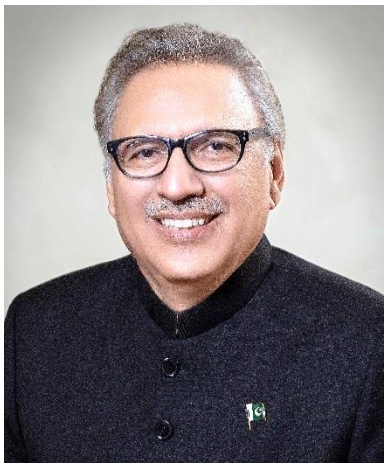
CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING (CAEPE)

Progress Report and Portfolio 2020-2021

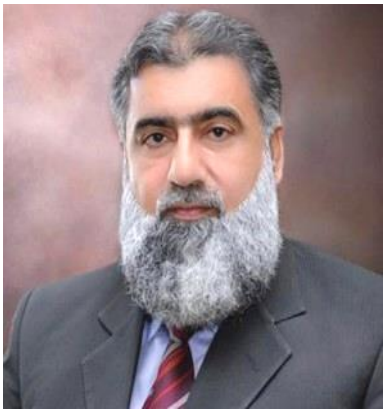
INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD

A PARADIGM SHIFT IN ELECTRONICS AND ENERGY RESEARCH



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

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



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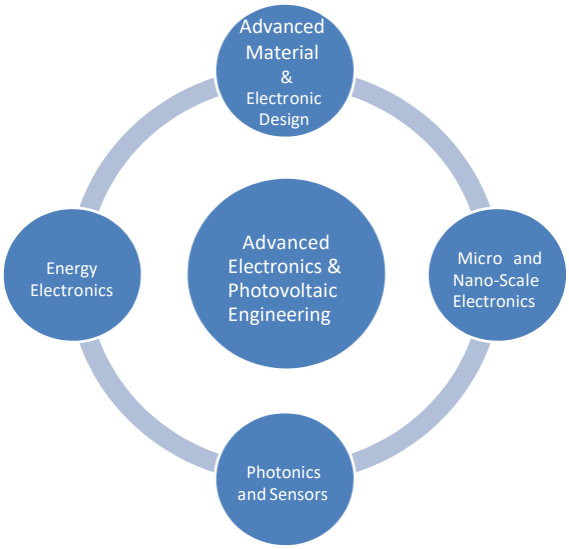
Engr. Prof. Dr. Ahmed Shuja Syed
Founding Executive Director (CAEPE)

TABLE OF CONTENT

At A Glance

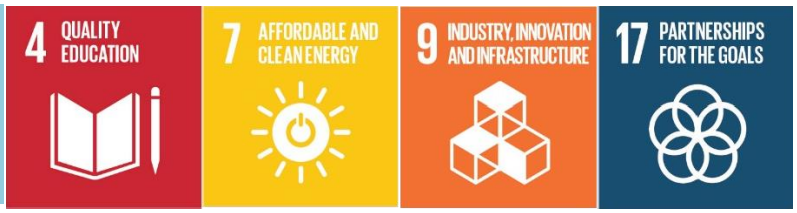
The Centre for Advanced Electronics & Photovoltaic Engineering (CAEPE) at International Islamic University, Islamabad is a university-wide Centre aimed to create knowledge and develop the cross-disciplinary market-driven research focused on the applications of Advanced Electronics & Photovoltaic Engineering 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 ~ 400+
- 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



Means of Engagement

- **Knowledge**
- **Learning**
- **Demonstration**
- **Impact**
- **Collaboration**



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

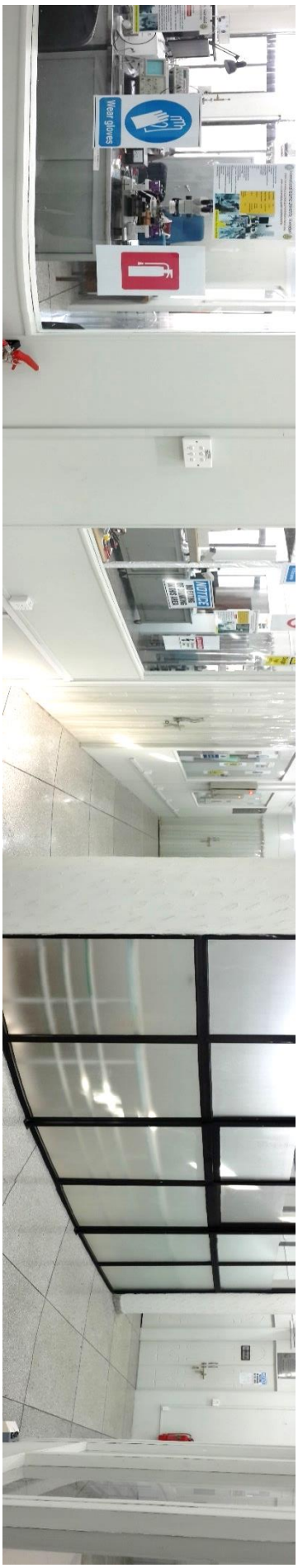
Impact Parameters	Quantum
Extent of Utility and Access	>400 scientific projects
Engagement of Returning Users	80%
Knowledge Creation & Dissemination in Process	>250 projects
Continual Skill Development	>4000 Runs
Responsiveness (Qualified Manpower Creation with Terminal Degrees in Dedicated Specialization; Collaborative Connections; Joint International Projects)	Manifold Increase on Yearly Basis

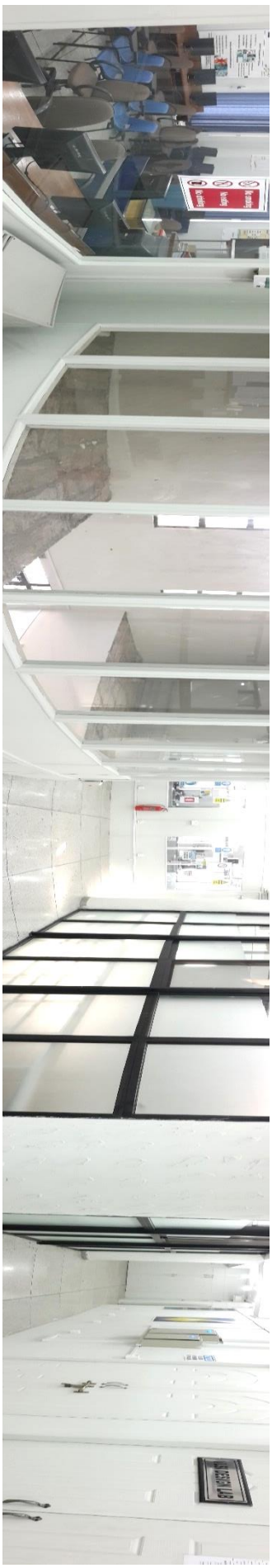
Sr. #	Content	No. of projects
1	Total number of the projects/users	*400+*
No. of student trained by the lab staff including BS Level Trainings on Design Suite		
2	Training Level - 1 (4 to 6 weeks)	200+
3	Training Level - 2 (Extensive Machine Training)	100+
4	No. of the department of Electrical Engineering (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

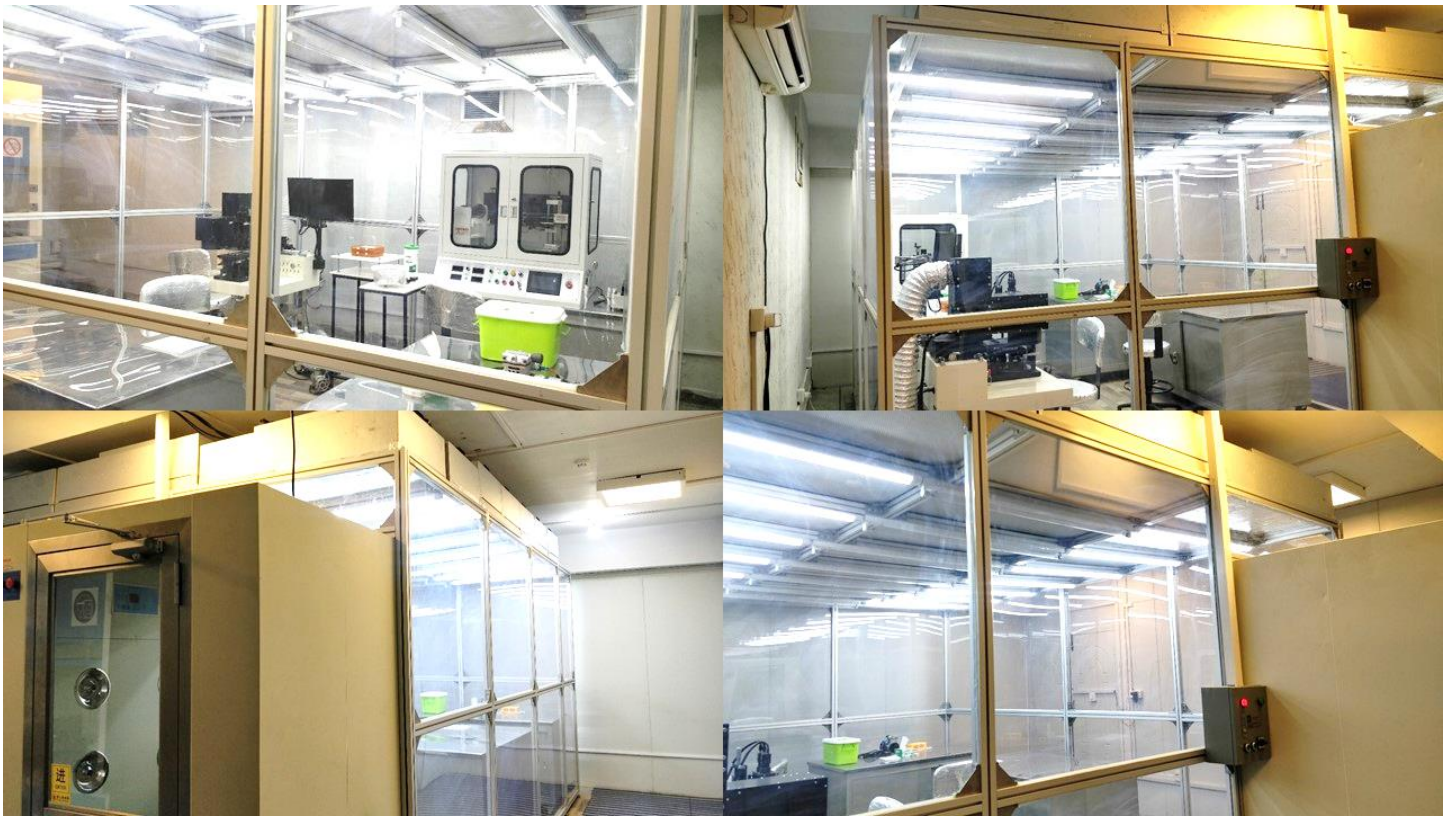
CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING

CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING

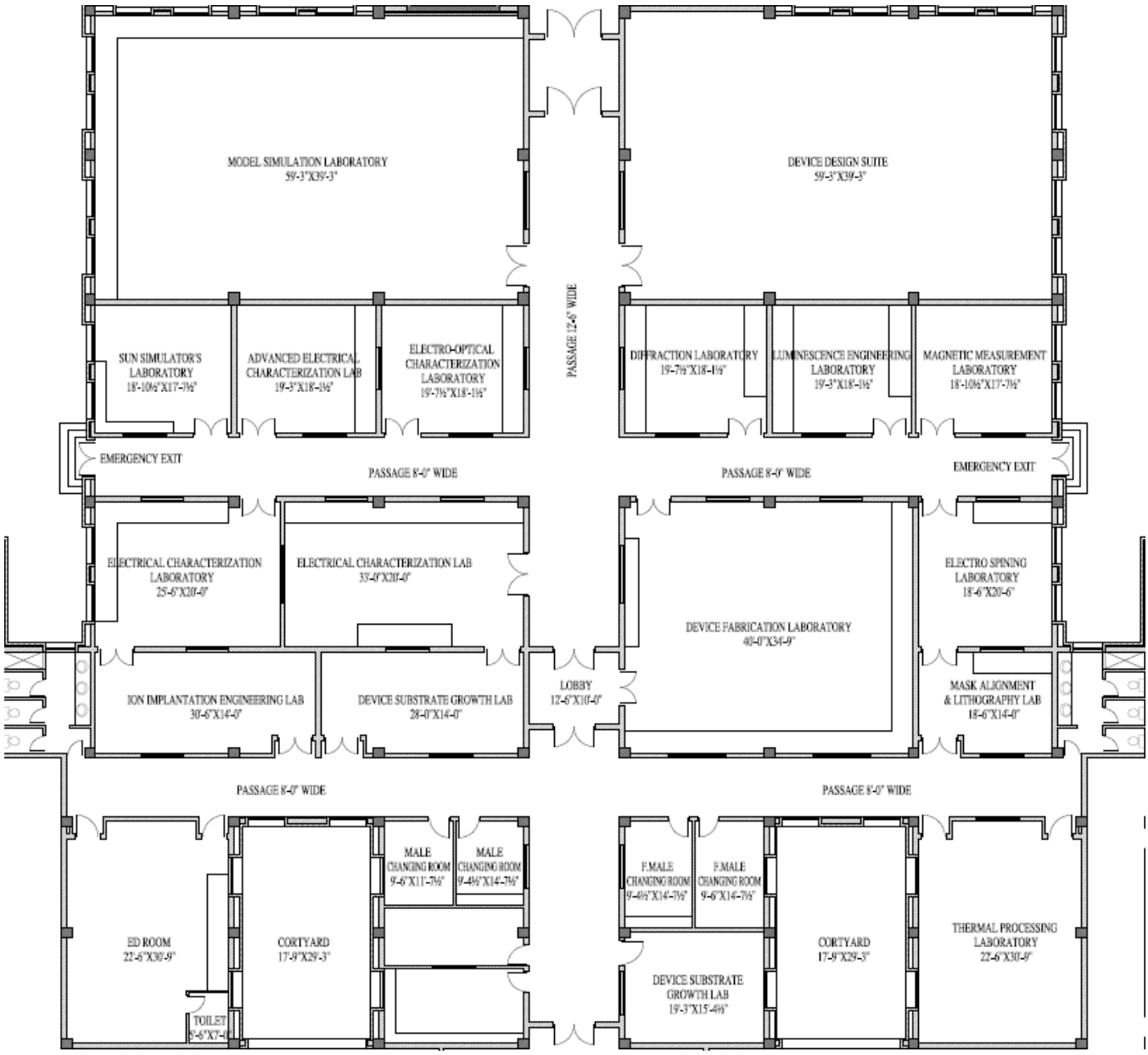

NOTICE
NO EATING
OR DRINKING
IN THIS AREA

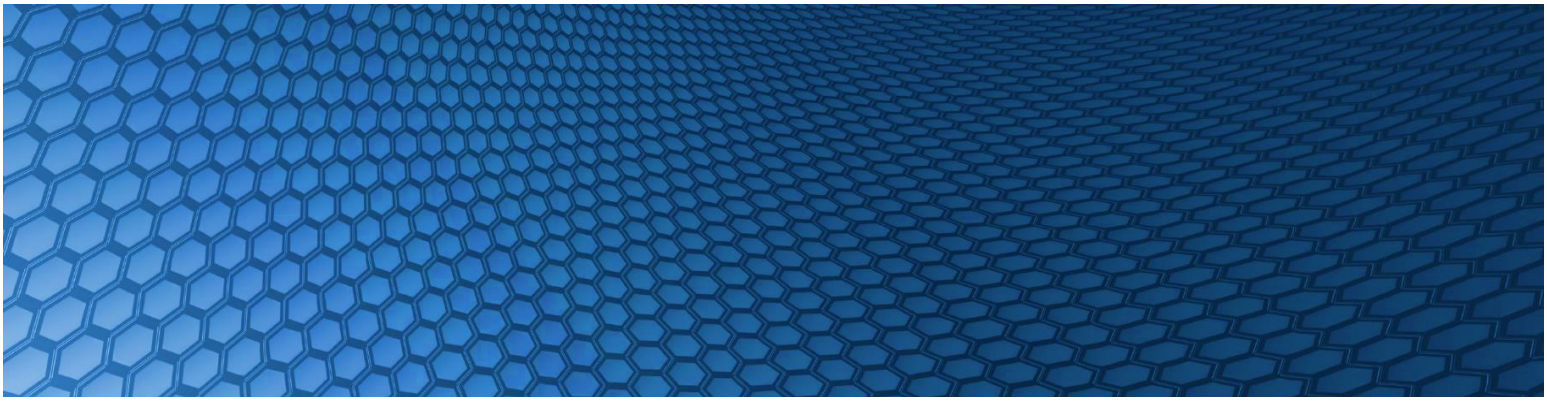

Wear gloves





CAEPE's NEW PHYSICAL INFRASTRUCTURE (UNDERWAY)





1- INTRODUCTION & FACILITIES

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

President Islamic University visited Centre for Advanced Electronics & Photovoltaic Engineering

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.

