDI) backbone. In our design, we have introduced the following two structural elements: (a) linear fluorocarbon -CH2C3F7 groups at the two terminal imide N, and (b) -Br and -CN as core-substitutions. These modifications are expected to offer a three-fold advantage. Because of large polarizability of these groups, both molecules show good solubility and solution processability. Electron-withdrawing nature of the core-substitution is expected to lower the Lowest Unoccupied Molecular Orbital (LUMO) and improve charge injection efficacy. Finally, the fluorocarbon chains are known to improve the surface crystallization and ordering in the solution printed thin films.

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Partner 4: HSMS

Deliverable D1: Roll-to-roll gravure printed resistive sensor

HSMS is the last in the chain of development. HSMS has already begun trials and found that the existing roll-to-roll gravure printing machine needed some modification for LABELONIK. Another hurdle was in the shipment of inks from Germany (SAR) to India (HSMS). Gravure inks with very volatile solvents, which are also highly flammable. The flammability of the inks makes the gravure inks dangerous goods. To overcome this issue, SAR developed a concentrated ink with a non-flammable solvent and arranged the shipment to HSMS in Aug. 2019. With this concentrated ink, HSMS can prepare a gravure ink by mixing a suitable volatile solvent. We have done some drawdown tests, but the machine trial is still pending. A cylinder for test printing is ready for initial trial (machine trial yet to be done).



BIOMEDICAL TECHNOLOGY

SIBAC

Experimental and clinical evaluation of a new measurement and evaluation method based on dynamic corneal deformation of the eye by a defined air pulse and its recording using Scheimpflug technology for the purpose of determining biomechanical parameters of the human cornea







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Project Summary

Corneal tissue is a fascinating anisotropic viscoelastic structure with interwoven collagen fibers enclosed in the extracellular matrix. Structure's intricate arrangement is integral to its strength; even a localized disruption could result in cornea steepening and vision degrading, commonly referred to as keratoconus. Keratoconus is part of a larger class of diseases commonly referred to as ectasia, all affecting collagen fiber architecture. As collagen fiber architecture is linked to tissue strength, the in-vivo biomechanical measurement could be a clear approach to detect, classify, stage, and track such disorders. However, the diagnosis of keratoconus conditions is not perfect especially subclinical keratoconus, resulting in increased reports of post-refractive surgery ectasia. Post-refractive surgery ectasia is a rare side effect of refractive surgery characterized by an abnormal change in corneal refraction and vision loss due to cornea steepening after surgery. Laser-based refractive surgery has come a long way with flap-based Laser-Assisted In Situ

Keratomileusis (LASIK) and Flapless Small Incision Lenticule Extraction (SMILE). The flapless SMILE surgery is hypothesized of being biomechanically uncompromising as the stronger anterior collagen is spared along with the use of photo disruptive laser and a smaller side cut. But. even in case of SMILE. post-refractive ectasia has been reported calling the need for better patient selection. Thus, more sensitive tools are needed to detect subclinical keratoconus. This proposal aims to develop a next-generation dynamic Scheimpflug imaging device and biomechanical software analytics for in-vivo quantification of corneal viscoelasticity. The next-generation dynamic Scheimpflug imaging device would have high temporal resolution and location-specific corneal deformation measurement. The biomechanical software analytics would incorporate a faster computational algorithm for inverse estimation of biomechanical properties. The project also aims to validate such cutting-edge devices and techniques in ex-vivo and in-vivo human subjects, both in normal and disease conditions.

Progress made/achieved

Software development Refinement and development of the inverse finite element method and associated tools

Clinical testing of the new device

Regional biomechanics of corneal ectatic disorders

Goals: To study the regional corneal biomechanics in normal and ectatic eyes using a new prototype air-puff applanation device (developed under this grant).

Experimental design: A total of 45 normal, 19 Pellucid Marginal corneal Degeneration (PMD), 30 Keratoconus (KC) and 9 Post-refractive Surgery Ectasia (PSE) eyes were analysed using the prototype. The prototype had three fixation targets to assess the superior (Sz), central (Cz), and inferior zones (Iz) of the cornea. All prototype reported and calculated biomechanical parameters from a viscoelastic model were analysed. Further, two Random Forest Models (RFM) were built, one with Cz parameters only and the other with all three zonal parameters together to evaluate if the addition of zonal measurements improved the biomechanical segregation between the normal, PMD, and KC eyes. The PSE eyes were excluded from RFM due to the small sample size.

