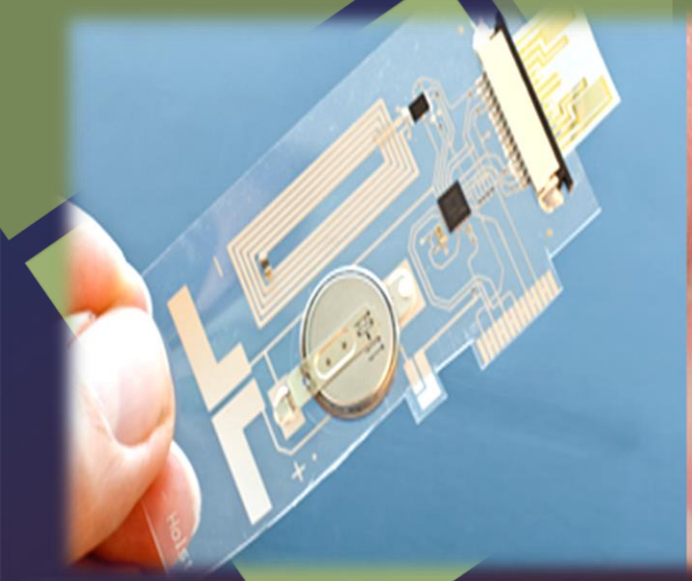
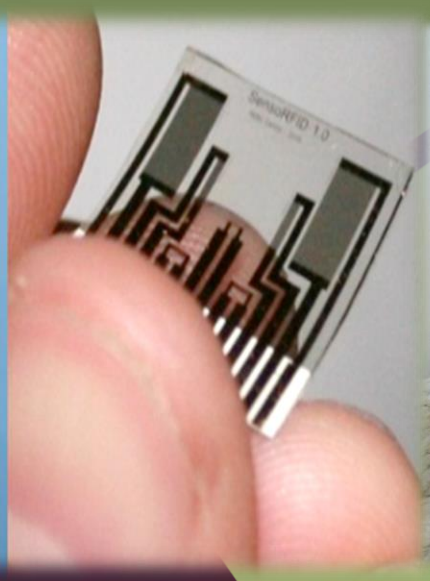
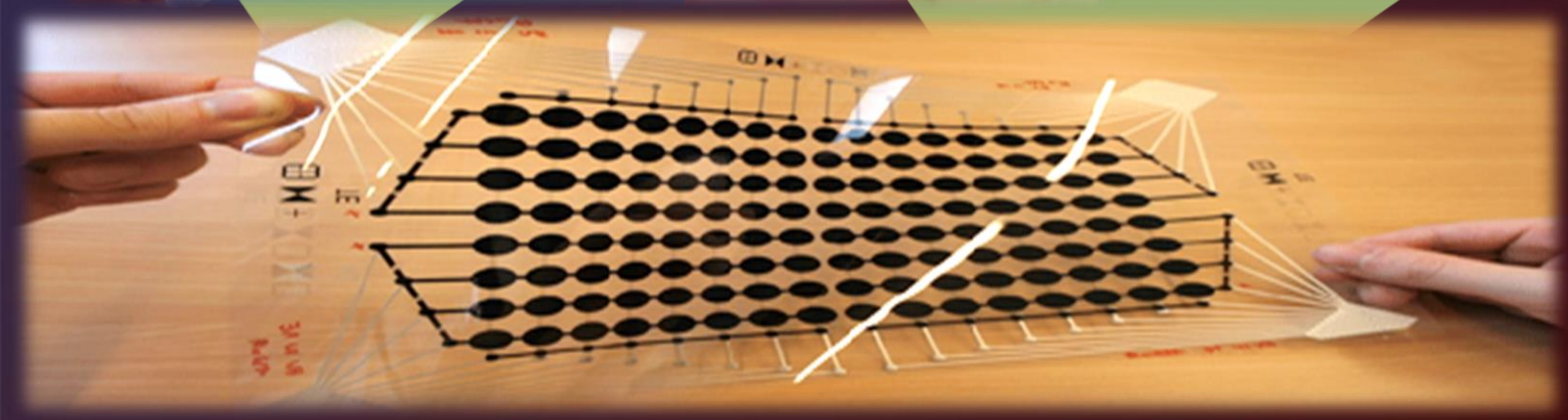
PROGRESS REPORT
&
PORTFOLIO 2021-2022







CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING (CAEPE)

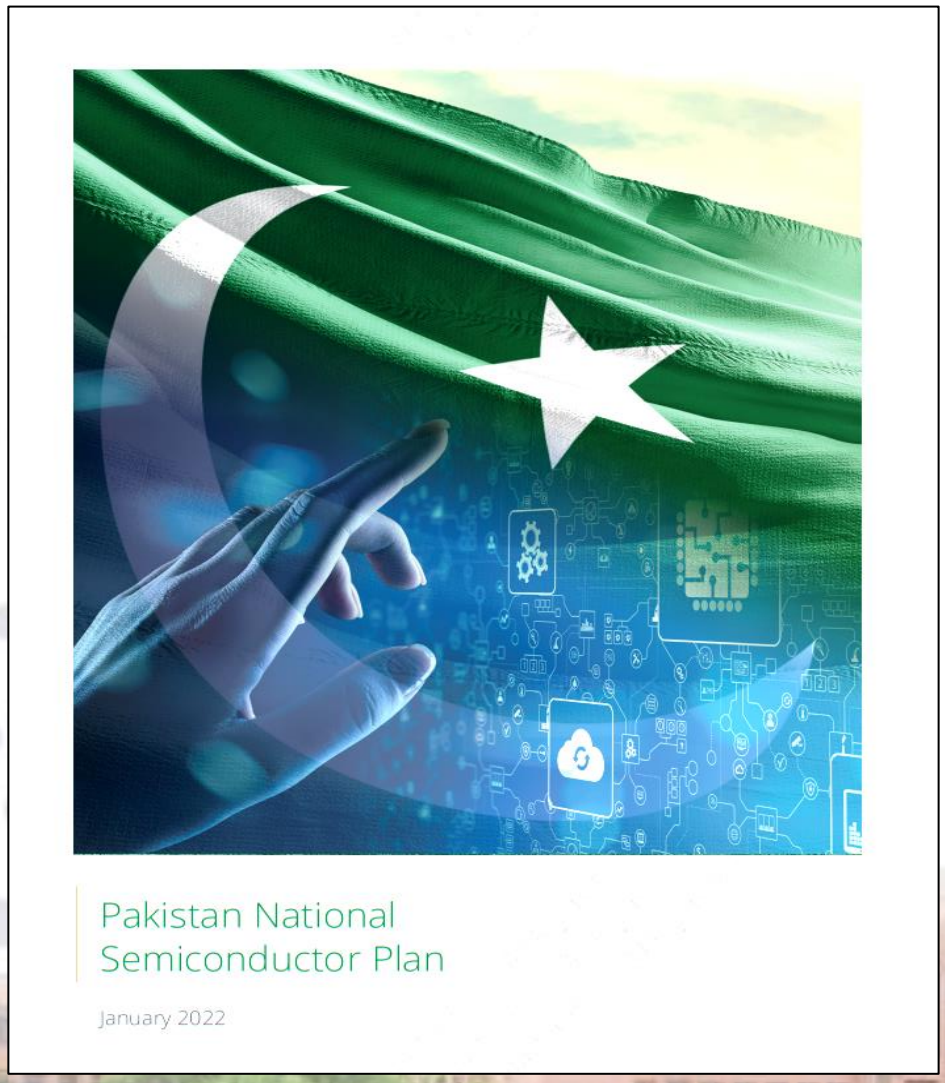
INTERNATIONAL ISLAMIC UNIVERSITY, ISLAMABAD

A PARADIGM SHIFT IN ELECTRONICS AND ENERGY RESEARCH

CAEPE has contributed to the development of Pakistan's first National Semiconductors Plan-2022

CAEPE team is also contributing a great deal in developing the first National Electronics Policy

CAEPE is also advising on several national and international fora pertinent to the Science, Technology and innovation (STI) interventions



H.E. Dr. Arif-ur-Rehman Alvi
Chancellor, IIUI/ President of Pakistan

Prof. Dr. Ahmad Salem Muhammad Al - Ameri
Pro Chancellor, IIUI

Prof. Dr. Masoom Yasinzai
Rector, IIUI

Prof. Dr. Hathal Homoud Alotaibi
President, IIUI

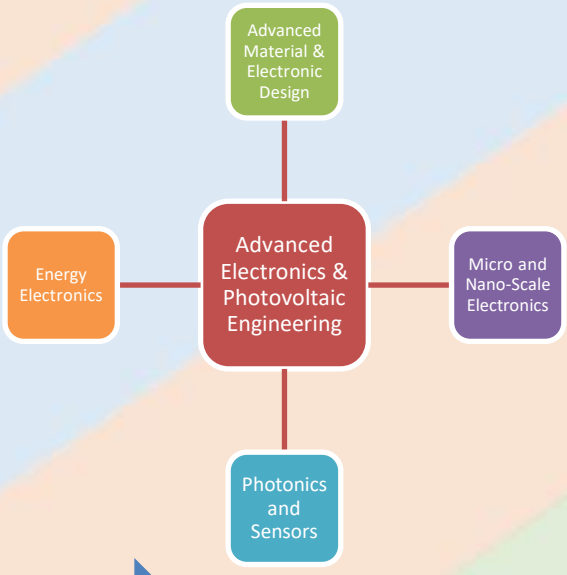
Engr. Prof. Dr. Ahmed Shuja Syed
Founding Executive Director (CAEPE)

CONTENT

At A Glance

The Centre for Advanced Electronics & Photovoltaic Engineering (CAEPE) at International Islamic University, Islamabad is a university-wide Centre aimed to create knowledge and develop the cross-disciplinary market-driven research focused on the applications of Advanced Electronics & Photovoltaic Engineering via processes, components and systems. This research and development is important for the convergence of energy, photonic and nano-scale electronics avenues for economic growth in the country. The overall objective of the Centre is to establish a sustainable source of research training for developing qualified manpower with a focus on future requirements, and facility access services in these fields that are applied to the national needs.

- CAEPE is a university wide indigenous Centre and a user-access facility
- Number of Scientific Projects Utilizing the Facilities in the Centre ~ 430+
- Enabling to target 4 Sustainable Development Goals (SDGs)
- Centre's Indigenous Research Problems are focused to create knowledge in Micro- and Nano-scale Engineering of Devices, Materials and Systems to enable solutions for Big Problems such as Connectivity, Energy, Improving Quality of Life



The Centre for Advanced Electronics and Photovoltaic Engineering (CAEPE) has aligned with the **Target Priority Area Number 1 (Growth and Academic Excellence)** and **Number 2 (Research and Collaborations) of IIUI's Strategic Plan 2022-26; Its strategies, Interventions and KPIs.**

1- INTRODUCTION

BACKGROUND

The Centre for Advanced Electronics duly approved in the 76th meeting of university's Board of Governors was re-named as Centre for Advanced Electronics & Photovoltaic Engineering (CAEPE) in the 80th meeting of the same esteemed board in 2017. Islamic Development Bank (IsDB), KSA's back-to-back international grants paved the way to establish a fully functional state-of-the-art Centre in Pakistan.

VISION

To create knowledge, develop and invent in the emerging areas of electronics and energy technologies.

MISSION

To conduct advanced electronics & photovoltaic engineering research that produces:

- New Technologies
- Processes
- Systems that may provide new or significantly enhanced knowledge for direct benefit to economic opportunity in Pakistan

RESEARCH PORTFOLIO

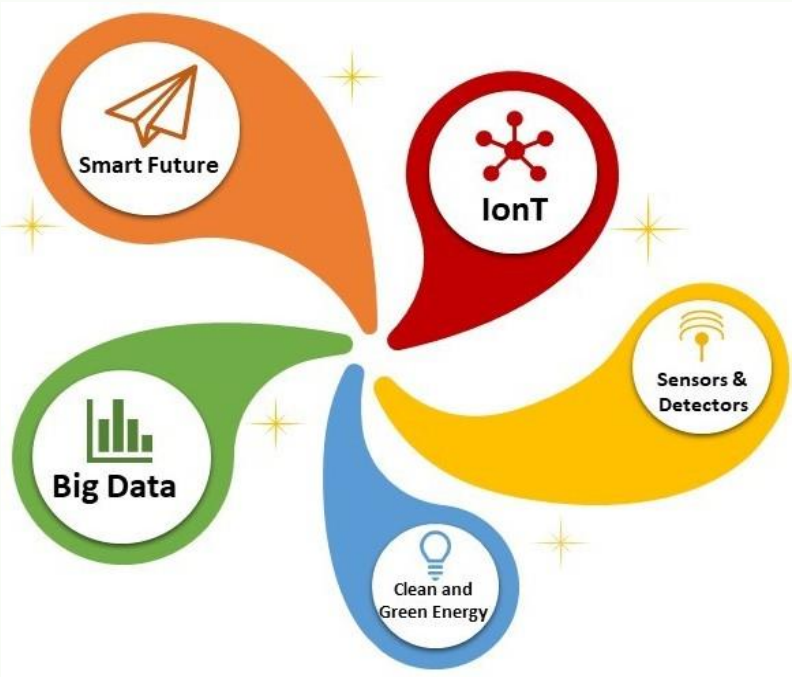
- Technology behind the Chip (Physical Layer Design)
- Semiconductor Fabrication
- Process Reliability
- Materials & Device Characterization
- Internet of Nano Things
- Power & Energy Electronics
- Photonics
- Novel Materials Devices, Circuits & Systems for Sensing, Detection, Communication & Computing

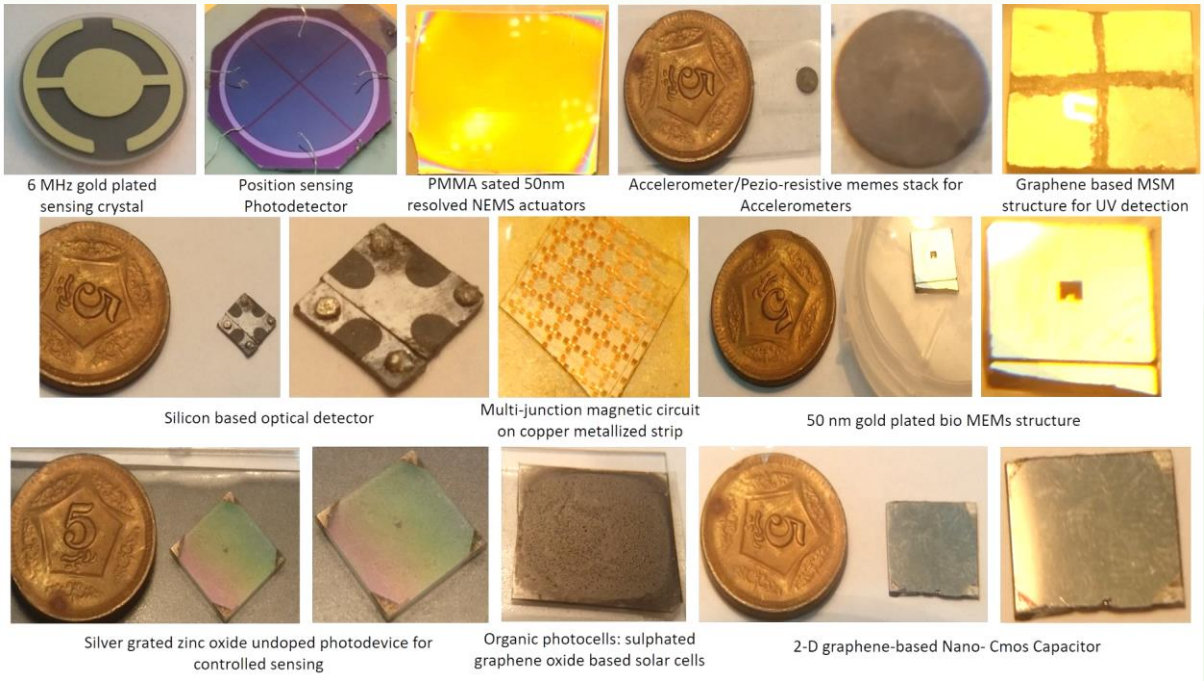
CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING

2- RESEARCH

Broader Application Areas

- Energy and Sustainability
- Semiconductors For Future
- Information and Communication Technologies for Future applications



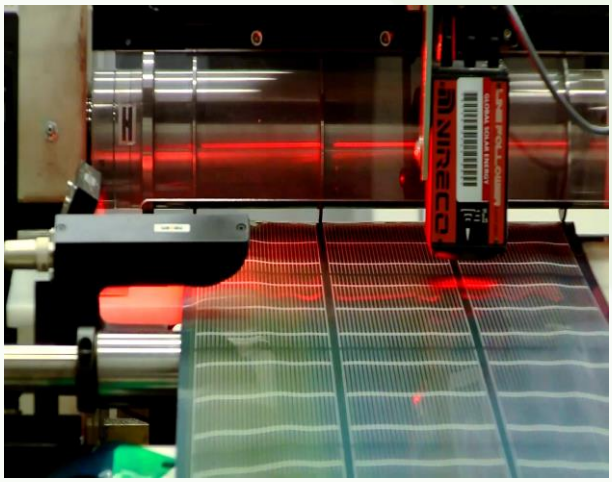


Prototypes & Fabrication of Devices in Various Research Projects

Energy and Sustainability

- Next-Generation Solar Cells & Power Devices
- Supercapacitors & Nano Harvesters
- Energy Storage Devices

Next-Generation Solar Cells & Power Devices



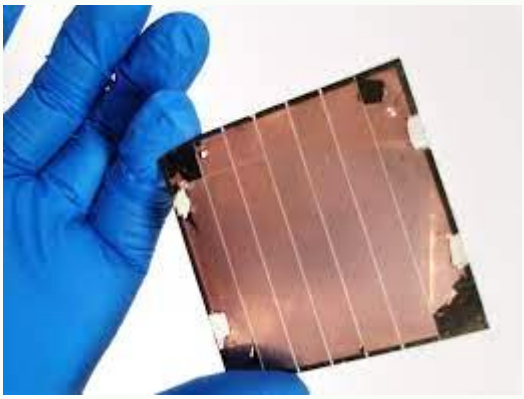
Solar cells have attracted much attention as a renewable energy source owing their unique properties and utility. The group focuses on all generations of solar cells starting from the conventional Silicon and II-VI based PVs but concentrates more on the development of next-generation solar cells, including thin film, dye-sensitized solar cells (DSSCs), organic/Perovskites, and quantum dot solar cells. Research is focused on selection of the materials system, design as well as fabrication process and characterization of next-generation solar cells..

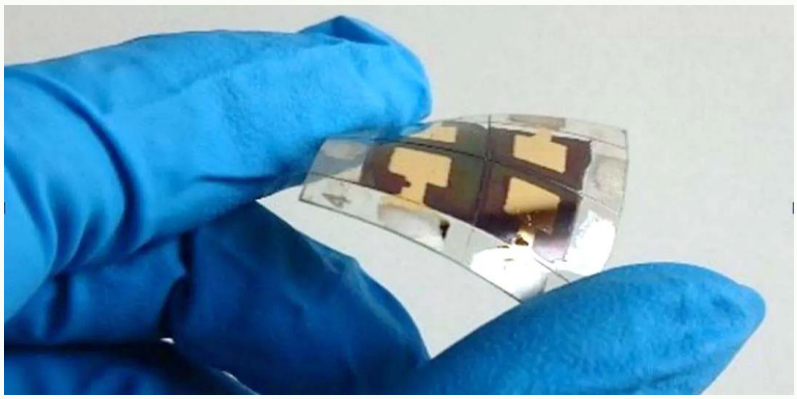
Power devices are the electronic devices that can be directly used in the power processing circuits to convert or control electric power such as MOSFET, Silicon Controlled Rectifier (SCR), DIAC and TRIAC. Major material used in power semiconductor devices is Silicon, III-V's and SiC.