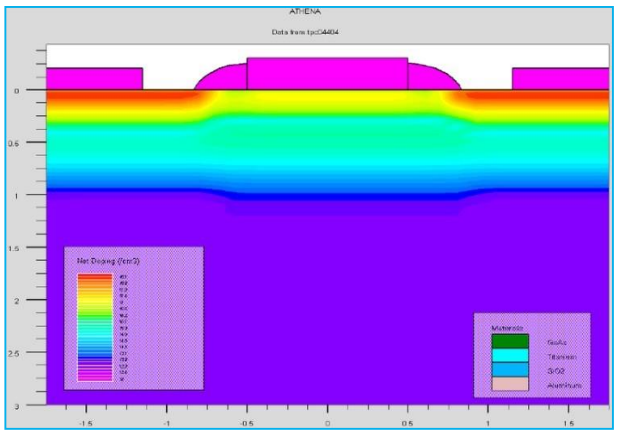
Device Modeling and Simulation explores scaling and process development of advanced electronic and photonic devices. These tools cover device transport and performance as well as process modules. These predictive tools help to provide physical insights into new devices, new physical phenomena arising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

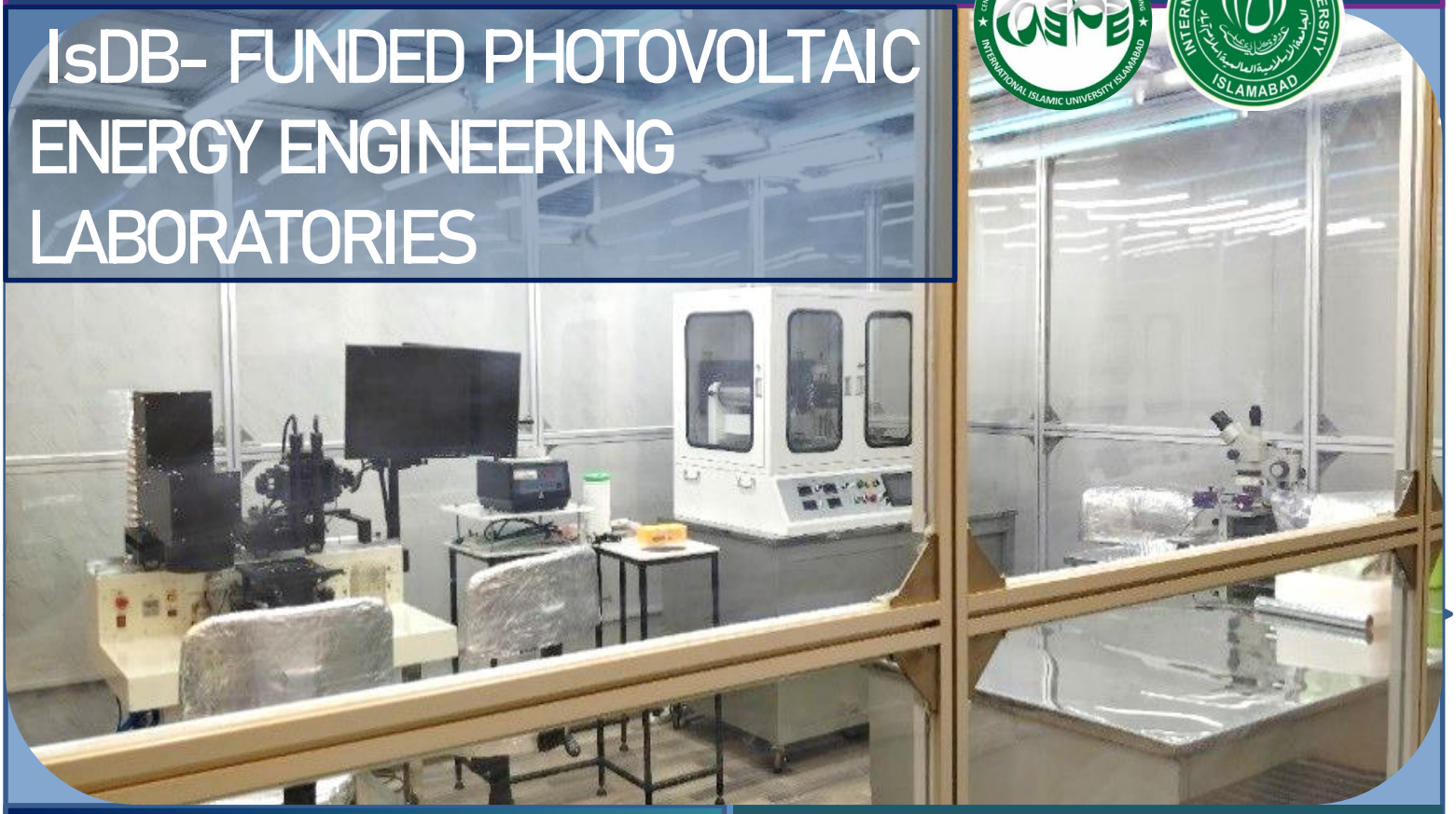
To apply interdisciplinary and bottom-up approaches that enable discovery of novel alternatives to complex Fab-less electronic device design and processes.

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:

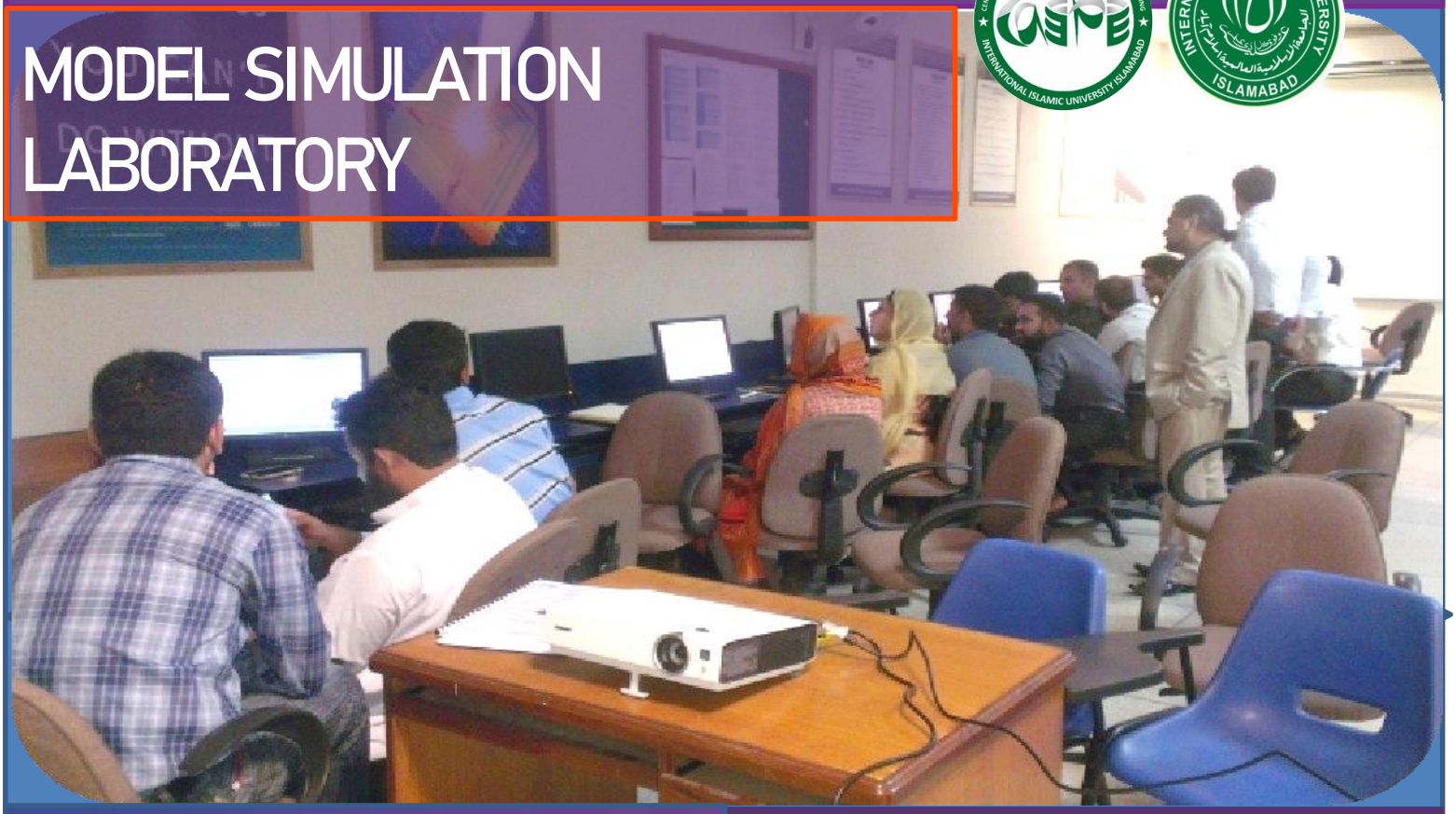
- PV phenomena in semiconductors
- Solar cell focused Multi-junctions, nano-heterostructures, thin-film electronics
- Metrology and Characterization of solar cells and photovoltaic processes for subsequent fabrication and utility

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



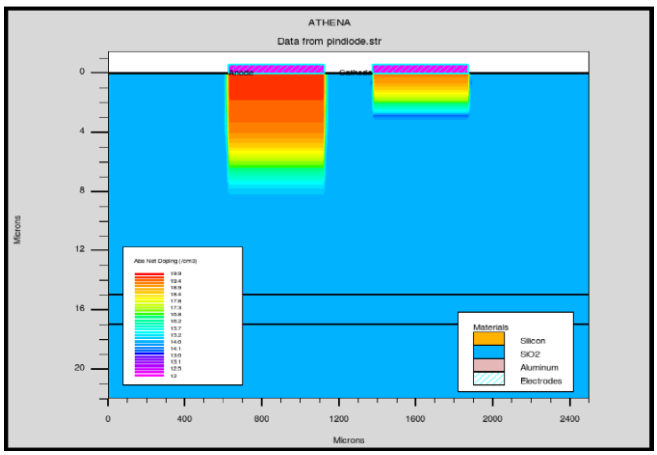
The Lab is focused to simulate the model cleanroom assisted device design and process knowledge for the students by providing them with the licensed tools and audio visual facilities. These tools are used to design and simulate the solid state devices as well as system level computation for diverse application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

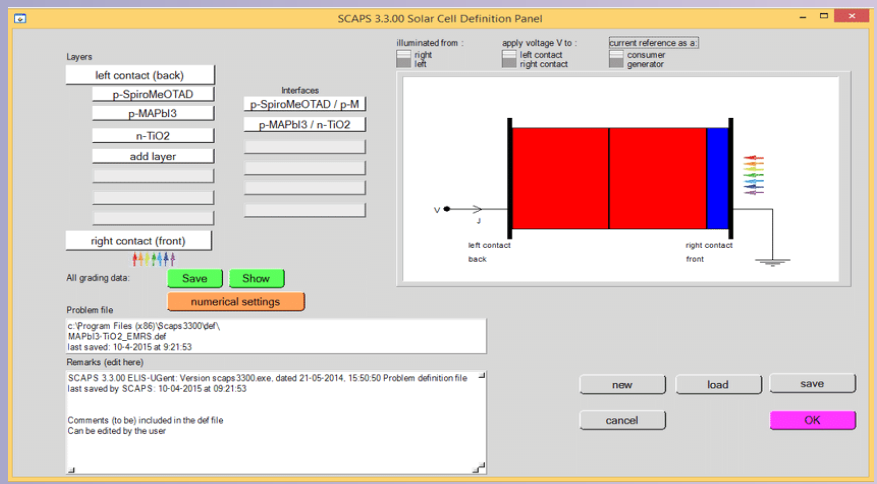
- Technology behind the chip
- Optimization of Processes
- Numerical modelling of solar cells
- Simulation of Opto- and photonic devices
- A.I assisted computing for applications
- Big data analytics



