

CONTACT

Dr Suresha S J
Technology Manager
Micro and Nano Characterization Facility
Centre for Nano Science and Engineering
Indian Institute of Science
Bengaluru 560 012, India

T: 080 2293 3253
080 2293 3181 Ext 109
E: mncf.cense@iisc.ac.in
www.mncf.cense.iisc.ac.in

MICRO AND NANO CHARACTERIZATION FACILITY

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YOUR ONE SOURCE OF MATERIALS AND DEVICES CHARACTERIZATION AND ANALYSIS





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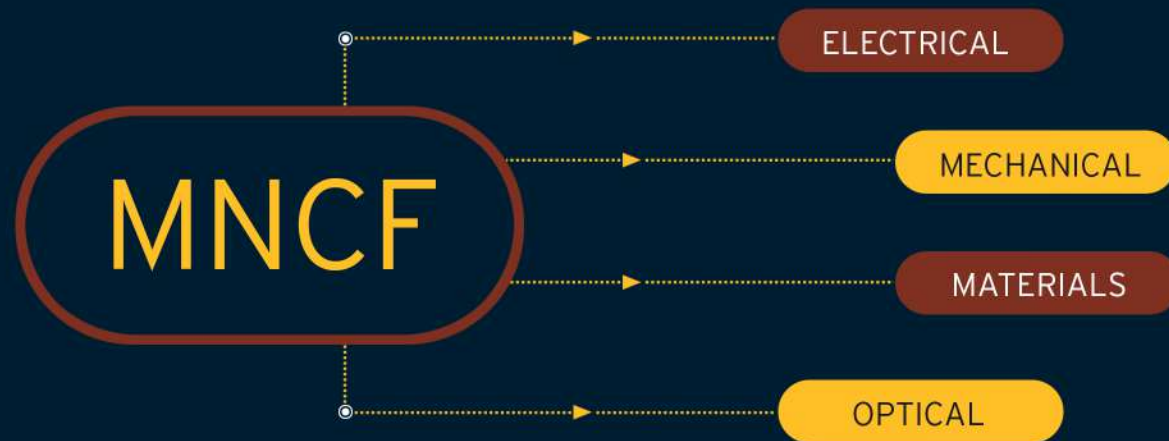
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OVERVIEW

The Micro and Nano Characterization Facility offers a wide variety of materials and device characterization services enabled by more than 35 pieces of equipment housed under a single roof at CeNSE, IISc. We have experienced staff to support the facility. We also network with other research laboratories, companies and start-ups to increase the breadth of our services.

Our characterization tools are broadly classified into four categories



VISION

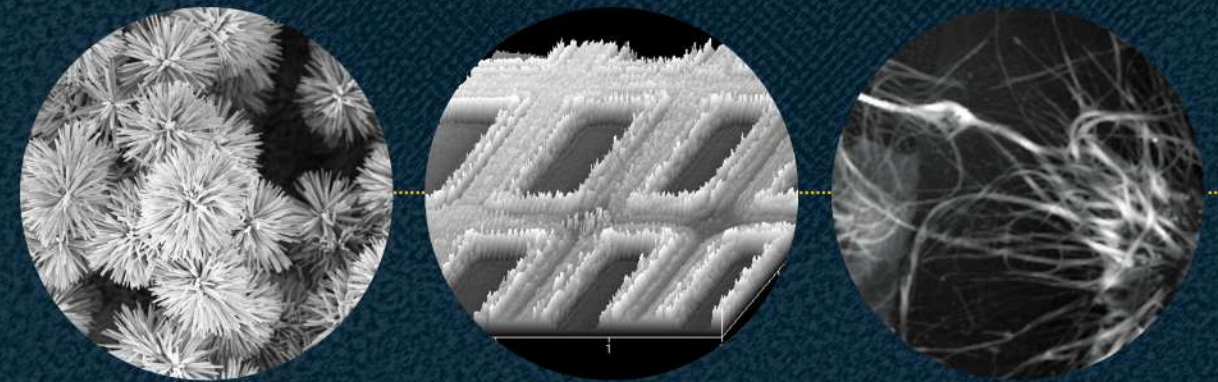
To be a reliable and sought-after global facility for characterization and analysis at the micro and nano scales.

MISSION

To provide highest quality services to academia, industries and national laboratories to solve challenging scientific problems.

