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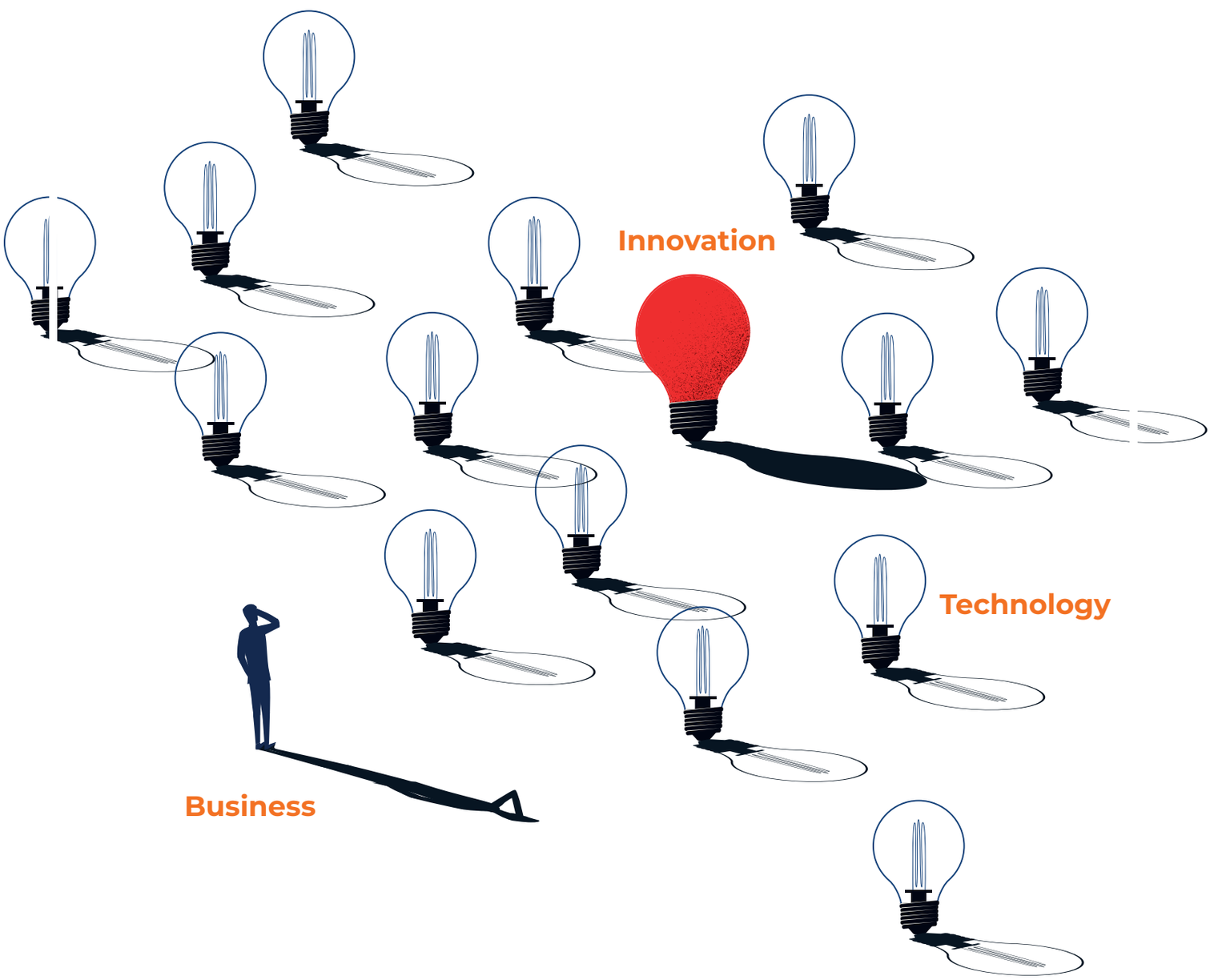

INSIDE

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01

Message

A Fad or Reality...

Role of a University Technology Transfer Organisation in 200 words'

A university technology transfer organization (TTO) plays a critical role in bridging the gap between academia and industry. The primary function of a TTO is to facilitate the commercialization of innovative ideas and research generated by faculty members and students. This is achieved by identifying and protecting intellectual property, negotiating licenses and contracts, and fostering collaborations with industry partners.

One of the primary responsibilities of a TTO is to protect the intellectual property generated by researchers at the university. This includes patents, trademarks, copyrights, and trade secrets. By protecting these assets, a TTO ensures that the university's innovations are not stolen or misused by others. Once the intellectual property has been protected, the TTO can then license it to third-party companies, who can then develop and commercialize the technology.

In addition to protecting intellectual property, a TTO also plays a crucial role in negotiating contracts and licenses. This includes negotiating agreements with industry partners, such as licensing agreements, research collaborations, and sponsored research agreements. These agreements help to establish a mutually beneficial relationship between the university and industry, allowing for the development and commercialization of new technologies.

Finally, a TTO fosters collaboration between the university and industry partners. By bringing together academic researchers and industry experts, TTOs can facilitate the development of new technologies and solutions to real-world problems. This collaboration can lead to new products, services, and innovations that can benefit society as a whole.

In conclusion, a university technology transfer organization plays a critical role in commercializing the innovative ideas and research generated by faculty members and students. By protecting intellectual property, negotiating contracts and licenses, and fostering collaboration with industry partners, TTOs help to bridge the gap between academia and industry, leading to the development of new technologies and solutions that can benefit society.

The above italicised essay on the role of a University technology transfer office has been generated by ChatGPT. FITT relates to this piece to an extent. It may be an acceptable basic version from the machine, which if it develops advanced writeups (as in other contexts), that would reflect not just the strength and use of the tool but also the kind of manpower redundancies it may trigger.

Welcome or unwelcome the disruptor but best wishes for the future.

Anil Wali

RESEARCH TALE 02

Flexible Self-powered Biomechanical Sensing: Towards High-efficiency Wearable Devices

Prof. Dhiman Mallick

Department of Electrical Engineering, IIT Delhi

The rapid progress in information and communication technologies has caused a proliferation of low-power microelectronics in people's daily lives. Artificial intelligence, Internet of Things (IoT), and Big Data are some of the technologies pioneering the development of modern society in this era of Industry 4.0 revolution. A smart world is envisioned to be scattered with physical sensors that collect and transmit data about almost anything, enabling intelligent decision-making. A large number of such distributed sensors comprise wireless sensor networks (WSNs), which are essential for several smart applications (Fig. 1). The requirement of conventional wired and battery-powered sources is a major bottleneck limiting their progress. Therefore, it is natural to turn over to batteryless technologies involving harvesting energy from ambient sources such as mechanical vibrations and motions. There has been a rapid growth in research within the fields of different energy harvesting methods over the last few decades for scavenging solar, thermoelectric, radio-frequency (RF), and mechanical energy. The root of the such prompt initiative lies in the current technological advancements blended with socio-economic and environmental requirements.

Mechanical vibrational energy is ubiquitous and abundantly generated in high density in almost all the activities around us and even our bodies. Biomechanical energy is an untapped energy pool that can create an ample amount of usable electrical power, which otherwise gets wasted and remains unutilized. Since a vast majority of the new-generation low-power devices are wearables, it makes sense to power them from the human body itself. This has paved the path for biomechanical energy harvesting (Fig. 2) to harvest energy from the motions of the human body. The biomechanical harvesting technologies need to be small, flexible, and biocompatible. While the rapid development of silicon-based microelectromechanical systems (MEMS) [1] has assisted in the miniaturization of these technologies, the limited flexibility of such devices is still a critical issue. Since most such devices need to be attached to the body, their Young's modulus of elasticity should match that of the human body. However, there is a wide gap between the modulus of elasticity of human muscle and skin and that of silicon. To overcome this issue, the focus has shifted towards flexible substrates [2] like Polyethylene Terephthalate that can be easily worn or stuck over the human body. Flexible and wearable biomechanical harvesters have become hot research topics as powering solutions for IoT applications and smart wearables.

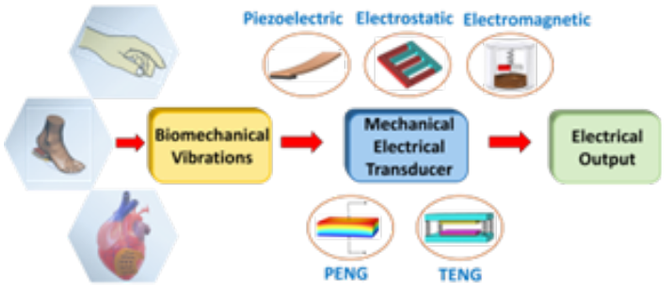
Figure 1: Primary sensing applications associated with Internet of Things (IoT)

Piezoelectric and Triboelectric energy harvesting mechanisms are the most efficient and widely employed strategies to convert low-frequency mechanical vibrations into electrical current. The affordable cost, vast choice of biocompatible materials, and high energy conversion efficiency make these devices suitable for biomechanical harvesting and sensing applications. Both harvesting technologies perform the same operation, albeit with different operating mechanisms. They are frequently coupled together to complement each other in the form of hybrid piezoelectric-triboelectric devices and often incorporate other transduction strategies, like electromagnetic and pyroelectric mechanisms, to enhance the transduction abilities.

Research is continuously being pursued on novel materials, structures, and technologies to develop hybrid biomechanical harvesters. Developing and integrating a simple, large-area deposition process for high-performance and compliant piezoelectric-triboelectric thin films is needed to develop an efficient transducer. Flexible, polymer-based materials provide an alternative to stiff thin films. They have attracted immense research interest in recent years due to their high transduction efficiency and large dynamic range. Polymer nanocomposites capitalize on the mechanical flexibility of polymers and the piezoelectric effect of added nanostructures. The addition of piezoelectric/ferroelectric nano powder within a non-piezoelectric polymer base provides a new direction for the development of flexible piezoelectric materials. We have developed [3], [4] an optimized process flow for Zinc Oxide (ZnO)/SU-8 and Barium Titanate (BTO)/SU-8-based nanocomposite films for biomechanical energy harvesting applications (Fig. 3). 15% ZnO/SU-8 and 20% BTO/SU-8 weight ratio of nanocomposite thin films shows the best output results and UV transmittance characteristics. The flexible nanogenerator fabricated using the optimized nanocomposites generates an open circuit voltage of 570 mV (ZnO/SU-8) and 780 mV (BTO/SU-8) using regular finger pressing.

Conventionally, the biomechanical harvesters based on piezoelectric and triboelectric mechanisms generate an alternating current between the electrodes. A bi-directional current cannot be used to power devices or charge loads directly, making the use of a rectifier indispensable. Incorporating a rectifier leads to additional power consumption, reduces efficiency, and prevents device miniaturization. Researchers have developed several strategies for generating a direct current triboelectric output (DC-TEG) without the use of a rectifier. These devices either involve electrostatic breakdown, dynamic Schottky junction, or mechanical switching. Establishing an electrostatic breakdown is not straightforward and increases the possibility of unintentional hazards. A dynamic Schottky junction between metal and semiconductor produces

Figure 2: Architecture of a Biomechanical Energy Harvesting System



a low amplitude direct current and has limited scalability. Mechanical switching involves sliding between TEG layers and metal contacts which creates excessive friction, leading to wear and tear and low durability, detrimental to the device's lifetime and performance. The most straightforward way to achieve a direct current output is to block the flow of reverse current through the electrodes during the separation cycle of TEG cycles. Moreover, this reverse current has a small amplitude and is often eliminated during rectification due to the high forward voltage drop of the rectifying diodes/switches.

