
# CENTRE FOR ADVANCED ELECTRONICS & PHOTOVOLTAIC ENGINEERING (CAEPE)

## INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD

# International Islamic University Islamabad

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 ~ 350+
- Enabling to target 4 Sustainable Develop- --ment 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

# CENTRE FOR ADVANCED ELELCTRONICS & PHOTOVOLTAIC ENGINEERING (CAEPE)

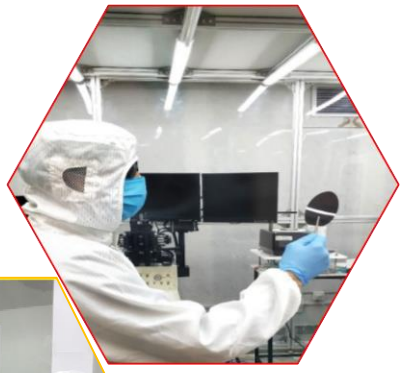
## CENTRE MISSION

To conduct advanced electronics & photovoltaic engineering research that produces:

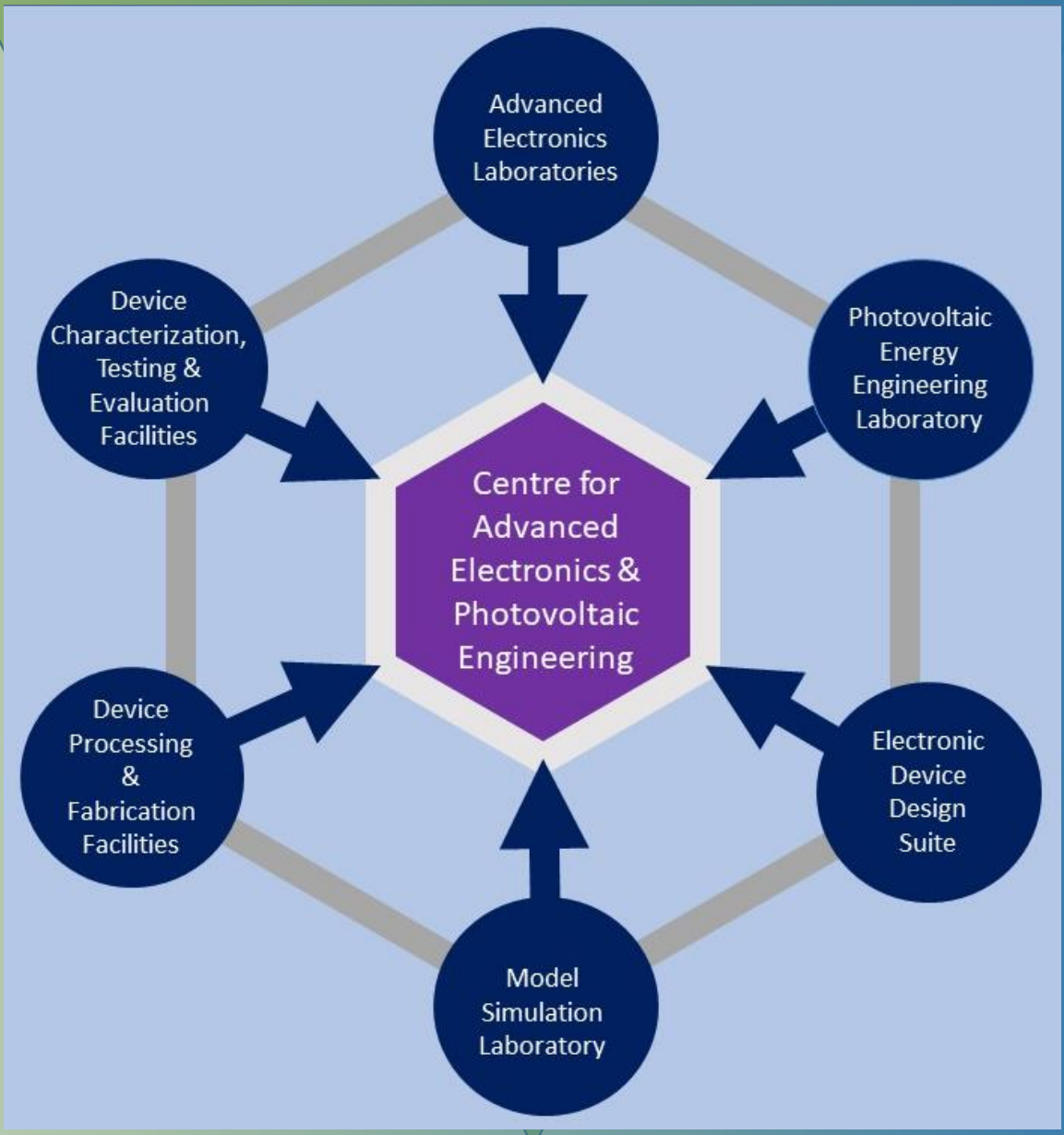
- New Technologies
- Processes
- Systems that may provide new or significantly enhanced knowledge for direct benefit to economic opportunity in Pakistan