VALUES

- Engage with users, students and scientists and provide services in a timely manner
- Respect the confidentiality of the work of users
- Constantly improve the functioning of the facility based on various inputs
- Be open to potential users for technical advice on measurements



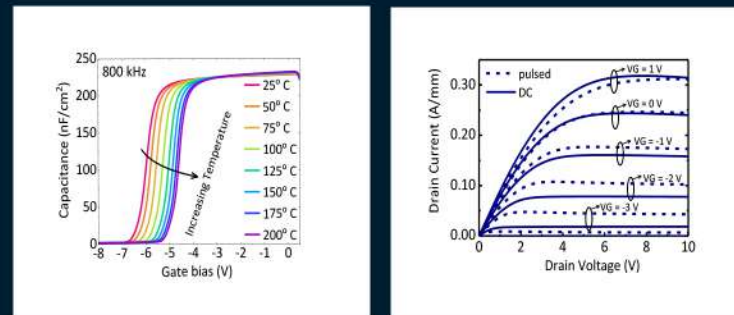
ELECTRICAL CHARACTERIZATION

Probing electrical properties of materials and devices are indispensable for scientific research as well as for enabling any technology. The Electrical Characterization Lab at MNCF offers state-of-art facilities for measurement of a whole suite of electrical transport properties including advanced device measurements at the cutting edge of research.

- Four-terminal current-voltage (I-V) measurements under DC and pulsed conditions (up to 0.5ms), from 5K to 500K
- Three-terminal RF and small-signal measurements up to 67GHz (with VNA)
- Capacitance-Voltage (C-V) and conductance-frequency ($G-\omega$) measurements from 1kHz to 5MHz from 5K to 500K
- Magnetic measurements (including Hall) from 5K to 500K up to a field of ± 2.5 T
- Measurements of current as low as 0.1 fA
- Measurements of samples as small as $< 1\text{cm} \times 1\text{cm}$ up to 6 inch in diameter

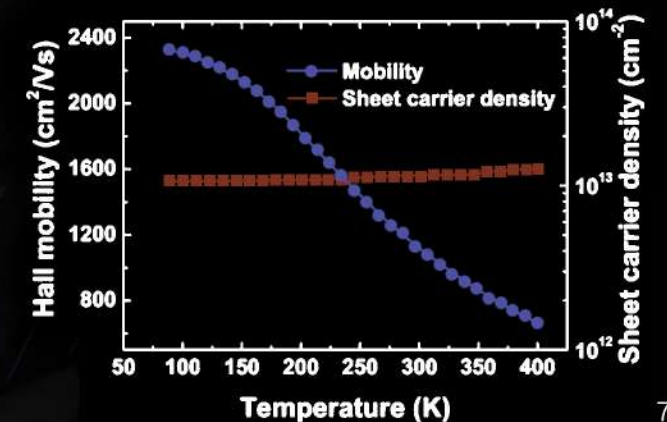


DC Probe Station 1



EQUIPMENT	VENDOR / MODEL	SPECIFICATIONS
DC PROBE STATION 1 WITH THERMAL CHUCK	Cascade / Micro Tech PM5 with Semiconductor Device Analyzer B1500A (SDA)	Temp: 25 - 200°C Voltage: $\pm 100\text{V}$ Current: $\pm 100\text{mA}$ CMU: DC $\pm 100\text{V}$, 1K to 5MHz AC: 30mV to 250mV
DC PROBE STATION 2		RT Only Voltage: $\pm 100\text{V}$ Current: $\pm 100\text{mA}$ CMU: DC $\pm 100\text{V}$, 1K to 5MHz AC: 30mV to 250mV WGFMU: 10V, 10mA
DC PROBE STATION 3	Lake Shore Cryotronics TTPX	Liquid Nitrogen Temperature: 77K to 400K Vacuum: 4×10^{-5} mbar
DC PROBE STATION 4	CRX-VF	Liquid Helium Temperature: 5K to 500K Vertical magnet field: $\pm 2.5\text{T}$ Vacuum: 4×10^{-7} mbar