Projects

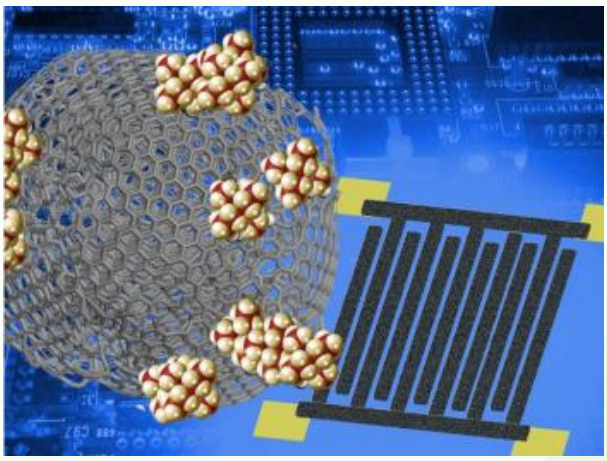
- Design, fabrication and characterization of solar cells based on doped perovskite materials
- Design, Fabrication and Evaluation of SiC based Passivating Contacts for Photovoltaic Solar cells
- Effect of Protons and Alpha particle Implantation on Solar Cells for Outer Space Applications
- Electrical and Optical Modelling of Bulk Heterojunction polymer solar cells.
- Capacitance Voltage process metrology of engineered ZnTe/CdTe based solar cells.
- Reliability of Device growth techniques for the Process optimization of CdZnTe Solar Cells.
- Design and Simulation of a HV SiC PIN Diode for high Power Application.
- Evaluation in design variants in Insulated Gate Bipolar Transistors (IGBT) for High Power Applications.
- Modeling and Simulation of Design Variants for the Development of Si-C Thyristors.
- Design of an energy efficient LDMOS with high breakdown voltage and low on resistance.
- High performance low noise amplifier design for wireless communication using GaN HEMT.
- Design, Fabrication and Evaluation of SiC based Passivating Contacts for Photovoltaic Solar cells

- Defect mapping for efficient fabrication of CdTe based Solar Cell.
- Device Simulations of Critical Parameters for the Thickness Optimization in Polymer-Fullerene based Organic Solar Cells.
- Dye-Sensitized Solar Cells.
- Design and Characterization of ZnCuSe structures for Next Generation Solar Cell Application.
- Design and modelling of 3rd generation polymer based organic solar cells.
- Effect of annealing dynamics of the Ion-Engineered ZnTe/CdTe based Solar Cell.
- Device modeling for the Efficiency enhancement of Cesium Lead Iodide Solar Cells.
- Modelling of Electron transport layer for mitigation of interface recombination for FAPb13 solar cells.
- Metal Contacts, Design and Engineering of 3C-SiC for High Power Devices





Supercapacitors & Nano Harvesters

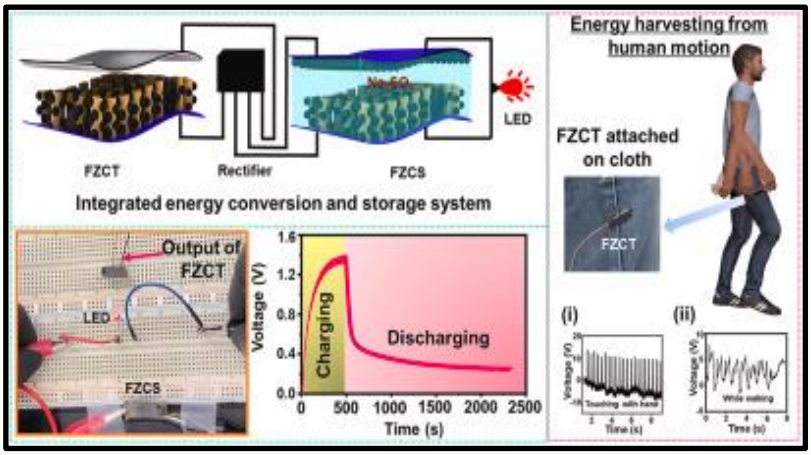


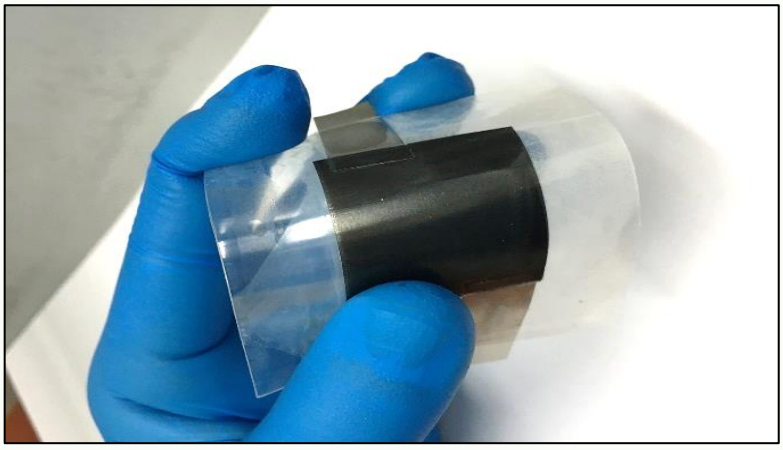
Power Supercapacitors are electrochemical devices that are well integrated with primary electricity generators in mobile systems powered by electric current. They are characterized by providing high electrical power for short periods (seconds), while the primary generators (batteries, fuel cells) are more suitable for supplying electric currents for long time and at constant load.

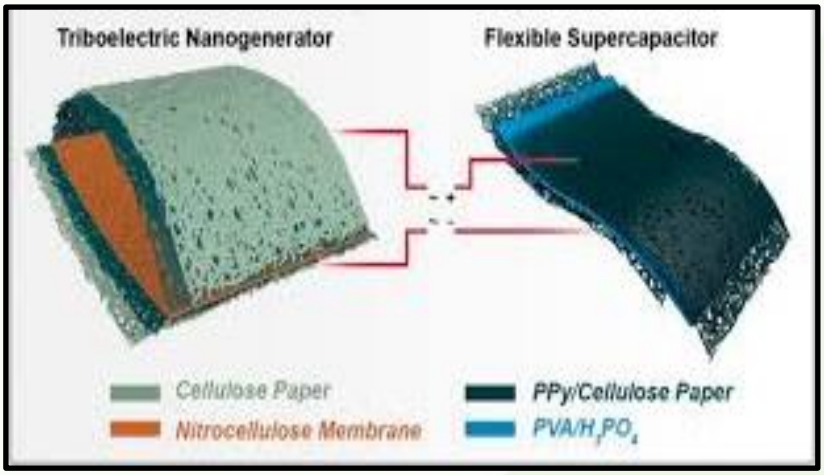
Projects

- Fabrication and Characterization of Hybrid Nano Generators for harvesting energy system applications
- Fabrication and Characterization of Hybrid Nano-generators using Bio-Materials
- Electrospun Polymeric Fibrous Mat Based Piezoelectric Nanogenerator
- Fabrication and characterization of Stretchable Super capacitor for Energy Systems Applications.
- Fabrication and Characterization of Graphene based Foldable Supercapacitor
- Super Capacitor Properties of Transistor Metal Oxide – Conducting Polymer – Graphene Ternary Nano Composites.

- Flag type nanogenerator for harvesting wind energy.
- Device modeling for the Efficiency enhancement of Cesium Lead Iodide Solar Cells.
- Development of MXenes based Electrodes for Flexible Energy Storage Applications







Semiconductors for Future

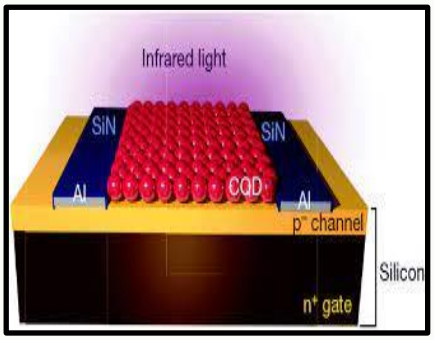
- Energy Efficient Nano Electronics
- Graphene Electronics
- III-V Device Engineering

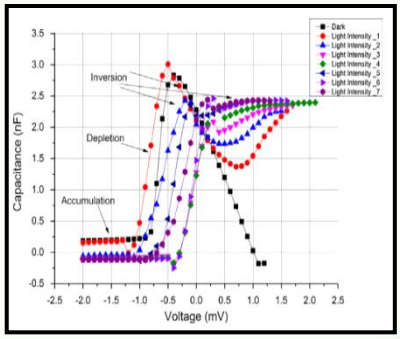
Energy Efficient Nano Electronics

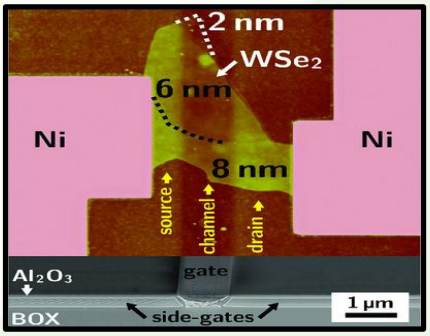
Unique nanoscale material and device properties provide opportunities to achieve improved performance and efficiency, and to enable new functionalities. The focus of nanoelectronics research has shifted from low-power switches for Boolean logic to emerging materials and devices for novel computing paradigms.

Projects

- Radiation-induced Engineering of ZnO Devices for Optoelectronic Integrated Circuit Applications
- Magnetron based copper oxide thin films for electro-optical devices
- Next Generation Energy Efficient process protocols in Si-CMOS Electronics.
- Design of Ultra-Thin Metal Layer for Cool MOS Electronics.
- Energy Efficient Contact Electronics in GaN for Variable Application.
- Analysis of High K dielectric for 14 nm technology node.
- Simulation, Formation and Characterization of TiN Samples for CMOS Process and Applications.
- Simulation and Characterization of Atomic layer deposited TiN for CMOS Processing and Applications.
- Effect of annealing dynamics of the Ion-Engineered ZnTe/CdTe based solar cell.
- Investigation of leakage parameters of HfSiO4 based MOS Capacitors for CMOS resistance.
- Comprehensive bias temperature instability (BTI) model with incorporated voltage, Temperature, frequency, and duty factor dependence for CMOS devices.
- Failure mode analysis of process, Voltage and temperature variations on several Fin-FET based SRAM sense amplifier.
- Characterization and Investigation of Functionalized MWCNTs based Polymer Nanocomposites.
- Investigation of Hardware Trojan induced by Hot Carrier Injection in MOS devices.

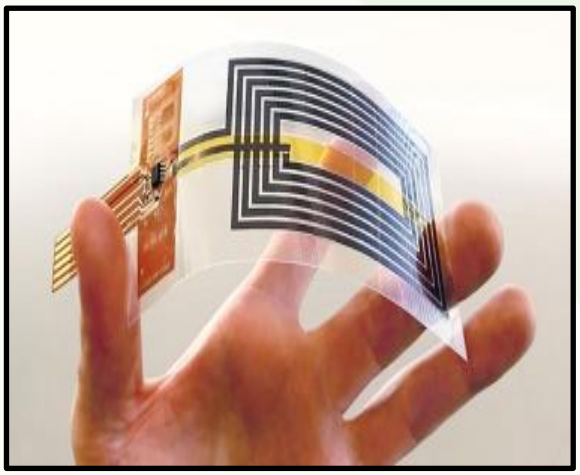






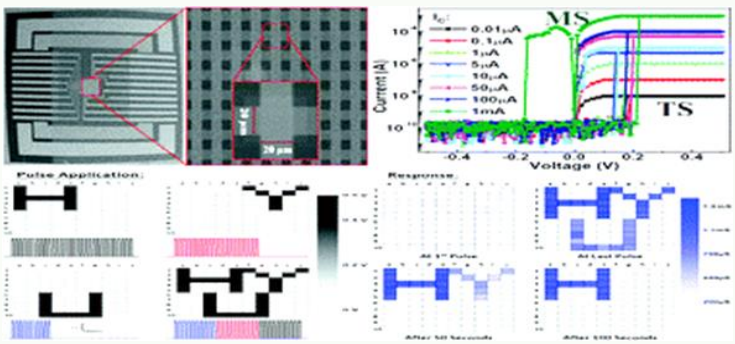
Graphene Electronics

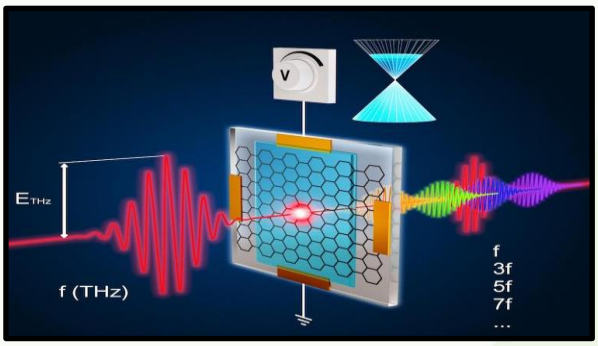
Graphene can be used as a coating to improve current touch screens for phones and tablets. It can also be used to make the circuitry for our computers, making them incredibly fast. Graphene has the potential to create the next generation of electronics currently limited to sci-fi., faster transistors; semiconductors; bendable phones and other electronics.

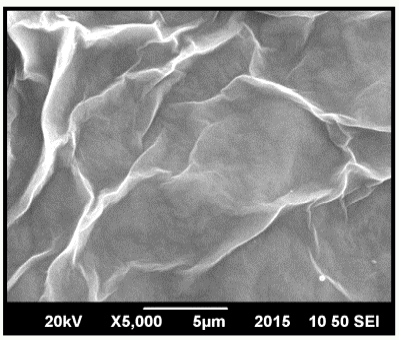


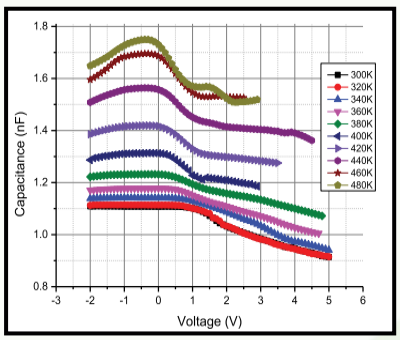
Projects

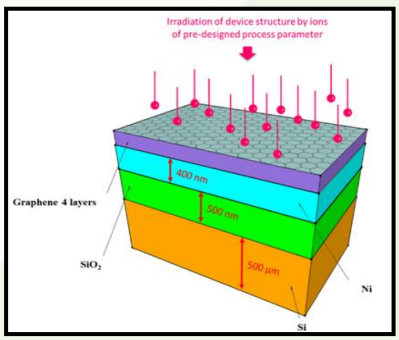
- Hyper Sensitive Electrical Characterization of 2D Graphene Transistor Matrix.
- SE Analysis of Novel Graphene Structures for Photonics.
- Fabrication and characterization of Graphene Induced Metal Semiconductor Metal (MSM) Structure for Detection and Sensing Applications.
- Implant-Engineering of 2D graphene MOS matrix.
- Simulation, Synthesis and Electrical characterization of multi-layer Graphene crystal for MOS transistor.
- Analysis and Characterization of multi-layer Graphene crystal for MOS transistors.
- Post fabrication device reliability analysis of Graphene based MOS Capacitors.
- Exploring the Avalanche behavior in Graphene-Based photodetectors.
- Spectroscopic Ellipsometry (SE) Analysis of Novel Graphene Structures for Photonics.
- Fabrication and Characterization of Graphene based Foldable Supercapacitor



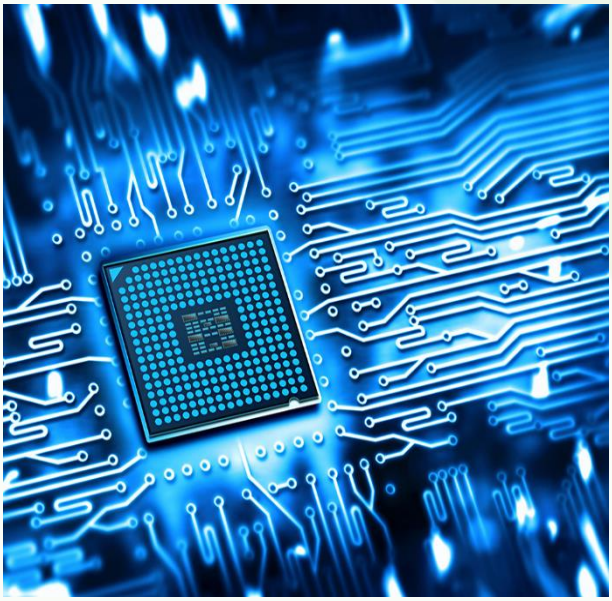








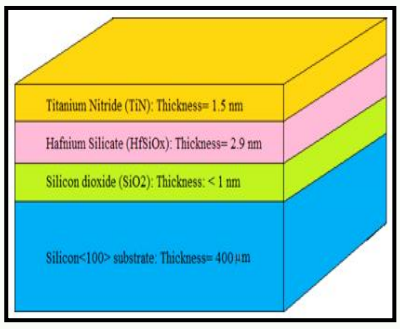
III-V Device Engineering

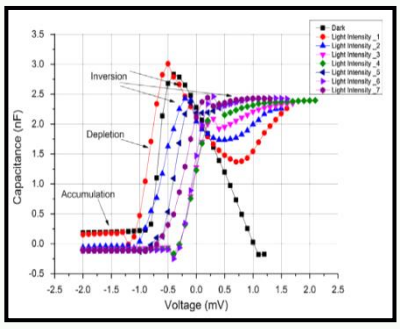


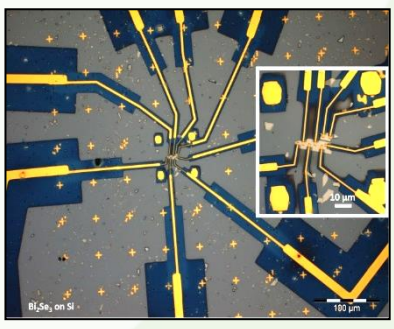
III–V semiconductors such as GaAs, InP, GaN, AlGaAs, InGaAsP etc. have wider applications in high-performance optoelectronics, microwave and millimeter-wave devices owing to their superior electronic properties including high electron mobility, direct band gap, and low exciton binding energy. The groups focuses on the III-V processing and device fabrication for diverse and versatile applications. Cleanroom device processing, ion implantation, test and validation of devices, and reliability studies are largely studied in various problems within this domain..

