

# MICRO AND NANO CHARACTERIZATION FACILITY



YOUR ONE SOURCE OF MATERIALS AND DEVICES CHARACTERIZATION AND ANALYSIS









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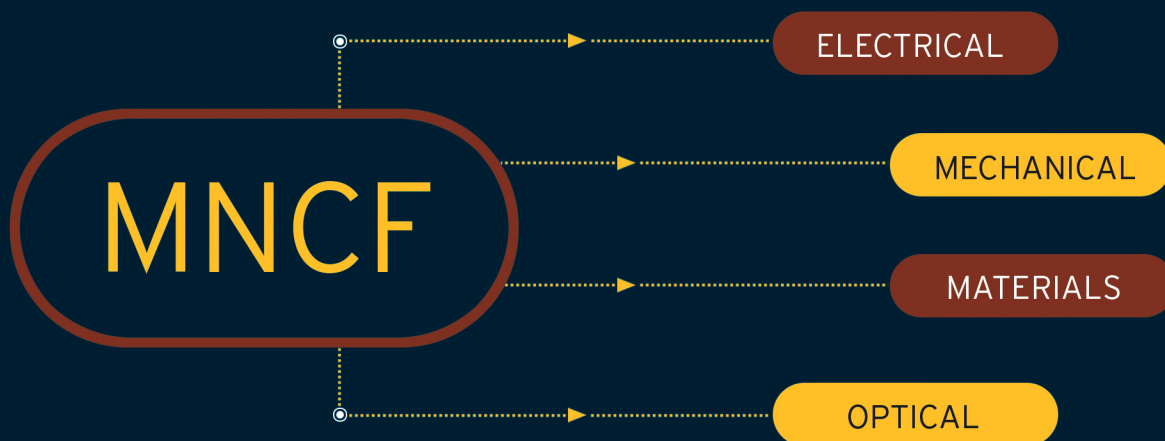


# OVERVIEW

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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.

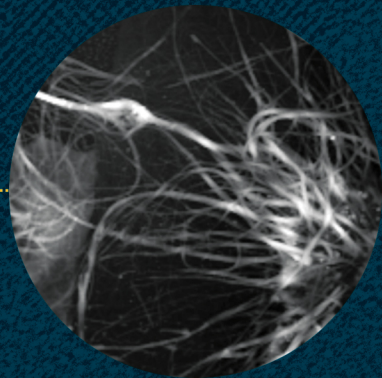
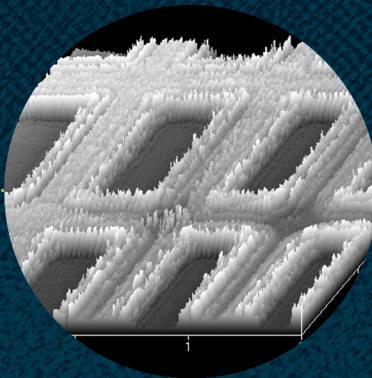
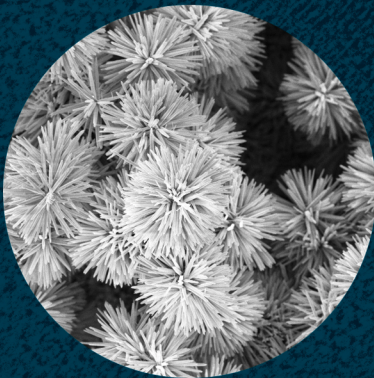
## **VALUES**