Our group presented an innovative strategy [5] for generating a direct current output that eliminates the reverse current but does not affect the forward current path of the TEGs. This is done using a novel contact-break switching method involving a pair of TEG electrodes and an additional switching electrode (Fig. 4). The developed direct current generator can serve as a direct powering solution without requiring an interfacing rectifier circuit. It harnesses biomechanical energy from activities like hand tapping and foot tapping. Due to its compact and cushiony design, this device is also suitable for biomechanical harvesting and sensing applications. The corresponding DC output voltages rises as the tapping intensity (amplitude and frequency) increases. During any locomotion activity, the entire body's weight falls on the forefoot. The human body exerts maximum pressure on this region, which can generate significant electrical output using a TEG device. The device is stuck beneath a specially designed sole that can be comfortably placed in any footwear. Our device uses a sponge, which is also used in the insole of footwear as a popular method of reducing foot fatigue. Therefore, the use of a sponge in this device allows the generation of direct current while providing an additional comfort to the person wearing it.

Wearable or flexible sensors have emerged as a rapidly expanding research field for various applications, including human-activity monitoring, human-machine interface, physiological disorder diagnosis, etc., to improve the quality of life. Wearable sensors can be directly affixed to the human body and worn as accessories to precisely identify the body's motion and dynamics. Combined with data analytic algorithms, these wearable devices can provide valuable data-based insights into biomechanics to quantify health parameters for biomedical monitoring, diagnosis, and several other critical applications. Primarily, wearable sensors are developed into clinical and commercial devices. Commercial wearables provide information to consumers regarding primary biomarkers such as heart rate, blood glucose, and activity tracking. Clinical wearables have been developed for healthcare professionals to monitor and analyze walking patterns and body posture and perform gait assessment tasks in different scenarios. In the modern world, gait and postural deformities are common due to an improper lifestyle. Monitoring and detecting these deformities become essential before they lead to permanent body impairment or cause a grave injury. Hindfoot deformities that correlate to the plantar pressure distribution are the prime reason for knee weakness and joint pains. There have been several investigations on plantar pressure mapping of the foot, and several pressure sensors have been developed in the recent past to map hind foot pressure. The majority of devices that have been described use a sensor with one of the following transduction mechanisms. Combining different transduction mechanisms in a sensor device allows a precise pressure measurement. This has motivated us to switch to a hybrid device involving multiple types of transducers. We have developed a novel, individually addressable 6×6 matrix-mapped pressure sensor for diagnosing foot deformities based on photopatternable BTO/SU-8 nanocomposites with dual piezoelectric/triboelectric transduction (Fig. 5). The designed sensor has a high resolution, mapping 36 pressure

Figure 3: a) Fabrication process flow of the nanocomposite-based hybrid generators. Three operating modes for b) 15% ZnO/SU-8 and c) 20% BTO/SU-8 based hybrid energy harvesters.

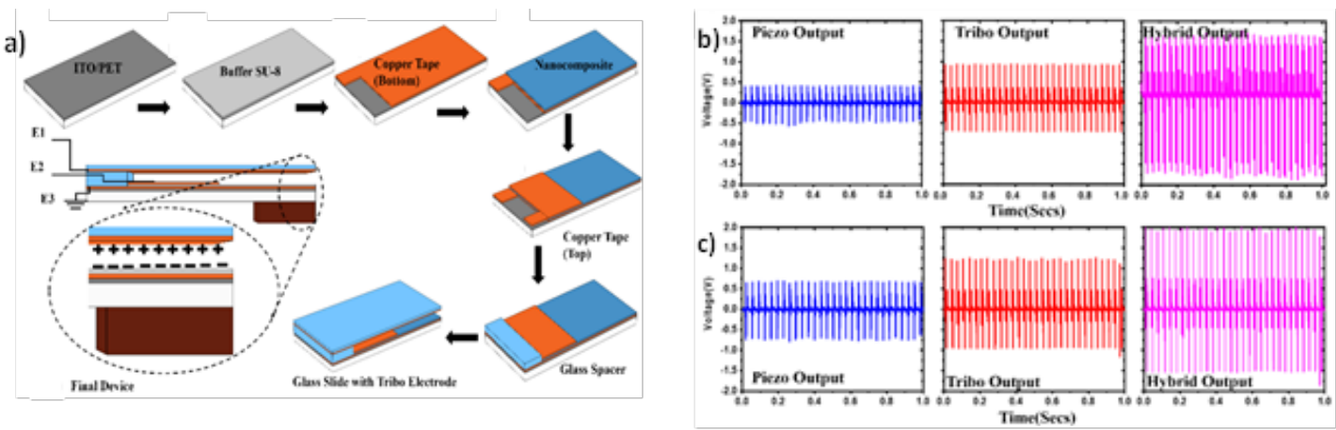
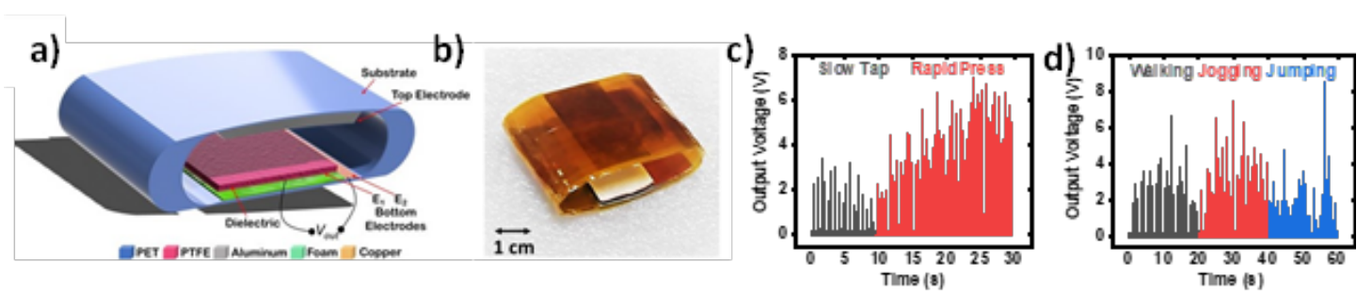


Figure 4: a) Schematic and b) fabricated prototype of a developed Direct Current Triboelectric Generator. A direct current device output under mechanical stimulus of c) Hand tapping and d) Feet pressing.

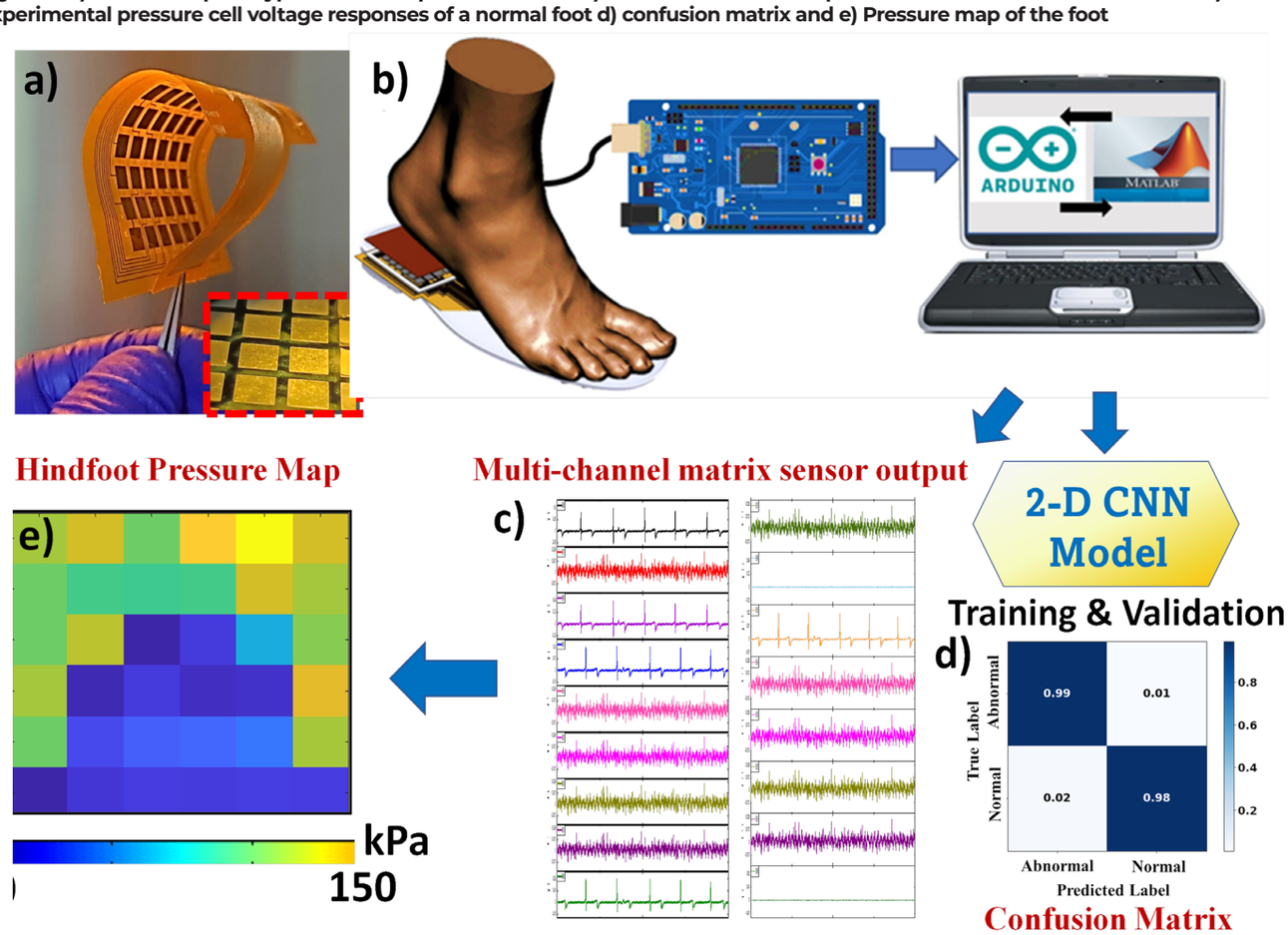


points uniquely and evaluating the generated pattern, correlating with the type of deformity. The sensitivity of the developed sensor is 34mV/kPa for 0-5kPa and 2.7mV/kPa for 5- 170kPa. We also used a convolution neural network (CNN-2D) to detect hind foot abnormalities with 0.1% model loss, 98% accuracy, 2% cross-feature differentiation, 98.01 % precision, 2% false positivity, and a 0.98 F1 score.