Results: Both the PMD and KC eyes had the inferior cornea as the weakest zone biomechanically (p<0.05). Further, some of the parameters indicated progressive biomechanical weakening from the superior to the central cornea and then further weakening to the inferior cornea in the KC eyes only (p<0.05). The PSD eyes were biomechanically the weakest since they had the lowest stiffnesses and the greatest magnitudes of deformations compared to the other groups in all corneal zones. The RFM analyses showed that adding regional measurements improved the segregation between the groups of eyes based on their biomechanical properties (p<0.001).

Conclusions: The regional biomechanical properties of ectatic corneas were quantified. Further study with larger sample sizes is warranted for clinical translation.

Status: Currently under review at translational vision science and technology journal

Software development and refinement for inverse finite element tool for post-refractive surgery biomechanics prediction

Goals: To develop an inverse Finite Element Method (FEM) based tool for predicting post refractive surgery biomechanics (developed under this grant).

Experimental design: The tool was developed using a free open-source package called CalculiX (under GNU general public license) (Figure 1). The package contains a pre- and post-processing module called CalculiX GraphiX (CGX) and an implicit and explicit solver called CalculiX CrunchiX (CCX). The tool has two distinct serially executing code blocks (Figure 2). The first was an inverse FEM block which calculates preoperative corneal material properties (Figure 2). The second code block was the forward FEM block which predicts the post-refractive surgery corneal deformation waveform based on the preoperative material properties (Figure 2). The inverse FEM block takes in the corneal elevation data from the Pentacam HR. This elevation data of anterior. bowman's, and posterior surface were converted to NURBS (non-uniform rational b-spline) surfaces and stored into an FBD file (geometry input format file for CGX) using a custom python script. Later instructions on creating the mesh were folded into it to the FBD file. The FBD file input to CGX pre-processing module produced the mesh file in INP format (ABAQUS/CAE input file format) as required by CCX. The INP file was further edited using custom python script adding into it the initial assumption of anisotropic hyper-elastic material property. The heart of the inverse FEM code block was Newton's method based iterative estimation of preoperative material property. The loop has two CCX solution substeps, first estimate the mesh shape once the intraocular pressure was brought down to zero mmHg, zero load simulation. Second, estimation of corneal zero loads mesh deformation under the pressure profile of the Corvis-ST air-puff (computational fluid dynamics derived profile stored inside the tool's library) acting against intra-ocular pressure. The above

iterative loop reduces the error of estimation between deformation amplitude in-vivo measured and calculated from FEM thus approximating corneal material property. The second code block starts by creating a postoperative corneal mesh, which was the subtraction of planned ablation profile from the preoperative corneal mesh. The postoperative mesh was then subjected to zero loads and air-puff FEM simulations similar to the inverse block to derive the predicted postoperative deformation waveform. However, the air-puff stimulation on forwarded FEM block was adjusted to incorporate surgical tissue alteration charateristics of photorefractive keratectomy (PRK), laser-Assisted in-Situ keratomileusis (LASIK) and small incision lenticule

extraction (SMILE). The deformation amplitude waveform prediction was adjusted using a random forest (RF) based artificial intelligence model. The RF model was trained using data collected from more than 345 eyes (200 LASIK, 55 PRK, and 90 SMILE eyes). The tool was built to run on an 8 thread 2.2 GHz Intel CPU and 8 GB 1866 MHz RAM test bench under standard condition. All calculations were optimized for Intel math kernel library.

Results: The tool achieved all required objectives and has entered into the alpha test phase of development. Average execution time under standard configuration was 4.13 0.9 hours.

Status: Currently undergoing alpha testing (laboratory testing)



Figure 1: Schematic of software tool predicting post refractive surgery biomechanics



Figure 2: Flow chart of the inverse finite element tool for post-refractive surgery biomechanics prediction

The project has completed Phase 1. The phase 2 of the project started in October 2019 with the following partners Narayana Nethralaya Foundation and OCULUS Optikgeräte GmbH. The

Publications

Journals

Francis M. Matalia H. Nuijts R, Haex B, Shetty R, Sinha Roy A, "Corneal Viscous Properties Cannot Be Determined From Air-Puff Applanation", J Refract Surg. 2019 Nov 1;35(11):730-736.

Khamar P. Teiwani S. Shetty R, Francis M. Vaishnav R. Francis M, M.M.A. Nuijts Anterior R, Sinha Roy A. Biometry on Biomechanics of Corneal LASIK flap and SMILE Stiffness of cap: A prospective, clinical study. with Chronic J Refract Medication or Surg. 2019

Patents filed

Narayana Nethralaya Foundation, 2019. Internatrional publication number: W02019/166886A1. International application number: PCT/IB2019/050661

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main objective during the extension is to finish the development and testing of the software tool to calculate the biomechanical properties of the tissue and to use it as a predictive tool.