Projects

- Fabrication and characterization of Ion-Engineering III-V Matrix for photonic Integrated Circuits.
- Electrical Isolation of GaN devices for application in photonic integrated circuits.
- Effect of annealing dynamics on Ion engineered GaN devices for photonics applications.
- Investigation of metal contacts engineering of InGaAsp for optoelectronics devices.
- Shelf life of GaN based High Electron Mobility Transistor (HEMT) for high frequency Application.
- Optimization of AlGaN based HEMT in TCAD for high frequency applications.
- Electrical Isolation of III-V matrix for photonic Devices.
- Energy Efficient Contact Electronics in GaN for Variable Application.
- Electrical isolation of GaAs and InP devices for System on Chip (SoC) Applications.
- Investigation of metal contact Engineering of AlN for Deep UV Photonics Application





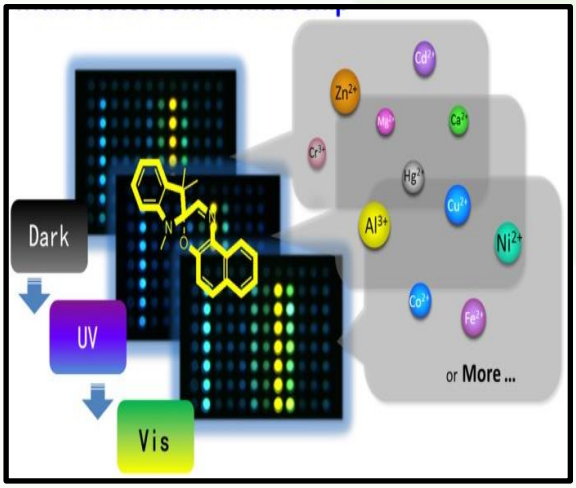


Information and Communication Technologies for Future Applications

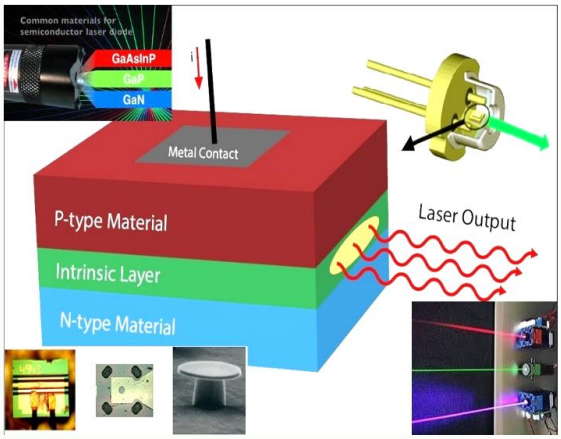
- Photonics
- Sensing & Detection
- Future Devices, Circuits & Systems

Photonics, Sensing & Detection

Photonics is increasingly used in diverse applications of sensing and detection including the motion sensors, photodetectors, chemical and biological sensing devices etc. The group focuses on Silicon, III-V and nano-scale materials/structures to fabricate such devices and provide process solutions addressing the problems in this area.



ZnO and other materials are focused in this research area for the fabrication of devices/output electronics for detection purposes. Various detection mechanisms are also understood by detailed evaluation and characterization methods utilized in these problems. Problems targeting the substrate/Platforms, photodiodes, detectors and MEMS based device architectures dedicated to UV applications are rigorously approached in a meaningful way to ascertain the appropriate technology readiness level.

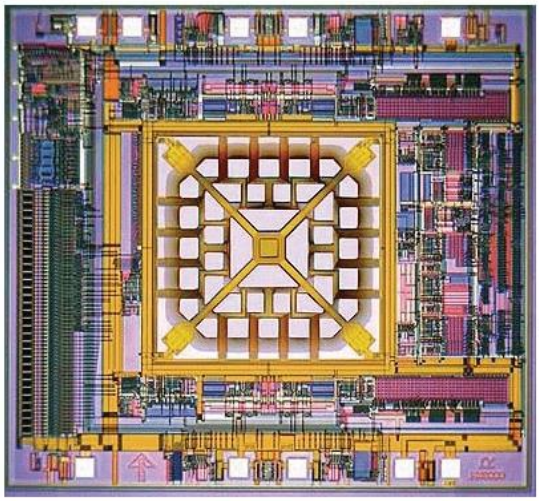


Projects

- InGaAsP based Metal-Semiconductor-Metal (MSM) structure for monolithic integration in photonic circuits
- A facile route to investigate the growth dynamics of AIN thin films over Si using state of the art DC/RF magnetron sputtering for UV sensing application
- PTAA Based Printed Organic Photo Detector Using IDEs
- Design and Characterization of Silicon Quadrant Detector for Robust Position Sensing.
- Design Optimization and Post-fabrication analysis of silicon differential diode for photonic applications.
- Investigation of metal contact Engineering of AlN for Deep UV Photonics Application
- Modelling of carrier multiplication layer of hetero junction avalanche photodiode.
- Device Engineering of AIN/Si based substrate Template for deep Ultraviolet Applications.
- ZnO Nano Wire Based Ultraviolet Detector.
- Advanced Electrical & Optical characterization of ZnO matrix for sensing applications.
- Effect of Ion Implantation on ZnO nano composites for photonic & detection applications.
- Fabrication and evaluation of contact electronics for undoped ZnO template
- Magnetron based copper oxide thin films for electro-optical devices
- Radiation-induced Engineering of ZnO Devices for Optoelectronic Integrated Circuit Application

- Development of intelligent/smart electronic nose system based on sensor array of temperature, humidity and CO entities
- Highly Sensitive Strain Sensor, based on ZnO Nano Fiber mat for Medical Applications
- Highly Sensitive Humidity Sensor based on ZnO and PVP Cross Linked Fiber Layered Structure
- Exploring the Avalanche behavior in Graphene-Based photodetectors

Future Devices, Circuits & Systems: Electrochromic NANO/CNTs, MEMS, Neuro-morphic Circuits, Nano sensors, RF Filters



Nanoscience and nanotechnology and their subfields, Nano photonics and Nano electronics had a tremendous impact on recent advances in sensing, imaging, and communication, with notable developments, including novel transistors and processor architectures.

Projects

- Development of intelligent/smart electronic nose system based on sensor array of temperature, humidity and CO entities
- Low-Power and solution-processed Resistive Switching device based on Cadmium Selenide Quantum Dots (CdSe QDs) for non-volatile memory applications
- Highly Sensitive Humidity Sensor based on ZnO and PVP Cross Linked Fiber Layered
- Structure
- Highly Sensitive Strain Sensor, based on ZnO Nano Fiber mat for Medical Applications
- Characterization and Investigation of Functionalized MWCNTs based Polymer Nanocomposites.
- Simulation and Characterization of defects of Au/Tu/SiO2/Si based devices for Chemical sensing applications.
- Design and analysis of chemical sensors for chemical warfare agents in MEMS design.
- Self-Healing strain Sensors.
- Design of Microstrip based RF switchable filter for S-band radar application.
- Fabrication of Silver nanowires based Self-Healing strain Sensors for wearable Electronics.
- All Printed Humidity Sensor Based on Methyl Red and PEDOT:PSS nano composite.
- Engineering of resistive switching memory devices for neuromorphic application using low temperature solution thin films

Key Publications (2020 to Date)

- Effect of Annealing Dynamics on the Ion-Engineered ZnTe/CdTe Solar Cells, Journal of Material Science: Materials in Electronics, **32,** 22143–22154 (2022).
- Analysis of Fractional Order Sliding Mode Control in a D-STATCOM Integrated Pow-er Distribution system, *IEEE Access*, **9**, 70337-70352, (2021).
- Defect mapping of active layer of CdTe solar cells using charge deep level transient spectroscopy (Q-DLTS), *Engineering Failure Analysis*, **119**, 104991, (2021).
- Energy management of a battery storage and D-STATCOM integrated power system using the fractional order sliding mode control – *Journal of Power and Energy Systems*, **7**, 996-1010, (2021).
- Design and Implementation of PV Fed Local UPS Inverter -*Pakistan Journal of Engineering and Technology*, **4**, 1-8 (2021).
- Selective Harmonics Elimination in Multilevel Inverter Using Bio-Inspired Intelligent Algorithms - *31st Australasian Universities Power Engineering Conference (AUPEC)*, 1-6, (2021).
- DQ Transformation Based Control of Single-Phase Grid-Tied Inverter 31st Australasian Universities Power Engineering Conference (AUPEC), 1-6, (2021).
- Modelling and Simulation of Design Variants for the Development of 4H-SiC Thyristors. *Silicon.* (2022): https://doi.org/10.1007/s12633-022-01766-9
- Flexible single-source precursors for solar light-harvesting applications. *In Sustainable Materials and Green Processing for Energy Conversion*, 279-304, 2022. [Book Chapter]
- Molecular engineering of ruthenium-based photosensitizers with superior photovoltaic performance in DSSCs: novel N-alkyl 2-phenylindole-based ancillary ligands. *New Journal of Chemistry*. (2022),
- **46**, 2739-2746.
- Investigation of Charge and Current Dynamics in PVA-KOH Gel Electrolyte Based Supercapacitor, Journal of Materials Science: Materials in Electronics, **33**, 2322–2335 (2022).
- Fluorene substituted thieno [3, 2-b] thiophene–a new electrochromic conjugated polymer. *Journal of Polymer Research*, **28**, 397, (2021).
- Thiophene-2, 5-diesters as electrochromic materials: The effect of ester groups on the device performance and stability. *Organic Electronics*, **96**, 106188 (2021).
- Fabrication of self-healing hybrid nanogenerators based on polyurethane and ZnO for harvesting wind energy. *Journal of Material Science: Materials in Electronics*. **33**, 3982–3993, (2022).
- Evolution of low-dimensional material-based field-effect transistors, *Nanoscale*, **13**, 5162-5186, (2021).
- Fabrication and characterization of graphene induced Metal Semiconductor Metal (MSM) structure for detection and sensing applications, *European Physical Journal-Applied Physics*, **93**, 10503, (2021).
- Carrier removal and transport in photonic integrated circuit ready InGaAsP/InP substrate: Electrical and transients of charges evaluation, *Materials Science in Semiconductor Processing*, **121**, 105384, (2021).
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- Fabrication of self-healing hybrid nanogenerators based on polyurethane and ZnO for harvesting wind energy, *J Mater Sci: Mater Electron*, **33**, 3982–3993(2022).
- Wide range and highly linear signal processed systematic humidity sensor array using Methylene Blue and Graphene composite, *Nature Scientific Reports*, **11**, 16665 (2021).
- Facile and low cost temperature compensated humidity sensor and signal conditioning system, *IEEE Sensors Journal*, **21**, 13, 14906-14914 (2021).
- Thiophene-2, 5-diesters as electrochromic materials: The effect of ester groups on the device performance and stability, *Organic Electronics*, **96,** 106188, (2021).

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- Numerical analysis guidelines for the design of efficient novel nip structures for perovskite solar cell, Solar Energy, Vol. 2017, 579-597, 2020.
- Performance investigation of Sb2Se3 based solar cell by device optimization, band offset engineering and Hole Transport Layer in SCAPS-1D, Current Applied Physics, Vol. 20, 973-981, 2020.
- Effect of fluoro-substituted acceptor-based ancillary ligands on the photocurrent and photovoltage in dye-sensitized solar cells, Solar Energy, Vol. 199, 74-81, 2020.
- Influence of device deposition techniques on the process optimization of CdZnTe thin-film matrix using charge-based analysis, Materials Science in Semiconductor Processing, Vol. 114, 105074, 2020.
- Electrical, charge transients and photo response study of as-deposited and phosphorus implanted Cdl-xZnxTe devices for PV applications, Radiation Physics and Chemistry, Vol. 166, 108498, 2020.
- The Coexistence of Threshold and Memory Switching Characteristics of ALD HfO2 Memristor Synaptic Arrays for Energy-Efficient Neuromorphic Computing, Nanoscale, Vol. 12, 14120-14134, 2020.
- Effects of Ag doping on compact TiO2 thin films synthesized via one-step sol–gel route and deposited by spin coating technique, Journal of Materials Science: Materials in Electronics, Vol. 31, 7172-7181, 2020.
- Fundamentals of metal halide perovskite nanomaterials: synthetic protocols, properties and their smart applications, Nanoscience, Vol. 1, 32-59, 2020.
- Diphenyl sulfone based multicolored cathodically coloring electrochromic materials with high contrast, Organic Electronic, Vol. 83, 105741, 2020.
- Inkjet printed self-healable strain sensor based on graphene and magnetic iron oxide nano-composite on engineered polyurethane substrate, Scientific reports, Vol. 10, 18234, 2020.
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- All printed organic humidity sensor based on egg albumin, Sensing and Bio-Sensing Research, Vol. 28, 100337, 2020
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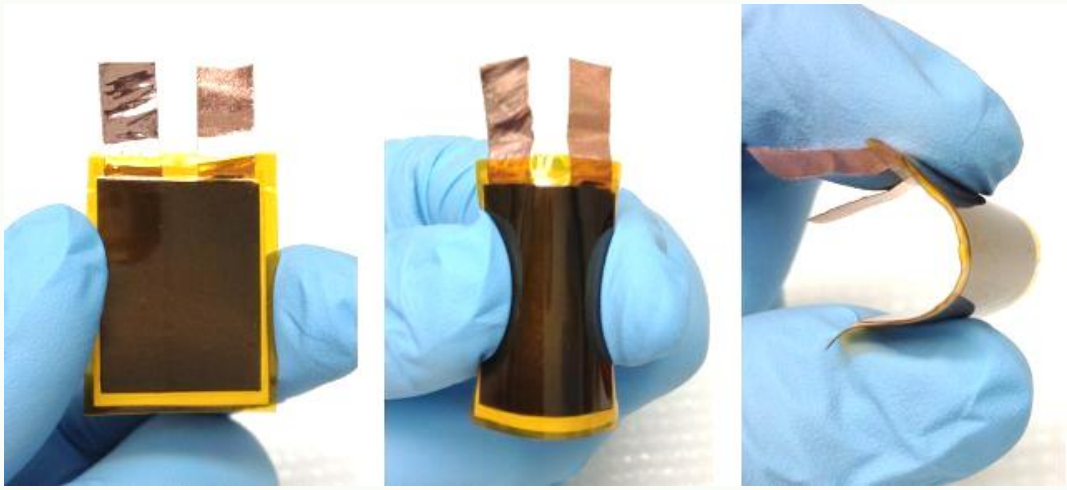
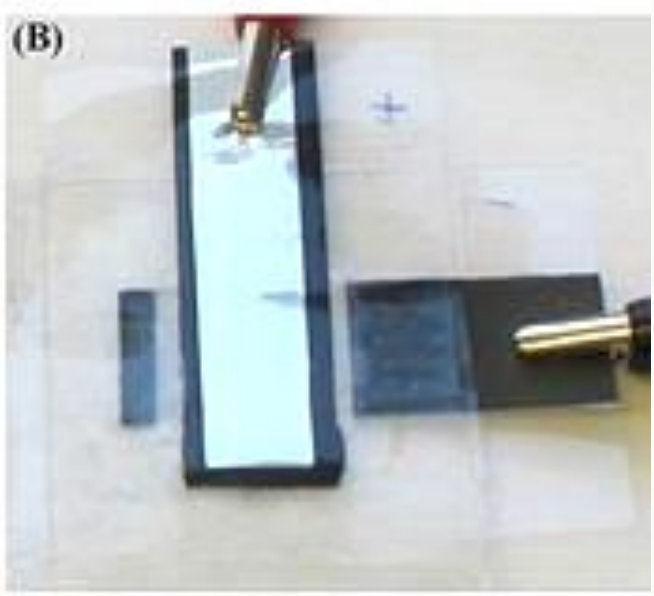
- Soft ionic liquid based resistive memory characteristics in a two terminal discrete polydimethylsiloxane cylindrical microchannel, Journal of Materials Chemistry, Vol. 8, 13368-13374, 2020.
- Highly bendable asymmetric resistive switching memory based on zinc oxide and magnetic iron oxide heterojunction, Journal of Materials Science: Materials in Electronics, Vol. 31, 1105, 2020.
- Solution-Processed Vertical Field-Effect Transistor with Separated Charge Generation and Charge Transport Layers for High-Performance Near-Infrared Photodetection, ACS Applied Electronic Materials, Vol. 12, 3871-3879, 2020.
- Enhanced Performance of Perovskite Single-Crystal Photodiodes by Epitaxial Hole Blocking Layer, Frontiers in Chemistry, Vol. 8, 791, 2020.
- Engineering Architecture of Quantum Dot-Based Light-Emitting Diode for High Device Performance with Double-Sided Emission Fabricated by Nonvacuum Technique, ACS Applied Electronic Materials, Vol. 2, 2383-2389, 2020.
- Interfacial Modification for Heightening the Interaction between PEDOT and substrate towards Enhanced Flexible Supercapacitor Performance, Chemical Engineering Journal, Vol. 379, 122326, 2020.
- Evaluation of defects and current kinetics for aging analysis of PEDOT: PSS based supercapacitors, Journal of Energy Storage, Vol. 28, 101243, 2020.
- Flexible Resistive Switching Memory with a Schottky Diode Function Based on a Zinc Oxide/Methylene Blue Heterojunction, Journal of Electronic Materials, Vol. 49, 4764-4772, 2020.
- Evaluation of defects and current kinetics for aging analysis of PEDOT: PSS based supercapacitors, Journal of Energy Storage, Vol. 28, 101243, 2020.

PATENT FILED IN 2021-22 (IIU, PAKISTAN)

- Methods of producing novel thiophene-2, 5-diester supercapacitive electrochromic materials for energy storage applications



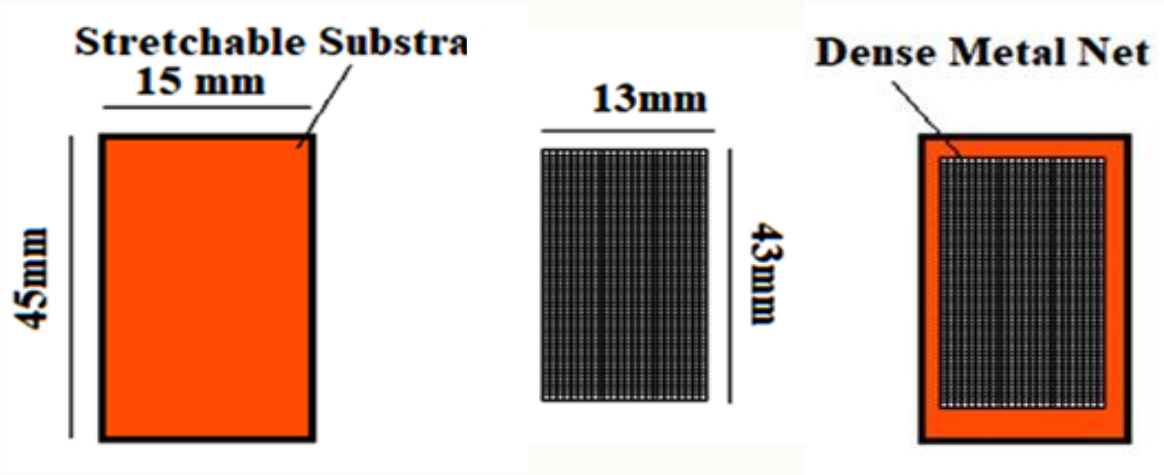
- Novel thienothiophene polymer and its synthesis method for electrochromic and flexible supercapacitor applications



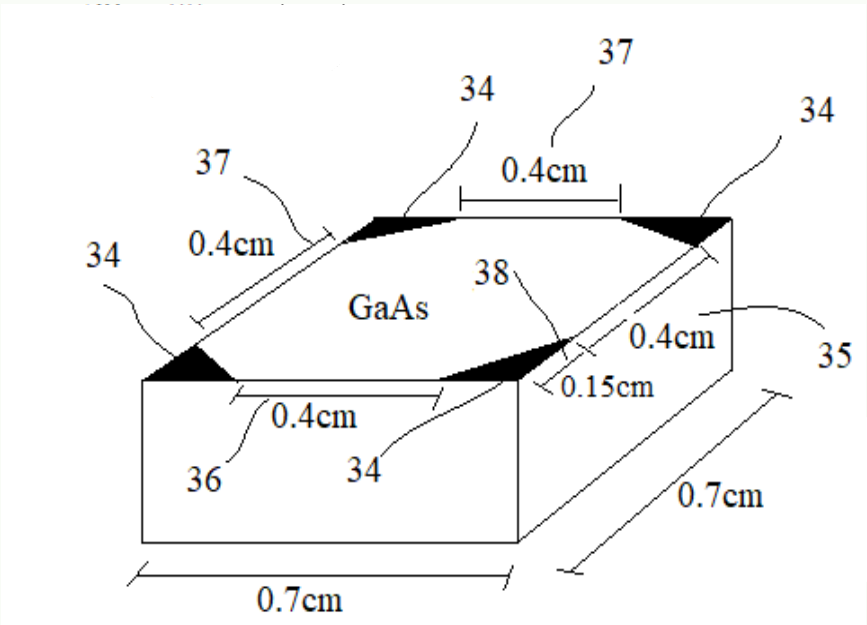
(Disclaimer: Inventions covered under Intellectual Property Rights)

