PATENT ACQUISITION AND COLLABORATIVE RESEARCH AND TECHNOLOGY DEVELOPMENT (PACE)

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1. PREAMBLE

The Department of Scientific and Industrial Research (DSIR) is continuing to operate the 12th Five Year Plan scheme on "Patent Acquisition and Collaborative Research and Technology Development (PACE)" during 2017-2020. The DSIR through the PACE scheme provides catalytic support to industries and institutions for development and demonstration of innovative product and process technologies, traversing the journey from proof of concept or laboratory stage to pilot stage, so that they can be launched for commercialization. The scheme supports ingenious work and assists in development of new technologies or creative/innovative application of the existing technologies to solve unmet needs of industry. The scheme also strengthens the interface between industry, R&D establishments and academic institutions by supporting collaborative proposals. The scheme also jointly supports initiatives of other Ministries / Departments aimed at technology development and demonstration, e.g. IMPRINT initiative of Ministry of Human Resource Development/ DST, wherein institutions of higher learning are being supported for development and demonstration of technologies.

Support is provided for proposals which give clear evidence of existence of proof-of-concept and aim at developing an innovative content for fulfilling an unmet need. Development and demonstration of technologies can be undertaken by industries alone (such as in-house R&D centres of the industry recognized by DSIR) or in collaboration with Universities, Public Funded Research Institutions or academic institutions. The technology development projects supported under the scheme aim at development of a new product or a process with attractive market potential which will result in significant benefits to the industry concerned in terms of raising its technological level, turnover, energy and material savings/recovery, export sales etc. Focus sectors include (i) Energy & Environment, (ii) Affordable healthcare including Drugs & Pharmaceuticals and Medical Equipment & Devices (iii) Agriculture, food & nutrition, (iv) Engineering (such as automobiles & auto-components, machine tools & foundry, automation & robotics, sensors etc.), (v) Specialty Chemicals etc.

2. OBJECTIVES

The objectives of the scheme are:

i. To support development and demonstration of indigenous product / process technologies, either by industry or by R&D organizations/ academic institutions/ universities aimed at commercialization of new products and processes;

ii. To jointly support initiatives of other Ministries / Departments aimed at technology development and demonstration, e.g. IMPRINT initiative of Ministry of Human Resource Development and DST, wherein institutions of higher learning are being supported for development and demonstration of technologies.

iii. To support collaborative research between Indian Industry and R&D organizations/ academic institutions/ universities for development and demonstration of lab scale technologies, aimed at commercialization of new products and processes;

3. ONGOING TECHNOLOGY DEVELOPMENT AND DEMONSTRATION PROJECTS DURING 2019-20

3.1 Development and standardization of manufacturing processes for large scale production of valuable secondary metabolites from callus-derived cells of vascular cambial explants of selected woody plant species - M/s Sami Labs Limited, Bangalore

M/s Sami Labs Limited, Bangalore has undertaken to develop and standardize the manufacturing processes for large scale production of valuable secondary metabolites from callus-derived cells of vascular cambial explants of six selected woody plant species and establish a 100 litres suspension culture pilot plant facility. The company is currently manufacturing the targeted secondary metabolites by direct extraction methods and the current project proposes to upscale and optimize the procedure developed at lab level through a new route of continuous perfusion of in vitro cambial tissue cultivation for commercial production of secondary metabolites from cambial explants of six medicinal plants. The new technique is expected to lead to cost reduction, reduction in energy consumption /emissions and would have positive impact on environment by sparing the medicinal plants from destruction. Project team were able to extract the cambium layer, able to grow it in varied solid medium and were able to sub-culture it for further proliferation. They were also able to extract secondary metabolites via solvent extraction method and performed standard analytical test to confirm the metabolite. Since inception of the project, project team were able to report best culture medium / conditions for the initiation of callus from 3 woody plant species.

The project has been recommended for DSIR loan support of Rs.150.00 lakh out of a total project cost of Rs.329.65 lakh. The Project is under progress.

3.2 Next Generation Data Processor Unit (NGDPU)- Rajasthan Electronics & Instruments Limited, Jaipur

M/s Rajasthan Electronics & Instruments Limited, Jaipur manufactures Data Processor Milk Collection Unit (DPMCU), a dedicated unit which receives, processes and transmits data and is used by various milk collection agencies in the dairy sector as one of its product line. The company is looking at new requirement for a scalable and modular product and has undertaken to develop and commercialize Next Generation Data Processor Unit (NGDPU) with a dedicated Single Board Computer based solution with customized hardware & software design having all smart and advanced features at a cost that is lower in comparison to their existing and prospective customers. The NGDPU will have a number of smart features and functionality of performing transaction viz. instant data upload on centralized server, instant calculation for payment etc. Initial prototype has been integrated and tested. NGDPU initial box design is readywith Interface PCB has been designed and tested successfully, interfacing with peripherals like Milk Analyzer, Printer, EWS and DI has been performed successfully. Software has been developed that includes Milk transaction (taking milk FAT and SNF data from Milk Analyzer, weighing data from EWS, slip printing and displaying the data in DI), Shift end summary, dispatch and rate picking.