Dinakaran S, et al. Influence of

Biomechanical Glaucomatous eves Treated Filtration Surgery. J Glaucoma. 2019.

Maheswari S. Khamar P. Shetty R, Patil R, Narasimhan R, Sinha Roy A. "Novel ultrastructural imaging technique of collagen distribution with ultra-high resolution PSOCT", IIRSI winter 2019

Khamar P. Shetty R. Francis M, Sinha Roy A, "Immediate Molecular and Biomechanic al response after LASIK, and SMILE" **ASCRS 2019**

A method to guantify the corneal parameters to improve biomechanical modeling. Filed by

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SOUND4ALL

Re-engineering high-end audiometric devices for robust and affordable audiological testing





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Project Summarv

Hearing impairment is one of the most common forms of disability and is widespread in countries like India. Children in rural areas suffer from this because of malnutrition and inadequate medical facilities. In urban areas, many adults are continuously exposed to high levels of noise, particularly in their work environments (e.g., in factories or construction sites). With regular screening, hearing impairment may be detected early and treated. While screening of newborns for hearing loss is slowly gaining momentum in India, it needs to be more widespread. However, monitoring children and adults regularly is almost non-prevalent. This is because the currently available screening equipment is expensive. Further, such equipment may only be used by specialists, who are in shortage. In this project the team will completely re-engineer such a screening device in order to (i) significantly bring down its cost, and (ii) enable it to be used by laypersons in the same manner that one uses blood pressure monitors or thermometers. More widespread availability of low-cost screening devices will enable their usage in schools, small healthcare centers, factories and construction sites. However, in order to significantly reduce the cost of screening devices, the newly designed devices will need to use a completely different hardware and software architecture, without sacrificing the quality of the screening. Developing such architectures and evaluating them are the main scientific goals of this project. In particular, the consortium will rely on two main techniques: (i) offload the involved signal processing algorithms onto a mobile phone, and (ii) instead of using expensive and specialized probes, as is the case in existing

screening equipment, they will use commercially available off-the-shelf components.

In Phase 1 of this project, it was aimed to reduce the cost such as equipment by building a hearing screening device based on off-the-shelf components. Rapid prototyping techniques also helped to explore many variants of ear probes. Further, the project team investigated the use of smartphones in hearing screening, which proved itself helpful. Project in Phase 1 developed promising prototypes for an ear-probe and a small smartphone assisted standalone device. Phase 2 will be governed by integrating both into a single well-tuned device, while at the same time optimizing all components for manufacturing techniques like injection molding. Further the project wants to proceed with improving the user experience with sensor data gathered outside the ear probe.

Progress made/achieved

TUM

The first phase of the project was finalized in the first three months of 2019. The work on the standalone prototype was continued. While PATH contributed large parts of the OAE algorithms, TUMcontinued working on other aspects, to make the device more suitable for evaluation in a clinical setting. This included mostly utility aspects, like battery management, data collection, and storage. Also, more prototypes were prepared and manufactured. In preparation for the second phase, the team started integrating the additional sensors in our prototypes as well as the software.

PATH Medical

otoacoustic emission (TEOAE) algorithm implemented on the stand-alone hardware platform was evaluated and optimized during

the first three months in 2019. Therefore, recordings were conducted at PATH and TUM to evaluate the usability and performance of the OAE algorithms in guiet environments. Based on those results parameters of the algorithms for artifact rejection, weighed averaging, and signal detection were optimized. The usability study at PATH served as input for UI optimization on the OLED

IIT Delhi

Manufacturing of the ear probe for Sound4all device

Design of the molds for manufacturing of the ear probe

Various iteration of mold design was manufactured using electric discharge machining and CNC machining. Mold designs are rectified after the printing of the parts and studying the defects formed in the parts. After the finalization of the design, parts are printed with various materials (ABS, PLA and PEBAX)

AIIMS

Clinical validation and functional testing of the sound4all device

Ethical clearance was obtained for testing of the device in patients. A total of 749 subjects were involved in this study. The comparison was carried out between Sound4all prototype, commercially available Neuro-Audio screen and the gold standard tests of ABER/PTA.

Subjects: About 749 subjects (419 Male & 330 female) were tested and evaluated in this study. The patients were recruited from the (i) outpatients visiting the department of otolaryngology, AIIMS, Delhi for hearing screening assessment and some pediatric subjects and (ii) the patient visiting Government Hospital at Ballabhgarh (rural setup).