PATENT FILED IN 2021-22 (IIU, PAKISTAN)

- A novel method for the performance evaluation of stretchable and foldable supercapacitor for energy storage application

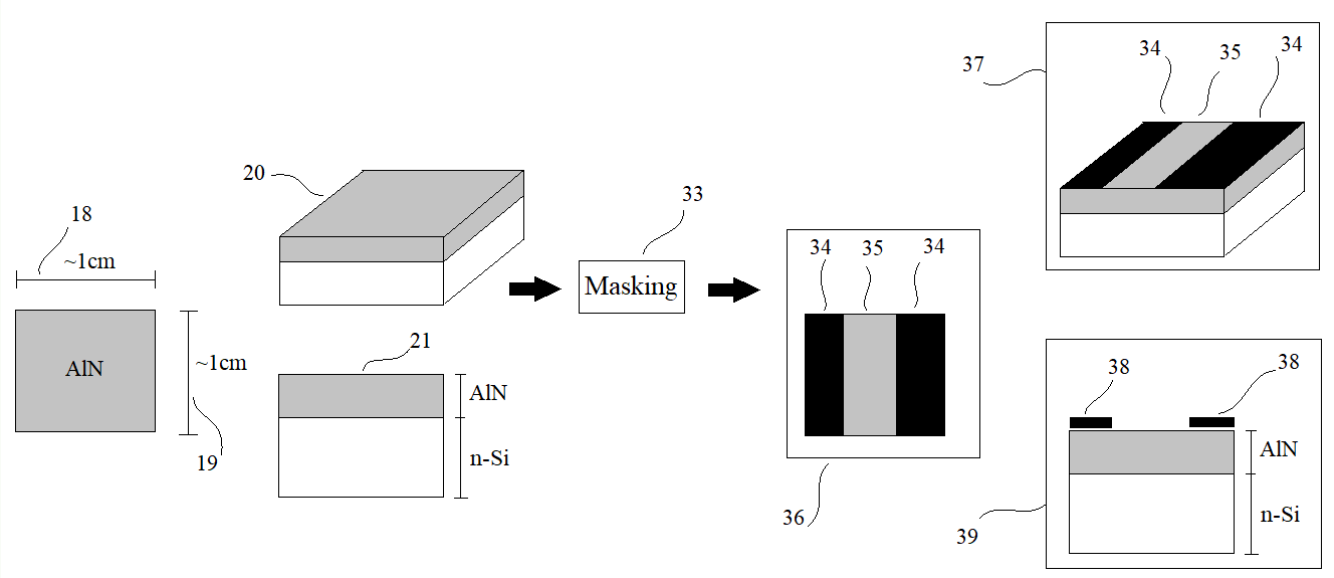


- An Electrical Isolation induced novel method for the fabrication of GaAs and InP based Photo Detectors



PATENT FILED IN 2021-22 (IIU, PAKISTAN)

- A Method to Sense the Low Energy Photons from Aluminum Nitride (AlN) Wide Bandgap Semiconductor for Photo-detection Applications



3- SERVICES

USAGE & TRAINING

The facility is an open access to IIU students and faculty as well as other universities and scientific organizations on a University's BOG approved Service Cost Model.

Entry into the Centre's facilities requires Safety Training through the Master Users. One should follow the General as well as Specialized Training Requirements to utilize the services. Other specific Health and Safety training may be required depending upon the machine to be used. Your technical contact will provide additional information as needed.

Individual equipment training is required and can be scheduled by contacting the appropriate technical or administrative staff for each facility.

Viable Experience; International & National Relevance

- About 14 Years of Device Design Experience on International Industrial Simulators/ Modeling Tools
- Connected to World-wide FABs
- About 8 years of rigorous Quality Assurance of Centre Process Characterization Tools
- Indigenous Machine Engineering
- Over 400 Nation-wide returning users on variety of projects since the formal inauguration of the facility
- Continuing ties with the strategic organization
- National and International Funded projects on the forefront of Advanced Electronics and Photovoltaic engineering, as part of Centre's portfolio

ACCESS

Access Support

CAEPE, being a leading user facility, has also access to the Epitaxial Growers, Ion Implantation Services, Fabs for Standard CMOS development, III-V Devices, MEMS/ Microsystems applications; with experience in taping out the chips and discrete devices.

CAEPE is also in collaboration with some of world's top of the line research groups and experimental facilities.

Access to the Centre Facilities

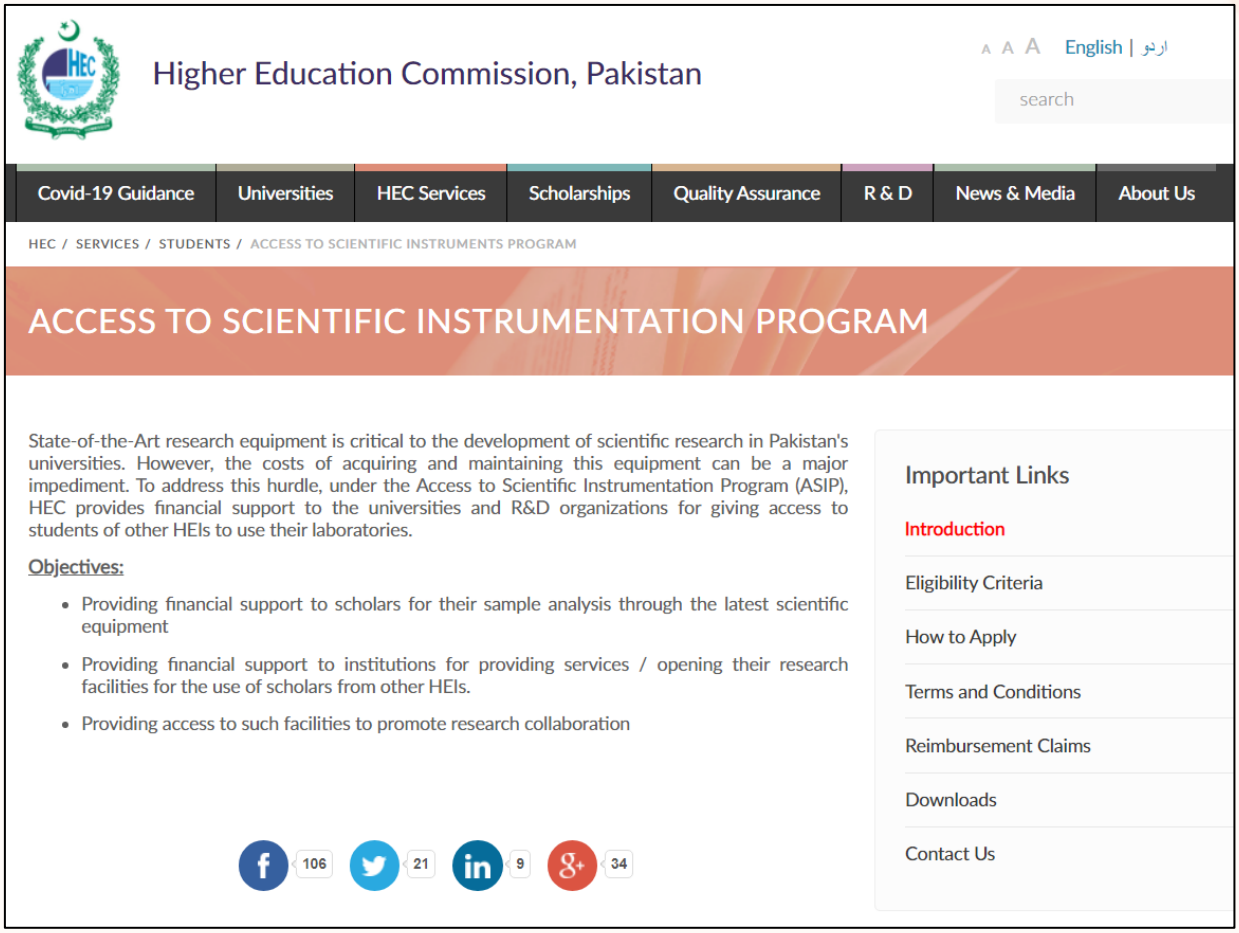
The Centre provides an open access to its facilities for all the users who wish to use its capabilities for their respective research. All the facilities are charged through the CAEPE Service Cost Model

https://www.iiu.edu.pk/caepe

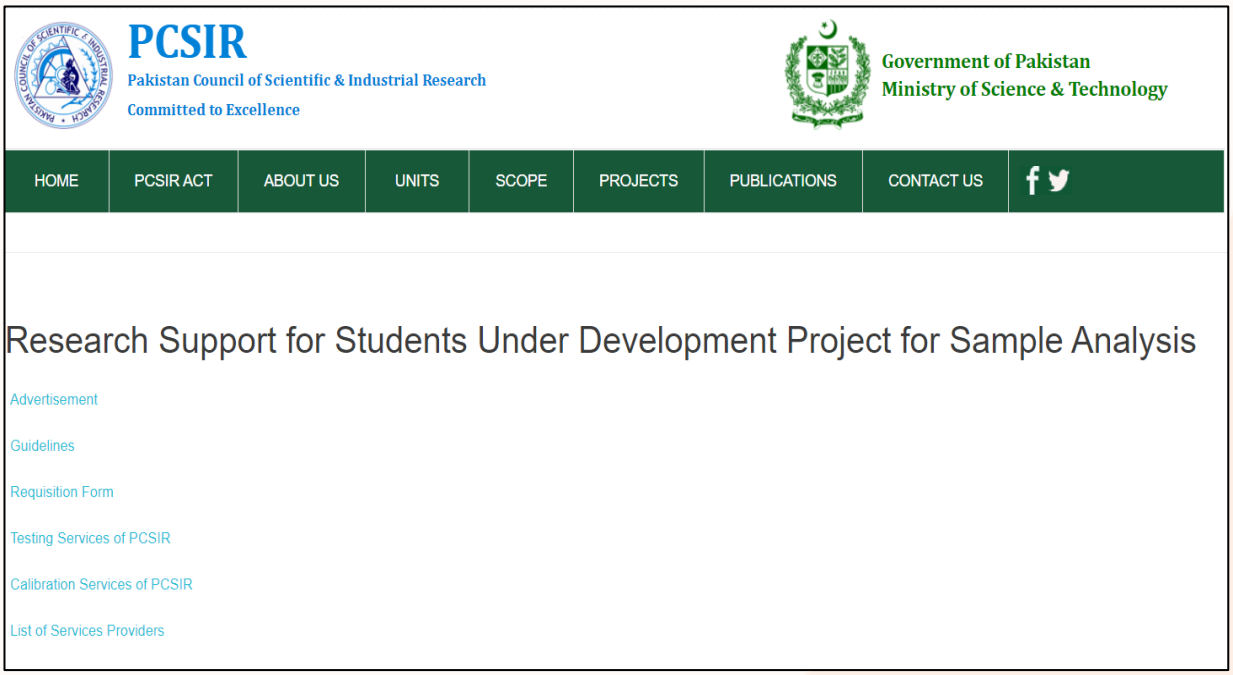
CAEPE is also part of the HEC "Access to Scientific Facilities" program and also part of the experimental repository of Pakistan

ACCESS

In order to provide wide users with the facilities that are available inhouse, CAEPE has became part of the HEC "Access to Scientific Instrumentation Program" and providing the access to the users outside the university as well



Apart from HEC ASIP portal CAEPE is also part of the "Research Support for Students Under Development Project for Sample Analysis program" started by Pakistan Council of Scientific and Industrial Research (PCSIR) in the year 2022.



Teaching and Training at the Centre

Current Academic Program

Centre is the custodian of Department of Electrical Engineering's MS/PhD program with strength in Advanced Electronics stream.

Facility Usage in Regular Teaching Hours

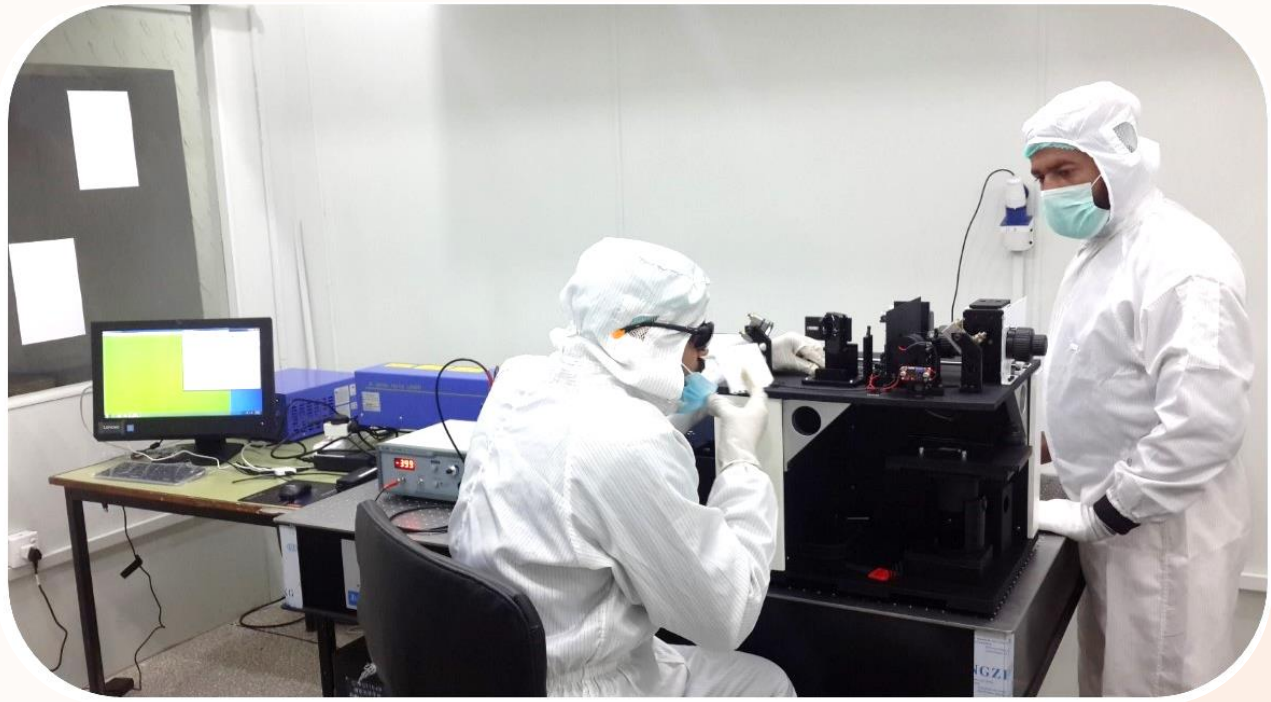
Undergraduate courses

- Microelectronics technology
- VLSI technology
- Optoelectronics
- Selected FYPs

Almost 100 undergraduate students, both from male and female sections of BS Electrical Engineering Program are being taught in the Centre for hand-on sessions in multiple courses.

Graduate (MS/PHD) Courses offered in the Centre

- Microelectronic Devices
- Microsystems Technology
- Optoelectronic Devices
- Microwave and Millimeter-wave Devices
- Advanced Computer Architecture
- Advanced VLSI Design
- Photonic Devices & Circuits



- MEMS and Micromachining
- Advanced Microelectronic Technology
- Advanced Semiconductor Devices
- Modeling and Simulation of Semiconductor Devices
- Photovoltaic Electronics
- Power Semiconductor Devices
- Photovoltaic Material system
- Analytical Methods in Nano-scale Electronics
- Micro fluidics and Lab-on-a-chip Systems
- Advanced Multiprocessor Systems
- VLSI Test Principle and Challenges
- Integrated Circuits (IC) Packaging
- Integrated Chip (IC) Manufacturing Technology
- Semiconductor Device Reliability
- Organic Electronics
- Smart Sensors Technology
- Infrared Detectors & Systems
- Energy Materials Design
- Advanced Thermoelectric Technology
- Special Topics in Nanoelectronics
- Advanced Nano-scale Photovoltaics
- Compound Semiconductor Device Processing
- Quantum Information Process Devices
- Computational Nano electronics
- Special Topics in Electronic Design Technology
- Special Topics in Micro and Nanosystem
- Special Topics in Optoelectronics and Photonics

Data Statistics

- A large number of students are getting trained, guided and supervised in the Centre since the very inception of the laboratories.

- Each project has an average tenure of almost 1 year and 2-3 years for MS and PhD research students, respectively, for experimental training and facility usage.

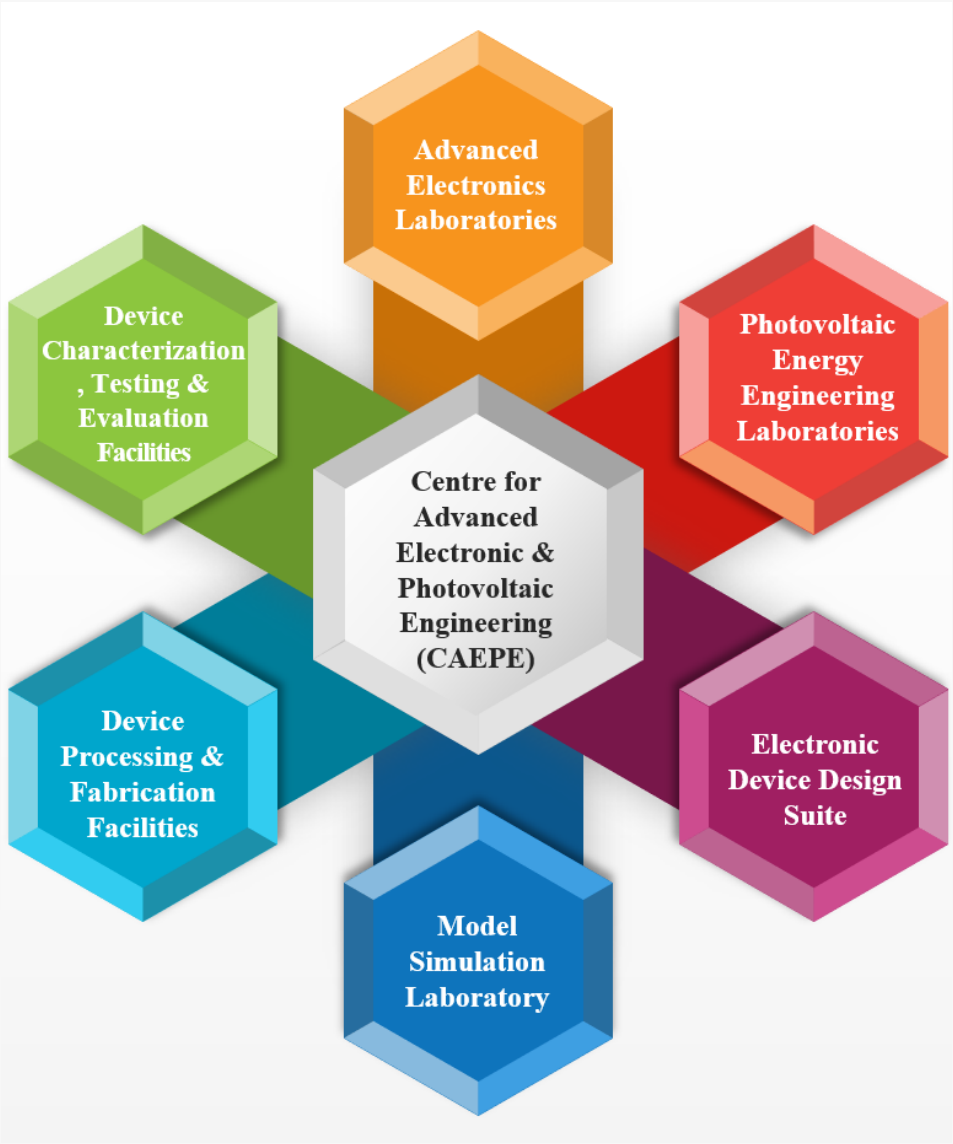
- Currently over 45+ students from graduate program alone from the Department of Electrical Engineering, are engaged with the Centre for taught courses and research access and supervision. Students and faculty members from other departments in the university and other organization are separately recorded with unique project's identification numbers.