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

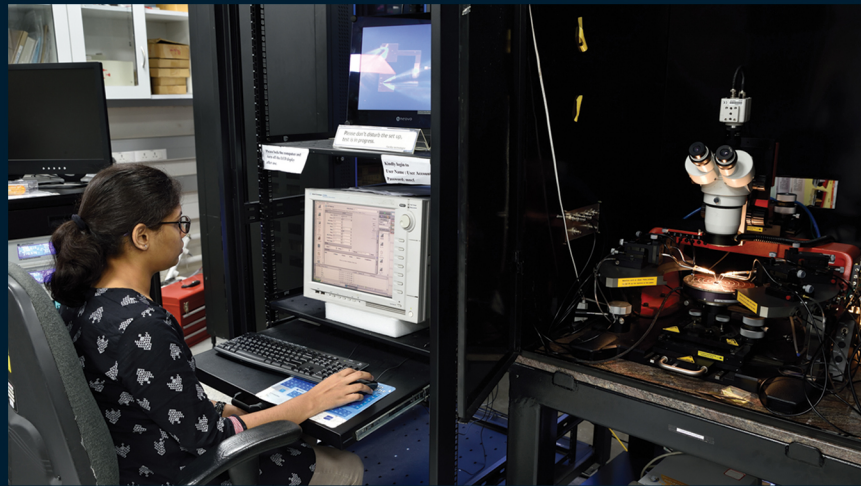




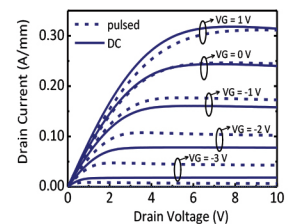
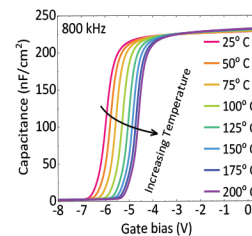
# ELECTRICAL CHARACTERIZATION

Probing electrical properties of materials and devices is 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  $\pm 2.5$  T
- Measurements of currents as low as Atto Amp (10-18A) up to 100 mA
- Measurements of samples as small as  $< 1\text{cm} \times 1\text{cm}$  up to 6inch in diameter



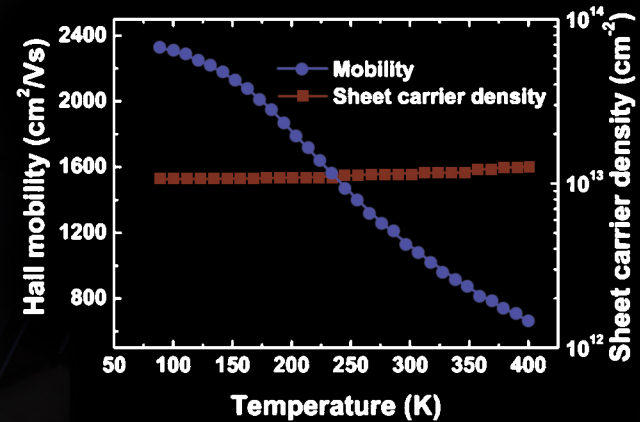
DC Probe Station 1





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

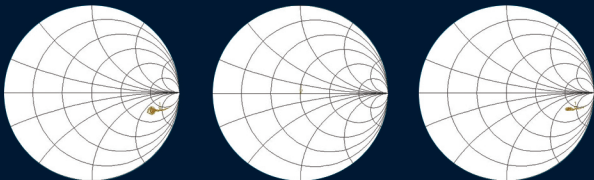
DC Probe Station 4 ▼



ELECTRICAL CHARACTERIZATION

| EQUIPMENT                                                       | VENDOR / MODEL                                                                              | SPECIFICATIONS                                                                                                                                                       |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RF PROBE STATION WITH VECTOR NETWORK ANALYZER (VNA)             | <b>Probe Station</b><br>Cascade MicroTech Summit 9000<br><br><b>VNA</b><br>Agilent / E8361A | <b>RF Probe Station</b><br>Probes Tips: 100μm, 200μm, 150μm pitch<br><br><b>VNA</b><br>DC bias: 0-40V<br>Number of connections: 2 Ports<br>TRL/LRM, SLOT calibration |
| MERCURY PROBE STATION (NON CONTACT AND NON DESTRUCTIVE PURPOSE) | Materials Development Corporation/<br>802B-150B-150                                         | Stage dimension: 6 inch max.<br>Smallest sample: 18mm<br>Ring contact: 48.6μ<br>Dot contact: 760μ                                                                    |
| ELECTROMAGNET                                                   | Polytronic / HEM-150                                                                        | Output Current: ± 30A<br>Output Voltage: ± 60VDC<br>Horizontal Magnetic Field Intensity: ± 1.7T                                                                      |