The Sound4all device is susceptible to noisy results than the neuro-audio screen one, which is suggestive of the performing less number of

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display of the device for online monitoring during OAE recordings.

PATH developed some concepts for integrating additional sensors into OAE algorithms like the in-ear calibration conducted prior to OAE measurements. As an example, capacitive sensors shall be used to monitor the probe fit in addition to the acoustic reflections captured by the probe's microphone, giving more accurate feedback to the operator.



patient than the neuro-audio screen one. Currently, the Sound4all device cannot be used by a layperson as it requires training and handling of the device.

The Sound4all device possess comparable sensitivity and specificity, but specificity is markedly reduced in noisy backgrounds. The prototype is working well in the adult population as compared to the pediatric population (0-5 Years), and the prototype is having a greater percentage of blocked/error, noisy results than the neuro-audio screen one.



Assembled probe with injection moulded parts design

MIDARDI

Microfluidic based detection of microbial communities and antibiotic responses in the management of diabetic foot ulcers - demonstrator to prototype



Manipal







Dhananjaya Dendukuri Achira Labs P. Ltd. Bangalore



Fraunhofer IZI-BB Potsdam-Golm



Project Summary

Diabetic foot ulcers (DFU) are often associated with type 2 diabetes and are therefore still being an increasing issue both in Europe and India. Though infected ulcers require proper antibiotic therapy, rapid and accurate detection of polymicrobial communities in the wound environment are critical in proper wound management. Current lab-based methods require two or more days for such a test.

The MIDARDI consortium has been developing a microfluidic-based lab-on-a-chip for rapid (<1 hour) and accurate detection of different types of bacteria, their virulence/fitness factors, and antibiotic resistant genes that may contribute to the dominance of certain types in DFU settings. The detection module (instrument) will aid clinicians in the decision-making process to improve specific outcomes that would concomitantly improve wound healing per se in DFU scenario. Further, it would provide a better understanding of the underlying microbial communities to develop treatment regimens to suit responses to individuals' lifestyle modifications.

A previously developed demonstrator system will be extensively validated to obtain data on the robustness of the results against variations of sample, temperature, humidity, reagents, manufacturing tolerances, etc., and to identify potential issues. The whole system will be optimized and developed towards a system prototype. Aspects addressed include storage stability, cost and the previously identified issues.

A second iteration testing series will finally be run. Besides that, the applicability to other market areas will be investigated, thus improving the commercial perspectives of the development.

Progress made/achieved

Partner 1 (Manipal School of Life Sciences, MAHE)

In MIDARDI-D2P. Manipal focused on standardization of an isothermal amplification method to incorporate in the point of care device being developed. Isothermal amplification methods are a streamlined, exponential way of identifying the target nucleic acid sequences, without the need of an external thermal cycler. The independence from a thermal cycler enables the device to be used in any healthcare setting without reliance on external machinery or specially trained personnel. There are many strategies available for isothermal amplification such as LAMP (Loop-mediated isothermal amplification), SDA (Strand Displacement Amplification). HAD (Helicase Dependent Amplification) and several others. LAMP enables the rapid amplification of DNA with high specificity and efficiency.

LAMP primers for the 16S rRNA region of 8 bacterial species were designed using primer explorer software with default parameter settings. Standardization of the LAMP assay with genomic DNA of nine strains of S. aureus is underway.



Partner 2 (Achira Labs)

IPreviously, Achira had built a readout instrument for the integrated BiFlow cartridges. This instrument electronically controls the pumping of the fluid as well as heating and cooling in the cartridge. They had established the proof-of-concept by performing a fully automated microarray hybridization of 16S rDNA on Biflow cartridge to detect Proteus, Enterococcus and Staphylococcus species. The next step is to collect more data to statistically verify the results and establish the specificity and sensitivity of the readout protocol.