Research Students Using the Centre's Facilities

4- FACILITIES

FACILITIES

The Centre is equipped with highly sophisticated design and experimental facilities divided into several laboratories:



- Advanced Electronics Laboratories
- Photovoltaic Energy Engineering Laboratories
- Electronic Device Design Suite
- Model Simulation Laboratory
- Device Processing & Fabrication Facilities
- Device Characterization, Testing & Evaluation Facilities

ELECTRONIC DEVICE DESIGN SUITE

This part of the Centre, incepted in year 2009, is focused to facilitate students and researchers to design and model VLSI/ULSI devices, circuits and systems. The "Design Suite" is equipped with state of the art, trade-off commercial design tools.

Device Modeling and Simulation explores scaling and process development of advanced electronic and photonic devices. These tools cover device transport and performance as well as process modules. These predictive tools help to provide physical insights into new devices, new physical phenomena arising from nano-size geometry, new materials and interfaces.

LAB MISSION

To provide research leadership in electronic design automation by utilizing design and test of advanced electronic circuits and systems.

RESEARCH PORTFOLIO

- Physical, circuit, System level designing and simulation capability
- Licensed Softwares with multifold capabilities to target both the 2D and 3D approach in devices and systems
- Process reliability and optimization techniques
- MEMS designing and evaluation
- Solar cells Simulations

Licensed Software	• Description
Silvaco TCAD	•Physical Layer designing and simulation software with capability to test and optimize the fabrication processes.
Cadence (Analog/Custom/digital IC design bundle)	•System and Circuit level designing and simulation software.
Soft MEMS (Mems Pro)	•To cater with the designing of the Micro-Electro mechanical systems where the systems have some form of moving part. Sensor and multiple detectors can be designed and simulated.
Mentor Graphics HEP	•IC Nanometer design; Design, Verification & Test; PCB Expedition.
IBM SRIM/TRIM and SUSPRE	•Ion Implantation simulations for electronically testing the impact of the different ion on to the sample/device. Mapping the damage and doping profile.
COMSOL	•With this software one can create physics-based models and simulation applications. This Model Builder enables you to combine multi-physics in any order for simulations of real-world phenomena. The Application Builder gives you the tools to build your own simulation application.

IsDB - FUNDED ADVANCED ELECTRONICS LABORATORIES

The primary objective of this crosscut facility is the development of metrology and characterization tools to support patterning, nano-engineered device processing and overall integrated circuit fabrication for variety of application areas.

The specific focus is on micro- and nano-engineered devices with unique properties that enable continuation of functional scaling, where existing technology tapers off, and supports a research environment and portfolio that explores critical nanometer scale semiconductor manufacturing, facilitating a world-class student resource and measurable value through novel materials, devices and Fab-less manufacturing options.

LAB MISSION

To apply interdisciplinary and bottom-up approaches that enable discovery of novel alternatives to complex Fab-less electronic device design and processes.

RESEARCH PORTFOLIO

- Process Reliability
- Materials & Device Characterization
- Internet of Nano Things
- Power Electronics
- Photonics
- Novel Materials Devices, Circuits & Systems for Sensing, Detection, Communication & Computing

Equipment	• Description
Multi-Head Probe Station	•For the characterizations of the systems that are larger in size and containing many different components placed on a single wafer. The system has highly precise probes that can be moved in micrometers through external control to either independently or cumulatively characterized.
Nano-Chip Reliability Grade Hall Effect System	•This is a initial electrical characterization system. The system has the capability to get the required electrical parameters such as mobility, conductivity, carrier concentration, etc.
ASMEC- Electro-Physical Characterization System	•This hyper sensitive system is the consortium of many different techniques with the capability to map the defect levels, Sensitive charge analysis, extremely low conductivity and mobility. The system is also equipped with the capability to lower and increase the temperature of the samples; that way real time efficiency of the devices can be extracted.
Metrology Grade Spectroscopic Ellipsometer	•For mapping the thickness and numerous other optical parameters such as refractive index, extinction coefficient, dielectric coefficient, etc. The machine shines a light on to a sample surface and based on the reflective data and sample model, the optical parameters are extracted.
Atomistic Layer Nanomaster Deposition System	•This system has the capability to deposit extremely thin layers in the regime of nanometers on to the sample surface. The system is the advanced version of the direct current heating system and has the capability to control the growth rate and the end thickness of the layer.
Rapid Thermal Processing (Annealing, Synthesis and RT-CVD System)	•Rapid thermal Processing or RTO is the annealing system with the capability to provide heat flux to the sample surface. The system can provide a constant temperature of maximum 1400^{o}C on to the sample and can achieve this high temperature within few seconds.
Impedance Spectroscopy System	•This system is used for BODE and Nyquist analysis of charge storage devices. The system has the frequency range of milli hertz to kilohertz.
MEMS Grade Spin Coating, Stirring and Baking	•This system is used for spin coating of different materials on the sample/device surface.
Fume Hood/Wet Bench/Dual Glovebox for Sample Preparation, Etching and Cleaning	•These systems are used for clean-environment-specific sample preparation, cleaning, dicing, cleaving and etching of the sample and devices.

IsDB- FUNDED PHOTOVOLTAIC ENERGY ENGINEERING LABORATORIES

The project is focused to cater the needs for development of the skilled human resource in the broader area of energy research with a special emphasis on PV engineering. The development of this laboratory in International Islamic University, Islamabad is university's first formal initiative to conduct teaching and research and produce trained manpower in this much desired area. In nutshell; the PV Engineering lab's project is targeted to:

- Capacity building of education and research in the PV engineering/energy sector in the country
- Producing high quality S&T manpower in the key areas of science and engineering of Photovoltaic technology

LAB MISSION

To study, research and propose solutions for:

- PV phenomena in semiconductors
- Solar cell focused Multi-junctions, nano-heterostructures, thin-film electronics
- Metrology and Characterization of solar cells and photovoltaic processes for subsequent fabrication and utility

RESEARCH PORTFOLIO

- Technology behind the Chip (Physical Layer Design)
- Photovoltaic Energy harvesting and Engineering
- Solar Cells
- Clean and Green energy
- Defect profiling and half life estimation of PV
- New materials and design for PV and fabrication processes
- Process window evaluation to optimize the performance benchmark
- Energy storage, battery and beyond

Equipment	• Description
Class 100 Clean room	•The facility is equipped with a class 100 cleanroom which is the first one in any educational Institution in Pakistan and is capable of facilitating the fabrication of Nano scale electronics and structures.
Class AAA Sun Simulator with complete diagnostics	•This system is capable of creating wavelength same as our sun so that we can test the solar cell inside the lab. The system is capable of accurately mapping the important parameters of the solar cells such as packing fraction and efficiency.
Plasma Enhanced Chemical Vapour Deposition System	•This system is used for the deposition of different layers through chemical reaction inside a closed chamber. The gases flow is controlled and the reaction potency is maintained for the growth of finer layers.
Magnetron Sputtering System	•This deposition system utilizes sputtering technique where the charged ions of the inert gas such as Argon are used to break the molecule of a material which are then transferred to the sample surface for the creation of a layer.
Scanning Electron Microscopy	•This system is used for the quantification of the sample surface and its composition. The system uses highly charged electrons to interact from the sample surface and gather information of the sample surface features. The system can see features as low as 5 nm.
Temperature Dependent Photo/Electro Luminescence Spectroscopy System	•This system is used for mapping the luminescence effect on the devices. The system uses laser of fixed wavelength to be illuminated on to the sample and the reflected data of light is passed through different analysis equipment to get the optical band gap and other important parameters.
EUV Lithography	•This system is used to transfer the pattern on to the sample/device surface. The system uses ultraviolet light to shine through a mask that is placed in-between the sample and the light source. The sample is quoted with a light sensitive material which changes its properties when exposed to the incoming light. With this system extremely small features in Nano meters in length can be made.

MODEL SIMULATION LABORATORY

The Lab is focused to simulate the model cleanroom assisted device design and process knowledge for the students by providing them with the licensed tools and audio-visual facilities. These tools are used to design and simulate the solid-state devices as well as system level computation for diverse application in Nano-electronics, Energy, Optoelectronics and Artificial Intelligence variables.

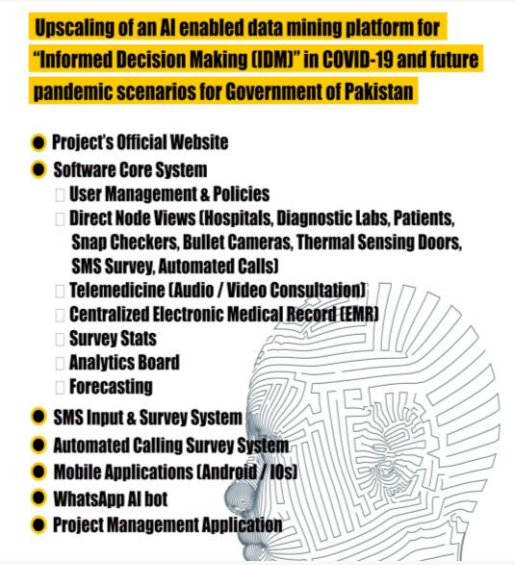
LAB MISSION

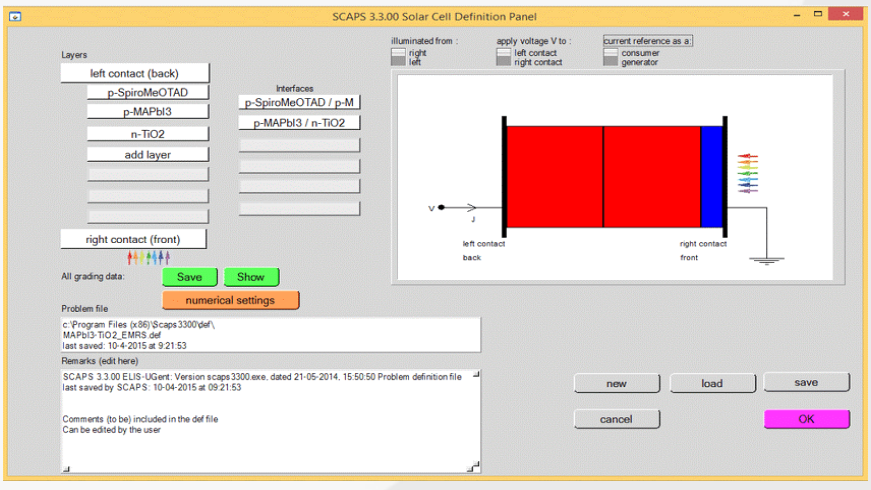
To develop a crosscut training facility as well as providing solution to big problems in design engineering, data analytics, A.I and sensors.

RESEARCH PORTFOLIO

- Technology behind the chip
- Optimization of Processes
- Numerical modelling of solar cells
- Simulation of Opto- and photonic devices
- A.I assisted computing for applications
- Big data analytics

Licensed Software	• Description
TCAD OMNI	•Physical Layer designing and simulation software with capability to test and optimize the fabrication processes.
AI Assisted Computational Test BED	• A Cloud based Multi Node Tele Health Framework Supported by AI & BIGDATA that can help us easily connect to "different data sources / nodes, which would help to decide the line of action on the basis of numbers, analytics and Trend-forecasting in COVID-19 and similar future pandemic scenarios.
SCAPS	•SCAPS (a Solar Cell Capacitance Simulator) is a one dimensional solar cell simulation programme capable of mapping different important parameters of the solar cell.





DEVICE PROCESSING & FABRICATION FACILITIES

The Lab has multiple systems that are capable of growing different thin and thick layers, films, device components etc. The processes are designed in such a way that several types of devices can be fabricated. The lab also comprises of the tools that can quantify the process outcomes and provide important information about the fabrication process efficiency.

LAB MISSION

To facilitate the need of in-house growth and fabrication of the devices and systems with optimum accuracy and efficient throughput

RESEARCH PORTFOLIO

- Starting wafer growth
- Physical and Chemical deposition
- Process quantification and verification
- Printable, wearable and casted circuits and devices
- Smart Sensors

Equipment	• Description
CZ Crystal Grower System with Vacuum Chamber for Oxide Single Crystals	•This system is used to make the starting wafers of Silicon for subsequent device manufacturing. The system can be tuned to get the desired doping and mobility ranges in the wafer. (Under procurement)
1200°C Quartz Tube Furnace (2" O.D) with Glove Box Purification System	• The system is capable of providing calculated heat flux to the system with in few second to alter the structural morphology of the device. The system can be used to provide Oxidation and Nitridation to the sample surface.
Electrospinning & Electrosparying Unit for Nano-Materials	•This system is used for the growth of very fine Nano fibers and sacrificial layers. The system is fully automated while using fine control of voltage, spraying angle and delivery amount. One can laydown very fine pattern on to the device surface.
Multi-function Film Coater with Turbo Pump: Thermal Evaporating + Carbon Coating + Plasma Sputtering	•This system uses all the profound physical growth techniques to grow the layers specific to your requirement. The system can chose between different growth strategy to get the optimum results.
Compact Precision Screen Printing Film Coater	•The machine is used to develop and print circuits and systems on to a varity of substrates and surfaces with precise accuracy and low latency.
DC/RF Dual-Head High Vacuum Magnetron Plasma Sputtering Coater with Film Thickness Tracking System	•This system uses both RF and DC techniques to sputter and grow layer on the device surface. This way the process acceptance of the machine is increased and the machine can grow almost all type of films.
PECVD Split Tube Furnace	•The system is capable of chemically grow multiple layer in a single machine operation cycle and can grow different material layers by CVD process. The system has 4 channel gas mixture and can provide low pressure environment for better operation.
Long Tape Casting Coater	•This system is used to laydown the layers of different material on to the long sheets and substrates. The system is profoundly used in the fabrication of solar cells and Super Capacitors.

DEVICE CHARACTERIZATION, TESTING & EVALUATION FACILITIES

The lab is equipped with the facilities and techniques that can characterize devices that are fabricated in-house. The lab has many diverse systems, targeting different paradigm of research. The lab can characterize solid state devices, sensors, detectors, solar cells, and printed circuits. This crosscut facility has some of the most latest systems that are essential for analysis at material, device and system level.

LAB MISSION

To provide analysis, diagnostics and characterization of Nano structure, films, features, devices, material and systems.

RESEARCH PORTFOLIO

- Magnetic measurements
- Material Composition and planes
- Structural analysis and surface profiling
- Ultra low current measurements
- Optical measurements

Equipment	• Description
Femto/Pico ampare meter	•This system is used for ultra low current measurement. The usage of this machine is profound and important when one is working with hyper sensitive electronics.
Film/Coating Thickness Profilometer	•This system uses stylus to move over a surface to profile the roughness, different small pattern that are grown on to the sample surface. The system is of keen interest for the researchers that are working in MEMS, NEMS and Nano structures.
Precision Grinding / Polishing Machine	•This system is used to cure the surface of the device to remove any dupree or any residual from the previous processes. This way the next process preformed on the device will not be hindered.
X-Ray Diffraction	•The system uses X-rays to scan the sample/device to find its composition, its planes and vectors. The system is actively used by material scientists, engineers, biologist and Chemist to examine their samples structures and crystallography.
Atomic Force Microscope & Scanning Probe System	•This system is used to see the atomic structures, bonding and roughness. The system can clearly map the layout of the devices at atomic level.
Vibrating Sample Magnetometer	•This system uses magnets to map the effect of magnetism on to the sample working and characteristics. The system can cool the sample down to liquid nitrogen temperatures and see its output from device perspective.

5- COVERAGE

Research Strength

- Technology behind the Chip (Physical Layer Design)
- Semiconductor Fabrication
- Process Reliability
- Materials & Device Characterization
- Internet of Nano Things
- Power & Energy Electronics
- Photonics
- Novel Materials Devices, Circuits & Systems for Sensing, Detection, Communication & Computing

Impact Quantification

Impact Parameters	Quantum
Extent of Utility and Access	>430 scientific projects
Engagement of Returning Users	70%
Knowledge Creation & Dissemination in Process	>260 projects
Continual Skill Development	>4100 Runs
Responsiveness (Qualified Manpower Creation with Terminal Degrees in Dedicated Specialization; Collaborative Connections; Joint International Projects)	Manifold Increase on Yearly Basis

Sr. #	Content	No. of projects
1	Total number of the projects/users	430+
	No. of student trained by the lab staff including BS Level Trainings on Design Suite	
2	Training Level - 1 (4 to 6 weeks)	220+
3	Training Level - 2 (Extensive Machine Training)	130+
4	No. of the department of Electrical Engineering (DEE), Faculty of Engineering & Technology (FET) students (MS/PhD) associated with the Centre (CAEPE)	45+
5	No. of Q.A Sessions on the machine	2000+
6	No. of International Training conducted of the lab staff	4
7	No. of National training conducted of the lab Staff	8