RF Probe Station ▾





ELECTRICAL CHARACTERIZATION

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

PPMS 9T ▼

PPMS 14T ▼

MPMS Squid ▼

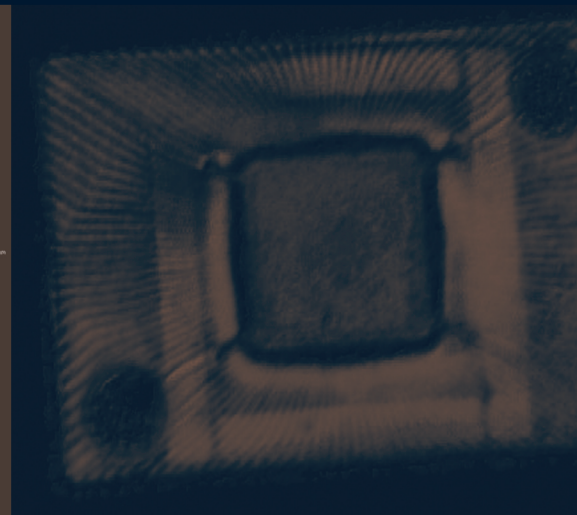
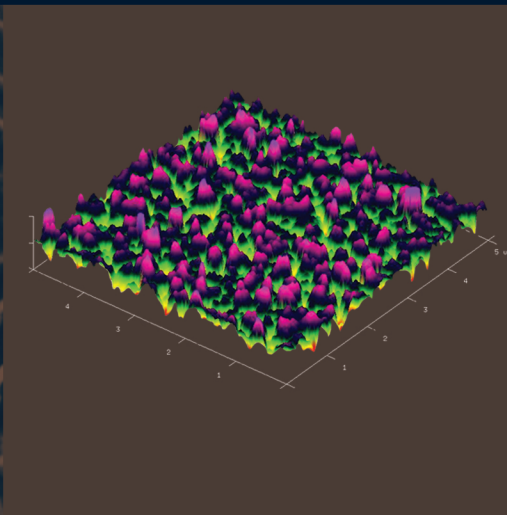
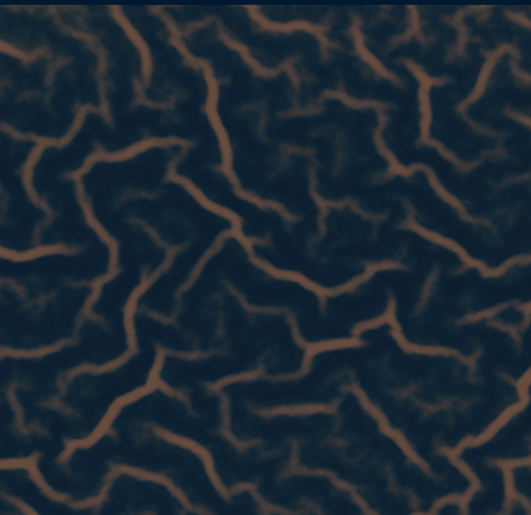


# MECHANICAL CHARACTERIZATION

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Characterization of mechanical properties is 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

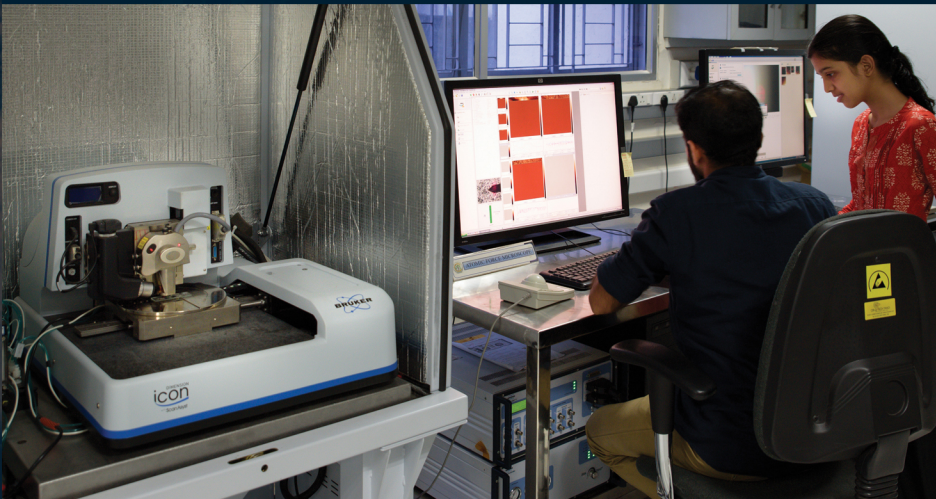




| EQUIPMENT                     | VENDOR / MODEL                 | SPECIFICATIONS                                                                                                                                                                                                                           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