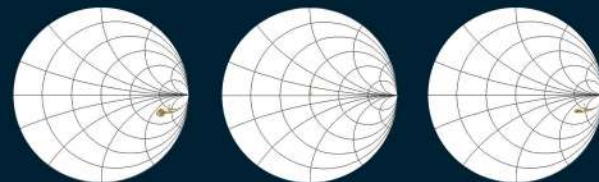
DC Probe Station 4 ▼



ELECTRICAL CHARACTERIZATION

EQUIPMENT	VENDOR / MODEL	SPECIFICATIONS
RF PROBE STATION WITH VECTOR NETWORK ANALYZER (VNA)	<p>Probe Station Cascade MicroTech Summit 9000</p> <p>VNA Agilent / E8361A</p>	<p>RF Probe Station Probes Tips: 100um, 150um and 200um pitch</p> <p>VNA DC bias: 0-40V Number of connections: 2 Ports TRL/LRM, SLOT calibration</p>
MERCURY PROBE STATION (NON CONTACT AND NON DESTRUCTIVE PURPOSE)	Materials Development Corporation / 802B-150B-150	<p>Stage dimension: 6 inch max. Smallest sample: 18mm Ring contact: 50um Dot contact: 800um</p>
ELECTROMAGNET	Polytronic / HEM-150	<p>Output Current: $\pm 30A$ Output Voltage: $\pm 60VDC$ Horizontal Magnetic Field Intensity: $\pm 1.7T$</p>

RF Probe Station ▼



ELECTRICAL CHARACTERIZATION

EQUIPMENT	VENDOR / MODEL	SPECIFICATIONS
PHYSICAL PROPERTY MEASUREMENT SYSTEM 14T (PPMS)	Quantum Designs / PM 811	<p>Modes: VSM, ETO, Resistivity, Heat capacity, thermal conductivity Temperature: 2K to 400K Magnetic field: -14T to +14T</p>
PHYSICAL PROPERTY MEASUREMENT SYSTEM 9T (PPMS)	Quantum Designs / PPMS 639	<p>Modes: VSM, ETO, Resistivity, Heat capacity, thermal conductivity Temperature: 2K to 400K Magnetic field: -9T to +9T</p>
MAGNETIC PROPERTY MEASUREMENT SYSTEM SUPERCONDUCTING QUANTUM INTERFERENCE DEVICE (MPMS SQUID)	Quantum Designs / MPMS 3-111	<p>Sensitivity of VSM DC Magnetometer $< 10^{-8}$ emu Temperature: 2K to 400K Magnetic field: -7T to +7T</p>