The project has been recommended for DSIR loan support of Rs. 40.00 lakh out of total project cost of Rs.117.00 lakh. The Project is under progress.

3.3 Development of Controller Release [CR] Formulation of Natural Highly-Purified Human Chorionic Gonadotropin [hCG] – M/s Sanzyme Ltd. Hyderabad & ICT Mumbai

M/s Sanzyme Ltd., Hyderabad in collaboration with Department of Pharmaceutical Sciences & Tech., Institute of Chemical Technology, Mumbai had undertaken a project on "Development of Controlled Release [CR] Formulation of Natural Highly - Purified Human Chorionic Gonadotropin [hCG] under PACE-TDD scheme. 99% pure hCG is used as a surrogate for LH [Lutenising Hormone] for triggering ovulation and maintenance of pregnancy. The role of hCG is not restricted to infertility treatment alone but has wider applications in the field of metabolic disorders such as Diabetes and other clinical conditions where hCG is being used for a process known as angiogenes is in the fields of vascular surgery and CNS surgery. Currently two forms or variants of hCG are available, either as highly purified form or the recombinant version of hCG. Despite recombinant version being available, only a single dosage form is available for clinical use. The project aims to improve compliance and reduce the frequency of injections and make the treatment more affordable and available to masses rather than to people of a certain class alone. The CR- release formulation using nano technology with release rates of either 15 or 30 days will reduce the frequency of injections required in infertility problems, maintenance of pregnancy and controlling metabolic disorders such as Diabetes. Project has demonstrated that HCG loaded microsphere is stable and in an in-vivo animal system HCG serum level is much higher than the marketed formulation. Project is currently looking forward to devise a method to scale up and latter commercial application.

The project has been supported by DSIR with a soft loan of Rs. 52.50 Lakhs to M/s. Sanzyme Ltd., Hyderabad and a grant of Rs. 52.24 lakhs to ICT, Mumbai out of a total project cost of Rs. 159.55 Lakhs. The Project is under progress.

4. COMPLETED TECHNOLOGY DEVELOPMENT AND DEMONSTRATION PROJECTS DURING 2019-20

4.1 MacroalgalBiorefinery for CO2 Sequestration and Production of Biofuel and Value-Added Compounds – M/s AquAgri Processing Pvt. Ltd., New Delhi

M/s AquAgri Processing Pvt. Ltd., New Delhi in collaboration with DBT-ICT Centre for Energy Biosciences, Institute of Chemical Technology (ICT), Mumbai and CSIR-Central Salt & Marine Chemicals Research Institute, Bhavnagar (CSIR-CSMCRI) had undertaken the project to demonstrate the concept of CO_2 sequestration through large scale controlled growth of macroalgal species (Ulva) in closed photo-bioreactors using CO_2 generated by power plants or other industries, and making the technology sustainable through conversion of the grown macroalgal biomass tobioenergy and other value-added products. Globally the dry sea plants are used to manufacture hydrocolloids and these have a wide application infood, cosmetics and toiletry industry. Aqua Sap derived from the fresh living algal plants is a plant nutrient, which contains substantial amounts of micro and macronutrients, naturally occurring Plant Growth Regulators (PGRs) and amino acids. The PGRs such as Auxins, Cytokinins and Gibberellins, accelerate the metabolic function of the plant there by boosting yield and productivity.

The concept of a multi-product macroalgal refinery using modular photo-bioreactors for CO_2 capture and growth of Ulva in vertical glass reactors to demonstrate efficient CO_2 sequestration coupled with downstream processing technologies for biomass deconstruction and separation of value-added products for economic sustainability is an innovative concept.

ICT and CSIR-CSMCRI has developed and demonstrated Ulva cultivation in flat panel and tubular photo-bioreactors (PBRs) made using glass, flexible HDPE and polycarbonate material with various designs. A polycarbonate tubular bio-reactor system gave excellent biomass productivity and thus higher rate of CO_2 sequestration. A 1KL system was erected for improvisation at M/s Aquagri project site with tractable integrated process successfully facilitated sequential extraction of the major value added components such as sap, lipids, protein ulvan and cellulose and company has commissioned a 10KL extraction unit for downstream processing of Ulva biomass at M/s Aquagri project site. Project was successfully completed with a recommendation for M/s AquAgri Processing Pvt. Ltd. to scale it further.