Partner 3 (Fraunhofer)

In the phase 1 of MIDARDI-project, a layout was developed that includes the following species: Achromobacter spp, Acinetobacter baumannii, etc. But various resistances haven't

Publications

Jnana A, Muthuraman V, Varghese VK, Chakrabarty S, Murali TS, Ramachandra L, Shenoy KR, Rodrigues GS, Prasad SS, Dendukuri D, Morschhauser A, Nestler J, Peter H, Bier F, Satyamoorthy K. (2020). Microbial Community Distribution and Core Microbiome in Successive Wound Grades of Individuals with Diabetic Foot Ulcers. Applied and Environmental Microbiology, 86: e02608-19. DOI: 10.1128/AEM.02608-19

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1. S. aureus genomic DNA (denatured at 95°C)

- 2. S. aureus genomic DNA
- 3. Negative control

Fig. Visualization of conventional 16S PCR performed with LAMP primers (FIP and BIP) on a 1.2% agarose gel (Sample loaded ~1µl, gel was run for 45minutes at 100 volts).

yet been considered here. For the current phase of the project, Fraunhofer adapted and expanded the microarray layout. Additional species and the resistances VIM, NDM, OXA48, and mecA are taken into account in the new array layout.

Partner 4 (BiFlow Systems)

The first set of cartridges for evaluation in India has been manufactured. However, due to COVID-19 situation, shipments to India became difficult so that further testing had to be postponed.

Cartridges with microarrays spotted by Fraunhofer have been tested on an in-house instrument for validation of the experiments carried out in the phase 1 of project (MIDARDI) in March 2019. A new, narrower spot spacing of only 300Qm was used in an agreement between Fraunhofer and BiFlow.

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INFORMATION RETRIEVAL, INFORMETRICS & **SCIENTOMETRICS (IRIS)**

11-13 June 2019, Cologne

Indo-German Joint workshop on Information Retrieval, Informetric & Scientometrics (IRIS) was organized on 11th - 13th June 2019 at GESIS - Leibniz Institute for the



In the modern connected world full digital information, and scholarly conte identifying the most relevant resource has become a challenge. A researcher any discipline of knowledge now has depend on online portals, digital librar and electronic repositories for reporti as well as finding scientific articles in area. Till now this has been provided various search engines by treating task of scholarly article search as a w search problem. This has complete ignored the bibliometric information, a associated metadata of scholarly articl The idea of this workshop is to bri together concepts from Information

Workshops

Social Sciences, Cologne, Germany. The workshop was coordinated by Dr Philipp Mayr, GESIS-Leibniz Institute for Social Science and Dr Vivek Kumar Singh, Banaras Hindu University.

| of | Retrieval and Scientometrics to identify |
|------|---|
| ent, | scholarly articles relevant to a given |
| ces | information need (or a context) and rank |
| r in | them based on their relevance to the |
| to | information need as well as their scholarly |
| ries | quality. The workshop brought together |
| ing | researchers working on this task from |
| an | different perspectives (namely Computer |
| by | Science, Informatics and Bibliometrics). |
| the | The workshop had invited presentations, |
| veb | posters and intensive panel discussions |
| ely | on the area, and had set a direction for |
| ind | future research including strengthening the |
| les. | bilateral cooperation between India and |
| ing | Germany in this area. |
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Research and innovation towards leapfrogging in frontier technologies (RILEAP)

22 - 23 July 2019, Chennai & 29 July - 1 August 2019 | New Delhi, Nagpur, Pune, Roorkee

Indo-German joint scientific workshop on Research and innovation towards leapfrogging in frontier technologies (RILEAP) was organized by International S&T Affairs Directorate (ISTAD), CSIR in collaboration with Fraunhofer e. V., Germany during 22-23 July and 29 July-1 August 2019 at CSIR-CECRI, CSIR-NCL, CSIR-CBRI, CSIR-NEERI, and CSIR-New Delhi.

The workshop aimed to develop concrete project proposals in the areas of common interest viz. sustainable buildings, water, advanced production technologies, battery technologies and share the same with industry, Government and other stakeholders. CSIR in consultation with industry stakeholders would



The workshop started with an inspiring keynote by Dr Gangan Prathap, APJ Abdul Kalam Technological University on "The Pinski-Narin influence weight and the Ramanujacharyulu power-weakness ratio indicators revisited" and by Dr Norbert Fuhr, Universität Duisburg-Essen on "Modeling interactive information retrieval and social media interaction as stochastic processes".

The workshop involved interaction and detailed discussions among research groups from both the countries. The academic program was so designed that it allowed for exploring possibilities of research collaborations between researchers from the two countries. A pairing session was held just after a session detailing the available joint collaborative project funding opportunities. Participating researchers realized the opportunities that exist for collaboration and welcomed the initiative and efforts. It is expected that there would be some joint project proposal submissions to different collaborative calls very soon.