We are now in the process of integrating our wearable devices with interface and power management circuits to improve the charging abilities of the developed devices. We believe that the integrated hybrid soft haptic wearables have multiple possible avenues for powering and sensing multiple parameters from a single device.

The field of biomechanical transducers is still in its initial nascent state, considering it has emerged in the last decade. They are becoming increasingly popular with every passing year. With the continuous improvement in the structure and discovery of novel materials, and strategies, their performance will achieve new breakthroughs. Our research group will continue to develop new ideas for harnessing biomechanical energy for wide array of harvesting and sensing applications. We hope that in the coming years, the technologies that we are developing will be translated into commercial devices and help improve the quality of life of countless individuals.

Figure 5: a) Fabricated prototype of a matrix pressure sensor b) Illustration of Data acquisition and circuit interface with GUI c) Experimental pressure cell voltage responses of a normal foot d) confusion matrix and e) Pressure map of the foot



Acknowledgment

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Faculty Profile

03

Prof. Anil Verma

Sustainable Environergy Research Lab (SERL)
Department of Chemical Engineering, IIT Delhi

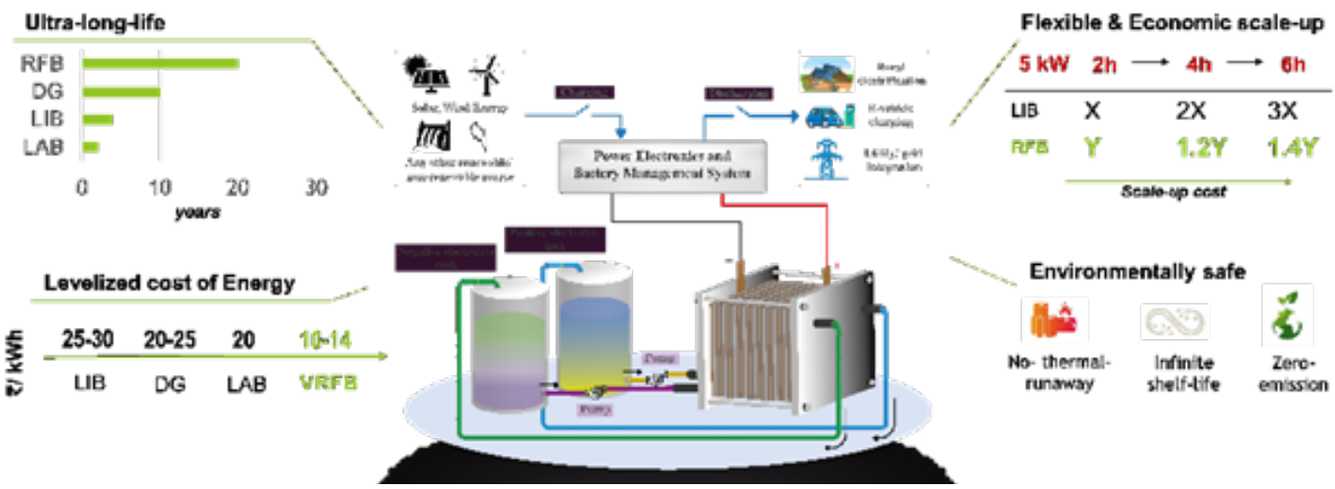
Dr. Anil Verma is currently serving as a Professor in the Department of Chemical Engineering at IIT Delhi. He completed his B.Tech. and M.Tech. (Silver Medal) from H.B.T.I. Kanpur. Before pursuing Ph.D. from IIT Delhi, he worked in Asian Paints (I) limited at R&D Centre in Mumbai. After completing Ph.D., he joined IIT Guwahati as a Senior Lecturer and worked there as Assistant Professor and Associate Professor till Aug. 2014. Later, he moved to IIT Delhi in Aug. 2014 as Associate Professor and became Professor of Chemical Engineering in 2018.

Amongst the various administrative responsibilities, presently Prof. Verma is the Head, Continuing Education Programme at IIT Delhi. He also heads the DST-IITD Centre on Energy Storage Platform on Batteries (ESPOB), which aims at developing next generation materials for electrochemical energy storage technologies, create human resource pool through training, network with industry and institutions and disseminate knowledge through short courses and workshops to industry and academia. Further, Prof. Verma is Editor-in-Chief of Indian Chemical Engineer (ICE), Journal of IIChE, published by Taylor & Francis. He worked as visiting Professor in Washington University in St. Louis, USA and as Fellow in Newcastle University upon Tyne, UK.

Prof. Verma is an active researcher in the field of Electrochemical Engineering and his work focuses on Batteries, Fuel Cells (PEMFC, DAFC, AFC, MFC), and CO_2 Electrochemical Reduction to value added products. Among different kinds of batteries, his focus is on Redox Flow Battery and Aluminum-ion Battery. His work includes from material to components to cells to battery and full system development along with power electronics. Prof. Verma has published over 100 research articles and monographs, filed 8 patents and supervised 13 doctoral students. Currently, 8 research scholars and 3 research associates are pursuing their research under his supervision. He has been a recipient of various awards and recognitions throughout his career such as Associate Editor-ICE, Amar Dye-Chem award for excellence in research and development, UKIERI Research Fellowship Award, etc. His research and development activity spans more than 25 sponsored R&D projects/consultancies. He has completed sponsored research projects by various funding agencies including DST; MHRD; SERB; ISRO; CRERE Saudi Arabia; Cenovus, Canada; LG (I) Limited; Saturnose, USA etc.

The team led by Prof. Anil Verma at Sustainable Enviroenergy Research Laboratory (SERL), Department of Chemical Engineering, consists of members from multi-disciplinary fields, working in unison to develop Vanadium Redox Flow Battery (VRFB) to a product-level technology. Prof. Verma initiated R&D on VRFB in 2016 focusing on lab-scale fundamental studies. While gaining significant know-how around the technology, the team filed its first patent in 2017. Further, the first working prototype of 6W power rating was developed and demonstrated in IIT Delhi's Open House – 2019. A year after that, they developed a second scaled-up prototype of 0.5 kW which was also used to power the charging kiosk facility installed at Wind-T, IIT Delhi in January 2021. Based on the on-site data of through-

Figure 1. Overview of the Vanadium Redox Flow Battery

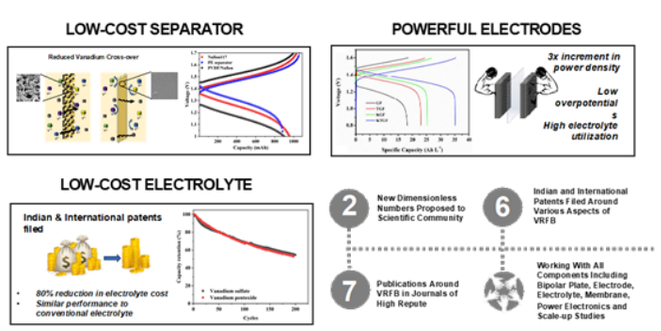


the-field installation, the team has been working on a new VRFB stack design (70% more compact and easy maintenance) which is the basis for development of 2 kW and 5 kW VRFB setups being developed at SERL. This technology has been demonstrated at various exhibition events such as NITI-Aayog's AIM-PRIME event 2022, IIT R&D Fair 2022 and IIT Delhi's Industry Day 2022 (Fig. 2). In most of the fairs/exhibitions, the team has received various awards.

Prof. Verma and his team has tried to cover every aspect of the VRFB technology including the material aspect (electrolyte, electrode, bipolar plates, membrane), the scale-up aspect (industrial design, containerization, maintenance techniques) as well as the development of dedicated power electronic (battery management system, IoT-enabled data acquisition, sensors for battery health monitoring). The group's translational work has generated 6 IP around the VRFB technology (international and Indian patents filed) in the scope of low-cost electrolyte using vanadium pentoxide (80% reduction in electrolyte cost), powerful electrodes (3 times more power density enabling compact stack size) and VRFB health monitoring system (Fig. 3). Moreover, they have published 7 high impact research articles in international journals including Chemical Engineering Journal, Journal of Energy Storage, Energy & Fuels, Environmental Science & Pollution Research, Materials Chemistry & Physics, etc.

Figure 2. Journey of SERL through the years

Figure 3. Scientific contribution from SERL

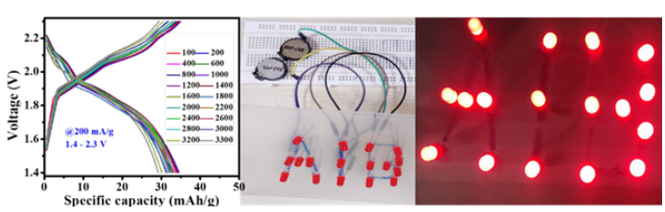


The team has won various awards including funding under DST's NICA 2020 (National Innovation Challenge Awards) for rural electrification, FITT-FIRE Award 2021 for developing VRFB based charging station of e-Vehicles in the IIT Delhi campus, etc. The team is working on a 2 kW to 5 kW VRFB setup to be installed at Transport Unit, IIT Delhi for providing a charging facility for the e-vehicles plying in the campus as part of the FITT-FIRE Award (Fig. 4). Prof. Verma along with his colleagues are also actively taking part for the training and dissemination of the knowledge. They are involved in 6-month online continuing education programme on Advanced Programme on Electric Vehicle Technology primarily for the working professionals.

Figure 4. VRFB based Charging Station (under development)

Prof. Verma is putting efforts to develop Al-ion battery. Based on the highly abundant element aluminum, the ultrafast rechargeable Al-ion batteries are envisioned to be low-cost, safe and environmentally friendly and more importantly it is an effort to see the self-reliant in battery technology. The team has established some preliminary know-how around the coin-cells (Fig. 5) and working towards pouch-cell prototypes.

Figure 5. Aluminum-ion Cells



Prof. Santosh Kapuria

Department of Applied Mechanics
Indian Institute of Technology Delhi

BIOGRAPHY:

Dr. Santosh Kapuria, currently the R. C. Malhotra Chair Professor in the Department of Applied Mechanics at IIT Delhi, was born in 1968 at Nabadwip, a historic mufassil town situated on the banks of Bhagirathi River in West Bengal. He possesses a consistently brilliant academic record, securing 11th rank in the state of West Bengal in the Higher Secondary Examination among nearly 300,000 students, for which the Chief Minister of the State felicitated him. He received his B.E. degree in Civil Engineering from Jadavpur University in 1989, where he topped the examination each semester and was awarded the University Medal. After scoring 99.96 percentile in the national level Graduate Aptitude Test in Engg, Kapuria completed his M.E. in Structural Engg in 1991 from the Indian Institute of Science. He received Prof. N. S. Govinda Rao Medal for securing the first rank among all M.E. programs of Civil Engg. Kapuria completed his Ph.D. from IIT Delhi in 1997 in two years and nine months, publishing 17 papers in top journals from the thesis.