5. TECHNOLOGY DEVELOPMENT PROJECTS UNDER IMPRINT INITIATIVE

IMPacting Research INnovation and Technology (IMPRINT), the first-of-its-kind Pan-IIT and IISc joint initiative, is a Ministry of Human Resource Development (MHRD) and DST initiative to address major engineering challenges that the country must address and champion to enable, empower and embolden the nation for inclusive growth and self-reliance. Department of Scientific and Industrial Research has partnered with MHRD in implementing this program. In order to pursue the mandates of IMPRINT, ten technology domains as grand engineering challenges have been thought of. DSIR is contributing in two sectors, viz, Manufacturing Technology and Water Resources. Five IMPRINT proposals of IITs/IISc/NITs in the two identified sectors for DSIR (Manufacturing Technologies and Water Resources) have been supported. DSIR grant support is matched by MHRD. The details of IMPRINT projects supported under PACE scheme are as follows:

5.1 Development of an innovative process to fabricate ultra-fine grained bimetallic thin sheets for microforming applications - IIT Madras

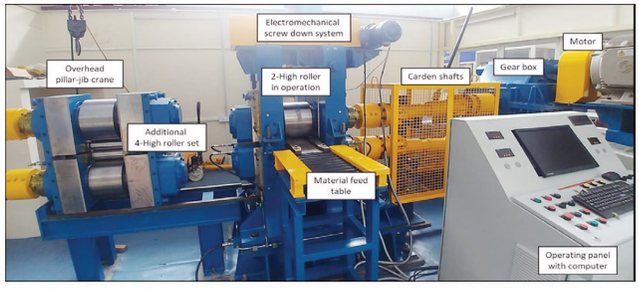
The project aims to develop micro deep drawn components made up of bimetals with ultrafine grained microstructure. Such micro-components have potential application in many industries such as consumer electronics, telecommunication, micro electro-mechanical system (MEMS), aerospace and defence. For this purpose, a novel approach involving combination of cryorolling (CR), warm roll bonding (RB) and asymmetric rolling (AR) have been proposed, aimed to fabricate thin bimetallic sheet, with equiaxed ultra-fine grained (UFG) microstructure. Possible advantages of using such material in microforming are: (i) Improved microformability by engineering desirable texture (ii) Overcoming challenges associated with size effect as observed during micro-manufacturing (iii) Strong interfacial bonding at bimetallic interface (iv) Excellent mechanical strength due to presence of UFG microstructure. There are two major novel ideas involved in this proposal:

Although all the three rolling processes (CR, RB, AR) has been extensively studied in a standalone basis, its only recently, researchers are trying to combine various process to

tailor required properties in sheet metals. In the present work, a novel combination of CR+ warm RB + AR is proposed for the first time to develop UFG bimetallic thin sheets. The thin UFG bimetallic sheets developed by this innovative method are expected to provide favourable texture for microforming, high bond strength between bimetallic interface and improved microformability. Microforming itself is a less explored domain. Although some progress has been made to microform metals and alloy, no attempt has been made by any researchers to obtain bimetallic micro-components of ultrafine grained microstructure using microforming process.

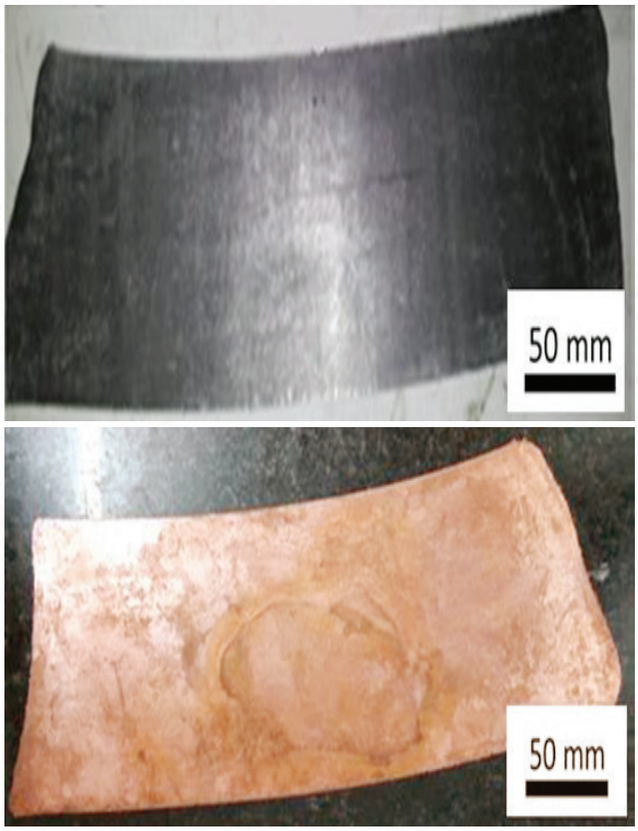
Bhabha Atomic Research Centre is a potential end user of the bimetallic micro components made by the proposed method. The Centre for Design and Manufacture, BARC has highlighted that product developed by this technology will find many purposeful applications in the Centre.