PPMS 9T ▼

PPMS 14T ▼

MPMS Squid ▼



MECHANICAL CHARACTERIZATION

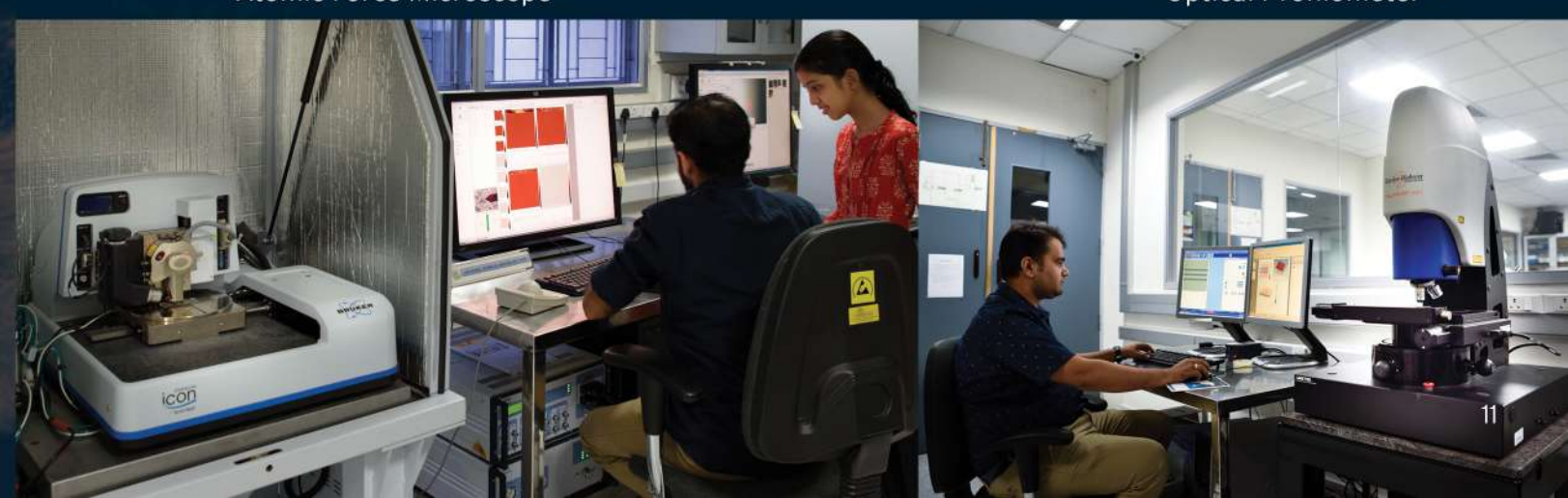
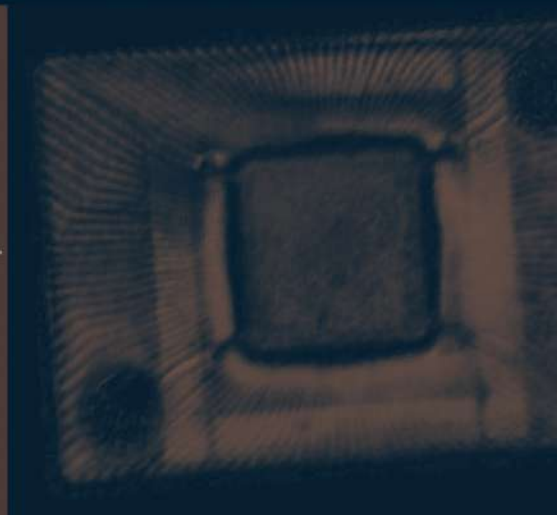
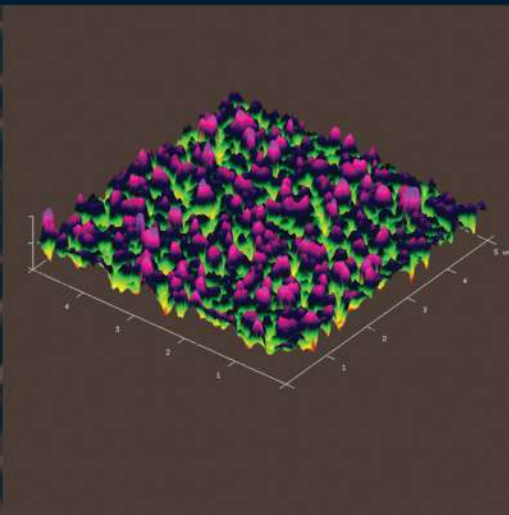
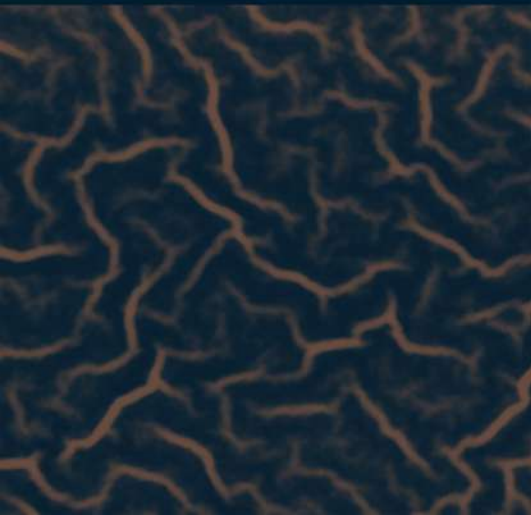
Characterization of mechanical properties are essential to materials research, product development and quality control. Understanding why and how products exhibit long-lasting performance or failure during use is often related to properties like modulus, yield stress or adhesion. Optimizing mechanical properties for a selected application is critical for processing, manufacturing and product performance. The Mechanical Characterization lab at MNCF houses state-of-the-art instruments to probe mechanical properties at micro and nano scale lengths:

- Film thickness, surface/interface roughness, pinhole defects and delamination of thin coated surfaces, all from a single measurement
- Electro lithography
- Analysis of piezoelectric and ferroelectric capacitors (D33)
- Tensile and compression testing system for high capacity force measurements upto 10 kN
- Surface potential
- Moduli measurements
- Characterization of MEMS devices and its packaging
- Ultrasound non-destructive imaging for micro crack analysis
- Vibration testing of small components for nodal and structural analysis