Prof. Kapuria began his professional career in Engineers India Limited (EIL), New Delhi, a premier engineering consultancy organization in Asia. There he gained a rich experience of eleven years from 1991 to 2002 in advanced engineering and industrial R&D. He earned the distinction of being the only engineer in EIL to have received the highest grade in the Annual Appraisal for eleven consecutive years. In Sept. 2002, he joined the Indian Institute of Technology Delhi as an Associate Professor in the Department of Applied Mechanics. He became a full Professor in November 2006 and was awarded the higher academic grade (HAG) in July 2013. He held the Rajat Gupta Chair from 2011 to 2015 and currently holds the R. C. Malhotra Chair. Prof. Kapuria served as Director of CSIR-Structural Engineering Research Centre, Chennai, a prestigious National Laboratory under the Ministry of Science and Technology, from Dec. 2015 to Dec. 2020. He was given the additional charges as Director (Additional Charge) of CSIR-Central Leather Research Institute for seven months in 2019 and Theme Director for Civil Infrastructure and Engineering Theme in CSIR from September 201 till the end of his tenure at CSIR. Prof. Kapuria thus possesses an extraordinary blend of experience in the industry, academia, and R&D institutions.

Dr. Kapuria has published over 150 papers in top journals and over 95 in conferences with over 4150 citations and an h-index of 36 (GS). He has guided 14 Ph.D. theses and handled 14 sponsored R&D projects and 12 consultancy projects with a total outlay of Rs. 560.8 million. His high-quality research has earned him national and international recognition. He is listed among the top 0.6% in the World Ranking of top 2% Scientists published by Stanford University. He has been a Humboldt Research Fellow at Technische Universität Darmstadt and a Fulbright Senior Research Fellow at Stanford University. He is only the second and the youngest civil engineer in India to become a Fellow of the four national academies, namely, the Indian National Academy of Engineering, the Indian National Science Academy, the Indian Academy of Sciences, and the National Academy of Sciences, India. He has served as a member of the Sectional Committees for Fellows' election for all four academies. He is also the first structural engineer to receive the prestigious J. C. Bose National Fellowship from DST in 2018.

Prof. Kapuria is an Associate Editor of the Journal of Thermal Stresses and was the guest editor of ACTA MECHANICA for a special issue on the mechanics of functional materials and structures. He has delivered several plenary, keynote, and invited lectures at national and international conferences and universities. He has served several national and international committees and professional bodies, including the Program Advisory Committees of SERB (DST), Expert Committee on Engineering Sciences of FIST Program of DST, Senate of Academy of Scientific and Industrial Research (AcSIR), CSIR-Engineering Sciences Research Committee, Engineering and Technology Subject Committee for DST-INSPIRE faculty awards, Infrastructure and Informatics Committee of INSA, Steering Committee of INAE, Advisory Committee for the Shanti Swarup Bhatnagar Prize, CII National Higher Education Committee, International Cooperation Advisory Committee of CSIR, Research Councils of CSIR-CBRI, CRRI, CMERI, CIMFR, and NAL, Management Councils of CSIR-CLRI, CMERI, and CBRI, Board of Governors of Engineering Council of India, Board of Governors of Construction Industry Development Council, and General Assembly of International Union of Theoretical & Applied Mechanics. He is one of the founding members of the international conference series, Asian Conference on Mechanics of Functional Materials and Structures (ACMFMS), which began in Japan in 2008. Later, he served as the General Chair of the third ACMFMS held in New Delhi in Dec. 2012. He was the Chairman of the Tenth Structural Engineering Convention, Chennai. He also served as a member of the International Organizing Committee for the biennial International Workshops on Structural Health Monitoring held biennially at Stanford University since 2013. The Indian Association for Structural Engineering elected him its President in 2019. He was appointed as Chairman of the INSA National Committee for the International Union of Theoretical & Applied Mechanics in 2021.

CONTRIBUTIONS:

Prof. Kapuria is a leading researcher in smart (multifunctional) composite structures. Specifically, his work pertains to laminated structures made of advanced composites, sandwich, and functionally graded materials integrated with distributed piezoelectric/SMA actuators and sensors. Such materials are used to achieve control of unwanted vibrations, shape control, and damage detection in inaccessible structures. Because of the application to micro-devices as well as to large structures, such as the new generation of passenger aircraft and ships, this work has been followed

by many researchers. The laminates made of these advanced materials are characterized by their high degree of anisotropy and inhomogeneity, unlike the traditional isotropic and homogeneous metals. In addition, the electromechanical coupling with smart piezoelectric materials makes their modeling even more challenging. A full-scale three-dimensional (3D) simulation of such structures is computationally too involved and intractable for functional structures. Hence, accurate but computationally efficient two-dimensional (2D) theories are essential for their analysis and design. Prof. Kapuria has made seminal contributions to achieving this goal, for which he is known internationally. His research uniquely encompasses theoretical, computational, and experimental mechanics and their applications in cutting edge technologies. Consequently, his contributions have appeared in top journals on theoretical mechanics (e.g. ASME Journal of Applied Mechanics, Int. J of Solids and Structures, Proc. Royal Society A), computational mechanics (e.g. Computer Methods in Applied Mechanics and Engg., Int. J. for Numerical Methods in Engg, Computational Mechanics) as well as different applications areas (e.g. Composite Structures, ASME J. of Vibration & Acoustics, Smart Materials and Structures, Structural Health Monitoring). His work is not only highly cited but also has opened significant avenues for further research.

Coupled electro-thermo-mechanical two-dimensional theories: Prof. Kapuria has pioneered the development of novel 2D multi-field efficient layerwise (zigzag) theories for the analysis of smart piezoelectric laminated beam, plate, and shell-type structures, which have emerged as the best available in the literature so far in terms of accuracy, computational efficiency, and robustness. He has shown, in direct comparison with full-field 3D analyses, that these new 2D theories give very accurate predictions of static, dynamic, and buckling responses under mechanical, electric, and thermal loadings, not only for composite laminates but also for the highly inhomogeneous sandwich laminates with soft cores. A novelty of these theories is using only five primary displacement variables and achieving the same or even better accuracy at much less computational cost than many higher-order theories with a much larger number of primary variables. His journal publications on the zigzag theories have received more than 1800 citations, indicating its impact on the area. Prof. Kapuria introduced the novel idea of accounting for the normal deformation due to thermal and electric loading without introducing additional deflection variables in the 2D theories, which has proved to be very effective in improving their predictions. The method has led to the development of improved theories for thermally loaded laminated structures.

Prof. Kapuria was the first researcher to experimentally characterize the thermomechanical behavior of functionally graded material (FGM) structures and validate theoretical models in 2008. This work is very useful in designing better FGM systems for high-temperature applications and has made a high impact, as evident from over 340 citations.

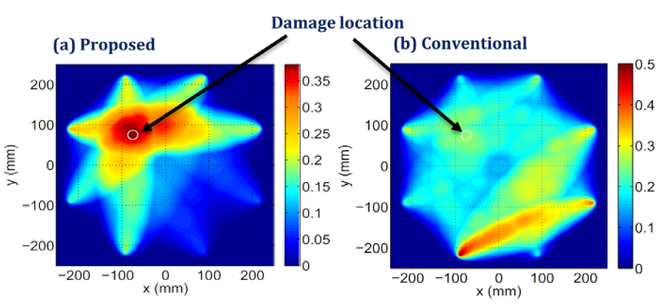
Coupled finite element (FE) models: Having presented accurate and efficient 2D theories, Dr. Kapuria developed new beam, plate, and shell finite elements based on them for analyzing practical elastic and smart composite structures of general geometries. Making innovative use of the improved discrete Kirchhoff technique, he circumvented the need for C1-continuity of the deflection variable in the zigzag theories and made the formulation suitable for standard FE programming. These elements yield results nearly as accurate as a 3D FE analysis but require computational time as low as 1/300th of the latter for a transient analysis. He established the suitability of these elements for modeling active vibration control of smart piezo-laminated structures. He has incorporated the nonlinear constitutive behavior of piezoelectric actuators into these FE models to exploit the use of strong electric fields for effective active vibration and shape control. He has further successfully extended the elements to model delamination and transducer debonding damages in the intelligent composite shell-type structures using efficient layerwise mechanics for the first time. For this purpose, he introduced a new hybrid point-least squares continuity method to satisfy the continuity of the nonlinear layerwise displacement field at the interfaces between intact and delaminated/debonded regions. Prof. Kapuria has also developed frequency domain spectral finite elements based on the zigzag theory to achieve many-fold computational efficiency for wave propagation analysis of straight and curved laminated beams. Prof. Kapuria is the first researcher to present a time-domain spectral element (TDSE) having C1-continuity for Euler-Bernoulli beams, which eliminates Runge's phenomenal encountered in the standard high-order finite elements and exhibits much faster convergence than the latter for high-frequency wave propagation problems. He later extended this model to develop TDSEs based on the advanced zigzag theory for fast simulation of wave propagation in multi-material laminated composite panels. This research has immense importance for structural health monitoring of composite and sandwich structures.

Benchmark 3D analytical solutions: Dr. Kapuria has presented benchmark analytical solutions of 3D piezothermoelasticity for static, dynamic, and buckling responses of piezoelectric composite structures without making any a priori assumptions on the variations of the field variables across the thickness. These solutions, presented for critical structural elements, namely, hybrid rectangular plates, circular plates, and cylindrical shells, have not only helped an accurate understanding of the complex interactions of various fields (thermal/electrical/mechanical) but also have been used as benchmarks for assessing the accuracy of new 2D theories developed for smart plates and shells.

Another seminal contribution of Prof. Kapuria has been the generalization of the powerful extended Kantorovich method (EKM), previously applied only to two-dimensional theory-based solutions of laminated plates, to obtain accurate solutions of their 3D deformations. He was the first to achieve it after A. D. Kerr proposed the EKM in 1968. The need for such accurate analytical solutions for the 3D boundary layer stress fields in laminated structures has been felt ever since Pagano (1970) showed the importance of edge stresses on the integrity of these laminates. He has employed this new mixed-field multiterm EKM to delineate boundary layer stress field in smart piezolaminated plates, representing the first application of the EKM to a multiphysics problem. Using the method, he has obtained 3D elasticity solutions of the classical free-edge stress problem of elastic and piezoelectric laminates, satisfying all boundary and interfacial continuity conditions exactly for the first time. This work has application in developing accurate solutions to several important unresolved problems of 3D piezo-thermo-elasticity.

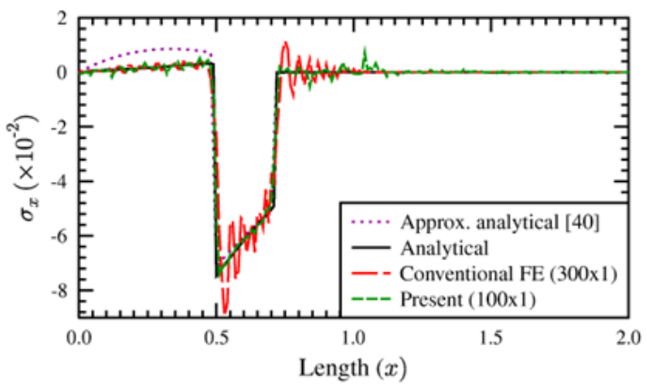
Application to Structural Health Monitoring (SHM) and Control: Dr. Kapuria has developed and experimentally demonstrated a novel Lamb wave-based refined time-reversal method for accurate baseline-free online detection and localization of damages in thin-walled structures (Fig. 1). He introduced the concept of 'best reconstruction frequency' and showed that at this frequency, the time-reversibility of Lamb waves is not only maximum but also invariant of temperature fluctuations. The latter is essential for a genuinely baseline-free method under varying temperatures. He also proposed an 'extended wave packet' for computing the damage index (DI), which drastically enhances the sensitivity of the DI to the presence of damage.