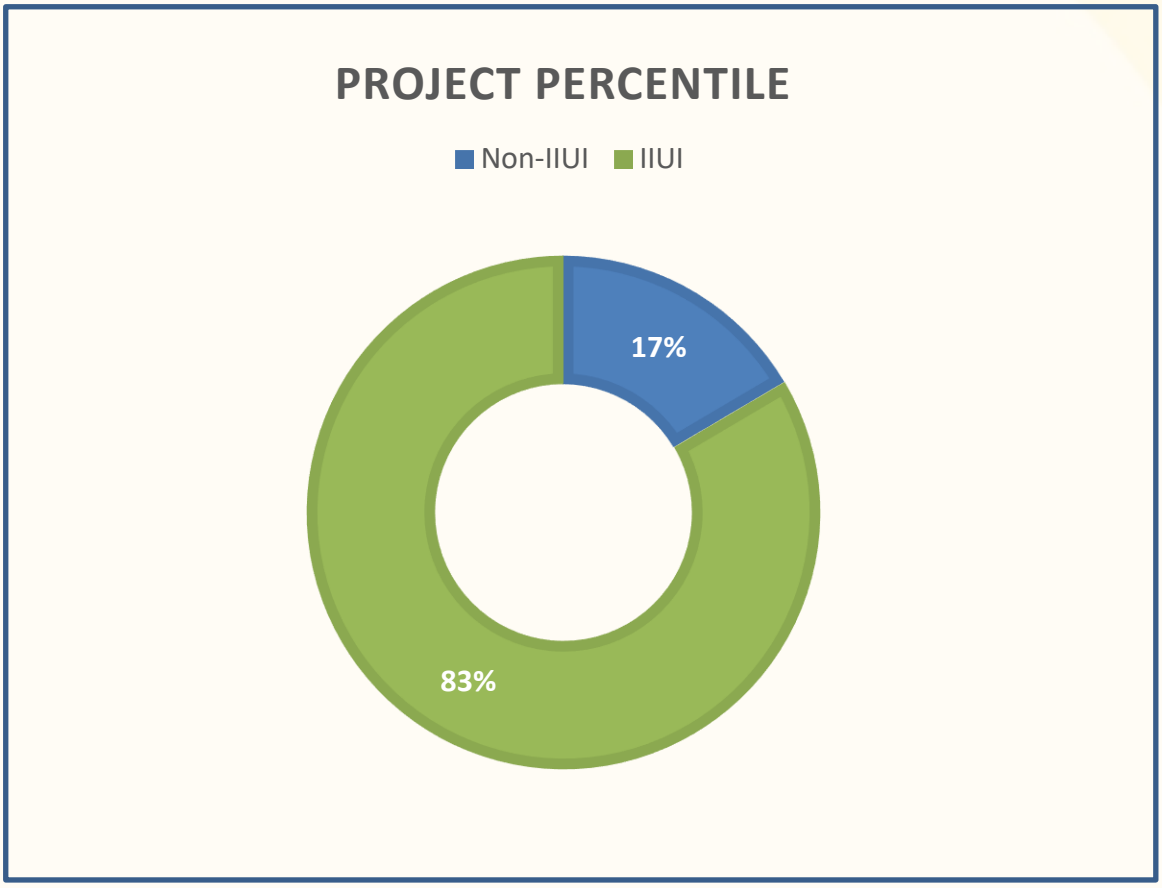
Programs & Projects

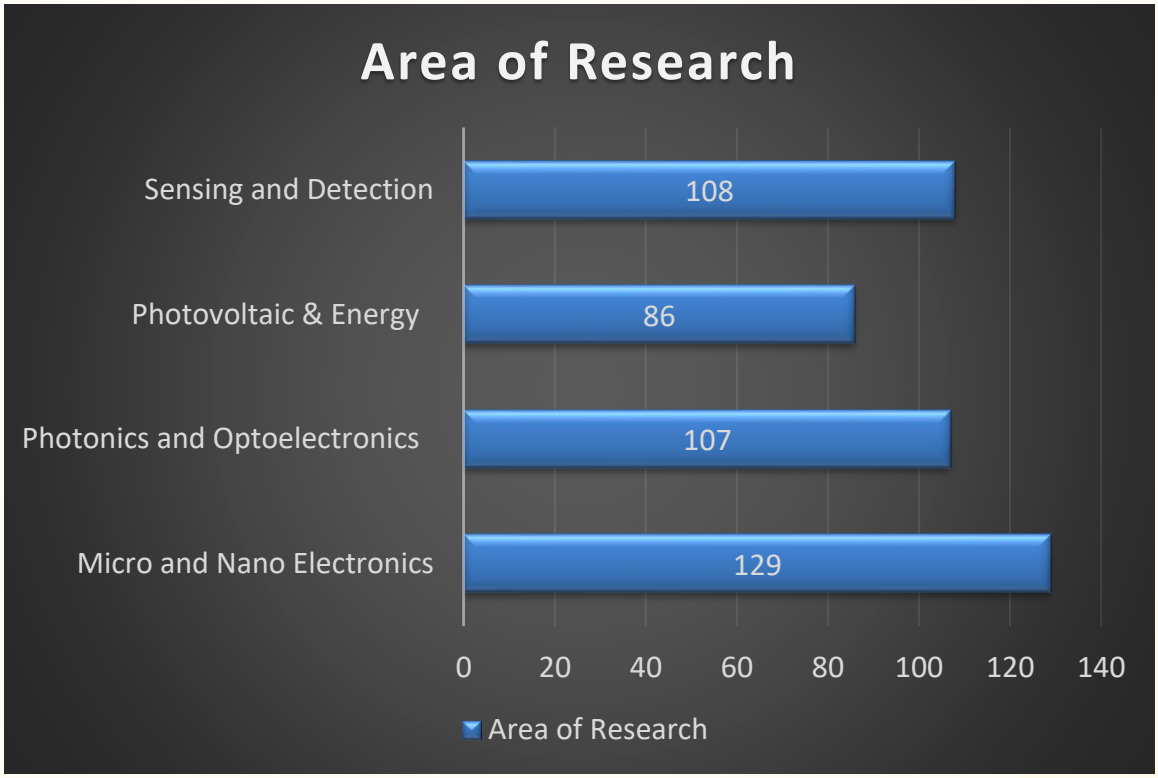
User's Spread within the Scientific disciplines

- Electrical and Electronic Engineering
- Physics/Nanotechnology
- Mechanical Engineering/Engineering Science/Materials Engineering
- Chemical & Process Engineering/Environmental Processes/ Civil Engineering
- Biomedical Engineering/ Bio Physics & Technology

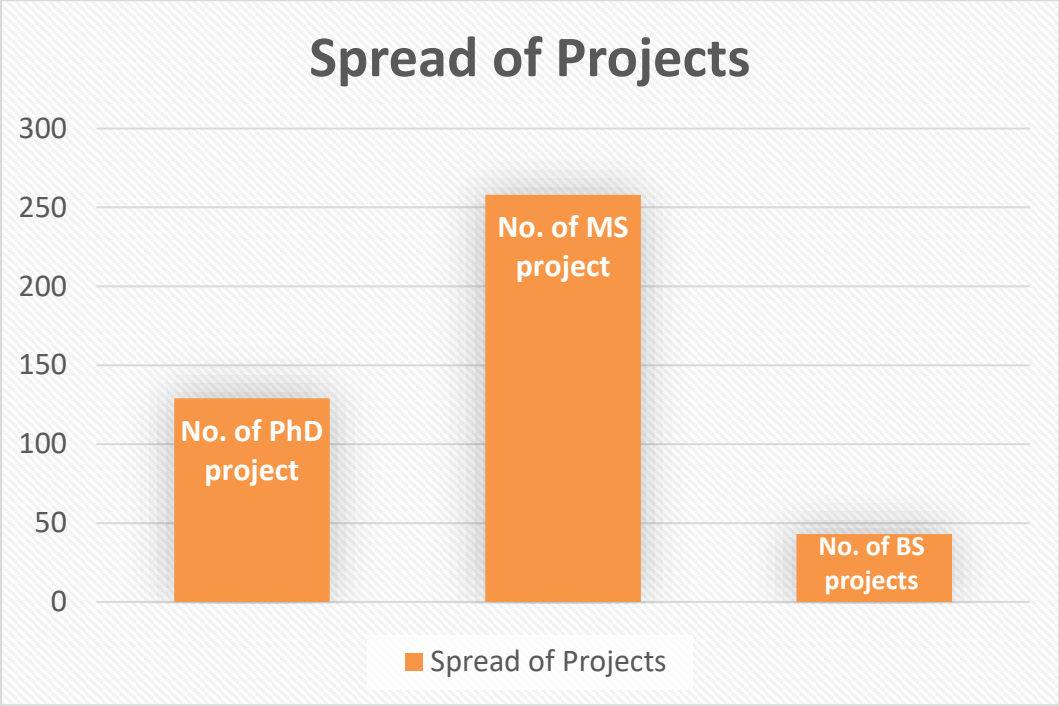
Some of the frequent users of the Centre's facilities having **multiple and diverse** scientific projects are listed below:

	SOME OF THE FREQUENT USERS
▪	Department of Electrical Engineering (International Islamic University, Islamabad)
▪	Department of Mechanical Engineering (International Islamic University, Islamabad)
▪	Department of Civil Engineering (International Islamic University, Islamabad)
▪	Department of Physics (International Islamic University, Islamabad)
▪	Department of Environment Sciences (International Islamic University, Islamabad)
▪	Department of Bio-Technology (International Islamic University, Islamabad)
▪	Sulaiman Bin Abdullah Aba Al-Khail – Centre for Interdisciplinary Research in Basic Science (SA-CIRBS) (International Islamic University, Islamabad)
▪	Bahria University, Islamabad
▪	School of Chemical & Material Engineering (NUST)
▪	College of Electrical and Mechanical Engineering (NUST)
▪	U.S Pakistan Center for Advanced Studies in Energy (NUST)
▪	COMSATS Institute of Information Technology, Islamabad
▪	COMSATS Institute of Information Technology, Abbottabad
▪	Gomal University, D.I Khan
▪	National Institute Of Lasers & Optronics (NILOP)
▪	The National Engineering and Scientific Commission (NESCOM)
▪	Riphah University, Islamabad
▪	The Islamia University of Bahawalpur
▪	Ummal - Qura university Makkah, KSA
▪	Federal Urdu University of Arts, Science & Technology, Karachi
▪	Mirpur University of Science and Technology
▪	University of Kotli, AJK
▪	Abdul Wali Khan University, Mardan
▪	Ghulam Ishaq Khan Institute (GIKI, Topi)
▪	National University of Computer and Emerging Sciences (FAST)
▪	Quaid-i-Azam University
▪	Allama Iqbal Open University
▪	Sardar Bahadur Khan Womens University
▪	University of Engineering and Technology (UET, Taxila)
▪	National University of Technology (NUTECH)
▪	Fatima Jinnah Women University, Rawalpindi
▪	National Center of Excellence in Physical Chemistry, University of Peshawar
▪	Pir Mehr Ali Shah Arid Agriculture, University Rawalpindi

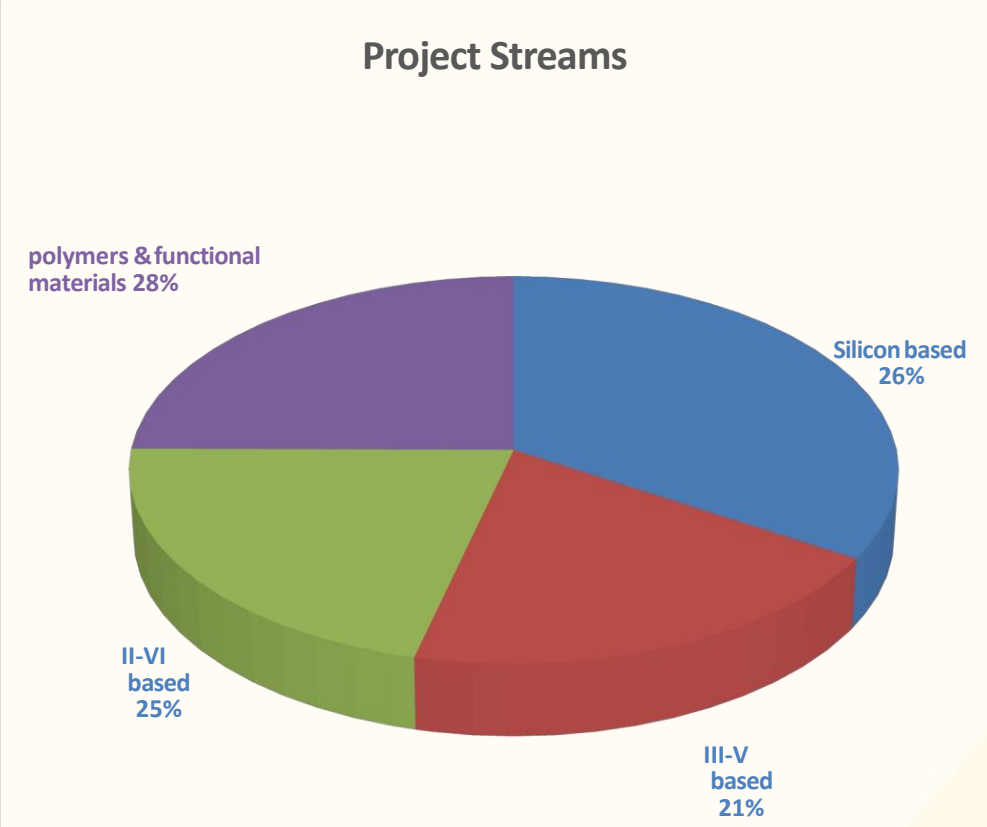




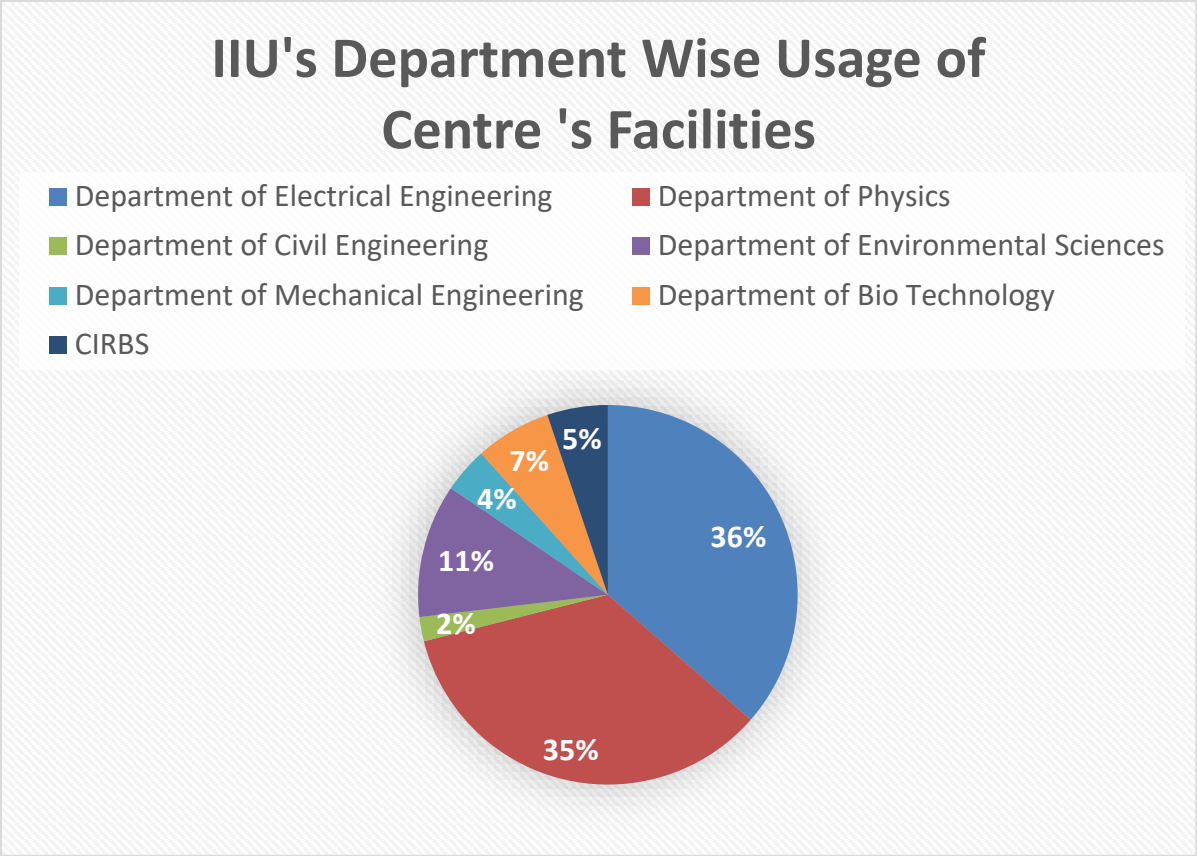
Spread of Research Activities: Theme Proportion



Proportion of Student - wise Usage of Facilities



Electrical & Optical Materials – Wise Usage of Centre's Facilities


IIU's Department Wise Usage of Centre 's Facilities
Department of Electrical Engineering
Department of Physics
Department of Civil Engineering
Department of Environmental Sciences
Department of Mechanical Engineering
Department of Bio Technology
CIRBS
36%
35%
2%
11%
4%
7%
5%

TEAM AND COLLABORATION

- **Prof. Dr. Ahmed Shuja Syed**
  Vice President (R & E), IIUI/Founding Executive Director CAEPE
- **Dr. Gul Hassan**
  Assistant Professor/ Cleanroom Manager
- **Dr. Erum Jamil (Till March 2022)**
  Assistant Professor/Incharge Department of Electrical Engineering (Focal point: Female students)
- **Dr. Saba Ashraf**
  Post Doctorate Research Associate ICRG project
- **Engr. Shoaib Alam**
  Research Associate/Laboratories Manager
- **Engr. Muhammad Ali**
  Research Associate/Research Liaison Manager
- **Engr. Faraz Qayyum**
  Lab Engineer/I.T & Networking Manager (Focal Point: Device Design Suite)
- **Mr. Shah Fahad**
  Research Assistant ICRG Project
- **Engr. Yousra Abid**
  PHD Student Research ship ICRG Project
- **Engr. Fakhra Farid**
  MS Student Research ship ICRG Project
- **Engr. Fatima Sajid**
  MS Student Research ship ICRG Project
- **Mr. Shoaib Waqas**
  Lab Technician
- **Engr. Majid Khattak**
  Lab Technician

CAEPE AFFLIATES

- Dr. Imran Murtaza (IIUI)
- Dr. Muhammad Sohail (IIUI)
- Dr. Yousaf Hameed Khattak (FUUAST)
- Dr. Faisal Baig (FUUAST)
- Dr. Zeeshan Najam (MNS UET)

Some of the Team Members at CAEPE

CURRENT INTERNATIONAL COLLABORATIONS

- **Peking University Shenzhen Graduate School, China** (Focal Point: Prof. Ahmed Shuja Syed & Dr. Imran Murtaza)
- **Joint International Research Laboratory of Information Display and Visualization, Southeast University, Nanjing, China** (Focal Point: Prof. Ahmed Shuja Syed)
- **James Watt School of Engineering, Glasgow University, UK** (Focal Point: Prof. Ahmed Shuja Syed)
- **North Carolina State University, USA** (Focal Point: Dr. Saba Ashraf)
- **Berkeley Labs, California, USA** (Focal Point: Prof. Dr. Ahmed Shuja Syed)
- **Universitat Politechnica de Valencia, Spain** (Focal Point: Dr. Yousaf H. Khattak, Dr. Faisal Baig)
- **Jeju National University, Korea** (Focal Point: Dr. Gul Hassan)
- **The Institute of Thin Films, Sensors and Imaging (ITFSI), University of the West of Scotland** (Focal Point: Dr. Imran Murtaza)

INDUSTRIAL PARTENER ENGAGED IN 2021-22

- Nizam Energy (PVT) Ltd, Pakistan
- Lightricity Ltd (LL), UK
- Cloud Labs (PVT) Ltd, Pakistan