EQUIPMENT	VENDOR / MODEL	SPECIFICATIONS
ATOMIC FORCE MICROSCOPE (AFM)	Bruker/ Dimension Icon	Scan Range: XY: 90µm x 90µm Z Range: 13µm Lateral resolution: 10nm Sample Size: ≤ 210mm in dia ≤ 15mm thick Contact Mode Tapping Mode ScanAsyst Mode based on peak force tapping Peak Force QNM Kelvin Probe (KPFM) /Surface potential microscopy Piezo Force Microscopy (PFM) Conductive AFM Liquid AFM Magnetic Force Microscopy (MFM)
OPTICAL PROFILOMETER	Taylor Hobson/ TalySurf CCI	Vertical resolution: 5nm Max. measuring area: 1.6mm x 1.6mm X-Y stitching: Advanced X, Y and Z stitching, extending the measurement range Pixels: 1024 x 1024 Lateral resolution: 0.4 to 0.6µm Surface reflectivity: 0.3% to 100%

Atomic Force Microscope ▼

Optical Profilometer ▼





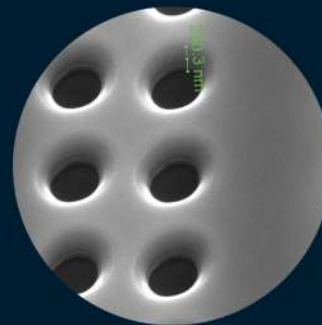
EQUIPMENT	VENDOR / MODEL	SPECIFICATIONS
MICRO SYSTEM ANALYZER (MSA)	Polytec / MSA500	Out-of-plane vibrations: upto 20MHz in-plane vibrations: 1Hz to 1MHz
SCANNING ACOUSTIC MICROSCOPE (SAM)	Kraemer Sonic Industries / KSI V400	Transducer: 50, 100, 150, 230 MHz
MICRO UNIVERSAL TESTING MACHINE (μ UTM)	Mecmesin / Multi test 10i	Load cells: 25N to 10kN Speed range: 1mm/min to 1000mm/min

EQUIPMENT	VENDOR / MODEL	SPECIFICATIONS
PRECISION NANO DISPLACEMENT SYSTEM (PNDS)	Radiant Technologies, Inc.	Piezo response upto 100V
MICRO SHAKER	Brüel & Kjær Sound & Vibration Measurement LDS® V406	Max acceleration: 5g Displacement continuous peak-peak: 7mm Max. Frequency: 1000Hz
DUAL AXIS RATE TABLE (-20°C TO 70°C)	Motion Dynamics / TES 3H3 TG	Max Rate: Inner/Outer axis (\pm 1500deg/sec and \pm 250 deg/sec)

MATERIAL CHARACTERIZATION

The Materials Characterization laboratory at MNCF houses capabilities to probe the micro and nano structure and chemistry of materials:

- Surface imaging with sub nm resolution
- Cathodoluminescence mapping
- Electron Beam Induced Current for device leakage studies (SEM)
- Micro manipulator to measure electrical and force measurements in situ
- Mapping chemistry at a lateral resolution up to 15µm and ~10nm depth resolution, Angles resolved XPS, depth profiling and Ultraviolet Photoelectron Spectroscopy (UPS) for electronic properties - work function and valence band offset
- Thin sample sections using FIB
- Lithography at micro to nano scale using FIB
- Circuit editing using FIB
- Analysis of material structure (atomic arrangements, structural defects, grains, particles etc) at a length scale ranging from micro to nano to atomic (TEM)
- Elemental compositional analysis using EDS



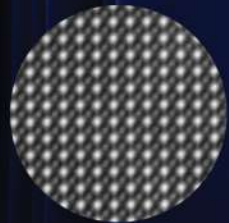
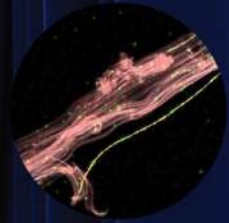
◀ FIB

INSTRUMENT	VENDOR / MODEL	SPECIFICATIONS
FOCUSED ION BEAM DUAL COLUMN SYSTEM	FEI / Helios Nanolab 600i	Electron beam resolution: -1.4nm 5 GIS ports: Platinum, Tungsten, Carbon, Iodine, XeF ₂ Circuit edit Omniprobe manipulator