Fig. 1: Baseline-free damage detection and localization using Lamb waves generated and sensed by surface-bonded piezoelectric transducers. (a) Based on a novel refined time reversal method (RTRM) method proposed by Prof. Kapuria's research group. The proposed method accurately predicts the location of the damage. (b) Based on the existing method. It is unable to localize the damage.



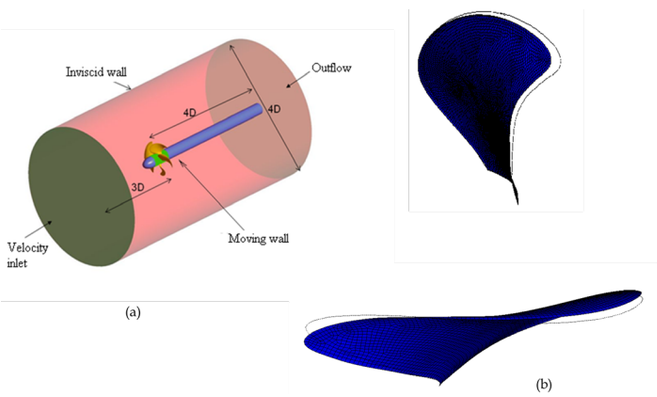
For the analysis and design of Lamb wave-based SHM systems, Dr. Kapuria has presented a dynamic shear-lag model for stress transfer in a piezoelectric wafer transducer bonded to a thin plate, considering the inertia of the system. It came more than 30 years after Crawley and Luis presented the static shear-lag model, which is not applicable for high-frequency guided waves used in SHM applications. He has developed a new class of enriched finite elements using local element-domain wave packet functions to enrich shape functions for wave propagation problems in elastic and piezoelectric media. It alleviates the problems of spurious oscillations and computational inefficiency encountered in the standard FE solutions in solving wave propagation problems having sharp/discontinuous wavefronts (Fig. 2). He has shown that this novel method is very effective in accurately detecting and sizing various types of damage in plates under varying temperatures. In contrast, the conventional time-reversal method is totally unsuitable for identifying damage under such variable temperature conditions. No other baseline-free method exists in the literature which has this capability.

Fig. 2: Stress wave propagation in a narrow elastic strip under thermal shock loading, showing sharp discontinuities at elastic (left) and thermal (right) wavefronts. The conventional finite element (FE) solution (red line) shows spurious oscillations, whereas the enriched FE proposed by Prof. Kapuria's group (green line) yields an accurate prediction of the discontinuous wavefronts. The black line shows the reference analytical solution.



Prof. Kapuria, in collaboration with NSTL, Vizag, showed, for the first time, the possibility of actively controlling the twist of a composite propeller blade using shape memory alloy composite (SMAHC) actuators for improving propulsive efficiency in dual/variable speed naval ships, thereby saving fuel and operating cost (Fig. 3). This work has high importance in developing next-generation naval ships.

Fig. 3: Adaptive control of a full-scale composite propeller of a naval ship using SMAHC actuation for improving hydrodynamic efficiency in off-design conditions. (a) Domain for flow analysis of the propeller. (b) Twist of propeller blade achieved by heating shape memory alloy causing significant improvement in hydrodynamic efficiency in off-design conditions.



Contributions to engineering practice: In Engineers India Limited, Dr. Kapuria handled diverse critical jobs such as analysis of high-pressure Reactor Vessels of Hydrocrackers, high-temperature Fluid Catalytic Crackers vessels, Offshore Process Platforms, and Deepwater Pipelines. He led several prestigious projects of national importance, the foremost among them being (a) the Deepwater Marine Pipeline Project for Gas Authority of India Ltd and (b) the first concrete Vehicle Assembly Building and Jet Deflector Ducts for PSLV in Sriharikota, Indian Space Research Organization (ISRO). He was instrumental in developing guidelines for designing high-pressure Diesel Hydrodesulphurisation reactors built in various refineries across India to produce fuel with new emission norms. His work on the design of expansion bellows used in piping systems has led to major modifications of an international code. He developed optimized designs of underground mounded vessels of different sizes for storing LPG for Bharat Petroleum Corporation Ltd, which they currently use to build these vessels across India. In CSIR-SERC, he conceptualized and initiated several futuristic projects for CSIR, including 'Large floating offshore structures and systems for renewable energy farming' towards achieving self-reliance in key infrastructural technologies.

Prof. Kapuria has made significant contributions to Indian Railways by undertaking a project for evaluation and management of longitudinal force transfer from the railway track to the masonry substructure (piers) of old railway bridges to ascertain their safety. The project involved live testing of ten steel and concrete railway bridges of various types under moving train conditions (Fig. 4). The train-bridge-pier systems were analyzed to estimate the force transfer and shock transmission devices were proposed to minimize the same. This study will help Indian Railways in augmenting the capacity of freight wagons passing through numerous old bridges along the rail network across India.

Fig. 4: Prof. Kapuria inspecting the preparation for testing of Pamban Railway bridge with moving train for its structural integrity assessment.

He also co-developed an indigenous technology called the Emergency Retrieval System (ERS) for quick restoration of power transmission lines (TL) when they fail (Fig. 5). The failure of TL towers occurs due to natural calamities such as cyclones, floods, landslides, and earthquakes, or manmade damages. Such failures cause interruptions in power transmission resulting in huge economic losses and loss of consumer service. While the permanent restoration of towers may take several weeks, the ERS can make it possible to restore the power within 2-3 days. Two patents have been filed based on this work, and the technology has been licensed to M/s Advait Infratech Limited, Ahmedabad. The Central Electric Authority and various state transmission companies have expressed keenness to deploy the product across the country.

Contributions to institute building:

Prof. Kapuria has been a dedicated teacher respected widely by the student community at IIT Delhi. His teaching has been enriched by his vast experience in the industry and research in frontier areas. Students guided by him are well placed as faculty members in the IITs and foreign universities as well as senior executives in reputed industries. He has worked as Chairman, Grades & Registration at IIT Delhi, during which he was instrumental in developing a new ERP system for Academic Management. He brought several systemic changes in the registration process, particularly in handling extreme cases. He has been an active member of several institute-level committees, including the Board of Academic Studies, UG Curriculum Review Committee, Convocation Committee, Faculty Affairs Committee, etc., at IIT Delhi.

Fig. 5a. Prototype test of ERS for 220 kV single-circuit TL tower

Fig. 5b. ERS structure for 440 kV double-circuit TL tower

Prof. Kapuria served as the Director of CSIR-Structural Engineering Research Centre, Chennai, from 2015 to 2020, when he successfully brought in systemic changes in the administration and R&D policy of this National Laboratory. These changes include (i) developing and adopting a new Vision and Policy Document, (ii) restructuring the departments, (iii) creating structures for nurturing talents and rewarding performance, (iv) resource sharing, (v) providing academic freedom to scientists while ensuring accountability, (vi) improving the work environment, (vii) shunning unethical practice in research and other activities, and (ix) developing standard operating procedures for fund allocation, project allocation, equipment purchase, works, etc. Prof. Kapuria's initiatives had resulted in a jump of 100% in the external projects earning in three years, in addition to a rise in the number of quality journal publications by over 50% in the same period. To start a new system of effectively utilizing research grants, CSIR launched 14 Mission Projects across its 38 laboratories. Out of these, two projects involving several CSIR Labs with a funding of Rs. 56.4 cr and Rs. 43.0 cr were conceptualized by CSIR-SERC under the leadership of Prof. Kapuria and were led by it, apart from being a significant contributor to another Mission Project. With total funding of Rs. 58 cr for two years in the three Mission Projects, it has been a historic achievement for SERC. Later, he successfully conceptualized and bagged a futuristic project of Rs. 20 cr on 'Engineering of large floating offshore structures and systems for renewable energy farming' with a view to capacity building in the country. Under his leadership, CSIR-SERC also commercialized several technologies and saw a many-fold increase in outreach programs. He was also nominated as the Theme Director for Civil Infrastructure and Engineering Theme, involving 11 CSIR Labs, wherein he brought in several new initiatives and projects, harnessing its synergy.

In summary, Prof. Kapuria has earned international reputation through his outstanding research contributions in the area of smart materials and structures. His work, uniquely covering theoretical, computational, and experimental mechanics and their applications in cutting edge technologies, has made high impact on the state-of-the-art, which has brought glory to India. His consistent outstanding academic credentials, his eminence as a prolific researcher of international repute, and his extraordinary blend of experience in the industry, academia, and R&D institutions have given him a deep understanding of all the stakeholders of the IIT system. On the research front, he aims at combining fundamental research in mechanics with globally competitive technology development. For example, currently he envisages developing integrated active-passive baseline-free technologies for health monitoring of critical structures in the aerospace, naval, automobile, and oil and gas sectors. It will encompass the development of associated analytical and computational mechanics solutions for fast and accurate simulations and data-driven models to design these SHM systems. It will also involve exploring the use of new classes of smart materials for better sensing and actuation at different scales. Prof. Kapuria is committed to nurturing students to become leaders in their fields, performing research of the highest global standards, and contributing his best to the growth of the institute.

Prof. Vamsi Krishna Komarala

Professor and Head at the Department of Energy Science and Engineering, IIT Delhi

Biographical sketch:

Vamsi Krishna Komarala is a Professor and Head, at the Department of Energy Science and Engineering, IIT Delhi. He has been associated with IIT Delhi since 2010. Initially, Prof. Vamsi's primary interest was implementing Plasmonic and Nanophotonic concepts for enhancing solar cell performance under 3rd generation solar cell concepts. Presently, research interest has been in silicon heterojunction solar cells fabrication and characterization.

Recently, he received Solar Challenge Award – 2021 with a research grant of 12.36 Cr. from the Technology Mission Development of Dept. of Science and Technology for developing "High-efficiency Silicon Heterojunction and Tandem Solar Cells," based on the 5G and 6G solar cell technology.

Prof. Vamsi has authored and co-authored around 70 articles in peer-reviewed international journals and 15 papers in conference proceedings. Under his mentorship, the Solar Photovoltaics Group has been working on silicon-based photovoltaic technologies due to material stability and abundance, generated know-how by publishing 50 research articles and a few patents granted and applied in this area with earlier external funding of around Rupees Five Crores. The group has since made a global impact with the research work - (a) that has led to the international collaborative projects from the Indo-EU (Germany, Finland, and Norway) and Indo-USA (sponsored by Intel corporation with Stanford University collaboration), (b) and a few articles made available for free due to their impact and highlighted in the Editorial news, while some of them highly downloaded (>6000 times), and received the appreciation letters from the Editorial Board, and (c) in the Renewable Energy organizations credited with innovative articles, oral presentations in European conferences, and got the nomination for European ENI Award in the energy area.