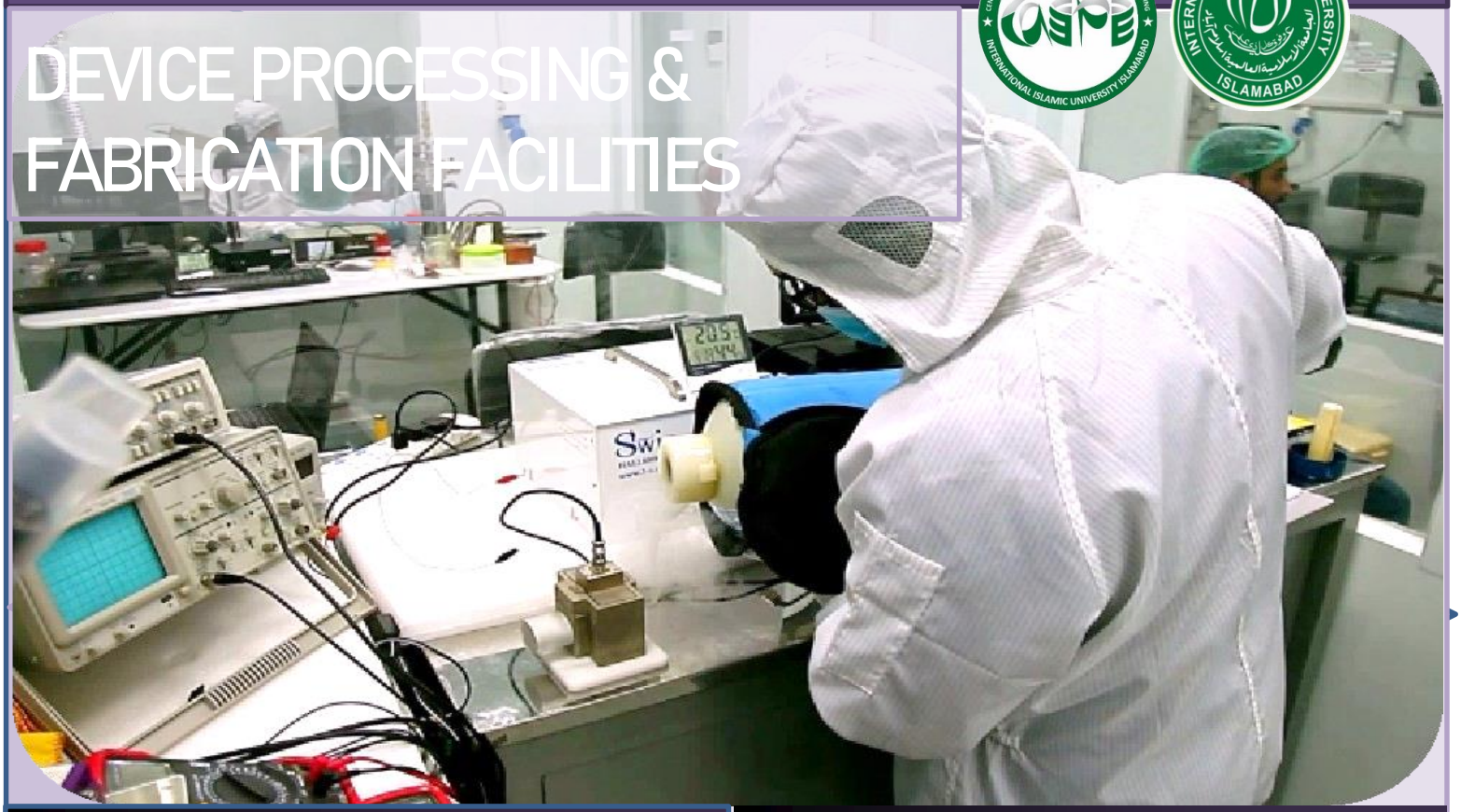
Licensed Software	• Description
TCAD OMNI	•Physical Layer designing and simulation software with capability to test and optimize the fabrication processes.
AI Assisted Computational Test BED	• A Cloud based Multi Node Tele Health Framework Supported by AI & BIGDATA that can help us easily connect to "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.

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

- Project's Official Website
- Software Core System
  - User Management & Policies
  - Direct Node Views (Hospitals, Diagnostic Labs, Patients, Snap Checkers, Bullet Cameras, Thermal Sensing Doors, SMS Survey, Automated Calls)
  - Telemedicine (Audio / Video Consultation)
  - Centralized Electronic Medical Record (EMR)
  - Survey Stats
  - Analytics Board
  - Forecasting
- SMS Input & Survey System
- Automated Calling Survey System
- Mobile Applications (Android / IOs)
- WhatsApp AI bot
- Project Management Application



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.

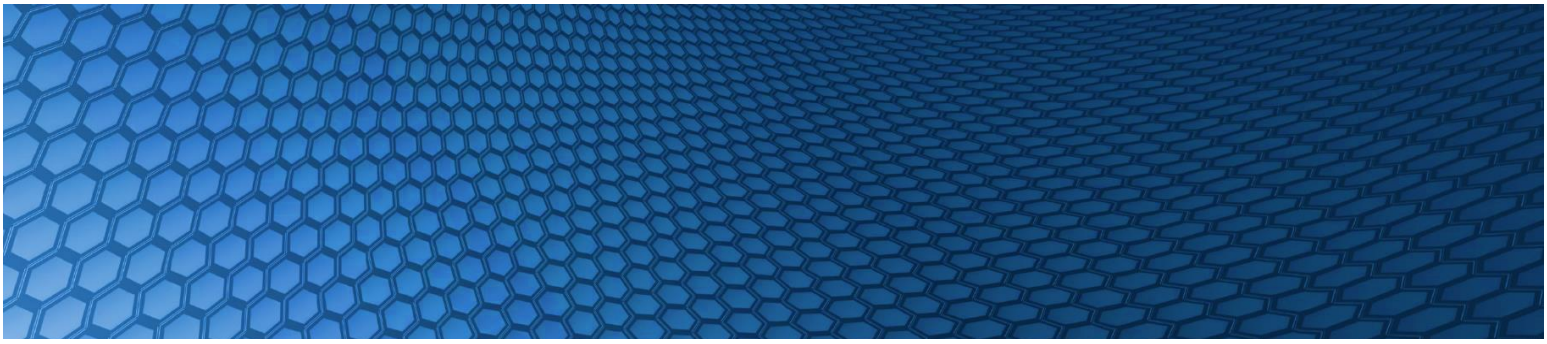
LAB MISSION

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

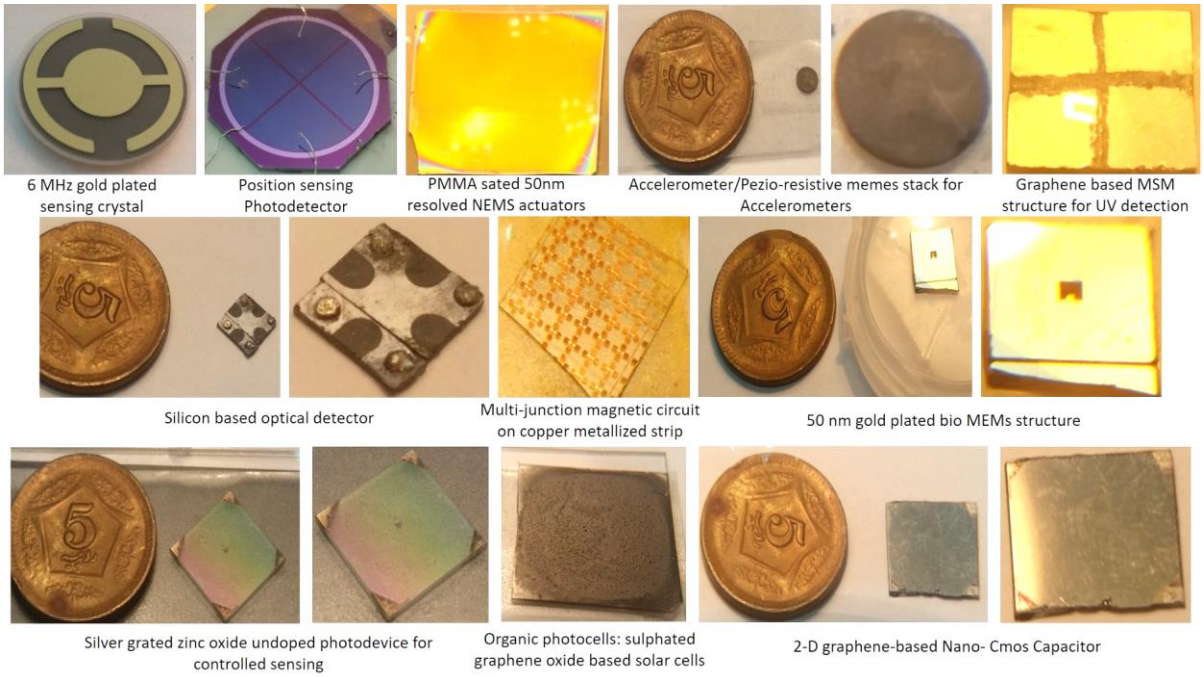
Equipment	• Description
Femto/Pico ampare meter	•This system is used for ultra low current measurement. The usage of this machine is profound and important when one is working with hyper sensitive electronics.
Film/Coating Thickness Profilometer	•This system uses stylus to move over a surface to profile 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.



2- RESEARCH, PUBLICATIONS & PATENTS

Research Themes and Scientific Problems Addressed

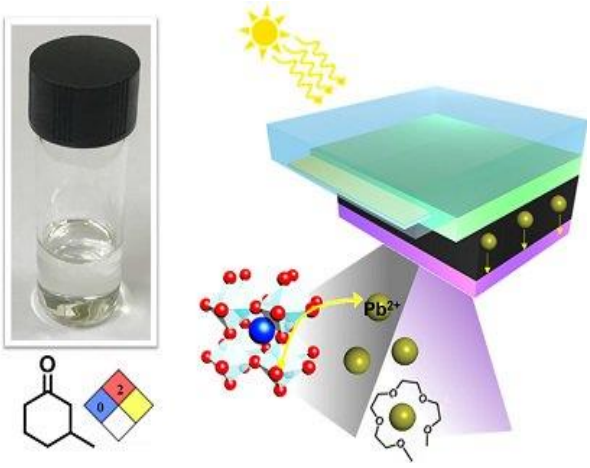
- Next-Generation Solar Cells & Power Devices
- Energy Efficient Nano Electronics
- Graphene Electronics
- Future Devices, Circuits & Systems: Electrochromics, NANO/CNTs, MEMS, Neuro-morphic Circuits, Nano sensors, RF Filters
- Photonics: Sensing & Detection
- Supercapacitors & Nano Harvesters
- III-V Device Engineering



Prototypes & Fabrication of Devices in Various Research Projects

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..

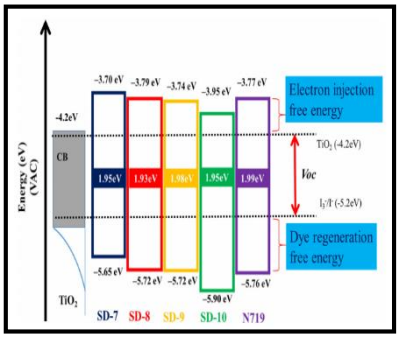


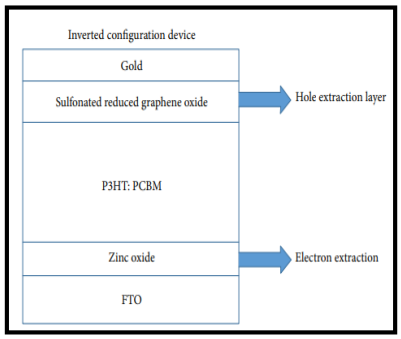
Power devices are the electronic devices that can be directly used in the power processing circuits to convert or control electric power such as MOSFET, Silicon Controlled Rectifier (SCR), DIAC and TRIAC. Major material used in power semiconductor devices is Silicon, III-V's and SiC.

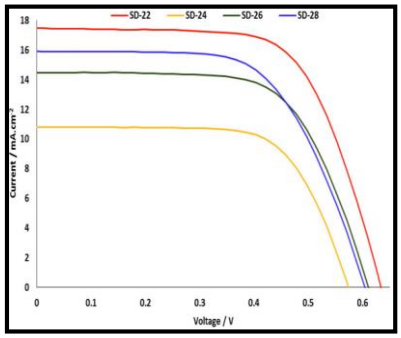
Projects

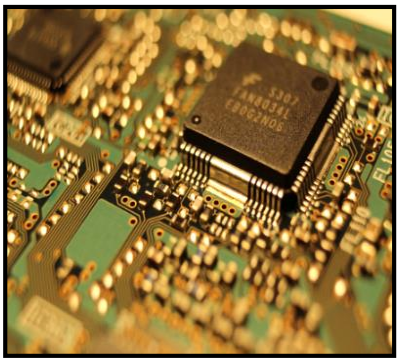
•Electrical and Optical Modelling of Bulk Heterojunction polymer solar cells.
•Capacitance Voltage process metrology of engineered ZnTe/CdTe based solar cells.
•Reliability of Device growth techniques for the Process optimization of CdZnTe Solar Cells.
•Design and Simulation of a HV SiC PIN Diode for 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.
•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.

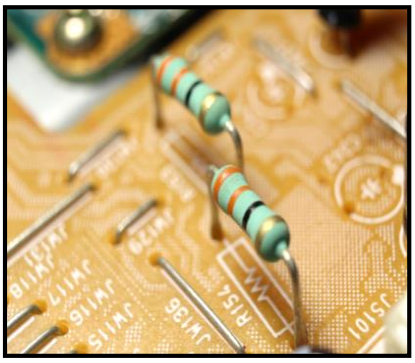
•Design and Characterization of ZnCuSe structures for Next Generation Solar Cell Application.
•Design and modelling of 3rd generation polymer based organic solar cells.
•Effect of annealing dynamics of the Ion-Engineered ZnTe/CdTe based Solar Cell.
•Device modeling for the Efficiency enhancement of Cesium Lead Iodide Solar Cells.
•Modelling of Electron transport layer for miltigation of interface recombination for FAPb13 solar cells.

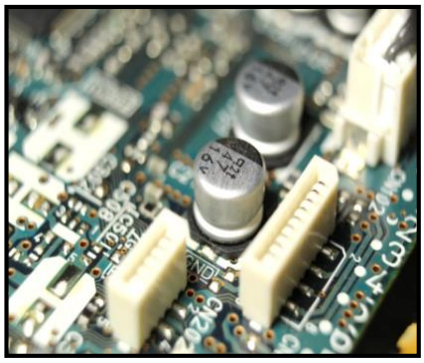










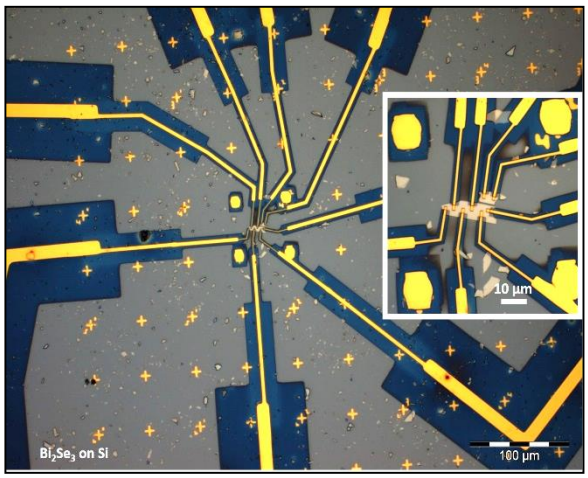


Key Publications

•Effect of Annealing Dynamics on the Ion-Engineered ZnTe/CdTe Solar Cells, Journal of Material Science: Materials in Electronics, 2021. (In press)
•Analysis of Fractional Order Sliding Mode Control in a D-STATCOM Integrated Power Distribution system, IEEE Access, 2021.
•Defect mapping of active layer of CdTe solar cells using charge deep level transient spectroscopy (Q-DLTS), Engineering Failure Analysis, Vol. 119, 104991, 2021.
•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.
•Investigations into Structure-Property Relationships of Ruthenium (II) Dyes with N, N'-diethyl group in Ancillary Ligand for Dye-Sensitized Solar Cells, Dyes and Pigments, Vol. 171, 107754, 2019.
•Optimizing reaction kinetics of sequential deposition technique for ambient air and solution processed hybrid perovskite thin films, Journal of Materials Science: Materials in Electronics, Vol. 30, 4250–4258, 2019.
•Design, Electrical, and Optical Modelling of Bulk Heterojunction Polymer Solar Cell, International Journal of Photoenergy, Vol. 2018, 2018.
•Simultaneous reduction and sulfonation of graphene oxide for efficient hole selectivity in polymer solar cells, Current Applied Physics, Vol. 18, 599-610, 2018.