In addition to the objective of promoting collaboration, the workshop discussed on research advances in the broader area of Information Retrieval (IR), Informetrics & Scientometrics. New advances in information retrieval models were discussed and interesting ideas for IR in scholarly article domain emerged out of the discussions. Advances in quantitative studies of science, including process of science production, were discussed in detail. Approaches for S&T evaluations in both countries were discussed by the participants. These discussions resulted in emergence of useful insight and ideas for the S&T evaluation exercises. The workshop included in-depth discussions on various issues in the research area and the participants benefitted from it a lot. It is expected that workshop will result into the starting of new research collaborations between different research groups from both countries. Dr Roshan Paul, Director, IGSTC gave a special address on IGSTC activities, schemes and different avenues bilateral collaboration between Indian & German researchers.

Two special issues of the following journals on the theme of the workshop are confirmed:

- Journal of Scientometric Research, Special issue on "Quantitative, Network-theoretic and Altmetric Analysis of Scholarly Big Data"
- 2. Scientometrics, Special Issue on "Bibliometrics and Information Retrieval"

provide the basic research ideas (TRL 3- 6) and identify topics and problem statements related to the Indian conditions. Fraunhofer would provide the expertise and support to take the research ideas to the next level (TRL 6-9) in a collaboration with CSIR, and industry would take it to commercialisation. In addition, thematic areas such as big data analytics, artificial intelligence, automation, mathematical modelling etc. can also be explored to improve services particularly to government stakeholders.

A workshop session on Battery Technologies at CSIR-CECRI, Chennai on 22-23 July 2019 was conducted.

Three parallel workshop session were held simultaneously on 29-30 July at the following topics at



Innovative technologies for assessment and mitigation of groundwater contamination (TEC4WATER)

- 1. Sustainable buildings at CSIR-CBRI, Roorkee
- 2. Water at CSIR-NEERI, Nagpur
- 3. Advanced production technologies at CSIR-NCL, Pune

Around 60-70 scientists, researchers, faculties, industry persons from India & Germany participated in various workshop sessions mentioned above on mutual topics of collaboration.

The concluding workshop session was held on Ist August in New Delhi where results of all the previous sessions were summarized and future course of action was pondered upon. Dr Rajiv Kumar, Vice Chairman, NITI Aayog addressed the session Indo-German collaboration in research & innovation and encouraged the scientists to innovate for India specific solutions. Dr K Vijayraghavan, Principal Scientific Adviser, Govt. of India; Dr Jasper Wieck, Deputy Chief of Mission, German Embassy, New Delhi, and Dr Shekar Mande, DG, CSIR also addressed the session. Director, IGSTC attended the session and interacted with the participants.

The workshop helped to prepare the concrete projects for joint implementation by Indian and German scientists.





16-18 September 2019, Chennai

The workshop "Innovative technologies for assessment and mitigation of groundwater contamination (TEC4WATER)" was held during 16-18 September 2019 at Anna University, Chennai. The workshop coordinators were Prof Elango Lakshmanan, Anna University and Prof Michael Schneider, Freie University, Berlin. The workshop was held primarily to brainstorm on groundwater



pollution and development of new techniques to mitigate the scenario.

The sessions were grouped under different aspects of groundwater contamination and its remediation. The major themes of the conference were geogenic contamination of groundwater, anthropogenic contamination of groundwater, modelling techniques and mitigation strategies.



engineers from different government departments sustainable methods to prevent and mitigate water these areas especially in bringing out affordable workshop served as a platform for the cross themes aimed at both the current state of the art and the future directions.

- human-induced contaminants in water:
- 2. Investigating their fate and transport in water and soil;
- 3. Developing methods for remediating or mitigating groundwater contamination due to these pollutants

have dealt with challenges in groundwater contamination and mitigation. A special session to decide about the plans for future was held and all the delegates expressed resulted out are to formulate research groups which consist of Indians and Germans in the following fields

- 2. Anthropogenic contamination and treatment
- 3. Industrial wastewater treatment

The delegates also have decided to look for the future calls of IGSTC (2+2), DST-DAAD, and EU Horizon 2020 for the formulation of suitable proposals. It was also decided to formulation of research group need not be restricted to the delegates who have attended, but also include all the other possible potential researchers. The field visit to northern Chennai aguifers was made to understand the impact of seawater intrusion. They also viewed the Managed aquifer recharge (MAR) structures which are prominently used for mitigation of coastal aquifers. Along with these, visits to the ancient traditional water recharge structures were also made. A field visit to the southern coastal part of Chennai was also carried out on 18th September to understand the effect of urbanization on the coastal aquifers, to see a traditional temple tank as a method of rainwater harvesting, and the location of the desalination plant that supplies drinking water to Chennai. Later delegates were also taken to the Mamallapuram a UNESCO's Heritage Site.