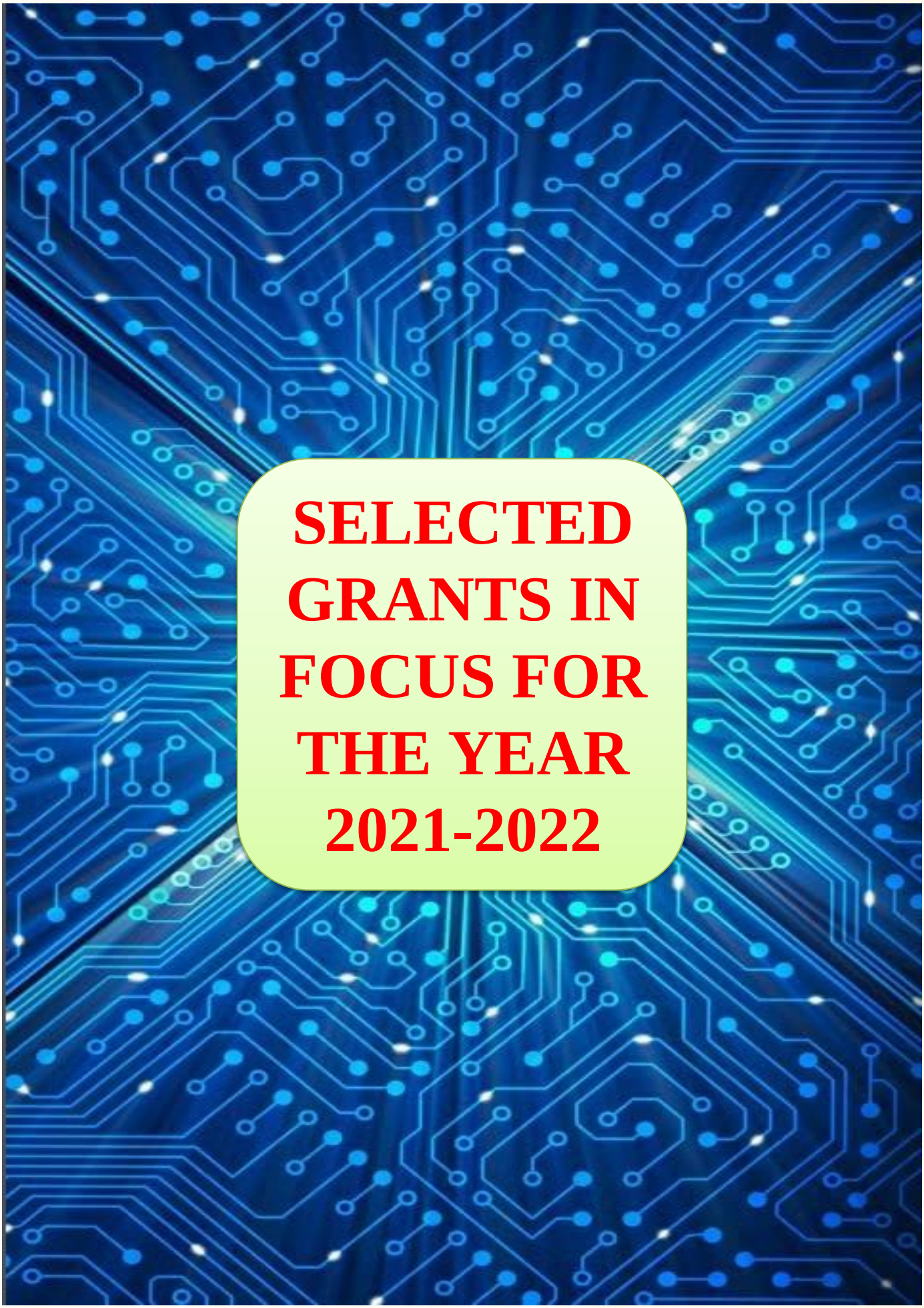
GRANT PORTFOLIO

The Centre is inherited with several local and international grants and user access portfolio acquired such as:

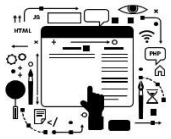
- IIU Research Fund for the Development of Device Design Lab
- IDB, KSA Technical Assistance Grant Program- Establishment of Advanced Electronics Laboratories
- IDB, KSA Technical Assistance Grant Program- Establishment of Photovoltaic Energy Engineering Laboratory
- USA's Department of Energy's Lawrence Berkeley Lab's User's Facility Access Program
- HEC's Grant for the Development of Model Simulation Suite
- Govt. of Pakistan's PSDP/Mega PC-1 Award Allocation for the capacity building of the Centre- Civil Works for the dedicated space development (~ 20,000 Sqft) & Central Laboratories Facility Development
- Pakistan Science Foundation – National Science Foundation, China, Joint Research Project
- Pakistan Science Foundation – Triple Helix Project Funding to fight Covid – 19 and future Pandemic
- Startup Research Grant Program SRGP, HEC
- Pak-UK Education Gateway, Innovative and Collaborative Research Grant (ICRG)
- National Research Program for Universities- NRPU grant, "Towards Wearable Electronic World: Smart Self-Healing Flexible and Ultra-Stretchable Strain Sensors and Devices for Medical Applications"

The Centre has been most active entity in the university by targeting the national and international funding calls including Asia Connect, Pakistan Science Foundation Consortium Projects, UNESCO – IUPAC, EPSRC – GCRF, British Counsel's ICRG, HEC's NRPU and HEC's GCF etc.

Experimental Activities - III


SELECTED GRANTS IN FOCUS FOR THE YEAR 2021-2022

Upscaling of an AI-enabled data mining platform for "Informed Decision Making (IDM)" in COVID-19 and future pandemic scenarios for Government of Pakistan



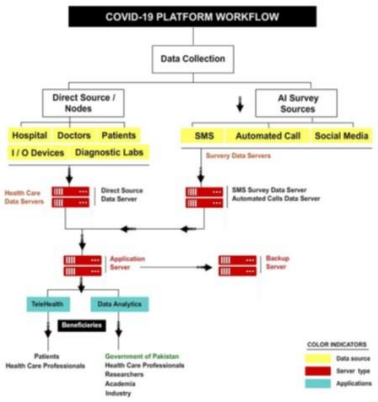
- **Principal Investigator:** Dr. Erum Jamil, Chairperson, Department of Electrical Engineering (F)
- International Islamic University, Islamabad
- **Co-Principal Investigator:** Dr. Gul Hassan, Assistant Professor, CAEPE
- **Industrial Partner:** Cloud Lab Pvt. Ltd, Karachi
- **Funding:** Rs 16.9 Million

The Goal

A **Cloud based Multi Node Tele Health Framework Supported by AI & BIGDATA** can help us easily connect to **"different data sources / nodes"** such as Hospitals, Doctors, Patients at home, Diagnostic Labs, Sensing devices and Data centers.

Centralized, data-based efficient Tele-medicine Support

Scheme of Activity



OBJECTIVES	OUTCOMES
OPTIMIZE AND UPSCALE • A robust AI based Tele Health Platform supported by Data Mining techniques. • Based on an already developed prototype • Help the Government of Pakistan and health care professionals to take informed deci7sion to counter / address COVID-19 and similar pandemic scenarios.	Product: An "optimized" and "up scaled" artificial Intelligence based mass scale survey using automated calls and SMSs Multi node common format input in unified format. Automated Filtration of patients: using Thermal Sensor hardware integration with Tele health framework Automated COVID-19 tests, surveys and data repositories using handheld devices
UTILIZE To develop a "post-testbed capability" for a "large access product" for massive applications with "Software – Machine" integration; which subsequently be utilized for versatile applications (e.g. Dengue, Smog etc.)	Bot-based remote health care monitoring of quarantined patients SMS based data input allowing people to input their health stats during quarantine-mode Appointment booking for Video Consultation during quarantine mode or as required by the patient/health provider. One Point Knowledgebase hub for Medical professionals Nationwide Centralized Medical Record access for confirmed & under observation COVID-19 patients.
TRAIN To train individuals in this highly desire able field who can then continue R&D and product development with direct socioeconomic impact in future	

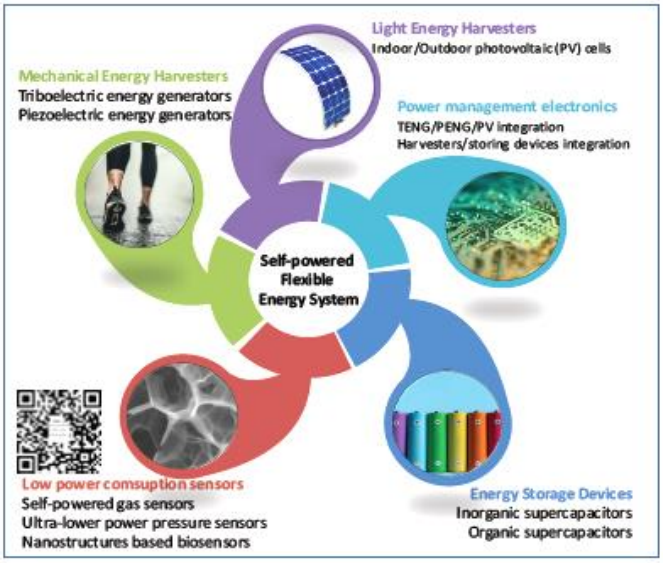
BRITISH COUNCIL | UNIVERSITY OF THE WEST of SCOTLAND UWS | PAK UK Education Gateway HEC/British Council Innovative & Collaborative Research Grants | INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD | HEC

FleEnSys

Investigation in Advanced Energy Harvesters and Energy Storage Devices for Self-powered Flexible Energy System

Grantee: Dr. Imran Murtaza (International Islamic University, Islamabad)
Co-Grantee: Prof. Dr. Ahmed Shuja Syed (International Islamic University, Islamabad)
PI from UK: Dr. Carlos Garcia Nuñez (University of the West of Scotland)
Project Budget: PKR 100 million; Commencement date: 28th June, 2021
HEC Grant No: 20-ICRG-165/RGM/HEC/2020

Overview

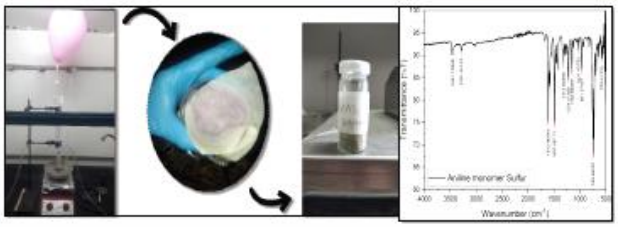


Objectives

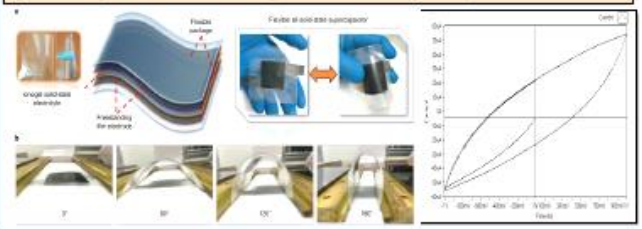
1. Synthesis & characterization of flexible materials: polymers & 2D structures
2. Fabrication of polymer & Graphene/MXene flexible supercapacitors (SCs)
3. Fabrication of flexible triboelectric & piezoelectric energy generators and PV cells.
4. Fabrication of SPAES based on SCs and energy harvesting devices.
5. Encapsulation & testing of optimized devices through FleEnSys industrial partner.
6. Validation, prototyping and up-scaling of self-powered electronics & sensing platforms

Research Outputs of IIUI

1. Synthesis and characterization of Polyaniline monomers

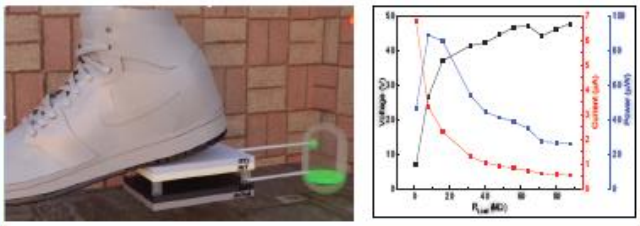


2. Development and testing of flexible Supercapacitors

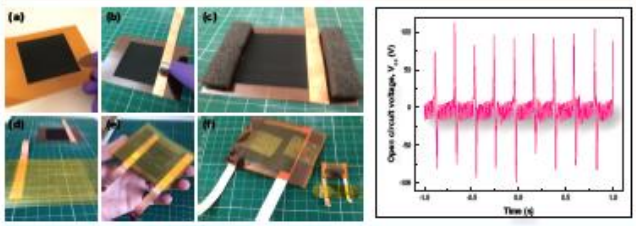


Research Outputs of UWS

1. Development and testing metal oxide based TENG



2. Development and testing of 3D graphene based TENG



Way Forward/Outcomes

Testing and validation of TEG, PV and SC devices based on newly designed and synthesized materials

Confirmation of continuous powering based on TEG+PV SPAES

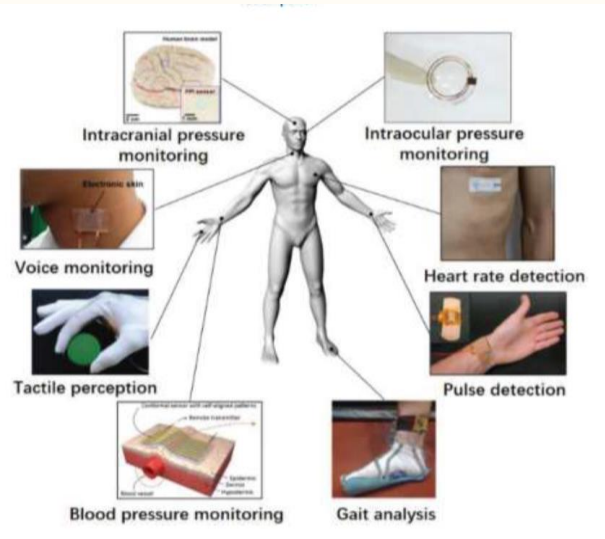
Confirmation of SPAES as valid energy source for wearable tech

USME | TFSI Institute of Thin Films, Sensors and Imaging | University of Glasgow | meLAB | lightricity | NIZAM ENERGY | UAM Universidad Autónoma de Madrid

NATIONAL RESEARCH PROGRAM FOR UNIVERSITIES (NRPU)

Towards Wearable Electronic World: Smart Self-Healing Flexible and Ultra-Stretchable Strain Sensors and Devices for Medical Applications.

Project Budget: 9.56 Millions

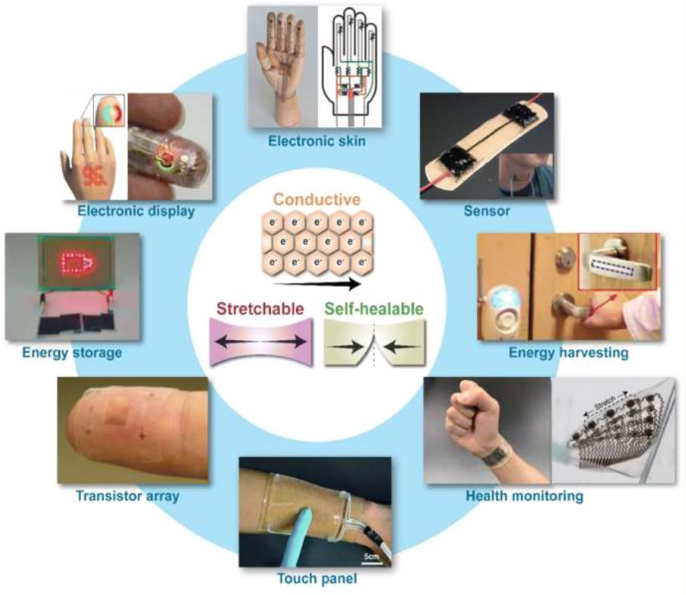


Introduction

Real breakthroughs in the design and processing of **solution processed self-healing materials** that would have far reaching consequences for the future **smart self-healing flexible and ultra-stretchable sensors** and its applications for **customized targets and biomedical usage**. Micro cracks and mechanical fractures in the strain sensors are very easily occurred under frequent deformation. The performance of the sensors are liable to the structure damage, which cause the loss of functionality of the sensor. Therefore**, smart sensors are necessary to be introduce** that has the self-healing property **to improve its reliability** and to maintain its function even **after breakdown and healed again**. To overcome the fracture problem of the strain sensors, exploring and developing of self healing conductors by using the various materials and nano-composites are necessary. The self-healing materials are the smart materials that **can restore some or all of its functions after cutting or suffering by external damage** such as mechanical damage. The self-healing property of the materials are not only prolonging the lifetime of products but also reducing the wastage of the materials. Especially, this function increases the reliability of the sensors.

Objectives

- Development of rational methodologies to **synthesize solution processed** self-healing Materials.
- Development of rational methodologies to control the formation of **functionalized self-healing materials** (doping, capping) under mild conditions.
- Identification of mechanisms/understanding and tailoring the specific interactions of solution processed **self-healing materials**.
- Nano composite films with induced self-healing properties.
- Preparation of UV curable polyurethane substrate for self-healing devices (Flexible sensors)
- Applications of solution processed self-healing materials in smart sensing (Strain sensors) like **human motion detection, health care, damage detection, characterization of structures, exhaustion studies of materials**, smart devices and many more.
- **Opens a new way to next-generation printed and flexible smart electronic technologies** and customized applications in **Pakistan.**
- **Indigenous Property creation for possible exploitation of the market demand in Pakistan.**



PRINCIPAL INVESTIGATOR AND COLLABORATOR
Dr. Gul Hassan – P.I
Prof. Dr. Ahmed Shuja – Co-P.I
Dr. Imran Murtaza – Co-P.I
Prof. Dr. Jinho Bae – Collaborator

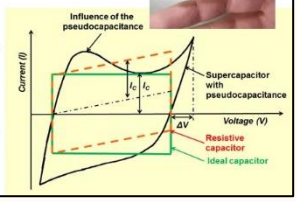
Development of Stretchable Polymer Based Supercapacitors for Energy Storage Systems

PSF-NSFC-II/Eng/C-IIUI(06)

Partnering Universities: *International Islamic University, Islamabad* and *Peking University Shenzhen, China*
Team: Prof. Dr. Ahmed Shuja Syed (P.I/Pakistan), Dr. Imran Murtaza (Co-PI), Prof. Dr. Hong Meng (P.I/China)
Cost: (Pakistan: Rs. 3.505 million China: RMB 1.65 million) **Duration**: 3 years (July 2018- June 2021)

Broader Application Area: Energy Storage Systems

Objectives: ***1)*** Preparation and characterization of intrinsically stretchable conducting polymers with acceptable properties for the subsequent development of supercapacitors; ***2)*** Device fabrication and characterization of stretchable polymer-based supercapacitors, followed by detailed analytics; ***3)*** Optimization and improvement of device performance parameters for technology-specific exploitation



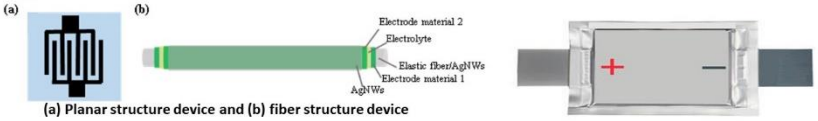
Methodology

A *five-tier approach was* used to address the problem. The overall methodology was broadly divided into:

- *Design and synthesis*
- *Device fabrication*
- *Analysis and optimization of material's parameters*
- *Evaluation, testing & characterization, and,*
- *Exploitation to further the device designing and fabrication at application level*

Outcomes

- ***Developed*** a recombination strategy to circumvent the contradiction between improvement of processability and maintenance electrochemical performance;
- ***Successfully used*** an electrochemical copolymerization "Chain-Lock" strategy to construct a conjugated polymer network
- ***Developed*** a facile strategy to strengthen the interaction between PEDOT and substrate by depositing metal ions on the substrate as an interlayer for robustness of the device
- ***Successfully fabricated*** PEDOT: PSS based supercapacitors and spanned them for more than ~120 days to be subsequently characterized with a special focus to evaluate the charging and discharging nature of aged supercapacitor's for the very first time, to the best of our knowledge.



(a) Planar structure device and (b) fiber structure device

Outcomes- *Contd.:*

- ***Fabricated*** a stretchable and foldable Polyurethane substrate along with dense metal net and spanned for ~15 days, in order to properly mitigate the electrolyte with anode and cathode within the device matrix.
- ***Developed*** a novel process routine for the thienothiophene electrochromic polymer synthesis exhibiting remarkable electrochromic and supercapacitive properties.
- ***Developed*** a systematic evaluation process of duly synthesized KOH based PVA electrolyte for stretchable super-capacitors providing an insight to the charge dynamics with in the active device regions and their roles in operational efficiency of the PVA-based electrolyte for the stretchable supercapacitor's manufacturing.