The research group is now moving towards the 'Knowledge Application side' after generating new knowledge with some global impact. They have received support from the Institute of Eminence grant for initiating the Silicon Heterojunction (a-Si:H/c-Si) solar cells work on an industrial scale wafer with the aim of technology development to attract industry funding and to have a global impact as an Institute of Eminence.

Silicon Heterojunction and colored solar cells development work

The present aspiration for Photovoltaic (PV) Technology is to meet sustainable development goals and be responsible for the planet and its inhabitants by focusing on an inexpensive way to convert solar energy into electrical power, thus making the energy from PV more affordable than before.

Figure 1: Fabricated Silicon Heterojunction solar cell and the cell schematic.

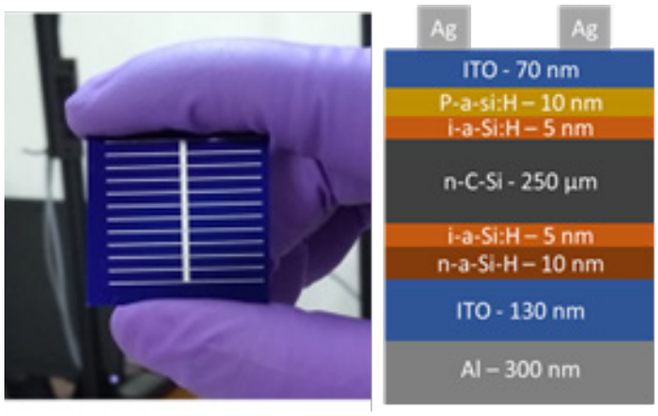
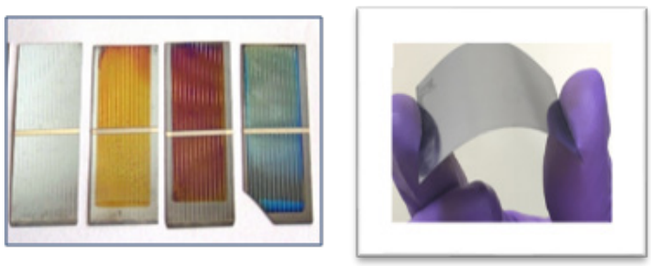


Figure 2: Colored and flexible solar cell development using nanoscience concepts.



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04

List of IPR applications filed during July- December 2022

Title	Main Inventor	Department
Method and apparatus for DDoS attack detection and mitigation in IOT network slices	Prof. Vireshwar Kumar	CSE
A system for measuring an applied force on a surface	Prof. Sitikantha Roy	AM
A multifunctional protective bilayer bimatrix composite coating	Prof. Deepak Kumar	CART
Method and system to protect clear text transmission of user identity in wireless networks	Prof. Brejesh Lall	BSTTM
High performing eco-friendly resins for replacing phenolic resins in non-asbestos organic (NAO)-copper-free brake-pads/shoes/clutch facings	Prof. Jayashree Bijwe	CART
A system and method facilitating distribution of content in a content distribution network (CDN)	Prof. Subrat Kar	EE
Bimetallic and monometallic adsorbents for removal of trace contaminants, and process for preparation thereof	Prof. Divesh Bhatia	CHEME
Device, system, and method facilitating light intensity control	Prof. Sumit Kumar Chattopadhyay	DESE
A method to control nitrogen doping in microporous carbon	Prof. Vipin Kumar	DESE
A method and a system for operating a microgrid	Prof. Bhim Singh	EE
A Transition metal based tetravalent cationic doped KTaO3 perovskite and preparation thereof for a highly stable and efficient photocatalyst.	Prof. Ashok Niwritti Bhaskarwar	CHEME
A bioreactor with a porous floating support for growing a biological material	Prof. Ashok Kumar Srivastava	DBEB
System and method for green synthesis of lithium-based oxide (LBO) for battery applications	Prof. Madhusudan Singh	EE
Multifunctional textile and method of its preparation thereof	Prof. Wazed Syed Ali	TFE
Pseudo elliptic evanescent-mode waveguide filter	Prof. Ananjan Basu	CARE
An integrator circuit for current monitoring schemes and a method for optimizing frequency performance	Prof. Sumit Pramanick	EE
Spray-infiltrated carbon-perovskite solar cell stack with N-I-P like junction formation	Prof. Viresh Dutta	CESE
Phosphine oxide immobilized Mo2 nanostructures, and preparation method therefor and applications thereof	Prof. Biswarup Chakraborty	CHY
Compact external cavity diode laser	Prof. Bodhaditya Santra	PHY
Multidirectional thermal protective performance testing instrument	Prof. Apurba Das	TFE
A re-usable multi-layered absorbent article	Prof. Rabisankar Chattopadhyay	TFE
Wafer-wafer bonding using recrystallized parylene material	Prof. Bhaskar Mitra	EE
3D printed microbubble generator assembly	Prof. Anushree Malik	CRDT
A system for fabricating three-dimensional (3D) printed components a method thereof	Prof. Pulak Mohan Pandey	ME
System and method for providing energy management in communication network	Prof. Swades De	EE
Method for controlling stress and under sacrificial etching in micro/nano sized Electro-Mechanical devices	Prof. Pushpapraj Singh	CARE
A system facilitating controlling and locking of laser and method thereof	Prof. Bodhaditya Santra	PHY
An eco-friendly silica nanoparticles-ZDDP based hybrid nano-lubricant additive and lubricant formulation thereof	Prof. Nitya Nand Gosvami	DMSE
An adsorbent material and a method of preparing thereof	Prof. Dipayan Das	TFE
A portable footwear traction characterization device	Prof. Arnab Chanda	CBME

Title	Main Inventor	Department
HyKi Turbine	Prof. Paruchuri Mohan Venkata Subbarao	ME
A method for continuous evaluation of three-dimensional (3D) motion perception and a system thereof	Prof. Tapan Kumar Gandhi	EE
A multifunctional cationic dye and a method for preparation thereof	Prof. Javed Nabibaksha Sheikh	TFE
Ignition pellets for TLUD cookstoves	Prof. Sangeeta Kohli	ME
Method of having low pull-in voltage and controlled hysteretic switching in MEMS structures	Prof. Pushpapraj Singh	CARE
A system and method for generating high-efficiency electrical-power using solar-PV tower with reflection concentration	Prof. Dalip Singh Mehta	PHY
A system for optimizing energy transmission and a method thereof	Prof. Shouri Chatterjee	EE
Biocidal polyurethane polymer and a method for production thereof	Prof. Bhuvanesh Gupta	TFE
Baseline-free damage detection under varing temperatures using PWAS actuated and sensed lambwaves without temperature compensation	Prof. Santosh Kapuria	AM
Prosthetic Biotribometer	Prof. Sujeet Kumar Sinha	ME
Side stand for two-wheeler	Prof. Yunus Patel	AM
Identification of a novel DNA aptamer specific for prostate cancer oncogene	Prof. Prashant Mishra	DBEB
Apparatus for determining the performance of firefighter clothing under wind-driven conditions	Prof. Prabal Talukdar	ME
Sound absorbing materials from NADES pre-treated cellulosic microfibrils	Prof. Shahab Fatima	CART
A method and system for producing master mold for microfluidic devices	Prof. Supreet Singh Bahga	ME
Method for generating tuned knee torque profile and a prosthetic limb apparatus thereof	Prof. Sudipto Mukherjee	ME
Pollution monitoring system and method thereof	Prof. Shouri Chatterjee	EE
System and method for optimizing data transmission in a communication network	Prof. Swades De	EE
Rivertech Hydrotech	Prof. Parigi Vedanti Madhusudhan Rao	DOD
Near infrared spectroscopy for protein formulation and uses thereof	Prof. Anurag S Rathore	CHEME
Power converter with multi-layered coil	Prof. Sumit Pramanick	EE
Total elbow replacement prosthesis for Indian		
population	Prof. Dinesh Kalyanasundaram	CBME
A cost-effective equipment for studying synergistic outcome of contact electrification and photovoltaic effect	Prof. Ankur Goswami	DMSE
A system and method for real time monitoring of		
charge variants of monoclonal antibodies using Raman spectroscopy	Prof. Anurag S Rathore	CHEME
A system and method for optically detecting tracking, status and monitoring activities of assets	Prof. Subrat Kar	EE
Mechanically strong antimicrobial polymeric gels for effective point-of-use water disinfection	Prof. Leena Nebhani	DMSE
Hydrokinetic turbine	Prof. Paruchuri Mohan Venkata Subbarao	ME
A splint device	Prof. Suresh Neelakantan	DMSE
Coumarin compound and method of preparation thereof	Prof. Ravi P Singh	CHY
A reconfigurable three-phase single-stage current fed electrolytic capacitor less bidirectional converter for onboard EV charging	Prof. Sumit Pramanick	EE
A textile-based triboelectric nano-generator for harvesting energy	Prof. Bipin Kumar	TFE
A lens-based scanner head for Agri-photonics application and method of working thereof	Prof. Amartya Sengupta	PHY
Detection and measurement of chlorine dioxide with data-driven modelling method	Prof. Anurag S Rathore	CHEME
A novel process for preparation of pegylated recombinant human granulocyte colony stimulating factor (PEG-GCSF)	Prof. Anurag S Rathore	CHEME
Drain extended NMOS(DENMOS) and a method thereof to optimize parasitic bjt trigger voltage and self-heating induced thermal runaway	Prof. Ankur Gupta	CARE

Technology Profile

05

Researchers at IIT Delhi Develop Technology for Industrial Scale Production of Nanofibres

Figure 1: Continuous Electrospinning Machine (Lab Prototype) Developed by IIT Delhi Researchers

We all know that nanotechnology has opened up innumerable possibilities for developing next generation functional materials. It is an emerging area and many countries around the world are investing heavily to take this technology to commercial scale.

Nanofibres, which are 1/1000th in diameter in comparison to a cotton fibre, is one such material that has found applications in making high efficiency industrial filters, automobile oil and fuel filters, scaffolds for tissue engineering, highly responsive electronic sensors, protective devices and many more. However, commercial production of nanofibres has been challenging.

To tackle this challenge, researchers at IIT Delhi's SMITA Research Lab have developed a technology for the industrial scale production of nanofibers, which is superior to the commercial technologies available in other countries.

Electrospinning is the most popular technology for producing these nanofibres, where nanofibres are deposited on a subtrate for such applications. Many challenges are faced during the deposition of nanofibres on substrates, which include continuous mass production of nanofibres over a wide width, high rates of deposition, uniform deposition, production of low diameter fibres, and adhesion etc.