## 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



# Laboratories




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

## Contact

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# 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.

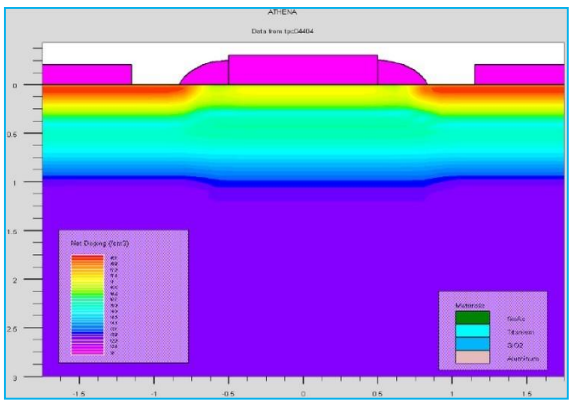
Device Modeling and Simulation explores scaling and process development of advanced electronic and photonic devices. These tools cover device transport and performance as well as process modules. These predictive tools help to provide physical insights into new devices, new physical phenomena arising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

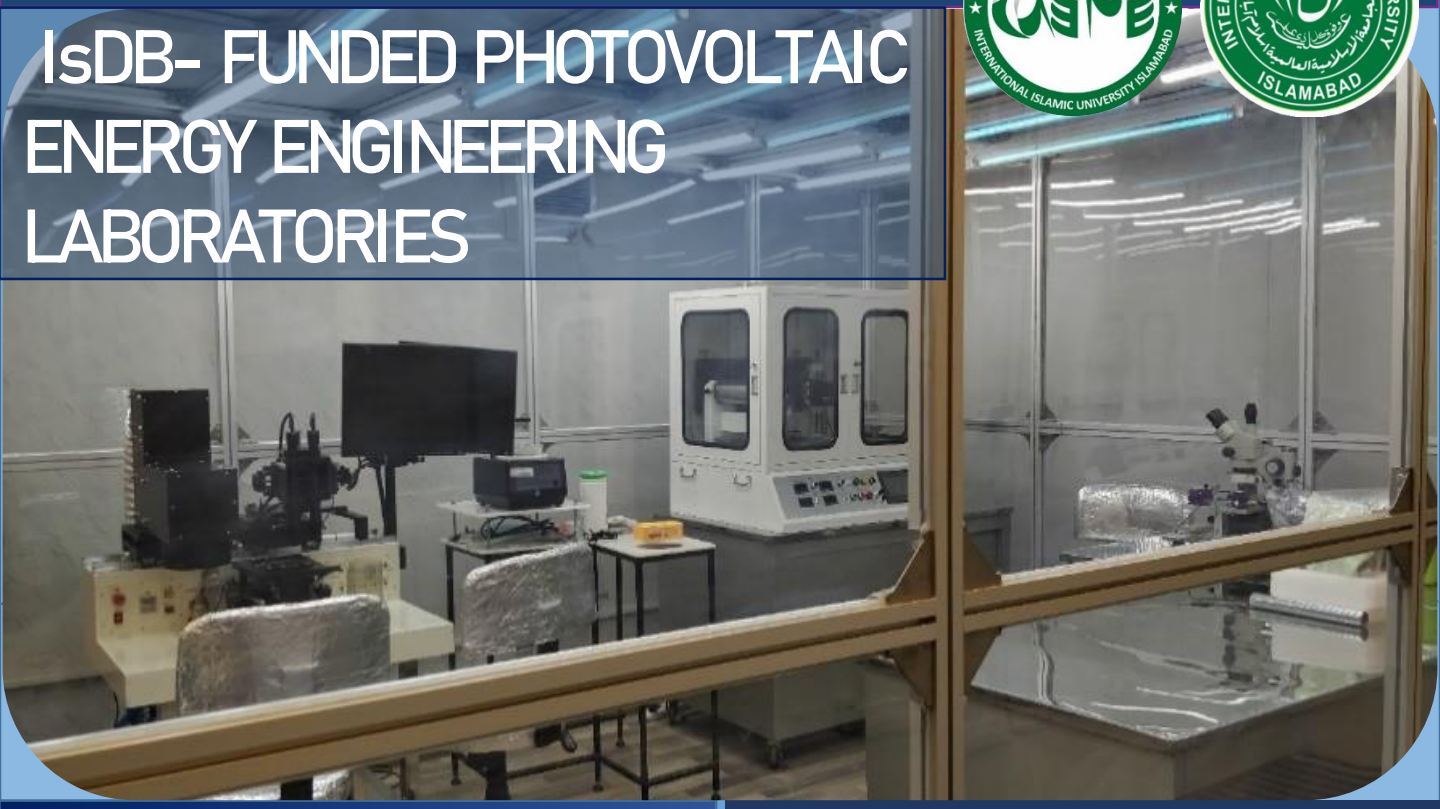
To apply interdisciplinary and bottom-up approaches that enable discovery of novel alternatives to complex Fab-less electronic device design and processes.