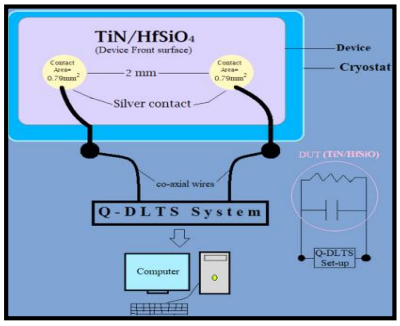
Energy Efficient Nano Electronics

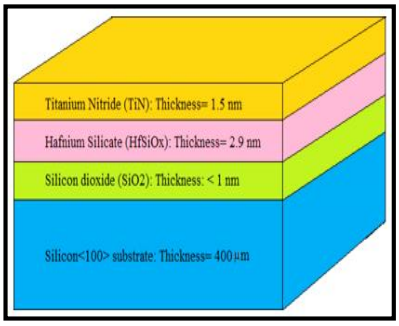


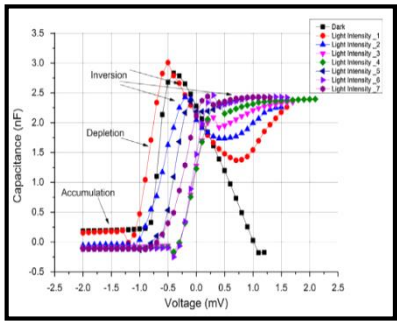
Unique nanoscale material and device properties provide opportunities to achieve improved performance and efficiency, and to enable new functionalities. The focus of nanoelectronics research has shifted from low-power switches for Boolean logic to emerging materials and devices for novel computing paradigms.

Projects

•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





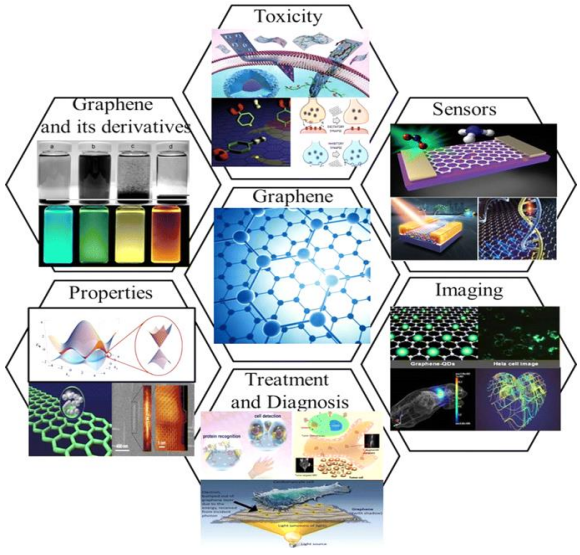


Key Publications

- Evolution of low-dimensional material-based field-effect transistors, Nanoscale, Vol. 13, 5162-5186, 2021.
- 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.
- Charge transient behavior and spectroscopic Ellipsometry characteristics of TiN/HfSiO MOS capacitor, Chinese Journal of Physics, Vol. 83, 10101, 2019.

Graphene Electronics

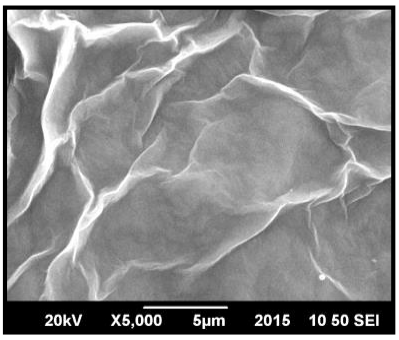
Graphene can be used as a coating to improve current touch screens for phones and tablets. It can also be used to make the circuitry for our computers, making them incredibly fast. Graphene has the potential to create the next generation of electronics currently limited to sci-fi., faster transistors;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

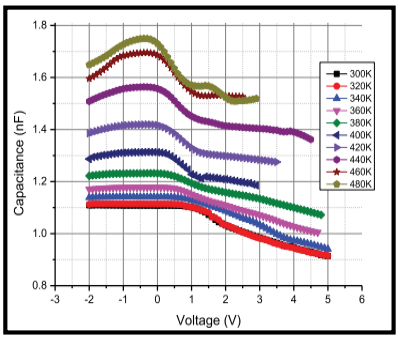


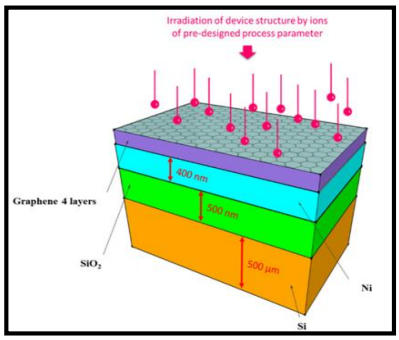
Projects

•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.







Key Publications

•Fabrication and characterization of graphene induced Metal Semiconductor Metal (MSM) structure for detection and sensing applications, European Physical Journal-Applied Physics, Vol. 93, 10503, 2021.
•Investigation of Transport mechanism in graphene-induced Metal-Oxide Semiconductor Capacitors (MOSCAP), Chinese Journal of Physics, Vol. 61, 351, 2019.
•Effect of light and heavy ion irradiation on graphene device matrix: Optical and Transport Characteristics, Radiation Physics and Chemistry, Vol. 156, 17, 2019.
•Simultaneous reduction and sulfonation of graphene oxide for efficient hole selectivity in polymer solar cells, Current Applied Physics, Vol. 18, 599, 2018.

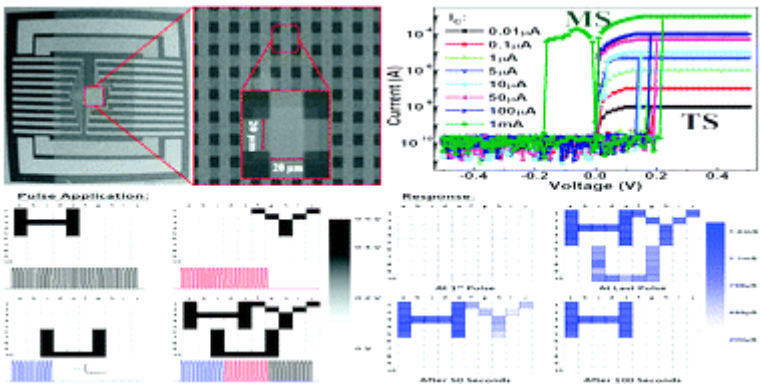
Future Devices, Circuits & Systems: Electrochromic NANO/CNTs, MEMS, Neuro-morphic Circuits, Nano sensors, RF Filters

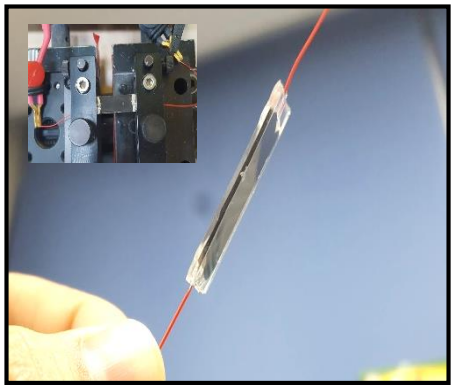
Nanoscience and nanotechnology and their subfields, Nano photonics and Nano electronics had a tremendous impact on recent advances in sensing, imaging, and communication, with notable developments, including novel transistors and processor architectures.

Projects

•Characterization and Investigation of Functionalized MWCNTs based Polymer Nanocomposites.
•Simulation and Characterization of defects of Au/Tu/SiO2/Si based devices for MEMS and 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.





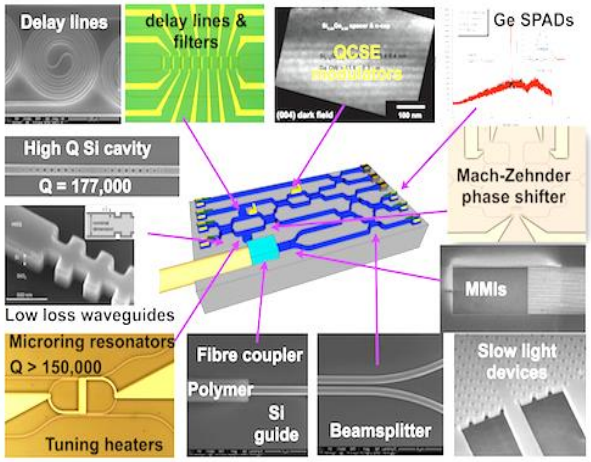
Key Publications

•Facile and low cost temperature compensated humidity sensor and signal conditioning system, IEEE Sensors Journal, 2021. (Inpress)
•Thiophene-2, 5-diesters as electrochromic materials: The effect of ester groups on the device performance and stability, Organic Electronics, 106188, 2021.
•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.
•Highly sensitive wide range linear integrated temperature compensated humidity sensors fabricated using Electro hydrodynamic printing and electrospray deposition, Sensors and Actuators B: Chemical, Vol. 308, 127680, 2020.
•All printed organic humidity sensor based on egg albumin, Sensing and Bio-Sensing Research, Vol. 28, 100337, 2020
•All printed full range humidity sensor based on Fe2O3, Sensors and Actuators A: Physical, Vol. 311, 112072, 2020.
•Soft ionic liquid based resistive memory characteristics in a two terminal discrete polydimethylsiloxane cylindrical microchannel, Journal of Materials Chemistry, Vol. 8, 13368-13374, 2020.
•Multi-colour electrochromic materials based on polyaromatic esters with low driving voltage, Journal of Materials Chemistry C, Vol. 7, 9467, 2019.
•Bandgap engineering in TiO2-Ge nanocomposite thin films, Arabian Journal of Science & Engineering, Vol. 44, 603-612, 2019.

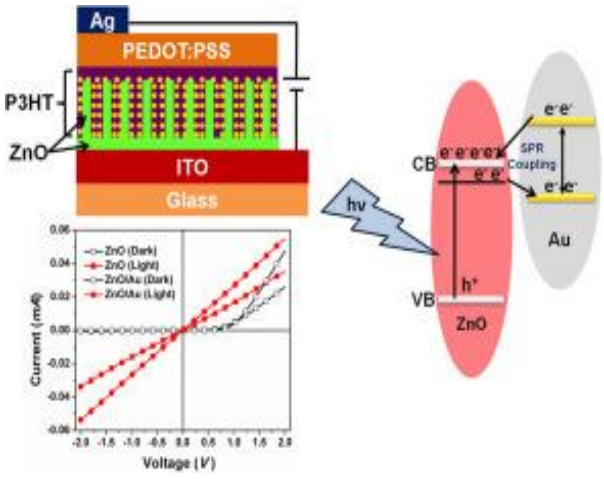
•The electrical behavior of functionalized multiwall carbon nanotubes decorated with polymer nanocomposites, Physica B: Condensed Matter, Vol. 556, 17-21, 2019.
•Mobility and perpendicular magnetic anisotropy in electrodeposited Co32Fe67B1 thin films using boric acid as boron source, Journal of Magnetism and Magnetic Materials, Vol. 458, 156–163, 2018.

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.

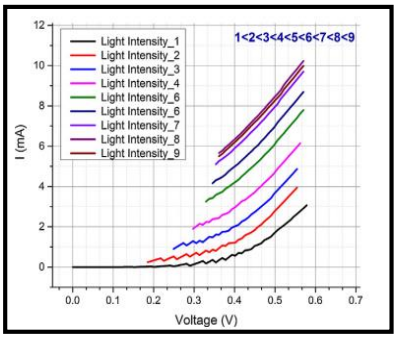


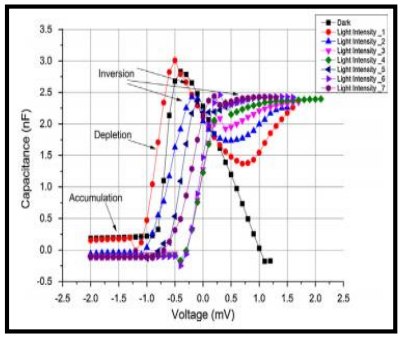
ZnO and other materials are focused in this research area for the fabrication of devices/output electronics for detection purposes. Various detection mechanisms are also understood by detailed evaluation and characterization methods utilized in these problems. Problems targeting the substrate/Platforms, 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.

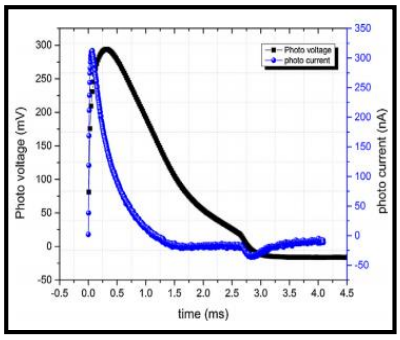


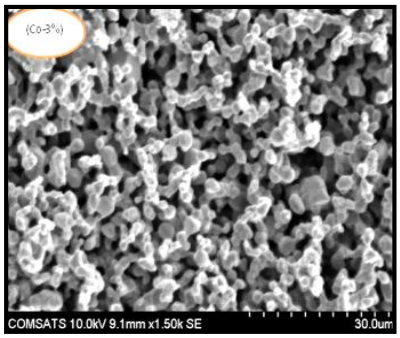
Projects

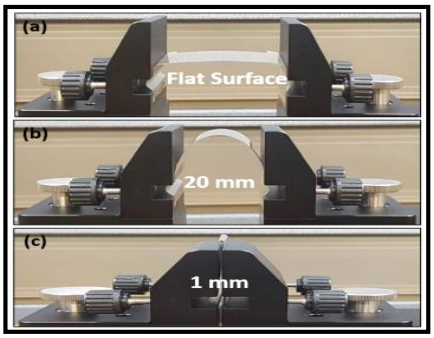
•Design and Characterization of Silicon Quadrant Detector for Robust Position Sensing.
•Design Optimization and Post-fabrication analysis of silicon differential for photonic applications.
•Modelling of carrier multiplication layer of hetero junction avalanche photodiode.
•Device Engineering of AIN/Si 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

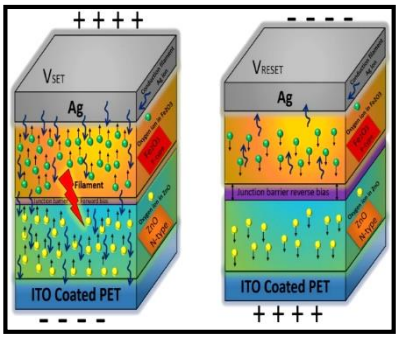












Key Publications

•Advanced Electrical Characterization of AlN/Si based Heterogeneous Junction for Photonic Applications, Materials Science and Semiconductor Processing, 2021. (In Press)

•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.