Both Al and Cu were procured, and basic characterization of both Al and Cu were made. An asymmetric rolling and roll bonding equipment was designed at IIT Madras. The custom designed set-up was manufactured by New Field Engineers Pvt. Ltd., Bangalore. The facility was housed in IIT Madras. All the related accessories of this machine were also procured.



Asymmetric Rolling and Roll Bonding Unit housed in IIT Madras

The step-2 is (i) Design of experiments for cryorolling (CR), (ii) Cryorolling of Al and Cu and (iii) Detailed microstructural characterization and mechanical property evaluation of cryorolled Al and Cu. This step is fully complete. The cryorolling experiments were carried out and characterized by mechanical testing (tensile testing) and microstructural characterization using TEM, EBSD and XRD. The objective of cryorolling was to develop ultrafine grained microstructure and high strength in Al and Cu sheets. The ultrafine grained microstructure is desirable for (i) improving micro formability by reducing size effect related issues which are commonly observed during 1 µm AVG. GRAIN SIZE 30 nm microforming and (ii) achieving high strength. After cryorolling (CR), the strength of both materials has increased almost three times. The TEM result showed the proof of formation of ultrafine grained microstructures in both Al and Cu.



Cryorolled Aluminium and Copper sheets.

The following have been achieved under the project :

- A custom designed "Asymmetric Rolling and Roll bonding setup" was successfully developed for fabricating bimetallic UFG sheets. The custom designed setup was fabricated at Newfield Pvt Ltd., Bangalore and housed at IIT Madras.
- Ultrafine grained sheets of Al and Cu were successfully developed via cryorolling. A significant strength enhancement (3 times increment) was found in ultrafine grained Al and Cu sheets as compared to their base counterpart.
- Based on FEM simulation and experimental roll bonding simulation (via plain strain compression testing), the roll bonding of ultrafine grained (cryorolled) Al and Cu are not found to be feasible.
- The process parameters for successful roll bonding were established based on Thermal stability study, FEM simulation and experimental roll bonding simulation via plain strain compression test.
- The actual roll bonding procedures to develop ultrafine grained Al-Cu bimetallic sheets is under process and at the final stage of completion.

The project has been supported by DSIR with a grant of Rs. 83.46 Lakhs out of a total project cost of Rs. 166.92 Lakhs. The Project is under progress.

5.2 Fabrication and evaluation of atomic force microscope probes with detachable and re-usable tips - Indian Institute of Science, Bangalore

The broad applications of atomic force microscope (AFM), from in-line nanometrology and imaging to nano-manipulation, are ultimately tied to the AFM probe. The AFM probe is a consumable part requiring frequent replacement, and its high cost contributes significantly to the running costs of AFM. The probe needs replacement when its tip is damaged even if the rest of it is functional. Here we propose batch fabrication of AFM probes wherein the probe-tip alone is replaced. Since several thousand tips can be fabricated in the same area as a conventional probe, this approach is highly cost-effective and facilitates development of advanced probing systems. The main objectives of the project are i) tip-less AFM cantilevers and detachable AFM tips are fabricated; ii) an AFM cantilever carrying a detachable tip is evaluated by imaging nanomaterials in different modalities and iii) automated detection of tip-wear, tip-replacement and re-use would be demonstrated.

To ensure quality control during nano-fabrication, it is essential to employ in-situ inline inspection and metrology tools. The AFM is the primary tool suited for this requirement since, unlike competing techniques such as the SEM and TEM, the AFM can operate in-situ with sub-nanometer precision and interact with a range of samples. However, every AFM requires frequent replacement of its tip, and the existing replacement techniques suffer from limitations ranging from imprecision, excessive time consumption to high cost that together act as major impediment for industrial use of AFM. The proposed replaceable tips address these issues and possess the following advantages:

1. The cost of replacement a single tip is reduced significantly. The probe is not replaced, and hence its properties need not be recalibrated.
2. Automated in-line inspection with reduced replacement time and increased precision can be achieved
3. Enables employing more sophisticated probes, with integrated sensing and actuation to achieve controlled interaction with 3D nano-scale samples.