The IIT Delhi researchers, led by Prof. Ashwini Agrawal and Prof. Manjeet Jassal from the Textile and Fibre Engineering Department, were able to solve all the above-mentioned challenges and develop a scalable prototype. The pilot machine developed at IIT Delhi has been validated in an industrial set-up for producing nanofibres at commercial scale. The technology has been granted patents in India, the UK and the USA.

"There are a few manufacturers outside India that make Continuous Electrospinning Machines. However, their products suffer from non-uniform deposition when low add-ons are required, which is an essential requirement for a cost-effective solution. In India, there is no company engaged in the mass production of nanofibres. Our research group is the first one to develop technology for continuous production of nanofibres over a large width of substrate suitable for various applications", said Dr. Ashwini Agrawal, lead researcher and professor in the Textile and Fibre Engineering Department, IIT Delhi.

Using their technology, the researchers have developed high efficiency fuel and oil nanofibre filters, which were found to be stable during the mechanical fabrication process and then during the life of the filter.

"The technology is a game changer for meeting tighter standards of vehicular pollutions, for protection of individuals from rising air pollution, and health care devices, etc.," Prof. Agrawal added.

Prof. V Dutta

DESE, IIT Delhi

Spray-Infiltrated Carbon-Perovskite Solar Cell Stack With N-I-P-Like Junction Formation

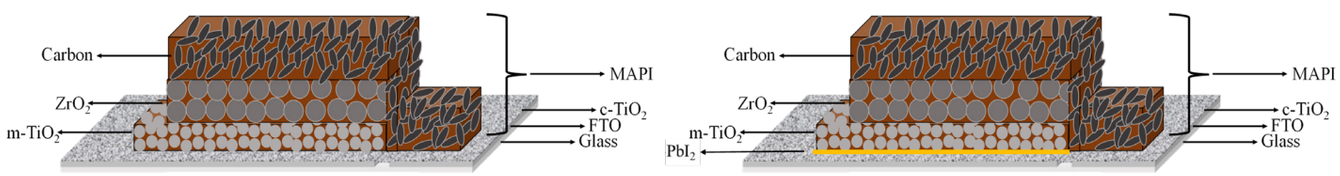
Mesoscopic carbon-based perovskite solar cells (C-PSCs) are considered as frontrunners for the commercialization of PSC technology because of their low-cost material inventory, scalable fabrication process and inherent device stability. Fully printable C-PSC devices are fabricated, in which perovskite solution is infiltrated via drop-caste or inkjet printing process. In this work, we demonstrated the infiltration of perovskite using an electric field-assisted spray technique (e-Spray). Sprayable precursor inks of low viscosity and toxicity are developed for this purpose.

Inherently, the stability of the C-PSC is high because of the hygroscopic carbon electrodes. However, the degradation of the perovskite material is initiated by the nonuniformity of the infiltrated material. We addressed this issue through uniform infiltration and crystallization of the perovskite by e-Spray.

Furthermore, we demonstrated the process of forming a thin metal iodide layer between the electron transport layer and the active material by controlled exposure of the e-Spray fabricated devices to moisture. This resulted in the formation of an N-I-P-like Junction formation within the C-PSC. This modification in the device architecture improves the device's performance, particularly enhancing the open circuit voltage. Also, the formed metal iodide layer is robust to moisture ingress and protects the perovskite from the extended edges of the device without carbon electrode capping.

The developed e-Spray technique and the protocol for the formation of N-I-P-like junction in the C-PSCs can be implemented for a large-area and roll-to-roll fabrication of C-PSCs with variable perovskite materials and is highly relevant for the commercialization of C-PSC technology.

Schematic representation of a) C-PSCs stacks infiltered with perovskite material, b) C-PSC stacks and formed PbI2-TiO2 interface, as reported in the filed patent.



Some Investigative/ Development Projects undertaken during July – December, 2022

Project/Title	Project Incharge	Department/Centre/ Schools
PLANNING, DESIGNING AND SUPERVISION OF THE FOUNDATION STRUCTURE FOR THE STATUE OF NETAJI SUBHAS CHANDRA BOSE UNDER THE CANOPY BEHIND INDIA GATE	Prof. Supratic Gupta	CE
WATER BALANCE OF THE INDUSTRY AND PERFORMANCE ASSESSMENT OF ETP FOR CLIENT	Prof. Vivek Kumar	DOD
ENHANCING THE PRICEX - PRE-OWNED VEHICLE PRICE PREDICTION ENGINE	Prof. Mausam	SCAI
EVALUATING THE FEASIBILITY OF USING THE NEW ASTM E3325-21 SAMPLE PREPARAT STANDARD AND EPA TEST METHOD 1311	Prof. Arun Kumar	CE
IMPLEMENTATION OF FIELD ORIENTATION CONTROL ALGORITHM IN EXISTING 1.3KW MOTOR CONTROL UNIT (MCU)	Prof. Amit Kumar	EE
ENHANCING CITIZEN AWARENESS AND BEHAVIOUR CHANGE BY DISSEMINATING SCIENTIFIC DATA	Prof. P. Vigneswara Ilavarasan	DMS
DEVELOPMENT OF BIODERGRADABLE FILMS WITH MULTIFUNCTIONAL PROPERTIES	Prof. Anup K. Ghosh	DMSE
(A):- FAILSAFE TEST FOR SUBSIDIARY LED SIGNAL, CALLING - ON, ROUTE & SHUNT WITH MTBF IN PART COUNT METHOD AS PER RDSO SPECIFICATION NO. RDSO/SPN/153/2011 REV. 4.1. DEVELOPMENT OF BIODEGRADABLE FILMS WITH MULTIFUNCTIONAL PROPERTIES. (B):- TO ADVICE ON HOE AN ELECTRONIC MANUFACTURING UNIT SHOULD BEL CONSTRUCTED TO TAKE CARE OF ENVIRONMENTAL FACTORS FOR PRODUCUNG QUALITY PRODUCTS.	Prof. Pushparaj Singh	CARE
BREAKING STRENTH OF WIRES FOR GRIPPLE	Prof. Puneet Mahajan	AM
AUTONOMOUS ROVER FOR 360 DEGREE IMAGE CAPTURING	Prof. Husain Kanchwala	CART
DEVELOPMENT OF SIMULATION MODEL AND OPTIMIZATION OF COIL DESIGN FOR RESONANT BIDIRECTIONAL WIRELESS POWER TRANSFER SYSTEM	Prof. Sumit Praminick	EE
ALGORITHMIC ASPECTS OF DRIVER UNBUNDLING	Prof. Sayan Ranu	CSE
TO AUDIT THE IMPLEMENTATION BY THE STATES OF THE DIRECTIONS ISSUED BY THE SUPREME COURT COMMITTEE ON ROAD SAFETY (GROUP B, C& D)	Prof. Geetam Tiwari	TRIPP
COMPUTER GRAPHICS AND ANIMATION FOR RESEARCH PROGRAM/ PROJECTS	Prof. Rahul Narain	CSE
ADVICE ON KNOWLEDGE GRAPH BASED QUESTION ANSWERING	Prof. Mausam	SCAI
INVESTIGATION INTO EFFICIENCY OF AUFERO POSITIVE IONIZATION BASED FILTERLESS MOBILE TECHNOLOGY FROM ENS NETHERLANDS	Prof. Dibakar Rakshit	ESE
GENERIC CONTROLLER BUILDING BLOCK IMPLEMENTATION USING TI DSP 28379	Prof. Santanu Mishra	CART
TESTS ON COUPLERS FOR KPC FLEXITUBE 25MM HIGH FATIGUE	Prof. Puneet Mahajan	AM
IMPLEMENTATION OF INTEGRATED SECURITY AND TRAFFIC MANAGEMENT SYSTEM	Prof. Sukumar Mishra	EE
C/O FOOTOVER BRIDGE/SKYWALK FOR CONNECTING IMPLEMENTATION OF INTEGRATED SECURITY AND TRAFFIC MANAGEMENT SYSTEM	Prof. Sukumar Mishra	EE
PREDICTING DRIVER'S PERFORMANCE IN A RACING SIMULATOR	Prof. Hariprasad Kodamana	CHEME
SPECIFICATION OF MONUMENTAL FLAG FABRIC	Prof. Bipin Kumar	TT

Project/Title	Project Incharge	Department/Centre/ Schools
TEST ON COUPLERS	Prof. Puneet Mahajan	AM
TESTS ON COUPLERS FOR KPC FLEXITUBE 20MMHIGH CYCLE FATIQUE	Prof. Puneet Mahajan	AM
PLATFORM FOR RELIABLE CHARACTERIZATION AND EVALUATION OF COMPARABILITY OF BIOSIMILAR DRUG PRODUCTS IN LYOPHILIZED AND LIQUID FORMULATIONS	Prof. Anurag Singh Rathore	CHEME.
CREATING AS CONTINUOUS PROCESS PLATFORM FOR PRODUCTION OF BIOTHERAPEUTIC PRODUCTS	Prof. Anurag Singh Rathore	CHEME.
TENSILE TESTS ON AI/POLYMER COMPOSITE SPECIMENS	Prof. Puneet Mahajan	AM
MULTIPHASE SIMULATION OF PLATE TYPE HEAT EXCHANGER WITH TUBULATORS AND DIMPLES	Prof. Bahni Ray	ME
TESTING OF REBAR COUPLER FOR HARSH INDUSTRIES 25MM HIGH CYCLE FATIQUE	Prof. Puneet Mahajan	AM
TENSILE TESTS ON AI/POLYMER COMPOSITE SPECIMENS	Prof. Puneet Mahajan	AM
SERVICE LIFE OF TA PINS	Prof. Puneet Mahajan	AM
INVESTIGATION ON EIGEN FREQUENCIES OF PIPES	Prof. Ashish K Darpe	ME
FEASIBILITY STUDY REALIZATION OF CTDSM TO ACHIEVE BAND WIDTH RANGING UPTO 1MHZ AND RESOLUTION RANGING FROM 15-16 BITS	Prof. Ankesh Jain	EE
SENTIMENT ANALYSIS ON PREDICTION MARKET DATA (PROBO)	Prof. Amitabha Bagchi	CSE
TESTS ON COUPLERS	Prof. Puneet Mahajan	AM
ADVICE ON VISUAL REPRESENTATION OF QUANTITATIVE DATA	Prof. Agam Gupta	DMSE
TENSILE TESTS ON GLASS FIBER GEOGRID SPECIMENS	Prof. Puneet Mahajan	AM
CHAPTER ON STRUCTURE & PERFORMANCE OF INDIAN AUTOMOTIVE SECTOR	Prof. Hussain Kanchwala	CART
ADHESION STRENGTH MEASUREMENT OF MULTILAYERED TARPAULIN	Rof. Naresh V. Datla	ME
CONCRETE MIX DESIGN FOR SILICON CITY, CRYSTAL HOMES	Prof. Supratic Gupta	CE
ENDURANCE TEST AND MODAL ANALYSIS OF PIPES	Prof. Ashish K. Darpe	ME
DEVELOPMENT OF VEIL OF 10-50 GSM OF T-LINK RESINS FOR ADHESIVE APPLICATION IN FRP COMPOSITES	Prof. Naresh Bhatnagar	ME
INVESTIGATION, ANALYSIS AND APPLICABILITY STUDY OF 99.99% PURE NICKEL WIRES	Prof. Suresh Neelakantan	MSE
COMPILATION OF GOOD PRACTICES AND LESSONS LEARNED ON SETUP AND IMPLEMENTATION OF NATIONAL SYSTEMS OF INNOVATION	Prof. Ambuj Sagar	SOPP
IMPACT ASSESSMENT OF USHA SILAI SCHOOL PROGRAM	Prof. Jyoti Kumar	DOD
LIGHT WEIGHT RM & WELDING PROCESSES STUDY FOR ROTATIONAL SEAT	Prof. Ayan Bhowmik	DMSE
IMPACT OF CHANGING RAINFALL PATTERNS ON TOLL ROAD TRAFFIC IN INDIA	Prof. Yama Dixit	CAS
DESIGN OF A MAGNETIC TOMOGRAPHY METHOD (MTM) BASED MEASUREMENT SYSTEM	Prof. Brejesh Lall	BSTTM
NEUROMORPHIC COMPUTING AND APPLICATIONS OF SPIKING NEURAL NETWORKS (SNN) FOR RESEARCH PROGRAM	Prof. Manan Suri	EE