▲ FESEM

INSTRUMENT	VENDOR / MODEL	SPECIFICATIONS
FESEM/EDS & FESEM/CL	Carl Zeiss / Ultra 55 (SEM) Oxford / EDS detector Gatan / Mono CL Kleindeik / Micromanipulator	Imaging Resolution: 0.8nm @ 15kV Elements detected: Boron to Uranium Cathodoluminescence: 135nm to 1700nm In situ IV and Force measurements

MATERIAL CHARACTERIZATION



Transmission Electron Microscope ▶



TITAN THEMIS

INSTRUMENT	VENDOR / MODEL	SPECIFICATIONS
TRANSMISSION ELECTRON MICROSCOPE	FEI / Titan Themis 3391	<ul style="list-style-type: none"> Ultra-bright XFEG gun 60-300kV, suitable for beam-sensitive samples 4K x 4K CMOS camera Single tilt and double tilt specimen holders New computerized 5-axis specimen piezo-stage Super-X quad EDS detector for super-fast elemental analysis Atomic resolution in TEM and STEM mode Field-free imaging in Lorentz mode for magnetic property studies Low dose imaging for sensitive samples HAADF (High Angle Annular Dark Field Imaging) and triple Dark Field/Bright Field (DF/BF) detectors for simultaneous imaging in STEM mode SAED (Selected Area Electron Diffraction)



MATERIAL CHARACTERIZATION

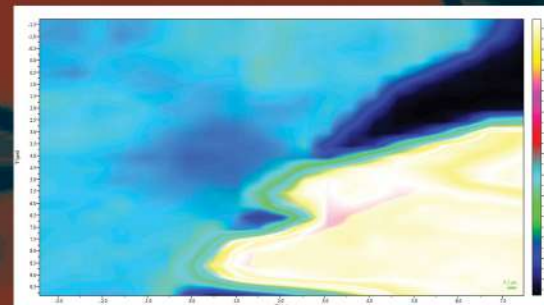
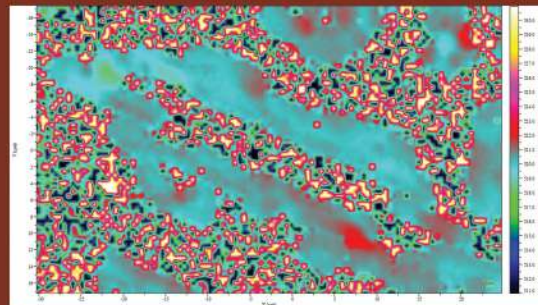
▲ X-Ray Photoelectron Spectroscopy

INSTRUMENT	VENDOR / MODEL	SPECIFICATIONS
X-RAY PHOTOELECTRON SPECTROSCOPY	Kratos / Axis Ultra DLD	<ul style="list-style-type: none"> Monochromatic source: Al Kα (1486.6eV) Dual source: Al Kα and Mg Kα (1253.6eV) Charge neutralizer Ar-ion sputtering Ultra-Violet Photoelectron Spectroscopy (UPS) XPS Imaging & Elemental mapping

OPTICAL CHARACTERIZATION

The optical characterization bay has several tools that caters to not only nano/microscale systems, but also for bulk materials:

- UV-Vis-NIR spectrometer for measuring optical transmission, absorption and scattering of different materials. Samples can include liquids and thin films.
- Raman and Photoluminescence spectroscopy with high spatial and spectral resolution. Also allows spatial mapping of the Raman/PL signal for planar samples, excitation at multiple wavelengths and measurements at cryogenic temperatures.
- Solar simulator with multiple beam sizes for characterizing photovoltaic materials, as well as testing material stability for paints, plastics and textile. Meets all 3 industry standards: IEC, ASTM and JIS for photovoltaic research.
- Powder and high resolution 4 circle x-ray diffractometry for characterization of crystalline materials, in powder and thin film form. Techniques for determination of crystallite size, film thickness, phase composition, stress and texture are available.
- Zeta PALS - Phase Analysis light scattering technique to measure the Zeta potential of colloidal particles in a suspension. Also allows the measurement of particle size in a wide range.
- Fourier Transform Infrared Spectroscopy (FTIR) system for determination of the local chemical environment of atoms in the specimen (solids/ liquids/ gases). It is possible to use both transmission and various reflection modes in the system, and to obtain sub-monolayer sensitivity.