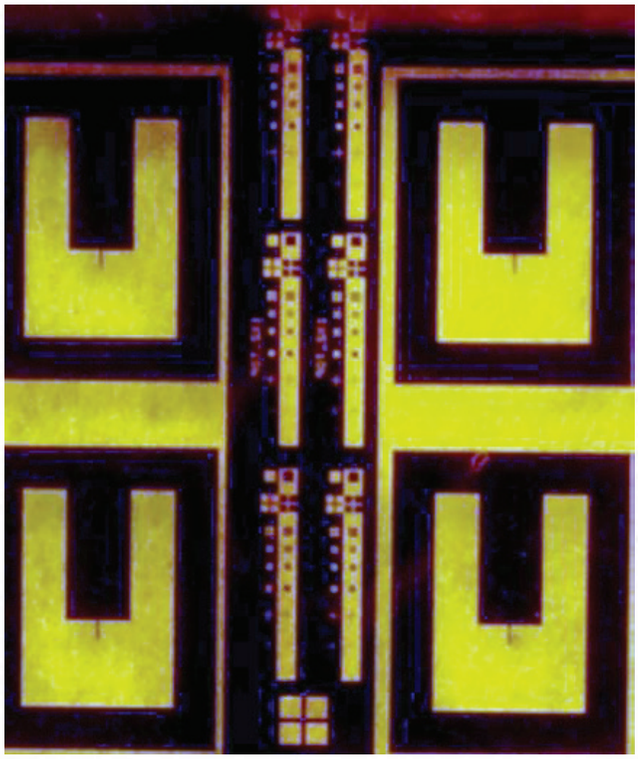
Literature survey was performed in order to develop a suitable recipe to fabricate detachable AFM probes and probes without AFM tips. A recipe was developed for batch fabrication of tip-less AFM probes. Suitable masks were designed and fabricated. Subsequently, batch fabrication of tip-less AFM probes has been successfully completed. The probes were fabricated using Silicon-on-insulator wafers by employing a combination of dry etching and wet etching. AFM tips have been fabricated on a substrate with the help of dry etching techniques. AFM probes with tips have also been successfully fabricated. New masks have been designed and fabricated for AFM cantilevers and the batch fabrication process of AFM probes with tips has begun. Masks have been designed for batch fabrication of detachable tips and the batch fabrication process has been started.

Investigation of an alternate design for the AFM probe has been undertaken, wherein the AFM probes would pick up tips by employing solid materials that can be temporarily melted by application of heat. Two materials were successfully evaluated for this capability, namely, paraffin wax and polycaprolactone (PCL). Centrifugal atomization has been employed to generate wax microspheres. The heating was provided by a green laser diode (wavelength 532nm) of power about 6mW focused on a tip-less micro-cantilever beam.

For evaluation of AFM probes with detachable tips, a Vibration Isolation Table has been purchased for development of an AFM with automatic tip-exchange capability. Automated tip pick-up been experimentally demonstrated. Automated tip detachment has been demonstrated. The tips picked up were evaluated by imaging a standard calibration grating in both contact mode and tapping modes of operation. The evaluation was done in commercial AFM. Further, they were evaluated both in air and in water. In all cases the image obtained was found to be identical to that obtained using a conventional AFM.

The automated tip-exchange module has been successfully demonstrated to replace tips during nano-indentation experiments. An artifact that enables determination of the sharpness of the AFM tip has been employed to detect tip quality and subsequently initiate automatic tip exchange.

The project has been supported by DSIR with a grant of Rs. 18.075 Lakhs out of a total project cost of Rs. 36.15 Lakhs. The Project is under progress.



Mask for fabrication of tip-less AFM probes

5.3 Low-cost Additive Manufacturing Technique for Fabricating Through - Substrate Vias based Three-dimensional Microstructures used in MEMS Applications – IIT Bombay

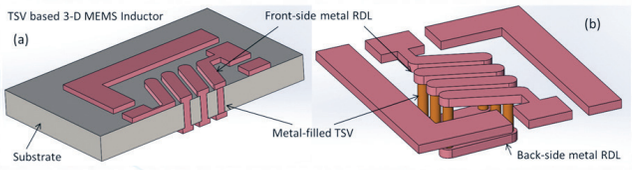
A low-cost additive manufacturing technique

is proposed to fabricate 3D microstructures required in MEMS applications, such as inductors. In the proposed 3D microstructures, top structures will be connected to the bottom structures by vertical metal-filled vias known as through-substrate vias (TSV). A low-cost electrochemical-discharge machining (ECDM) will be used to create holes in borosilicate-glass and silicon substrates. Conductive metals such as copper, nickel, etc., will be deposited in these holes by a novel void-free, "aspect-ratio-dependent electrodeposition" technique. To form top-side and bottom-side coils, layer-by-layer polymer lamination and electrodeposition will be used. Wettability study of polymer mold with the electrolyte will be performed. Electrical characterization and reliability analysis of metal-filled TSV will be carried out. The TSV-based 3D inductors made by the proposed method will incur lower fabrication cost, shorter electrical interconnect path, faster signal speed and reduced foot-print area as compared to conventional inductors.