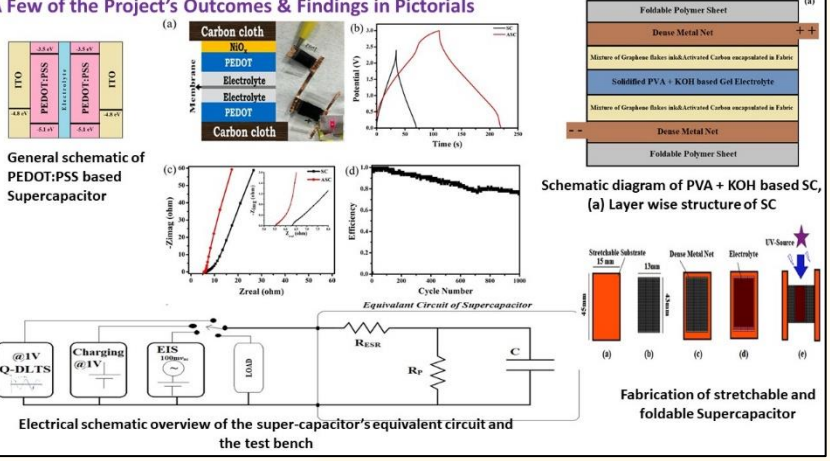
Publications from the Project

6 Publications in world renowned journals *(Macromolecules, Chemical Engineering Journal, Journal of Energy Electronics, Organic Electronics, Journal of Materials Science: Materials in Electronics and Materials Chemistry-A)* directly from the project with a ***cumulative impact factor*** of ***~44***

Patents Filed to IPO, Pakistan (Inventions from the Project)

1. "Methods of producing novel thiophene-2,5-diester supercapacitive electrochromic materials for energy storage applications" filed at IPO Pakistan. **(Patent Application # 437/2021)**
2. "Novel thienothiophene polymer and its synthesis method for the electrochromic and flexible supercapacitors applications" filed at IPO Pakistan. **(Patent Application # 563/2021)**
3. "A novel method for the performance evaluation of stretchable and foldable supercapacitor for energy storage application" filed at IPO Pakistan **(Patent Application# 846/2021)**

A Few of the Project's Outcomes & Findings in Pictorials



General schematic of PEDOT:PSS based Supercapacitor

Schematic diagram of PVA + KOH based SC, (a) Layer wise structure of SC

Electrical schematic overview of the super-capacitor's equivalent circuit and the test bench

Fabrication of stretchable and foldable Supercapacitor

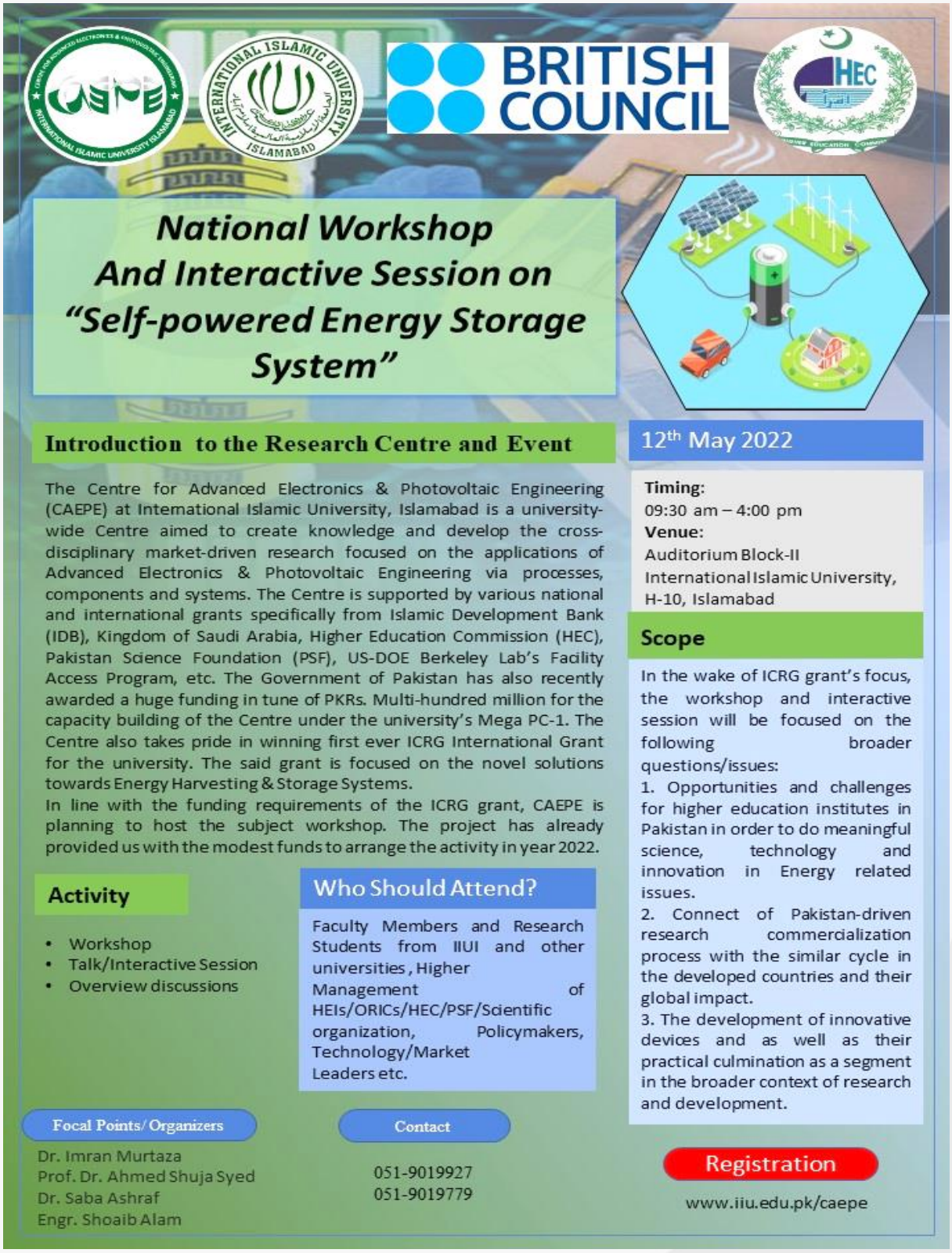
EVENTS & VISITS

Events

The Centre hosts a week-long workshop for the faculty and the students of the Faculty of Engineering & Technology, every year; this activity is usually connected with Pakistan Engineering Council CPD program. The workshop is aimed to introduce the new technologies present in the Centre (CAEPE) to the students and the teachers, and train them on some of the cutting-edge research tools.

CAEPE in its present form and previously as IDB-funded laboratories project had taken several initiatives to conduct seminars, training weeks, national level workshops to introduce the frontiers of Advanced Electronics and PV Engineering to a larger audience. Similarly; we have been part of several international conferences in capacity of conference directors/advisors, co-organizers & focal point of tutorial sessions, international and technical committees, and keynote/plenary speaker.

The Centre also host the workshop on the frontiers of Self power Energy Storage Systems in line with the approved Pak Education Gateway ICRG grant. The main theme of the workshop is to introduce new and future technologies to the wide variety of audience that include students, academician, Industry representatives and scientist for the National Community.



The Centre in its capacity has taken part in many national and international Conferences. Some of the workshops and conference are shown below:

NATIONAL CENTRE FOR PHYSICS

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International Workshop on Nanomaterials for Energy Conversion, Emerging Photovoltaic and Optoelectronic Technologies (NEEPO-21)

Virtual

21 - 22 September, 2021

Introduction

Renewable and cost-effective energy supply is one of the biggest challenges impacting global environment and human life. Likewise, optoelectronic devices have significant contribution for energy efficiency. With the innovation in the growth techniques, and the emergence of novel nanomaterials, the solar energy conversion and electronic technologies are entering into a new regime offering the potential of solution processability and flexibility for next-generation smart technologies and IoT. The next generation hybrid solar cells based on nanomaterials and technology are evolving as strong candidates for the cost-effective solutions for smart applications. However, there are several accompanying challenges vis-a-vis the scale-up production and commercialization of these technologies.

National Centre for Physics (NCP) regularly organizes the "International Workshop on Nanomaterials for Energy Conversion, Emerging Photovoltaic and Optoelectronic Technologies (NEEPO)". NEEPO-21 is the fourth in this series and owing to COVID-19, this will be a **'Virtual Workshop'** to be held using ZOOM platform. NEEPO-21 will focus on (1) the basics, (2) the recent developments in the field and challenges associated with the nanomaterials based solar energy conversion and (3) next generation photovoltaic and optoelectronic devices. One session of the workshop will be exclusively organized for young researchers. We also offer a platform for an online poster session during the workshop. As per traditions, the workshop aims to provide the local research students, scientists and engineers a platform to interact with world renowned scientists in the field.

IMTIC 2021

6th International Multi-Topic ICT Conference 2021 (hybrid)

Home | Call | Tutorials & Symposium | Key Note Speakers | Dates | Committees | Submission | Registration | Gallery | Sponsors

IMTIC'21

International multi-topic conference

MEHRAN UNIVERSITY, JAMSHORO, PAKISTAN

FAISAL MOSQUE ISLAMABAD

CONFERENCE THEME

Following the success of IMTIC series, 6th International Multi-Topic ICT Conference 2021 (IMTIC'21) will continue its tradition in the education and industrial hubs of Pakistan, respectively – Jamshoro and Karachi. This year, IMTIC'21 is jointly organized by Mehran University of Engineering & Technology (MUET), Jamshoro, and Sir Syed University of Engineering and Technology (SSUET), Karachi in technical Collaboration of EU Capacity Building in Higher Education CENTRAL project. IMTIC is an international forum for researchers to exchange the information regarding novel aspects of technology, applications, and the development of value-added services in the field of Information and Communication Technologies.

CONFERENCE NEWS

Visits

Some Important visits to the Centre are:

Former Advisor COMSATS University and inventor of EVM, Prof. Waqar Haider Bukhari visited the Centre

Dr. M. Zafar Iqbal, Fellow Pakistan Academy of Sciences, Professor Emeritus in Physics, Quaid-i-Azam University, Islamabad visited the Centre



Prof. Dr. Waqar Mahmood Director KICS, UET Lahore & Member Prime Minister's Task Force on Science & Technology visited the Centre today and discussed ideas for the collaborative projects of national interests..




Dr. Aftab Ahmad Chattha, (Founder and President, National Academy of Young Scientists (NAYS) Pakistan; Chairman, Islamic World Young Scientists Academy and recipient of Best Young Scientist, Pakistan Cardiac Society and Innovation Award from SATHA) visited the Centre alongside his team

Faculty members Dr. Faiza Jan Iftikhar & Dr. Qamar wali from NUTECH visited the Centre

Prof. Dr. Imrana Ashraf (Department of Physics, Quaid-i-Azam University Islamabad) visited the Centre and interacted on various themes of research

Minister of Higher Education Afghanistan, Sheikh Abdul Baqi Haqqani, Chancellor of Kabul University and other high officials from Afghanistan visited the Centre

Dr. Kamran Amin, Special Research Assistant, University of Chinese Academy of Sciences National Center for Nanoscience and Technology, Chinese Academy of Sciences
Along with Dr. Aftab Ahmad President of National Academy of Young Scientists. Director Innovators Club, Pakistan and National Director of Global Union of Scientists for Peace visited the Centre

Prof. Dr. Jameel un Nabi, Rector University of Wah visited the Centre alongside Prof. Dr. Zulfiqar Ahmad (Director ORIC) of University of Wah.

Dr. Muhammad Farooq (Senior Scientific Officer) from PCSIR visited the Centre

Dr. Nazar Zaidi (Senior Vice President, AMD, California, USA) and Dr. Muhammad Ali Muhammad (Director Research, Policy & Business Intelligence at Special Technology Zones Authority, Pakistan) visited the Centre today and interacted on various shades of Innovation and Research including the Pakistan Semiconductors Plan.

Officials from National Technology Council visited the Centre

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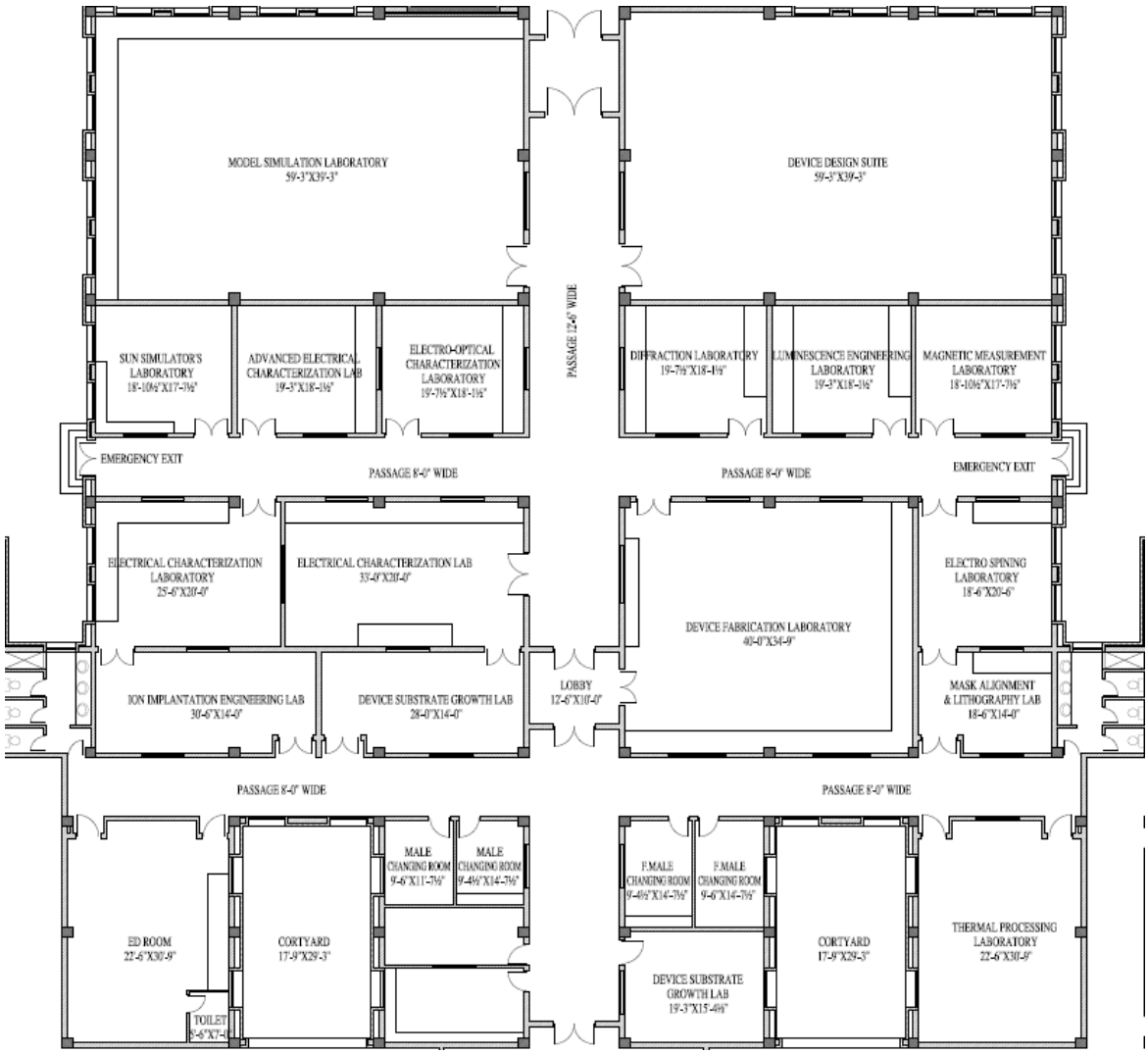
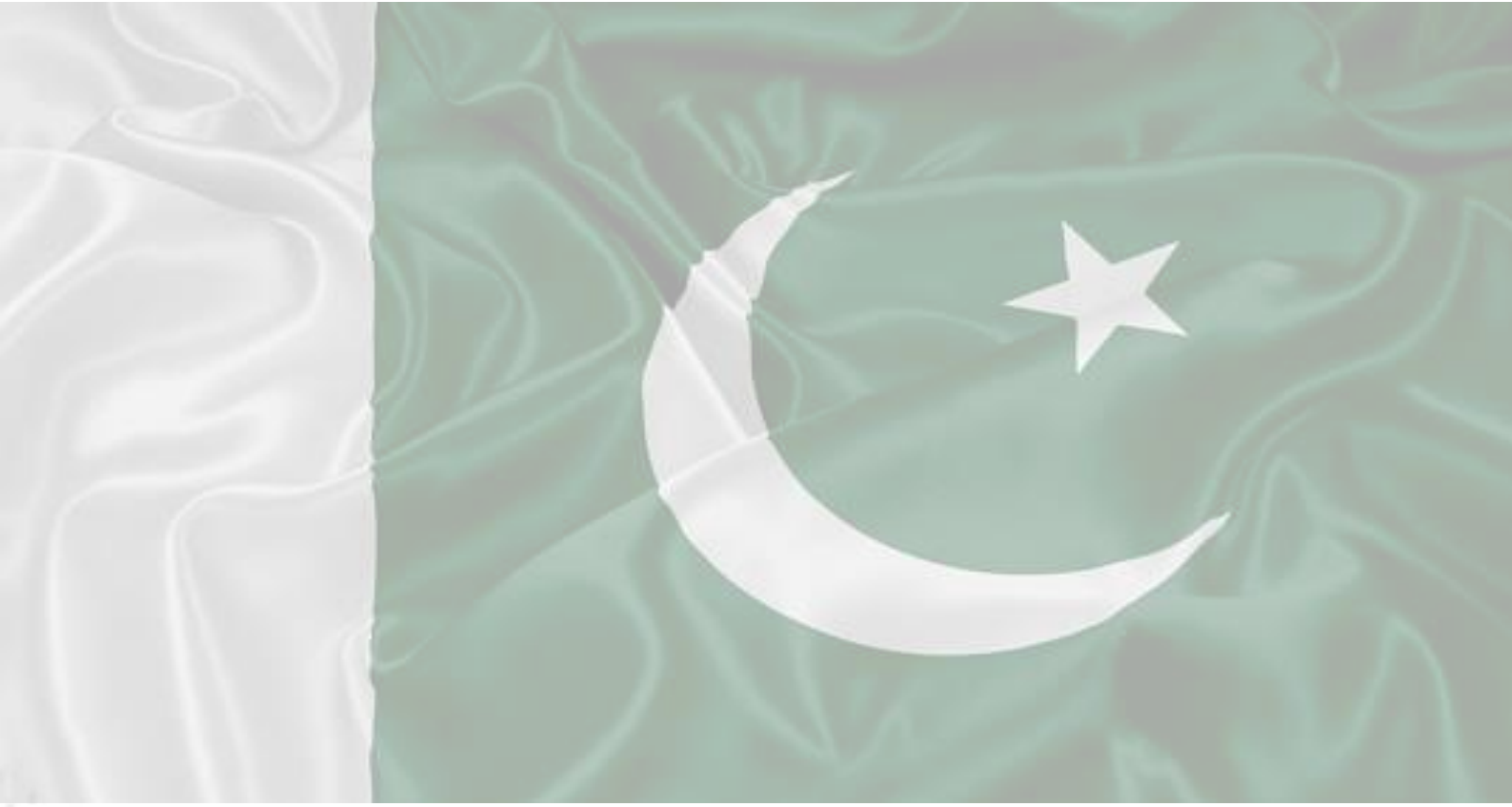
CAEPE's NEW PHYSICAL INFRASTRUCTURE (UNDERWAY)





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Talk:

- Prof. Dr. Ahmed Shuja Syed (Executive Director)
- Dr. Gul Hassan (Cleanroom Manager)
- Engr. Shoaib Alam (Laboratories Manager)

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