▲ X-ray Diffractometer

INSTRUMENT	VENDOR / MODEL	SPECIFICATIONS
X-RAY DIFFRACTOMETER (POWDER AND 4 CIRCLE)	Rigaku / Smartlab XRD	Source: Cu-K(alpha) 1.54 Angstrom Parallel beam and Bragg bentonite optics for thin film and bulk respectively High resolution and ultrahigh resolution XRD Detector: Point detector (0D), line detector (1D), Area detector (2D)
UV VIS NIR SPECTROPHOTOMETER	Shimadzu/ UV 3600 MPC 3100	Wavelength range: 200nm to 3300nm 3 detectors: PMT, InGaAr and PbS 3 modes: Transmittance, absorbance and reflectance
SOLAR SIMULATOR	Newport/ Oriel Sol 3A	Class AAA Solar Simulator Xenon Arc Lamp Air Mass filter: 1.5G
QUANTUM EFFICIENCY	Newport/ Oriel - IQE 200	Wavelength Range: 350nm to 1100nm Spot size: 1mm x 2.5mm Tungsten lamp

OPTICAL CHARACTERIZATION

INSTRUMENT	VENDOR / MODEL	SPECIFICATIONS
ZETA POTENTIAL ANALYZER UTILIZING PHASE ANALYSIS LIGHT SCATTERING (PALS)	Brookhaven Instruments Corporation / Zeta PALS	<p>Zeta potential Size range: 3nm to 30μm Zeta potential range: -150mV to +150mV Sample conc.: 10v/v% Sample vol.: 1.5ml</p> <p>Particle size Size range: 3nm to 3μm Sample vol.: 3ml to 4ml Sample conc: 0.1mg/ml to 10v/v%</p>
RAMAN AND MICRO PHOTOLUMINESCENCE (PL) SPECTROSCOPY	Horiba / Lab RAM HR	<p>Spectral Resolution: 0.3cm^{-1} per pixel Spatial Resolution: 1μm Wide range of scan: 200nm to 1500nm Confocal microscope Polarizers Lasers: 532nm, 785nm and 266nm Raman / PL mapping Low temperature: 8K</p>
FTIR	Perkin Elmer/ Frontier MIR	<p>Spectral range: 7800cm^{-1} to 350 cm^{-1} Spectral resolution: 0.5cm^{-1} to 64 cm^{-1} Detector: TGS and MCT Modes: UATR, Diffuse reflectance, Specular reflectanc, Transmission</p>
STA	Perkin Elmer/ STA 8000	<p>Temperature range: 15$^{\circ}$C to 1500$^{\circ}$C Heating rate: 0.1$^{\circ}$C/min to 100$^{\circ}$C/min Calorimetric accuracy: \pm5 % Thermocouples: PT-PT/Rh (Type R)</p>

FTIR & STA ▼

Raman & Micro PL ▼



MICROSCOPES

S. No.	INSTRUMENT	SPECIFICATIONS
1	OPTICAL MICROSCOPE FOR MATERIAL ANALYSIS LEICA / DM 2500M	<p>Objectives: 5X, 10X, 20X, 50X, 100X Transmitted light: 12V, 100W halogen lamp 2 incident light axis</p> <p>Digital camera (DFC 400) Image resolution: 1.3 to 3.3megapixels Exposure time: 100μsec to 30sec Bright field, Dark field, Polarization applications</p>
2	OPTICAL MICROSCOPE FOR FLUORESCENCE ANALYSIS LEICA/ DM 2500	<p>Objectives: 5X, 10X, 20X, 40X, 100X Binocular</p> <p>Digital camera (DFC 450C) Image resolution: 5megapixels Bright field, Dark field and fluorescence applications</p>
3	STEREO MICROSCOPE LABOMED/ CZM6	<p>Transmitted light: 12V, 10W halogen lamp Incident light: 12V, 20W halogen lamp Eyepiece: 10X Binocular</p>
4	STEREO MICROSCOPE LEICA/ S6D	<p>Camera: Leica EC3 Pixels: 2048 x 1536 Zoom: 6.3:1 Magnification: 6.3x to 40x Spatial Resolution: 432 lp/mm</p>
5	EDUCATIONAL MICROSCOPE	Leica