Project/Title	Project Incharge	Department/Centre/ Schools
DEVELOPMENT OF MOSQUITO REPELLENT NONWOVEN FABRIC USING PLANT-BASED ESSENTIAL OIL	Prof. S. Wazed Ali	TT
INTELLIGENT HYDROPONICS USING SPRESENSE	Prof. Supreet Singh Bahga	ME
RF NETWORK STACK	Prof. Abhishek Dixit	EE
LEAKAGE CURRENT SENSOR PROTOTYPE DEVELOPMENT	Prof. Santanu Mishra	CART
DESIGN AND ANALYSIS OF DIAPHRAGM TO ACHIEVE A LIFE CYCLE OF 1 MILLION CYCLES AT 165 BAR PRESSURE IN A METALLIC PRESSURE SENSOR	Prof. Jayant Jain	DMSE
HIGH-SPEED WIRELESS TERRAGRAPH TECHNOLOGY TRIAL IN THE 60GHZ BAND	Prof. Huzur Saran	CSE
DEVELOPMENT OF LIFI NETWORK	Prof. Abhishek Dixit	EE
REDUCING THE PARTICLE SIZE OF NATURAL MINERAL TOURMALINE (MOGS HARDNESS-7)	Prof. Deepak Kumar	CART
IDENTIFICATION OF KEY PERFORMANCE INDICATORS FOR ITEMS OF DELHI USING SIMULATION	Prof. Sai Chand	TRIPP
ASSESSMENT OF PI/PU INSULATION FOR THERMAL COMFORT AND ENERGY EFFICIENCY	Prof. Hussain Kanchwala	CART
TRAFFIC PERFORMANCE EVALUATION AND OPTIMISATION OF HIGHWAYS IN DELHI USING MICROSIMULATION	Prof. Sai Chand	TRIPP
	TRIPP	ME
DEVELOPMENT AND DEPLOYMENT OF INDUSTRIAL IOT SENSORS FOR SMART WAREHOUSE	Prof. Sunil Jha	ME
HIGH PERFORMANCE COMPUTING (HPC) COURSE CONTENT	Prof. Subodh Kumar	CSE
TESTING OF MIG BIOCOOKER COOKSTOVE DEVELOPED	Prof. Priyanka Kaushal	CRDT
PRELIMINARY STUDY OF THE DRIVETRAIN SYSTEM FOR THE DEVELOPMENT OF INTELLIGENT CONDITION MONITORING SYSTEM (CMS) FOR WIND TURBINE	Prof. Shahab Fatima	CART
TAXONOMY BASED RECOMMENDATION FOR FREE NEWS	Prof. Tanmoy Chakraborty	EE
ANALOG FE FOR HIGH DYNAMIC RANGE CMOIS SENSOR	Prof. Rakesh Kumar Palani	EE
PROOF CHECKING OF DPR FOR CONSTRUCTION OF RAIL CUM HIGHWAY UNDER WATER TUNNEL INCLUDING APPROACH ROAD ACROSS MIGHTY RIVER BRAHMAPUTRA APPROXIMATELY IN BETWEEN PACKHIGAON (JAMUGIRI) AND KALIABOR TEA ESTATE (SILGHAT) UNDER PROJECT VARTAK IN ASSAM STATE INCLUDING MAINTENANCE FOR A PERIOD OF 10 YEARS.	Prof. K. N. Jha	CE
SEPARATING THE WHAT FROM THE HOW IN PRETRAINED LANGUAGE MODELS: A STEP TOWARDS GENERIC AI	Prof. Tanmoy Chakraborty	EE
DEEP LEARNING APPROACHES FOR IMPROVED PATIENT CARE IN CARDIOVASCULAR DISEASE	Prof. Anurag Singh Rathore	CHEME
MEDIATEK RESEARCH FELLOWSHIP	Prof. Swades De	BSTTM
RECOMMENDING FIRST RESPONSE SERVICES TO PATIENTS THROUGH NATURAL LANGUAGE CONVERSATIONS	Prof. Mausam	CSE
ALGORITHMIC FAIRNESS IN ALLOCATION PROBLEMS	Prof. Sayan Ranu	CE
Algorithmic Fairness In Allocation Problems	Prof Sayan Ranu	CE

Abbreviations

AM	Department of Applied Mechanics
BSTTM	Bharti School of Telecommunication Technology and Management
CARE	Centre for Applied Research in Electronics
CAS	Centre for Atmospheric Sciences
CART	Centre for Automotive Research and Tribology
CBME	Centre for Biomedical Engineering
CE	Department of Civil Engineering
CHEME	Department of Chemical Engineering
CHY	Department of Chemistry
CRDT	Centre for Rural Development and Technology
CSE	Department of Computer Science and Engineering
DBEB	Department of Biochemical Engineering and Biotechnology
DESE	Department of Energy Science and Engineering.
DMS	Department of Management Studies
DMSE	Department of Material Science & Engineering
DOD	Department of Design
EE	Department of Electrical Engineering
HUSS	Department of Humanities and Social Sciences
KSBS	Kusuma School of Biological Sciences
MATHS	Department of Mathematics
ME	Department of Mechanical Engineering
PHY	Department of Physics
TFE	Department of Textile and Fiber Engineering

and many more...

HAPPENINGS

Hon'ble President of India, Smt. Droupadi Murmu graced the closing ceremony of IIT Delhi's Diamond Jubilee Celebrations on September 3, 2022

On the occasion, the President virtually inaugurated IIT Delhi's state-of-the-art Research and Innovation Park and an exhibition of technologies developed by the Institute.

Meta and MeitY Startup Hub launched the XR Startup Program on September, 2022 in the presence of Shri Rajeev Chandrasekhar, Minister of State for Skill Development and Entrepreneurship and Electronics and Information Technology of India & Mr. Joel Kaplan, Vice President, Global Public Policy at Meta. The program aims to nurture and accelerate XR Tech Startups across India, focusing on Tier II & III cities of India. FITT IITDelhi (Foundation for Innovation and Technology Transfer) is one of the four implementation partners.

MOUs With FITT

An MoU was signed between FITT and Adani Green Energy Limited on 2nd of August 2022 for collaborative technology development in the Renewable Energy sector.

FITT signed an MOU with EcoAutoMo Pvt Ltd on August 2, 2022 for the development of Autonomous Guided Vehicles.

MoU signed between Department of MSME, Government of Madhya Pradesh and FITT, today, in the presence of Shri Shivraj Singh Chauhan, Honorable CM of Madhya Pradesh on November 22, 2022

SNIPPETS

FITT invites proposals under the 22th Biotechnology Ignition Grant (BIG) Scheme of BIRAC from January 1, 2023 to February 16, 2023. For details: www.fitt-iitd.in

NEWS AND VIEWS

Altair India inks pact with FITT Delhi to support startups

As part of the Altair incubator outreach initiative, Altair collaborates with startup incubators to identify, support, and mentor budding startups and provide them with its simulation, optimization, and machine learning technologies... Altair, a computational science and artificial intelligence (AI) firm, announced the launch of the Altair India incubator outreach initiative in collaboration with Foundation for Innovation and Technology Transfer (FITT) at Indian Institute of Technology Delhi (IITD) to equip startups with the latest technologies.

As part of the Altair incubator outreach initiative, Altair collaborates with startup incubators to identify, support, and mentor budding startups and provide them with its simulation, optimization, and machine learning technologies... *Sources: Internal, July , 2022*

Altair India inks pact with FITT Delhi to support startups

Shri. Piyush Goyal, Union Minister of Textiles, Minister of Commerce and Industry, and Minister of Consumer Affairs, Food and Public Distribution inaugurated a Public Systems Lab (PSL) at IIT Delhi. *Sources: Internal- August 16, 2022*

Why do engineering aspirants prefer CSE over other core branches?" Ex IIT-Delhi director questions obsession with computer science

Former IIT Delhi director V Ramgopal Rao wrote in a recent social media post that it is easier for mechanical or civil engineers to move to CSE or IT-related jobs, and not the other way around.
Sources: India Express- September 2022

Four startups led by IIT-Delhi students win grant of ₹50 lakh each

Four start-ups led by IIT-Delhi students have won a grant of ₹50 lakh each under the Endowment Nurture Fund Initiative of IIT-Delhi.

The fund launched by the IIT-Delhi Endowment Management Foundation was set up to provide a cushion to IIT-Delhi's student teams to take risk and experiment with innovative ideas, products or business models that in turn helps spread the culture of innovation and entrepreneurship among the student community. *Sources: Internal, November 17, 2022*

Cabinet clears ₹19,744-cr National Green Hydrogen Mission

The National Green Hydrogen Mission will go a long way in government efforts toward building the renewable energy capacity of the country. The mission is expected to add about 125 GW of renewable energy capacity to the country. The addition will help to reduce our dependence on fossil fuel imports and through the mission, the government aims to reduce fuel imports by over ₹1 lakh crore.
Sources: Live Mint, January 4, 2023

CORPORATE MEMBERSHIP OF FITT

FITT invites the industry/industry associations/R&D organisations and financial institutions to become corporate members of FITT at a nominal annual subscription. A corporate client can participate in technology transfer and joint R&D programmes of the Institute on a priority basis with FITT providing the interface. Membership form can be downloaded from www.fitt-iitd.in.

New Corporate Members:

1. Araina Enterprises Pvt. Ltd
2. The East India Technologies Pvt Ltd
3. Computeminions Pvt Ltd
4. Motherson Innovations

LEADERSHIP @ FITT

Prof. Rangan Banerjee, Director IIT Delhi, Chairman FITT
Dr. Anil Wali, MD FITT
Col. Naveen Gopal (Retd.) , COO FITT

FITT promotes innovation and offer best of the incubation facilities especially in NCR and the country as a whole to nurture ideas and develop technology solutions. Interested can e-mail us at: mdfitt@gmail.com

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