Solar thermochemical technologies for green and sustainable development

17-18 October 2019, Cologne

The Indo-German workshop on Solar thermochemical technologies for green and sustainable development (SOLOGREEN) was organized at Envihab, DLR, Germany on 17-18 October 2019. The workshop was coordinated by Dr Martin Roeb, DLR Germany and Dr K. Srinivas Reddy, IIT Madras. .

Solar thermochemical processes can supply high-temperature process heat as the necessary energy source for the performance of endothermic chemical reactions, which can be used to produce high-value solar fuels



The technical presentations included the new developments in the solar reactor systems solar fuels, where eminent speakers from India and Germany presented their work. The recent advancements in solar energy capturing, application to process industries, and methods to achieve high temperatures were presented. Around 70-80 participants from various

(mostly hydrogen and syngas) or for particles treatment (to drive calcination reaction). This workshop concentrated on the evolution and current state-of-the-art of such reactors that are used for particle treatment and solar fuel production. The main objective of the workshop was to promote the solar thermochemical process to both the industrial and research partners in Germany and India, which would enhance the cooperation between German and Indian partners in science and industry.

research institutes in India & Germany were present in the event. The technical topics covered in the workshop were solar reactor design & modeling and materials/technologies for fuel production, solar reactor systems high-temperature applications, solar particle treatment for the future, etc.



The advanced developments in solar reactor and CO2 capture through solar

H2O or CO2 splitting. This new technology has the potential to achieve a high-temperature in a smaller fresnel lens tunnel.

collaboration is focused towards writing of proceed beyond the current state of the art. This conference enabled both the Indian and German participants to exchange ideas and academia and industry.

Computational Mathematics: challenges and opportunities towards exascale computing (IGCM)

2-4 December 2019, Bangalore

The Indo-German conference on Computational Mathematics: challenges and opportunities towards exascale computing (IGCM) was held at Department of Computational and Data Sciences, Indian Institute of Science (IISc), Bangalore, India, during 2 - 4 December, 2019. This event was jointly organized by IISc, Bangalore, MEC Hyderabad & University of Hohenheim. The Workshop was coordinated by Prof Sashikumaar Ganesan, IISc Bangalore and Prof Philipp Kügler, University of Hohenheim.

The purpose of this Indo-German Workshop was to provide an interdisciplinary forum for researchers around the world to present and discuss the most recent innovations, trends, and challenges in the frontier areas of computational mathematics. IGCM was planned to foster interactions among High Performance Computing (HPC) research community and to provide a forum to present and discuss challenges in Exascale computing.





Around 100 particpants including invited speakers, researchers from India & Germany participated in the event.

In addition to the conference events, a round-table discussion on "Funding and Collaborative opportunities" has been arranged on 2nd December during dinner. Representatives from DFG, DAAD and Uni-Heidelberg were also participated and shared the information. It has been decided to apply to the Indo-German Call (IGP) for research collaborations between IISc and Uni-Heidelberg with Julich Supercomputing Center as a partner and planned to organise the next Indo-German conference in Germany.

> INDO-GERMAN SCIENCE & TECHNOLOGY CENTRE 103

IGSTC-CONNECT Plus Programme

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Indo-German Science & Technology Centre and Alexander von Humboldt Foundation (AvH) jointly launched the **IGSTC-CONNECT** Plus Programme in May 2018. The Programme is aimed at boosting Indo-German networking and long term collaboration among the participants of the **Indo-German Frontiers of Engineering Symposia (INDOGFOE),** which is co-organised by the Department of Science and Technology (DST) and the Alexander von Humboldt Foundation.

INDOGFOE is a series of interdisciplinary, bilateral conferences, which brings together outstanding, early career Indian and German engineers and scientists from industries, universities, and other research institutions. This creates a platform to introduce their areas of research and technical work, thereby facilitating an interdisciplinary transfer of knowledge and methodology, which may lead to the development of cooperative networks of young scientists from both countries.

To encourage collaboration among the participants of INDOGFOE, AvH has devised a

follow-up Programme **CONNECT**, which allocates residence allowances for working visits of participants in INDOGFOE partner countries for up to a total of 30 days per conference. In order to support working visits of successful CONNECT applicants from India and Germany, IGSTC will implement, administer and manage the IGSTC-CONNECT Plus Programme. Under this program, IGSTC will support international travel expenses for successful Indian and German CONNECT participants, thus promoting the scientific exchange and networking.

Who can Apply?