The key objective of this research project is to develop a low-cost fabrication method to fabricate Through-Substrate Vias, which can be used to make three-dimensional Microstructures required in MEMS Applications, e.g., interposers, and inductors. In order to make through-holes in non-conductive materials such as fused silica, borosilicate glass, electrochemical discharge machining method was developed. The developed process is capable of creating multiple through-holes having an opening size of less than 500 µm in the desired locations. Compared to the conventional laser ablation and plasma etching, this alternative process is relatively low cost and have a high etch rate.

ECDM is a hybrid process that combines the principles of electrochemical machining (ECM) and electro-discharge machining (EDM) while machining electrically non-conductive materials. Although the ECDM has been earlier reported for glass machining, only a single tool electrode has been used so far, which results in a single hole formation at a time. In applications where a large number of through-holes are required, this 'serial' approach not only increases the overall process time but also results in alignment error.

To overcome the existing issues, a novel 'multi-tip array tool' electrode is used, in which the simultaneous machining of multiple holes in a single run is demonstrated to reduce the overall process time. To demonstrate the application of the process, a 3D inductor is planned to be fabricated.



Schematic of the proposed 3D inductor in a non-conductive glass substrate.

Since there is no commercial setup available for the ECDM process, an in-house setup was developed.

This setup had three main parts: computer numerical control (CNC) operated working stage, electrolyte tank with electrodes (tool and counter electrode), and pulse power supply. The working stage (Make: Holmarc Inc., Model: HSMC454) had a linear positioning accuracy of 1 µm in all the three axes, and its movement was controlled by stepper motors. Electrolyte tank was made up of acrylic to prevent corrosion. A commercially available submersible pump was used to maintain the electrolyte flow, to remove debris and excessive heat from the machining zone. Commercial grade (Merck Millipore Ltd.) alkaline electrolytes, i.e., NaOH and KOH, of varying concentrations were used. Silica substrates (optical grade,

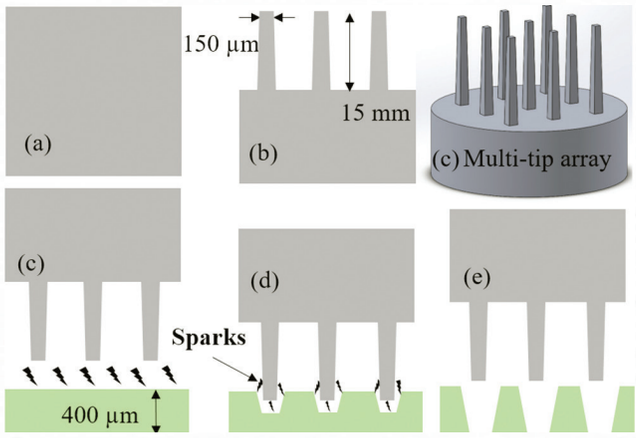
double side polished, the surface roughness R_a<1.2 nm) were obtained from Siegert Wafer GmbH. Silica substrate having dimension 20×25×0.4 mm^3 was used as a work-piece.

The multi-tip array tool electrode was made up of stainless steel by using wire-EDM. A stainless steel circular ring was used instead of commonly used plates as the counter electrode. A circular ring was chosen as counter-electrode to maintain the same interelectrode gap, ensuring the formation of a constant electric field, which resulted in uniform material removal in all the through-holes. A high voltage (200 V) and high current (20 A) three-phase pulsed direct current power supply (Make: Ionics power solutions limited, Model: DC pulsed 200V 20A) was chosen to meet the demanding power requirement of multi-tip array tools during ECDM. To study the effect of frequency and duty cycle combinations on the resultant through-hole arrays, pulse frequency was varied from 500 Hz to 100 kHz, while the duty cycle was varied from 50% to 90%. Digital storage oscilloscope (Make: Gwinstek Ltd. Model: GDS1104B) was used to monitor the voltage and current signals during the machining process.

Optical image showing in-house developed 3-axis ECDM experimental set-up

Traditionally, the through-holes are machined by using a single tip tool integrated with CNC, which create a single through-hole at a time. However, this approach is time-consuming and has several limitations if multiple holes are required. In order to make the process cost-effective, a multi-tip array tool is proposed in this work to get precise array holes with uniform machining characteristics at the pre-designed locations in one go.

In the multi-tip array tool, the geometrical parameters such as tool tip size, pitch, and length become the dominant parameters affecting the entire machining process. Being a parallel process, it would create the entire through-holes array precisely at the tip locations at the same time eliminating the misalignment issue. The wire-edm process was chosen as a faster way to fabricate different arrays of tool electrodes. The only limitation of multi-tip array tools formed by the wire-EDM process is that tool electrodes having circular cross-section cannot be fabricated. Thus, tool arrays having square/ rectangular cross-section were fabricated.