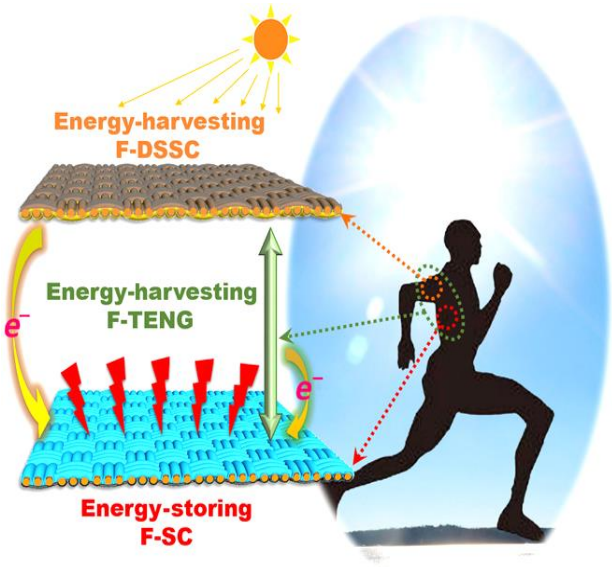
•Defect anomaly in cobalt-doped ZnO nanostructures using optical and charge transient analysis, Chinese Journal of Physics, Vol. 58, 159, 2019.

•Investigation of the sensing mechanism in cobalt doped ZnO matrix based on structural, morphology, optical and electrical studies, Journal of Optoelectronics and Advanced Materials, Vol. 20, 180, 2018.

•Electrical and photo-stimulated characteristics of all-implanted CMOS compatible planar Si photodiode, Optik – International Journal for Light and Electron Optics, Vol. 155, 297, 2018.

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.



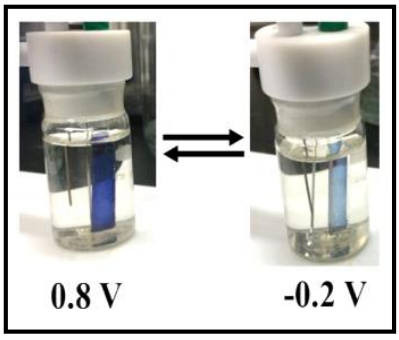
Projects

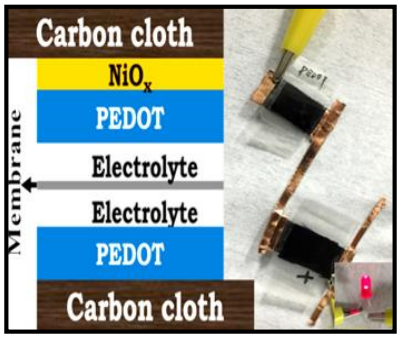
•Fabrication and characterization of Stretchable Super capacitor for Systems Applications.

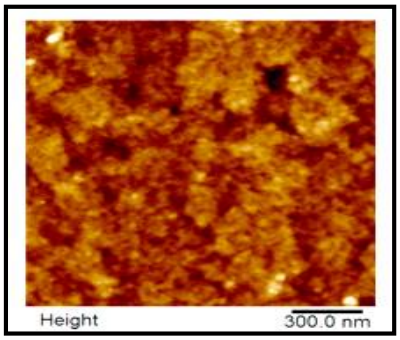
•Super Capacitor Properties of Transistor Metal Oxide – Conducting Polymer – Graphene Ternary Nano Composites.

•Flag type nanogenerator for harvesting wind energy.

•Device modeling for the Efficiency enhancement of Cesium Lead Iodide Solar Cells.







Key Publications

•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.

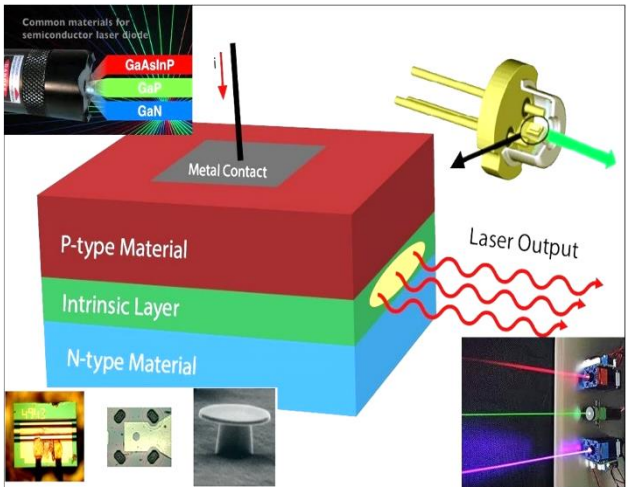
•Flexible Resistive Switching Memory with a Schottky Diode Function Based on a Zinc Oxide/Methylene Blue Heterojunction, Journal of Electronic Materials, Vol. 49, 4764-4772, 2020.

•Evaluation of defects and current kinetics for aging analysis of PEDOT: PSS based supercapacitors, Journal of Energy Storage, Vol. 28, 101243, 2020.

•Recombination strategy for processable ambipolar electroactive polymers in pseudo capacitors, Macromolecules, Vol. 51, 5258, 2018.

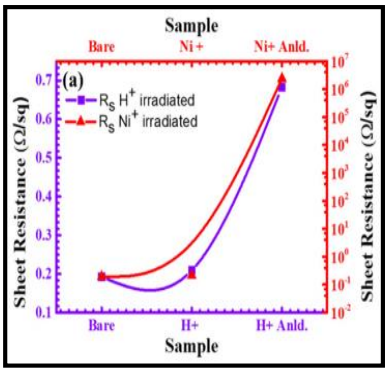
III-V Device Engineering

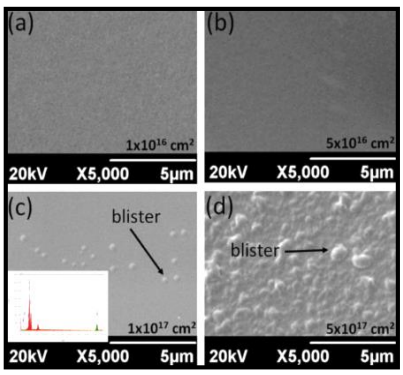
III–V semiconductors such as GaAs, InP, GaN, AlGaAs, InGaAsP etc. have wider applications in high-performance optoelectronics, microwave and millimeter-wave devices owing to their superior electronic properties including high electron mobility, direct band gap, and low exciton binding energy. The groups 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..

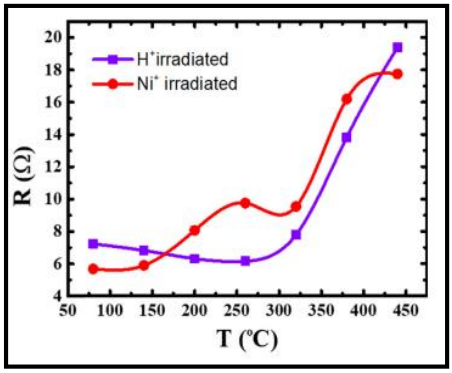


Projects

•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.





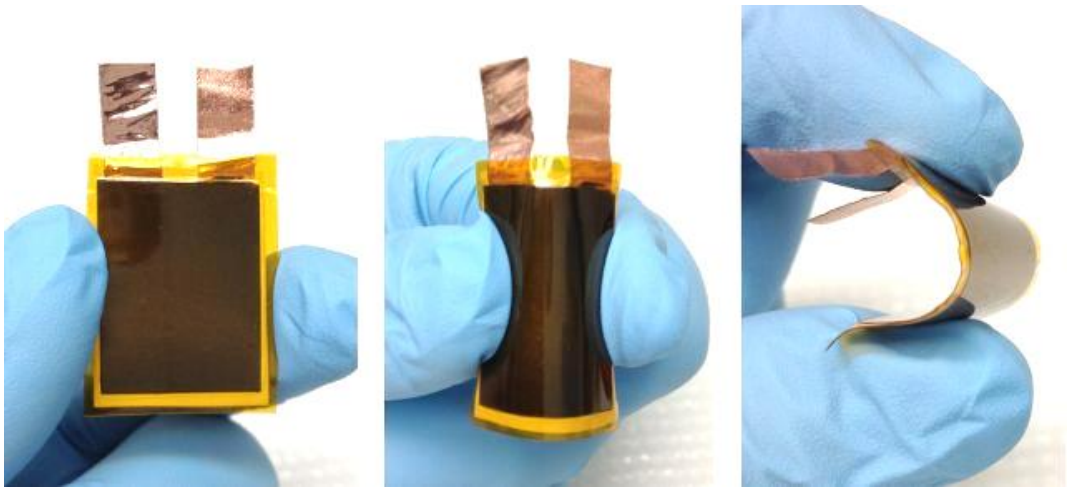


Key Publications

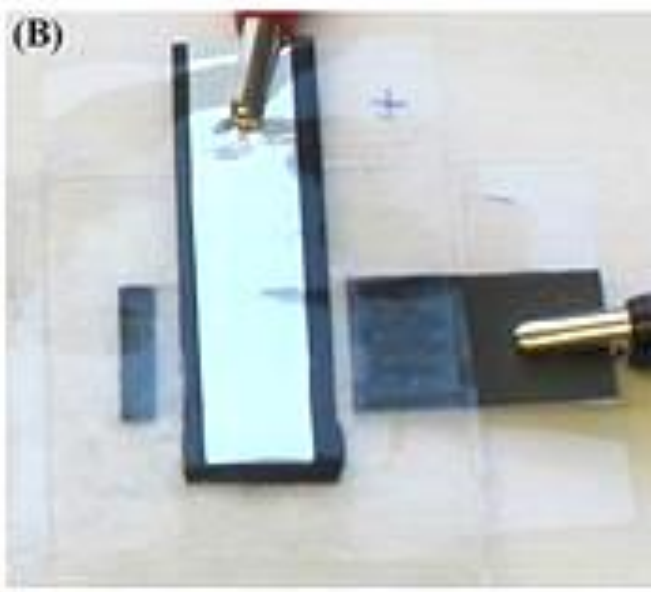
•Carrier removal and transport in photonic integrated circuit ready InGaAsP/InP substrate: Electrical and transients of charges evaluation, Materials Science in Semiconductor Processing, Vol. 121, 105384, 2021.
•Ion-induced Electrical Isolation in GaN-based Platform for Applications in Integrated Photonics, IEEE Access, Vol. 7, 184303, 2019.
•Analytical Formulas for Mean Gain and Excess Noise Factor in InAs Avalanche Photodiodes, IEEE Transactions on Electron Devices, Vol. 65, 610, 2018.
•Structural, optical and annealing studies of nitrogen implanted GaAs, Physica B: Condensed Matter, Vol. 20, 180, 2018.

PATENT FILED IN 2020-21 (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



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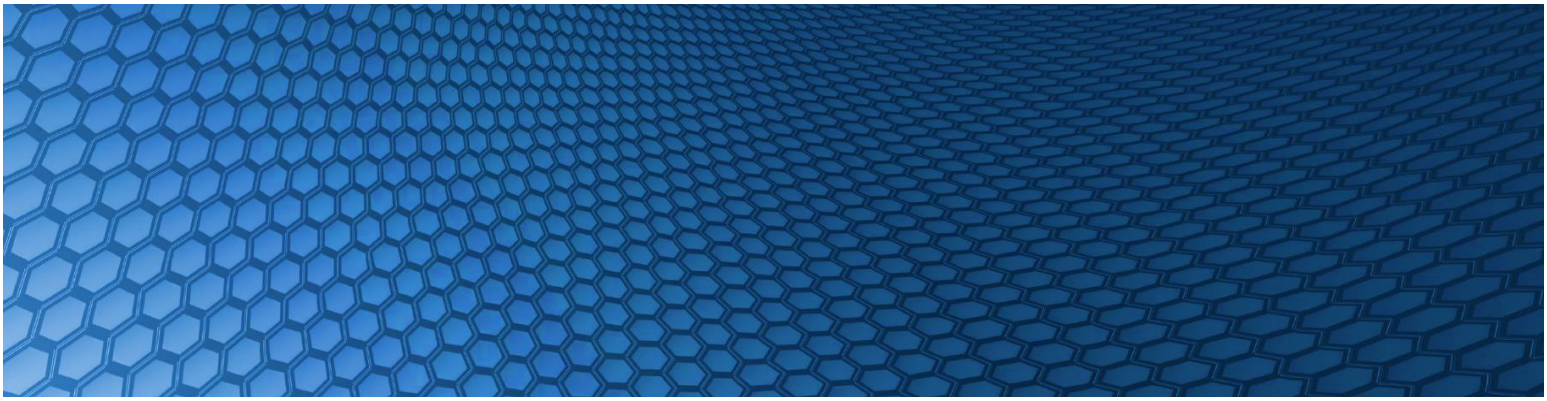


3- GRANTS, TEAM & COLLABORATION

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)

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

TEAM AND COLLABORATION

- Prof. Dr. Ahmed Shuja Syed
  Vise president (HS & R)/Founding Executive Director CAEPE /Advisor to the Rector & President (Engineering Programs), IIUI
- Dr. Gul Hassan
  Assistant Professor/ Cleanroom Manager, CAEPE
- Dr. Erum Jamil
  Assistant Professor/Incharge Department of Electrical Engineering
  (Focal point: Female students/Users, training & Workshop)
- Engr. Shoaib Alam
  Research Associate/Laboratories Manager, CAEPE
- Engr. Muhammad Ali
  Research Associate/Research Liaison Manager, CAEPE
- Engr. Faraz Qayyum
  Lab Engineer/I.T & Networking Manager, CAEPE
  (Focal Point: Device Design Suite)
- Mr. Shah Fahad
  Research Associate, CAEPE
- Engr. Toqeer Ahmed
  Lab Engineer, CAEPE
- Mr. Shoaib Waqas
  Lab Assistant, CAEPE
- Engr. Majid Khattak
  Lab Technician
- Mr. Zahid Mushtaq
  Lab Technician, CAEPE

Interns

- Mr. Fazal Abbas
- Engr. Ijlal Haider
- Engr. Ali Ramaiz
- Mr. Saad Zia

SELECTED GRANTS IN FOCUS FOR THE YEAR 2020-2021

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

Award of Rs 16.9 million

The COVID-19 virus has impacted the global population in grave and unsettling ways.

In this scenario, Big Data, Artificial Intelligence and Mobile Computing are key to understanding the impact that Coronavirus shall have.