The applicant must have participated in one of the INDOGFOE in India or in Germany and must have started a cooperation with at least one participant of the partner country. Cooperating partners must have participated in the same conference. Either the applicant or the hosting partner must be based in India or Germany at the time of application.

Evaluation

All IGSTC-CONNECT Plus applications from Indian and German scientists submitted to AvH along with AvH-CONNECT scheme will be exclusively and independently reviewed and evaluated by AvH according to the principles and practices of AvH-CONNECT. IGSTC will further scrutinize the AvH recommended applications before taking a final decision on travel support.

Funding Support

Travel expenses of successful Indian and German IGSTC-CONNECT Plus applicants are covered in accordance to the following procedure:

- The travel expenses covered by IGSTC are economy class flight tickets, medical insurance and visa fees. Further, local journey may be covered by shortest route and preferably by public transport.
- For Indian applicants, IGSTC may purchase flight tickets or reimburse tickets

purchased by the applicant, in accordance with the envisaged travel period (as stated in AvH-CONNECT granting note and ultimately confirmed by the applicant).

• For German applicants, IGSTC will acquire flight tickets in accordance with the

envisaged travel period (as stated in AvH-CONNECT granting note and ultimately confirmed by the applicant) and may consider the air connection suggestions by the applicant. After execution of the ticket purchase, IGSTC will provide digital flight ticket / ticket confirmation details to German applicant in due time.

IGSTC will not accept and consider any applications submitted directly to IGSTC.

For more information and application procedure contact **AvH Berlin office.**

IGSTC-CONNECT Plus Fellows



Prof Anirban Guha Department of Mechanical Engineering Indian Institute of Technology Bomba

Title of the Project Practical trials leading to the development of a passive assistive device for elderly people Host Institute Dr Sebastian Fudickar, Department of Health Research, CvO Universität Oldenburg

Visit Period: 29th July – 26th August 2019

Objective of the project

To develop a passive assistive device with a lower level of complexity than the devices reported in literature to assist in walking of older adults and people with neurological diseases. This would have significant advantages over the large heavy and expensive active assistive devices usually reported in literature





Summary of Progress

Extensive simulation-based studies carried out in India helped in establishing salient design parameters of an ideal passive active device with the least level of complexity. A first prototype of such a device was constructed. Pilot studies conducted after approval from the Institute Ethics Committee of IIT Bombay led to the construction of a second prototype with design improvements. An extended trial in IIT Bombay indicated the scope of improvement in gait parameters but also established the need for further design changes.

The second prototype was brought to the University of Oldenburg, Germany, An improvement in stability was attempted by redesigning a significant portion of the device. The re-imagined design (third prototype) required a combination of flexible and rigid sections within a single extended attachment. This was achieved by the innovative use of a 3D printer in the University of Oldenburg. The final device required components of the old design to be integrated into the 3D printed attachment. This was achieved with the help of the workshop facilities in the University. Dr. Sebastian Fudickar was actively involved in every step of the process of redesign and enlisted the help of many student and staff members of the University - Bjoern Friedrich, Jule Deiters and David Saß to name a few.

An extended discussion was conducted with Dr Nils Eckardt, an expert in marker based tracking and evaluation of gait parameters, about the range of data which can be captured to evaluate the performance of the device. The experience of Dr Eckardt also helped in identifying the set of trials which should be carried out and the method of analysing the data. The device was taken to the Gaitlab of Dr Eckardt and a preliminary pilot study was conducted with GAITRite (for capturing footfall related parameters) and VICON (for capturing joint angles by analysing trajectory of markers placed on the human body) in synchrony. Two surfaces were used for walking - smooth and uneven. Four kinds of walking conditions were attempted - without wearing any assistive device, wearing the attachments for the assistive device but without any assistance, wearing the assistive device with weak assistance and wearing the assistive device with strong assistance. Three walking speeds were studied - slow, normal and fast. Analysis of the results is underway.

Visual inspection has clearly established that the device designed in the University of Oldenburg is more stable than the two earlier prototypes. The successful integration of soft (flexible) and hard (strong) sections within a single 3D printed attachment and its ability to withstand the stresses of a laboratory trial have been established. However, stability of a component of the device, though perhaps adequate for laboratory trials, was considered insufficient for outdoor trials which might be conducted in future. It would certainly not be suitable for final implementation of the device where a user is expected to wear it for long periods. These considerations have led to the conceptualization of a fourth prototype with significant design changes. A design decision was taken to accept lower level of adjustability in view of improving stability. Fabrication of this prototype is underway.



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