Schematic showing multi-tip array (33□) tool electrode and the machined through-holes by ECDM, (a) Cylindrical block, (b) Formation of tool electrode (c) beginning of ECDM process, (d) during the ECDM process, (e) Through-holes formed in a silica substrate.

Any electrically conductive material with good mechanical strength, such as tungsten, tungsten carbide (WC), copper, brass, etc., can be used as tool material; however, stainless steel was chosen due to its lower cost, good electrical conductivity, relatively higher melting point, and good wear resistance.

The successful execution of this project will result in the knowledge addition in the area

of micromachining and manufacturing of MEMS microstructures. There will be a better understanding about the role of ECDM in MEMS applications.

Following are the expected outcomes of this project:

a) Process outcome:

- Electrochemical-discharge micromachining process for hard-to-machine-materials such as borosilicate glass and silica
- Optimized process parameters to create multiple Through-holes formation
- ECDM based Micromilling process
- Optimized electrodeposition parameters for void-free metal deposition

b) Prototype outcome:

Successful application of the proposed methodology will be demonstrated by fabricating following two prototypes:

- The in-house developed electrochemical discharge machining setup

Through-substrate vias based 3D interconnects.

The project has been supported by DSIR with a grant of Rs. 72.69 Lakhs out of a total project cost of Rs. 145.38 Lakhs. The Project is under progress.

5.4 Designing and fabrication of an aerodynamic lens for nanoparticles of variable size – IIT Hyderabad

The main objective of the project is to design and fabricate an instrument (aerodynamic lens) to tightly collimate beams of nano/microparticles and fabricate a high resolution mass and imaging spectrometer for real-time analysis of the chemical composition of aerosols with designed mass resolutions of $m/\Delta m$ of ~ 700, upto a mass of 800 amu., with fast response rates upto 10 Hz or better. The project also aims to develop a large through put method to fabricate microstructures with resolutions of better than 0.5 mm using the aerodynamic lens system. The robust and compact instrument will be designed for deployment on mobile systems, terrestrial and airborne. The industry partner for the project is H. Fillunger and Co. Pvt. Ltd., having extensive experience in vacuum systems, plasma deposition systems etc. and will collaborate in the fabrication of the lens system. The project also proposes to develop a methodology for deposition of thin and uniform layers on surfaces for additive fabrication of microstructures using the lens system.

Under the project, design and fabrication of a low cost, compact, high resolution mass spectrometer is carried out for the first time in India. The assembly of the spectrometer has been completed. First stage of the aerodynamic lens has been tested and more lenses are being added and testing is under progress. The electronic system of the Spectrometer is under testing and the characterization of the Spectrometer would be under taken after integration of the electronics. M/s Fourvac Technologies is participating in fabrication of the spectrometer and a MoU has been signed with M/s Gray Scientific Laboratories (GSL) for commercialization.

Three versions of aerodynamic lenses have been designed and developed. All the three versions for nano droplets have been used. Each component has been designed and fabricated. A high resolution mass spectrometer has been assembled in house. The data acquisition system has been developed.

The project has been supported by DSIR with a grant of Rs. 25.60 Lakhs out of a total

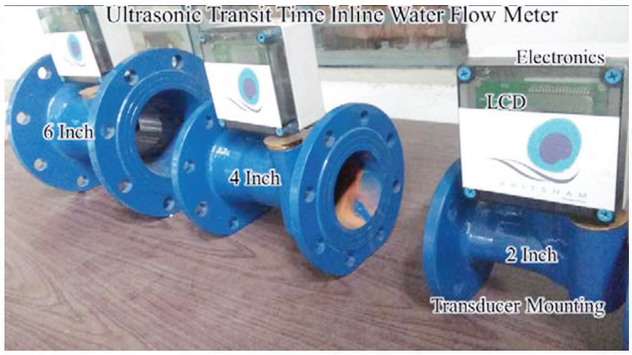
project cost of Rs. 51.20 Lakhs. The Project is under progress.

5.5 Continuous discharge measurement in small open channels by using ultrasonic tomography – IIT Kanpur

The project aims to develop a continuous real-time discharge monitoring system for small open channels (width 1 to 50 m) by tomographic reconstruction of ultrasonic transit-time measurements. The system will be designed to be accurate, cost-effective, field deployable, easy to calibrate and capable of unattended real-time data transmission. The developed system will be tested under laboratory and field conditions and determine its range of measurement errors under different channel geometry and flow conditions. The developed system will be a user-friendly commercial product.