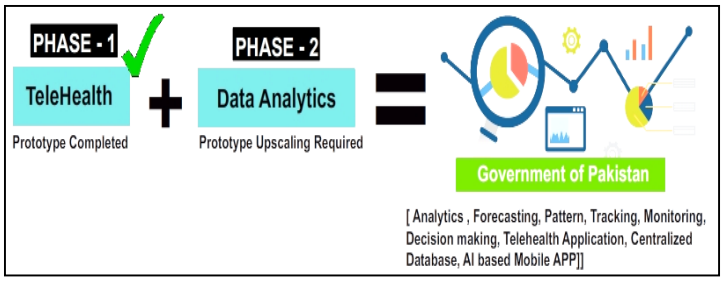
We have proposed in this project the recent advancements in telehealth and big data technologies to move primary care services to smart environments for COVID-19.

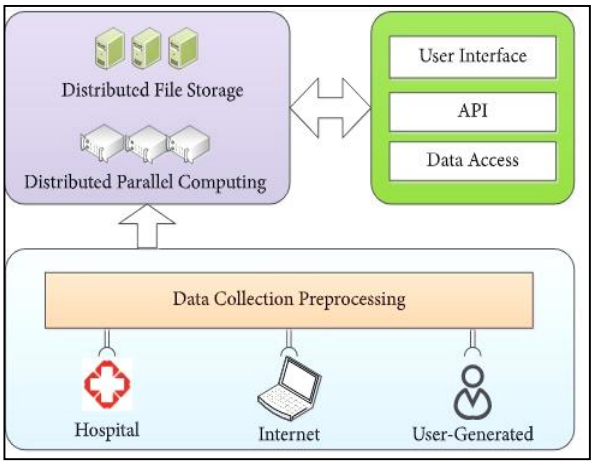
A Cloud based **Multi Node** Tele Health Framework Supported by **AI & BIGDATA** can help us easily connect to "different data sources / nodes" such as Hospitals, Doctors, Patients at home, Diagnostic Labs, Sensing devices and Data centers.

The COVID-19 Government/Public agencies will benefit most from the "**Intelligently analyzed**" data for rapid, but informed, decision making.The deliverable product will be in the form of "upscaling" our developed prototype of Cloud-based Tele Health application to an Intelligent Data Mining Platform (supported by Artificial Intelligence), which would help the Government of Pakistan and Health Care Professionals to decide the line of action on the basis of numbers, analytics and Trend-forecasting in COVID-19 and similar future pandemic scenarios.

Looking at the available resources and the utilization in Pakistan's COVID-19 National Command and Control Center; the presence of such optimized platform on a larger scale is greatly needed.

The Tele Health Framework will not only be helpful analyzing data and patterns, but nodes connected to user end (Patients) will allow them to use advance AI features which includes Video Consultation, Bot-based Health Monitoring, AI multilingual information bots and maintain centralized electronic record.





Principal Investigator:

Dr. Erum Jamil

Department of Electrical Engineering (Female Campus)/ Centre for Advanced Electronics and Photovoltaic Engineering

International Islamic University, Islamabad

Co- Principal Investigator:

Dr. Gul Hassan

Assistant Professor/ Cleanroom Manager, CAEPE

Industrial Partner:

Cloudlabs (PVT), ltd, Pakistan

Project current status & final outcome after upscaling

TRIPLE HELIX PROJECT

IsDB-IIU PHOTOVOLTAIC ENERGY ENGINEERING PROJECT

Principal Investigator: Prof. Dr. Ahmed Shuja Syed

Introduction:
The project, shaped as a result of Islamic Development Bank's funded internationally competitive Technical Assistance Grant **worth US$ 0.6 Million**, 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 Photovoltaic (PV) engineering. The development of this R&D project at the Centre for Advanced Electronics & Photovoltaic Engineering (CAEPE) in the International Islamic University (IIU), Islamabad is university's first formal initiative to conduct teaching and research and produce trained manpower in this much desired area. The successful establishment of this laboratory is augmenting the efforts of Government of Pakistan in the social sector, which has just started taking energy education seriously and this initiative is certainly amongst some pioneering steps in this direction.

Status & Accomplishments:
The grant made the Centre equipped with R&D grade highly sophisticated machines in addition to a variety of design, process, testing and evaluation facilities that the Centre is already housed with. The facilities are greatly supporting the PV related teaching, research and testing & evaluation cycles on continual basis. The subject grant is on an advanced stage of academic and scientific support with the usage of procured machines in conjunction with the facilities already developed in the previous IDB-TAG namely Advanced Electronics. This may be witnessed by viewing a thriving number of users and research projects in the broader areas of Energy, Photovoltaics and Energy Electronics.

Key Accomplishments:
There have been many accomplishments made during the grant period. Some of the important ones are:

- Establishment of Pakistan's first Class 100 (ISO-5) Clean room for device fabrication
- Numerical Solutions provided to the larger R&D community to predict performance parameters of PV solar with optimized engineering design
- Sequential process solutions presented for the fabrication of II-VI based solar cells, Dye-Sensitized and Perovskite-based PVs
- Novel charge assessment technique developed for the effective mapping of pre- and post-packaged PV Solar devices for better efficiencies
- Hundreds of cross-trained research students/faculty/STI workers on the design, development, evaluation, testing and qualification of PV Solar and power devices

Development of Stretchable Polymer Based Supercapacitors for Energy Storage Systems

Pakistan Lead: Prof. Dr. Ahmed Shuja Syed (International Islamic University)

Co-PI: Dr. Imran Murtaza (International Islamic University)

Chinese Lead: Prof. Dr. Hong Meng (Peking University, Shenzhen)

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

Budget for the project: Rs. 27 Million

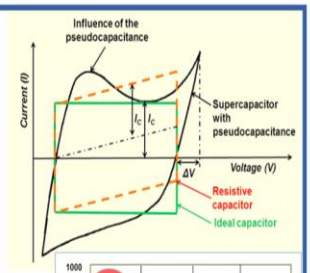
Overview

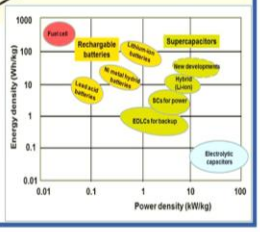
- The problem under focus, which is applied and interdisciplinary in nature, lies at the heart of energy storage systems.
- In this project, intrinsically stretchable conducting polymers will be designed, synthesized and applied to develop the stretchable supercapacitor devices for subsequent energy storage applications. While creating the molecular design, process strategies such as introducing side chains to increase flexibility, utilizing the interactions of hydrogen bond to increase stretchability, or designing three-dimensional network-like structures will be considered.
- The results of such study will be helpful to figure out relationships between molecular structures and their intrinsic stretchability as well as capacitance. Prototype devices including sandwich structure, planar structure and fiber structure will be exploited for energy electronics regimes. These devices may achieve high energy-storage ability even under high stretchability and expected to yield a great potential in wearable electronics in the system level energy storage applications including the IoNT configurations.

SuperCaps at a Glance

Battery vs supercapacitor

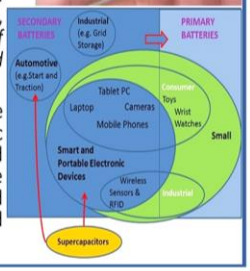
Function	Supercapacitor	Lithium-ion (general)
Charge time	1–10 seconds	10–60 minutes
Cycle life	1 million or 30,000h	500 and higher
Cell voltage	2.3 to 2.75V	3.6 to 3.7V
Specific energy (Wh/kg)	5 (typical)	100–200
Specific power (W/kg)	Up to 10,000	1,000 to 3,000
Cost per Wh	$20(typical)	$2 (typical)
Service life (in vehicle)	10 to 15 years	5 to 10 years
Charge temperature	–40 to 65°C (–40 to 149°F)	0 to 45°C (32° to 113°F)
Discharge temperature	–40 to 65°C (–40 to 149°F)	–20 to 60°C (–4 to 140°F)





Objectives

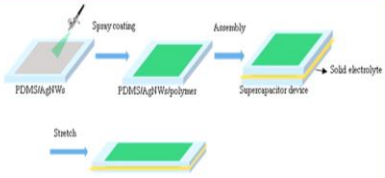
- **Objective 1:** Preparation and characterization of intrinsically stretchable conducting polymers with acceptable electrical, electrochemical and mechanical properties for the subsequent development of supercapacitors;
- **Objective 2:** Device fabrication and characterization of stretchable polymer-based supercapacitors, followed by detailed analytics (*analysis of relationships between device design and performance*);
- **Objective 3:** Optimization and improvement of device performance parameters for technology-specific exploitation (by choosing suitable materials and designing *novel* configurations, and realization of the combination between maintained performance and considerable stretchability for polymer-based supercapacitors).



Methodology

A *five-tier approach*; as detailed below; will be used to address the problem. The overall methodology is broadly divided into:

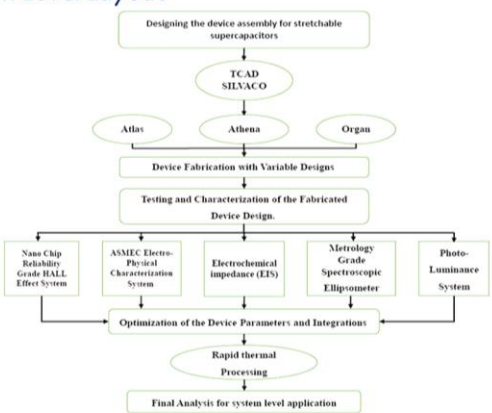
- Design and synthesis
- Device fabrication
- Analysis and optimization of material's parameters
- Evaluation, testing & characterization, and,
- Exploitation to further the device designing and fabrication at system level



Preparation process of stretchable supercapacitor device

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

System Level Layout



Overall Framework

Sensor being powered	• Combining a secondary battery (lithium ion for instance) plus energy harvester (solar cell, piezoelectric generator, seebeck generator etc)
Practical Issues	• Energy harvester typically can't generate large amount of power • Secondary batteries require recharging plus possible interval resistance that may hinder sufficient charging by the harvester
Solutions	• Longer cyclic life, minor internal resistance, combination of EDLCs and harvester which is effective replacement of battery powered sensor devices. • Very good temperature characteristics (ability to operate in frozen ambient)

Supercapacitors good for	• Extremely high pulse power, capacitance diversities, rapid charge/discharge capabilities
Supercapacitors provide/ supports	• Design to achieve significantly extended battery life spans, back up times when used with the secondary battery
Supercapacitors are broadly employed	• In energy harvesting, instantaneous power pulse, power hold up circuits of NG energy systems (designed to satisfy challenging power, size, cost and efficiency requirements), and quick charge applications
NG energy Systems Issues and Relevance of supercapacitors	• Solar, wind, hydropower, vibrational and RF energy systems). All suffer, currently, from a great deal of wasted energy that supercapacitors may be able to effectively harvest
Motivation to design efficient and effective energy systems	• In response to the improved and increasingly tested employment of SCs, supplier's throughout the passive component industry are striving hard to maximize. The energy and power density of these devices while continuing to limit their ESR.

For Queries & Discussion, Please contact ahmed.Shuja@iiu.edu.pk

Investigation in Advanced Energy Harvesters and Energy Storage Devices for Self-powered Flexible Energy Systems (FleEnSys)

Title of Project:	Investigation in Advanced Energy Harvesters and Energy Storage Devices for Self-powered Flexible Energy Systems (FleEnSys)
Duration of Project:	36
Total Budget for the Project	100 Million

CAEPE and its affiliates from the department of physics,(IIUI); in collaboration with University of the West of Scotland and James Watt School of Engineering, University of Glasgow, UK has won the Innovative and Collaborative Research Grant of the tune of 100 million in total. The project is backed by the industrial partners from all sides to come up with a product that can be readily marketed (**Lightricity, UK** and **Nizam Energy, Pakistan**). This is one of the six awarded projects in first ever **Pak-UK Gateway** R&D call.

Small portable electronic devices demand low-cost and affordable energy solutions (Figure) developed on non-conventional substrates such as fabrics, plastics, paper, etc., capable of providing sufficient energy to achieve the desired continuous powering of sensors, and low-power electronics. Ideally, a 24/7 powering of such technology is required, allowing this technology to be utilized e.g. for health monitoring, security tracking, vehicle navigation, or robotic interactions, guaranteeing a safe environment, high efficiency, and great feasibility. This would also negate the need for human intervention to replace bulky batteries, or to use wires, the latter becoming a wireless technology. Having highlighted the main challenges of the current technology in terms of energy budget, main areas of investigations included in the FleEnSys project aim to find an effective solution to address the aforementioned drawbacks.

Grantee: Dr. Imran Murtaza ***Co-Grantee: Prof. Dr. Ahmed Shuja Syed***

Some of the Team Members at CAEPE

CAEPE AFFLIATES

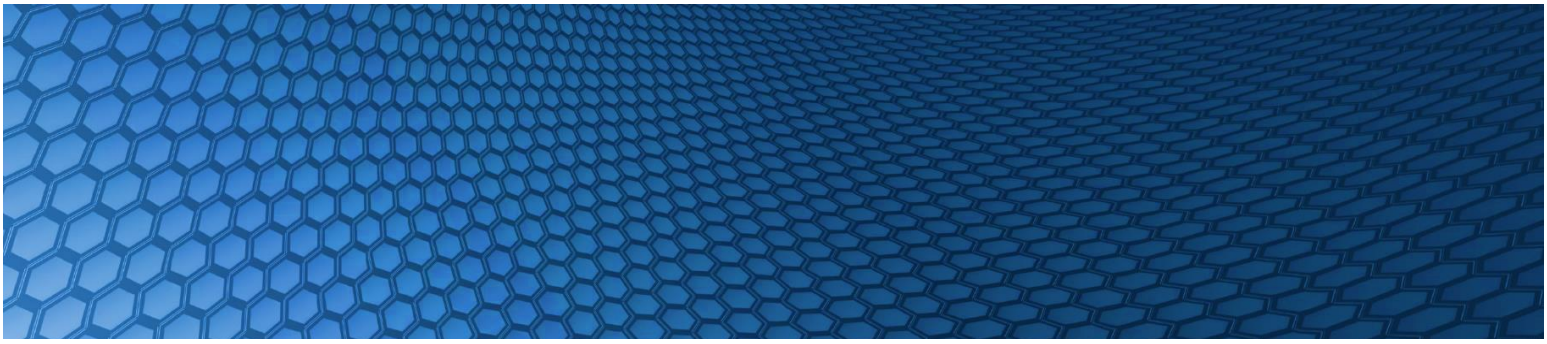
- Dr. Imran Murtaza (IIUI)
- Dr. Erum Jamil (IIUI)
- Dr. Muhammad Sohail (IIUI)
- Dr. Yousaf Hameed Khattak (FUUAST)
- Dr. Faisal Baig (FUUAST)
- Dr. Zeeshan Najam (MNS UET)
- Dr. Saba Ashraf (IIUI)

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)
- **Marquette University, USA** (Focal Point: Dr. Erum Jamil)