## 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

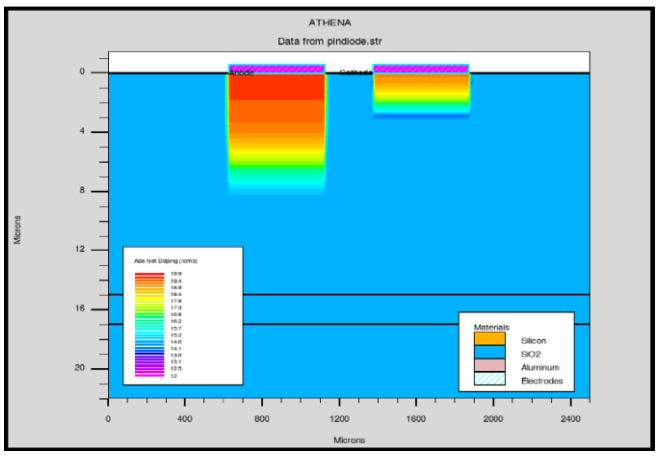
The Lab is focused to simulate the model cleanroom assisted device design and process knowledge for the students by providing them with the licensed tools and audio visual facilities. These tools are used to design and simulate the solid state devices as well as system level computation for diverse application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

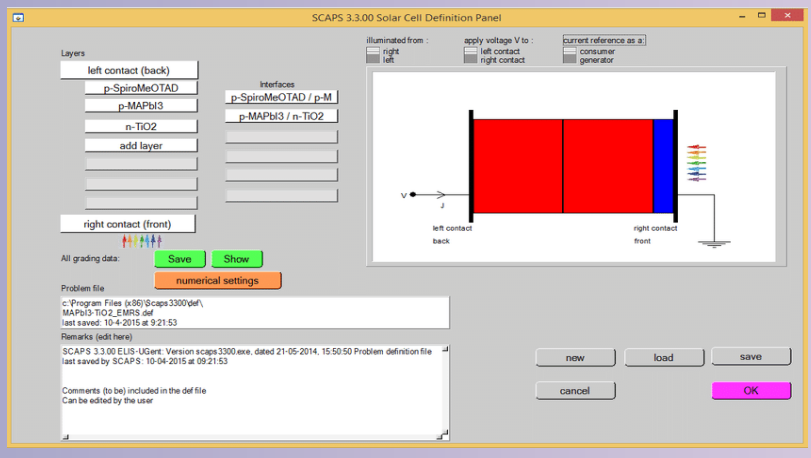
- Technology behind the chip
- Optimization of Processes
- Numerical modelling of solar cells
- Simulation of Opto- and photonic devices
- A.I assisted computing for applications
- Big data analytics



| 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. |

# A PARADIGM SHIFT IN ELECTRONICS AND ENERGY RESEARCH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- Dr. Gul Hassan (Cleanroom Manager)
- Engr. Shoaib Alam (Laboratories Manager)