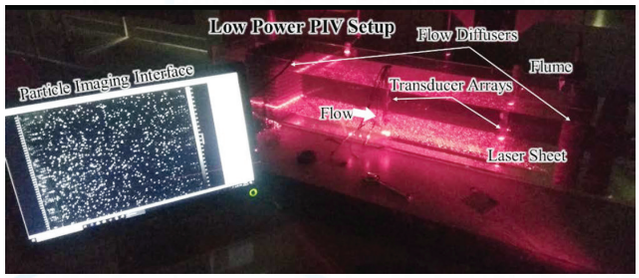
Small rivers and channels dominate Indian rural and urban landscape. Monitoring discharge in them has direct utility in managing water-resource distribution issues prevalent in India today. The infrastructure for discharge data collection in small rivers is either absent or greatly limited by manual methods that use current-meters, floats, and gauges. The continuous discharge monitoring instruments that are readily available in the market like Acoustic Doppler Current Profiler (ADCP) and Laser Doppler Anemometer (LDA) are too expensive for multiple deployments. The motivation is to fill this gap by developing a discharge measurement system that is inexpensive, easy to deploy, operate and maintain, and requires minimum calibration. The scope of this project is to develop and test an ultrasonic transit-time discharge measurement system for small channels (width 1 to 50 m). The configuration of the ultrasonic transducers will be designed to get a cost effective flowmeter with measurement error of less than 5%.

Automated calibration setups (gravity mass method) for high (up to 40 LPS) and low (up to 0.55 LPS) flows have been designed and successfully fabricated. Ultrasonic transducers for developing flowmeters are identified and tested with commercially available and in-house designed electronic circuitry. An in-house inline ultrasonic flowmeters (UFM) for pipes has been developed. The flow rates estimated by the developed UFM are found to be in good agreement with actual flow rates. The results suggest that ADC circuit boards are more suitable for UFMs compared to more commonly used TDC circuit boards. The developed UFM got ISO 4185 certification.

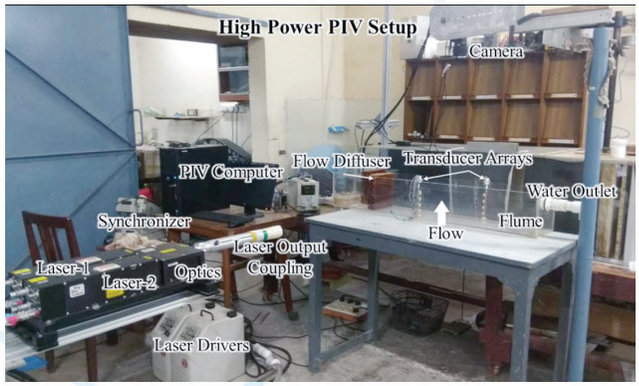


UFM for 2, 4, and 6-inch pipes.

The UFM developed for pipe has been successfully deployed in field for continuous monitoring. An ultrasonic transit time open channel flowmeter was built using the selected pair of transducers and developed circuit boards. Discharge measured in a laboratory flume using two pairs of transducers. Developed a flow meter system with four pairs of sensors and made a real time velocity plotter for data acquisition. A gravity mass method calibration system was set up to validate the discharge and setup Particle Image Velocimetry (PIV) to validate the velocity profile from the developed system.

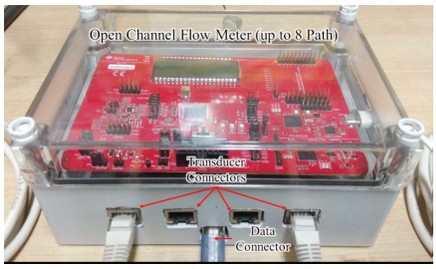


Small power PIV for both vertical and horizontal velocity profile



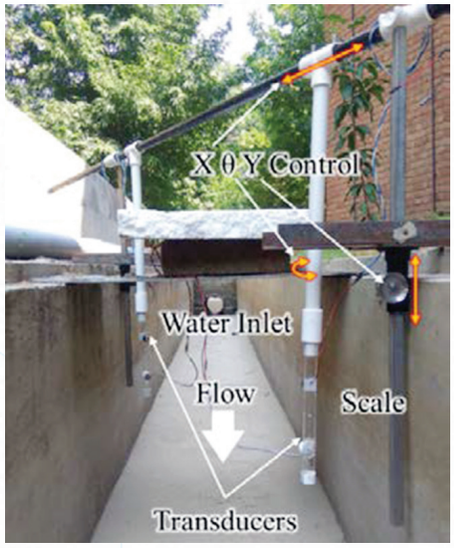
High power PIV for horizontal velocity profile

The computational fluid dynamics (CFD) analysis was conducted for theoretical profile and discharge of the laboratory flume and the developed system. The velocity profile of laboratory flume was captured using the developed open channel system was found to be in good agreement with the gravity mass method, CFD and PIV profiles. An open channel flow meter was developed for up to eight paths. It has been successfully tested on a laboratory flume for four paths.



Open channel flow meter with configuration up to 8 paths

The developed open channel system with single path configuration tested in 0.5 m and 2 m channels.



Open channel (0.5 m width) with transducer assembly for testing

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