INDUSTRIAL PARTENER ENGAGED IN 2020-21

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



4- TEACHING, SERVICES & CLIENTAGE

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

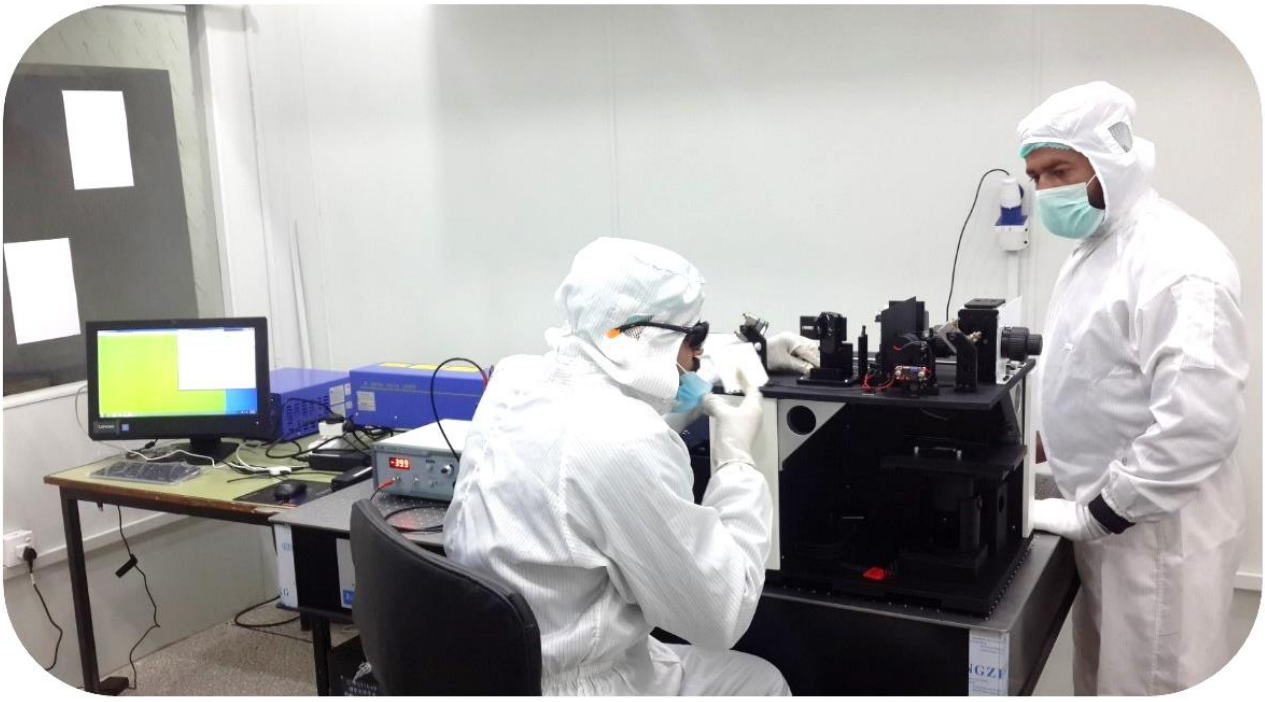
CAEPE, being a leading user facility, has also access to the Epitaxial Growers, Ion Implantation Services, Fabs for Standard CMOS development, III-V Devices, MEMS/ Microsystems applications; with experience in taping out the chips and discrete devices.

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



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

Under graduate 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

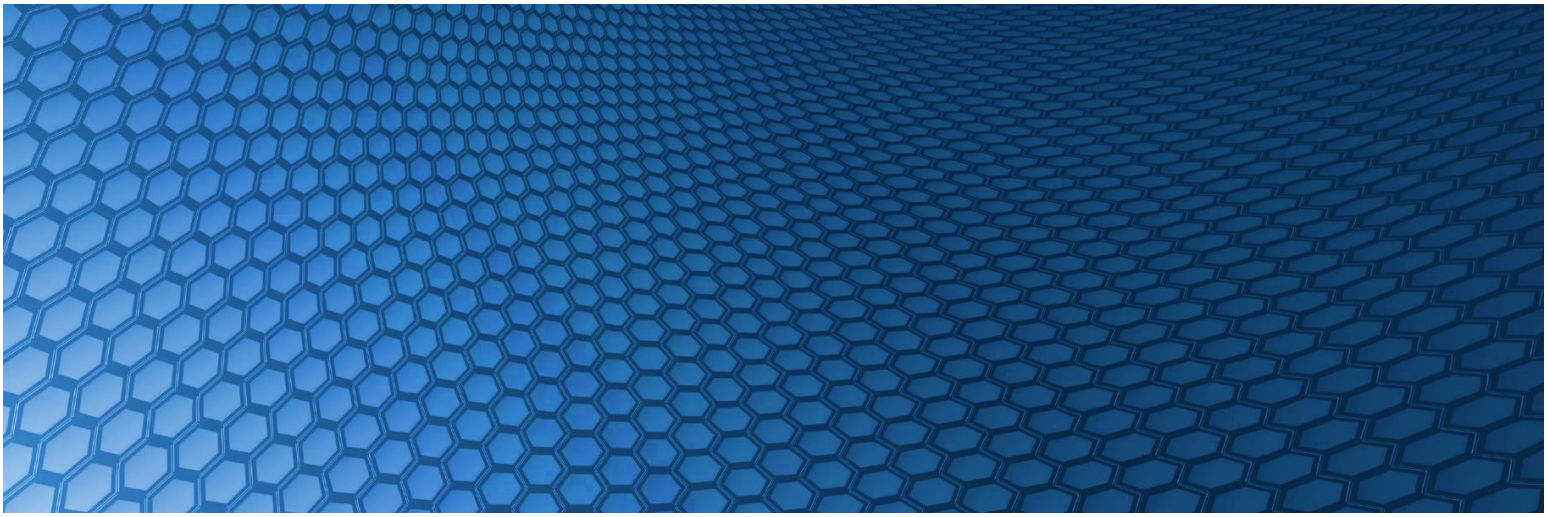
Data Statistics

- 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



5- STATISTICS

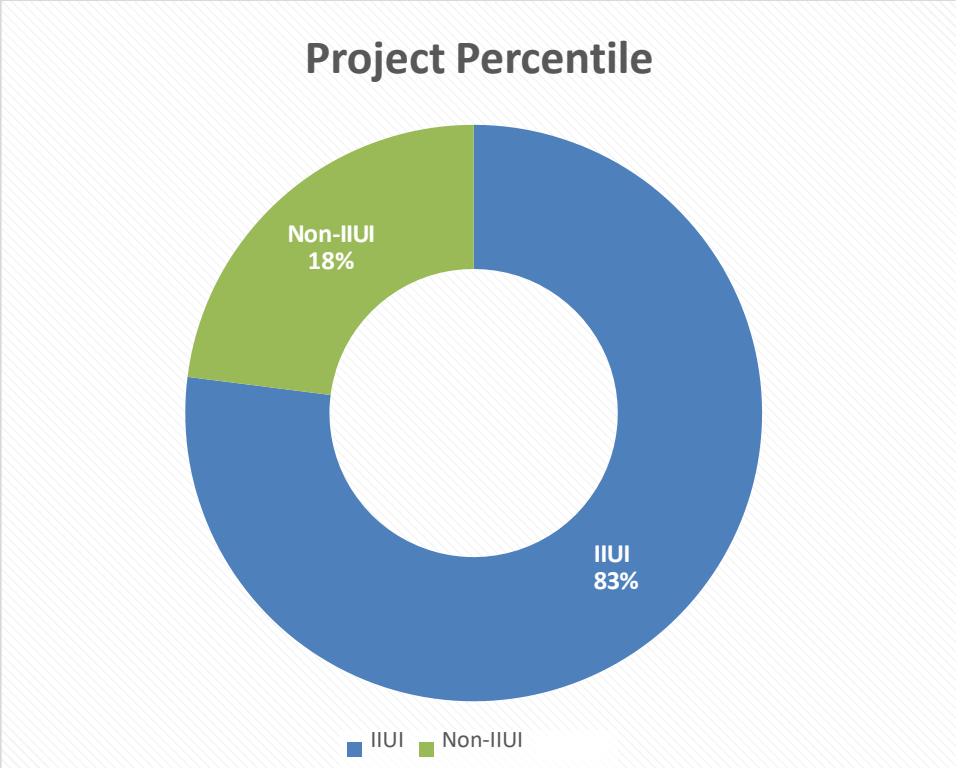
Programs & Projects

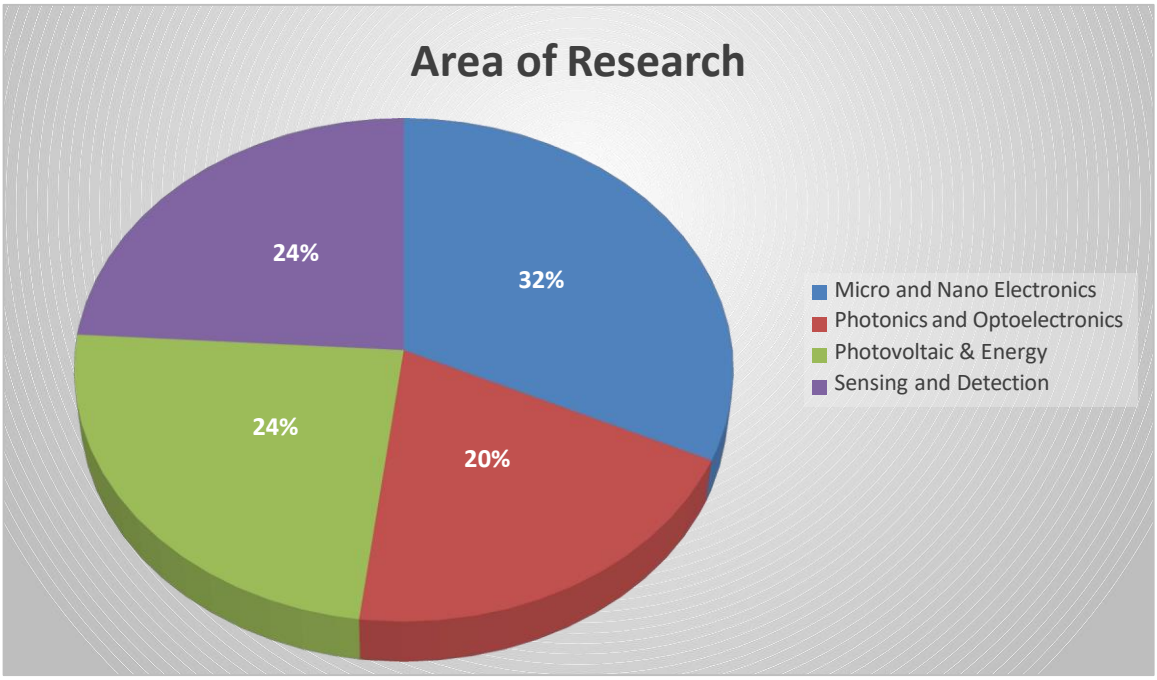
User's Spread within the Scientific disciplines

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

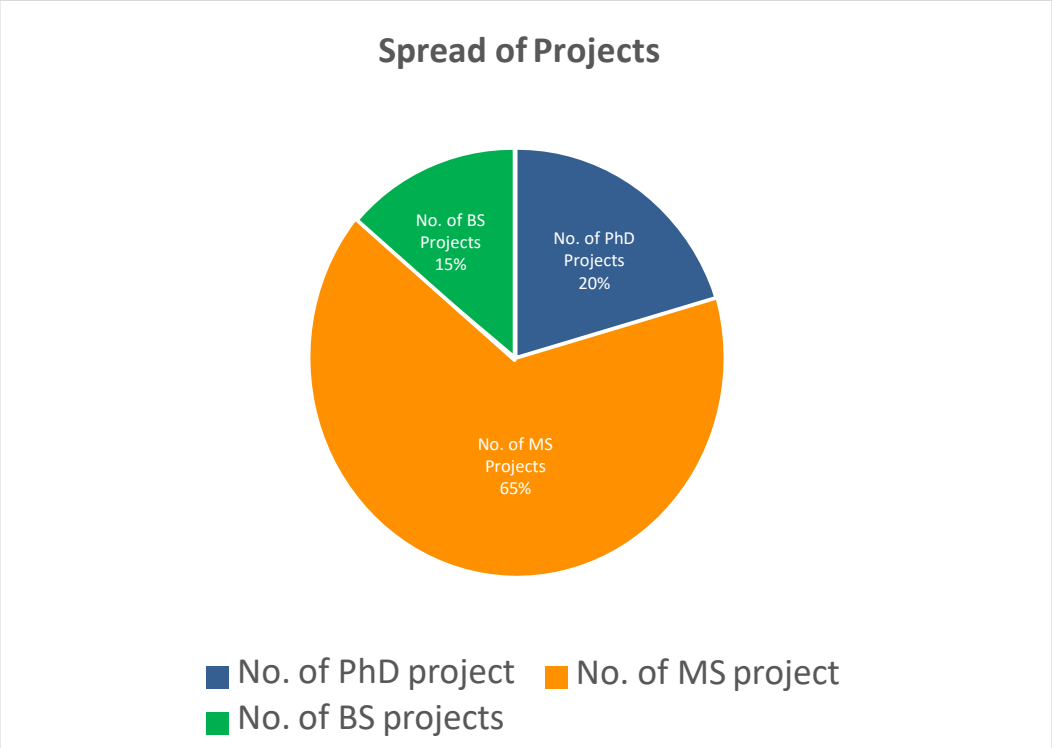
Some of the frequent users of the Centre's facilities having **multiple and diverse** scientific projects are listed below:

	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)**

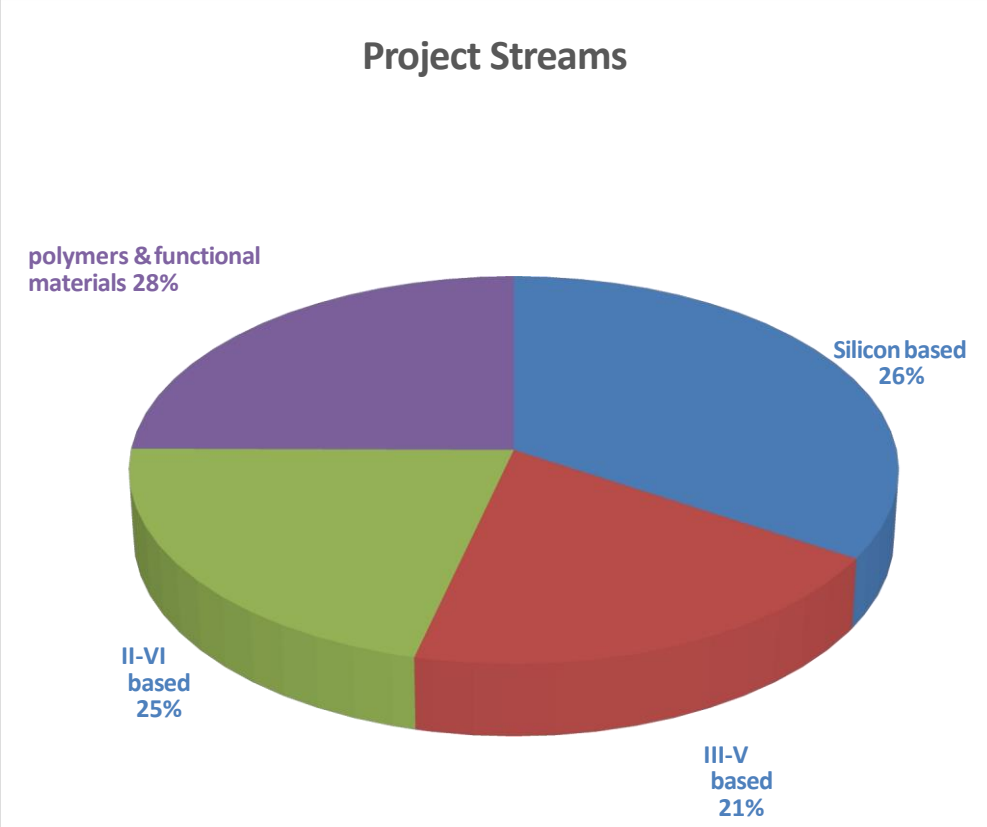




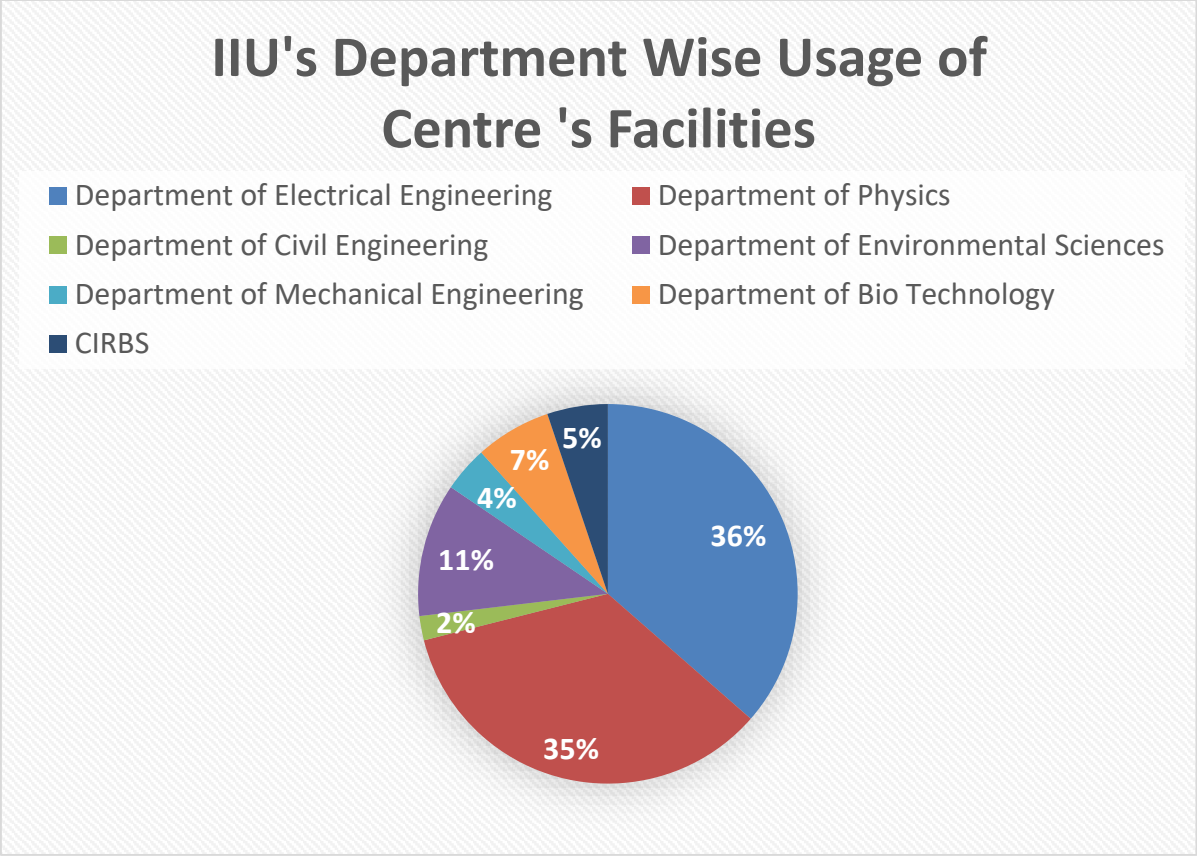
Spread of Research Activities: Theme Proportion



Proportion of Student - wise Usage of Facilities



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



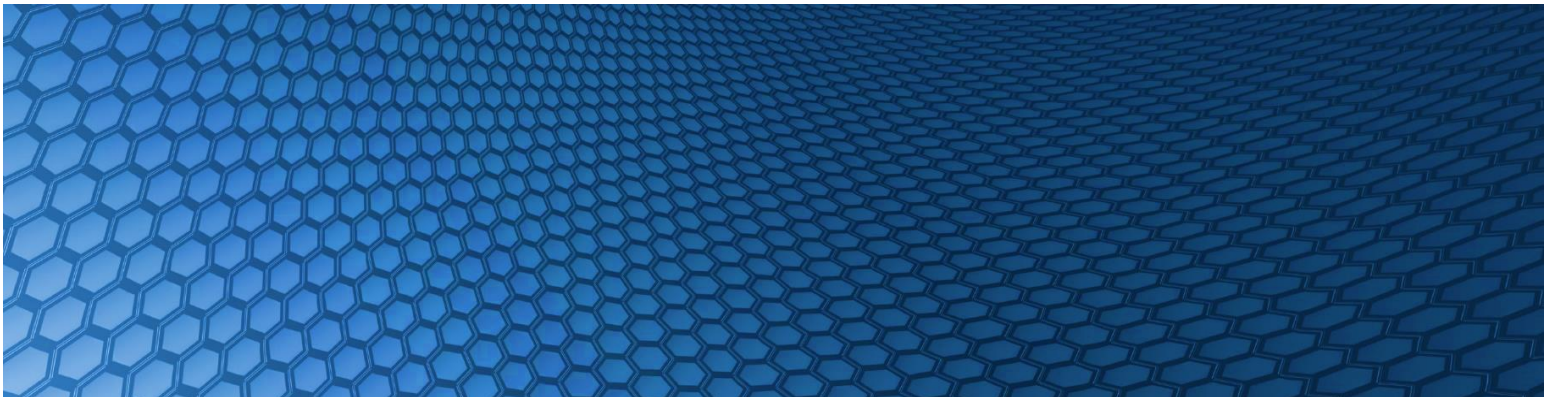
List of Frequent/Primary Users* from Faculty Members in the University

Dr. Naeem Ahmad	Dr. Rafiullah Khan
Dr. Shaista Shehzada	Dr. Islamud Din
Dr. Javed Iqbal	Dr. Rehana Mustafa
Dr. Waqar Adil	Dr. Ghulam Mustafa
Dr. Nyla Jabeen	Engr. Waqas Haroon
Dr. Masoom Yasinzai	Dr. Mehwish Taneez
Dr. Ahmed Shuja Syed	Engr. Mamoon Riaz
Dr. Syed Salman Hussain	Dr. Sobia Tabassum
Dr. Seyab Khan	Dr. Syed Ali Imran
Dr. Afzal Hussain	Dr. M. Mumtaz
Dr. M. Mumtaz	Dr. Bushra Hazeef Kiyani
Dr. Laraib Ahmed Khan	Dr. M. Rahim
Dr. Bashir Ahmad	Dr. Inayat Ali Khan
Dr. Ahsan Ullah Kashif	Dr. Abdul Hameed
Dr. Erum Jamil	Dr. Aqsa Arshad
Dr. Kashif Nadeem	Dr. Gul Hassan
Dr. Wiqar Hussain Shah	Dr. Kiran Abdullah
Dr. Bushra Bari	Dr. Rakshanda Aziz
Dr. Shumaila Sajjad	Dr. Maliha Asma
Dr. Imran Murtaza	Dr. Athar Masood
Dr. Bushra Uzair	Dr. Saba Ashraf
Dr. Zulfiqar Ali	Dr. Wiqar Hussain Shah
Dr. Ikram Ullah	Dr. Syed Ali Imran Bokhari
Dr. Syed Athar Masood	Dr. Aliya Shehzadi

*** Secondary Users Not Counted**

Impact Parameters	Quantum
Extent of Utility and Access	>400 scientific projects
Engagement of Returning Users	80%
Knowledge Creation & Dissemination in Process	>250 projects
Continual Skill Development	>4000 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	*400+*
No. of student trained by the lab staff including BS Level Trainings on Design Suite		
2	Training Level - 1 (4 to 6 weeks)	200+
3	Training Level - 2 (Extensive Machine Training)	100+
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



6- 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.

Visits

Some Important visits to the Centre are:

A high profile visit from Ministry of Science and Technology and Pakistan Science Foundation visited the Centre

Dr. Zain ul Aabdin, Director General, R&D from Higher Education Commission visited the Centre

Registrar National Technology Council of Pakistan and senior program evaluators from Institute of Space Technology and UET Peshawar visited the Centre

Senior Editor from News & Media Industry visited the Centre

Team members from Electronic Design, Circuits and Systems group from PAF KIET, Karachi visited the Centre

Faculty from Quaid –e- Azam university visited the centre

Staff from Independent Urdu news, UK visited the Centre

ADDRESS

CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING (CAEPE)
FIRST FLOOR,
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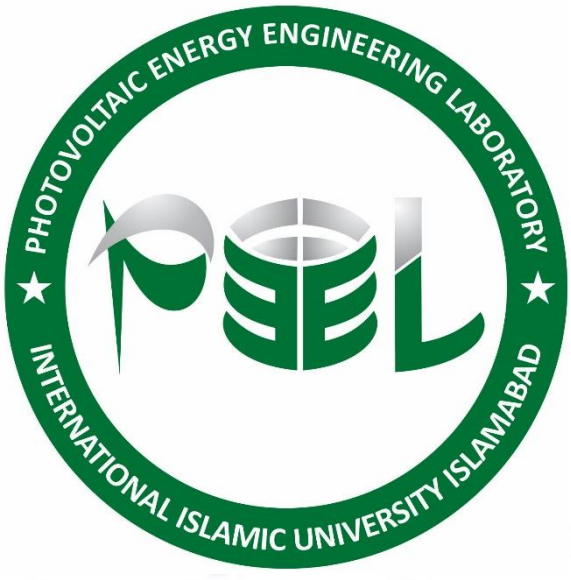
Talk:

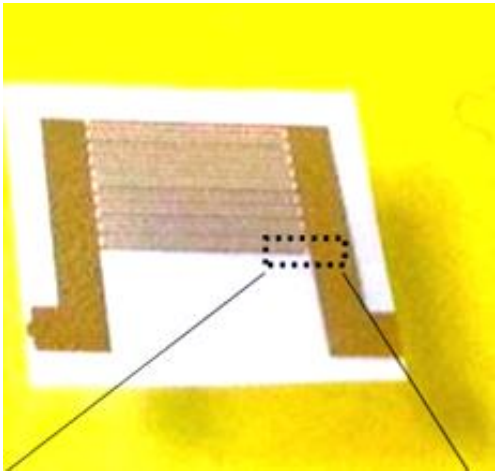
- Prof. Dr. Ahmed Shuja Syed (Executive Director)
- Dr. Gul Hassan (Cleanroom Manager)
- Engr. Shoaib Alam (Laboratories Manager)

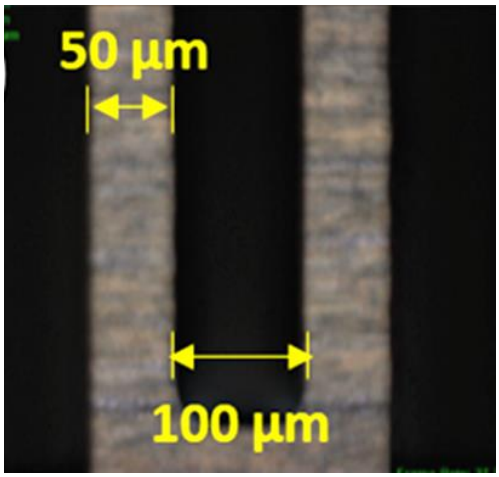

ADVANCED ELECTRONICS LABORATORIES
INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD

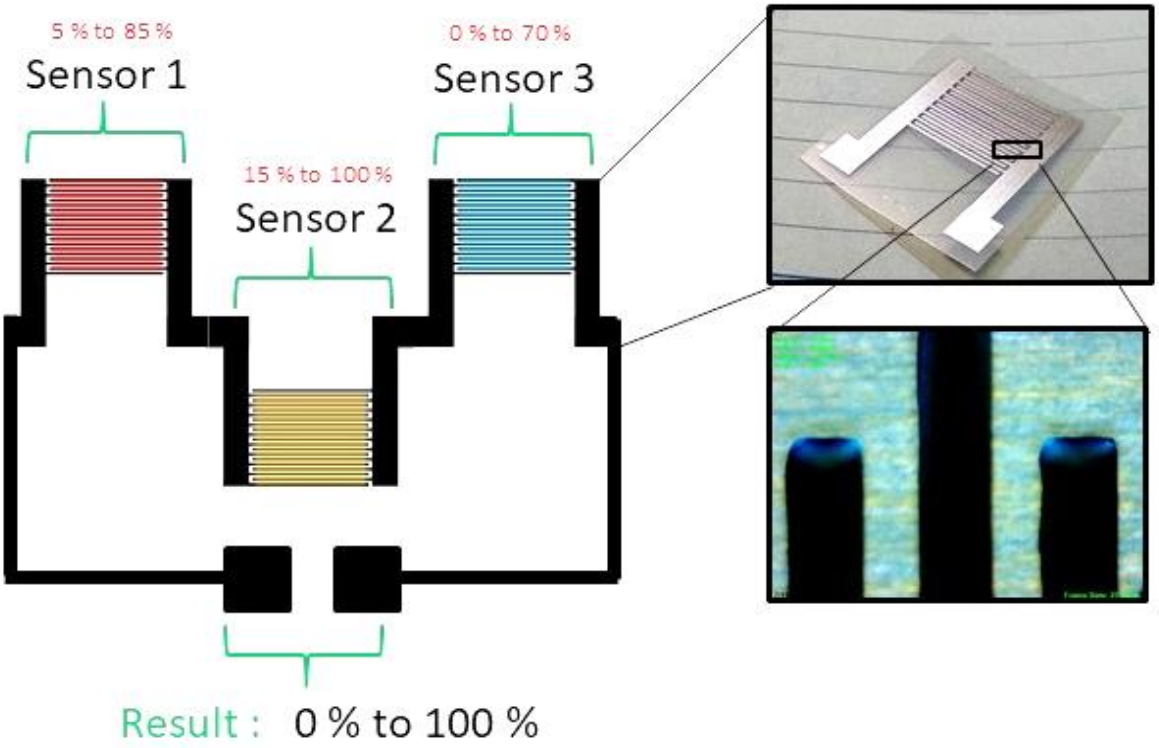

CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING
INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD


PHOTOVOLTAIC ENERGY ENGINEERING LABORATORY
INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD

International Islamic University Islamabad







Indigenously developed Humidity Sensor At CAEPE

PAKISTAN ZINDABAD

CAEPE PROGRESS REPORT 2020-2021