Atomic Force Microscope ▼

Optical Profilometer ▼





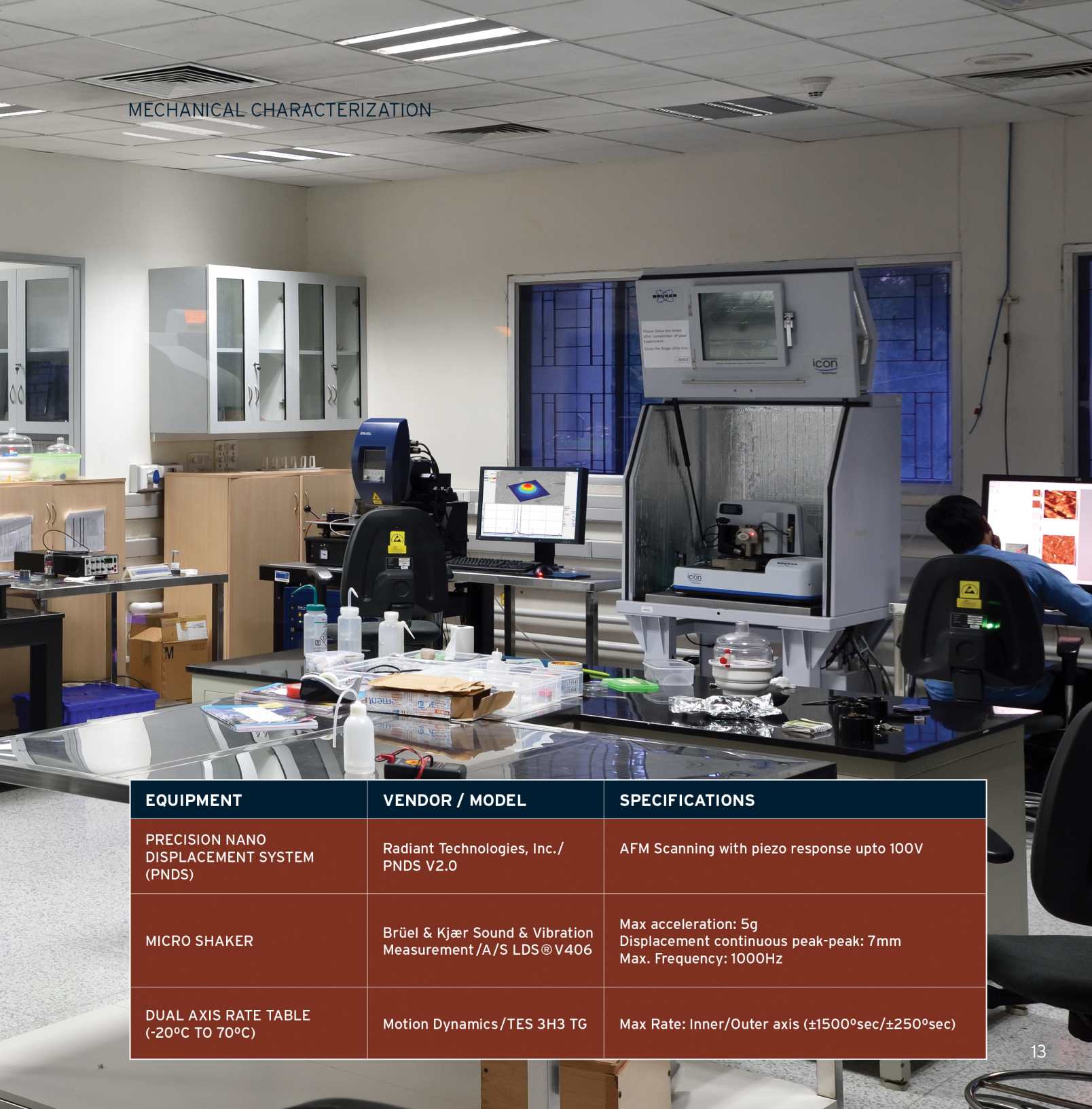
## MECHANICAL CHARACTERIZATION



| EQUIPMENT                                    | VENDOR / MODEL                      | SPECIFICATIONS                                                          |
|----------------------------------------------|-------------------------------------|-------------------------------------------------------------------------|
| MICRO SYSTEM ANALYZER (MSA)                  | Polytec / MSA500                    | Out-of-plane vibrations: upto 20MHz<br>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 ( $\mu$ UTM) | Mecmesin / Multi test 10i           | Load cells: 25N to 10kN<br>Speed range: 1mm/min to 1000mm/min           |



## MECHANICAL CHARACTERIZATION



| EQUIPMENT                                 | VENDOR / MODEL                                            | SPECIFICATIONS                                                                           |
|-------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------------------|
| PRECISION NANO DISPLACEMENT SYSTEM (PNDS) | Radiant Technologies, Inc./ PND5 V2.0                     | AFM Scanning with piezo response upto 100V                                               |
| MICRO SHAKER                              | Brüel & Kjær Sound & Vibration Measurement /A/S LDS® V406 | Max acceleration: 5g<br>Displacement continuous peak-peak: 7mm<br>Max. Frequency: 1000Hz |
| DUAL AXIS RATE TABLE (-20°C TO 70°C)      | Motion Dynamics/TES 3H3 TG                                | Max Rate: Inner/Outer axis (±1500°sec/±250°sec)                                          |

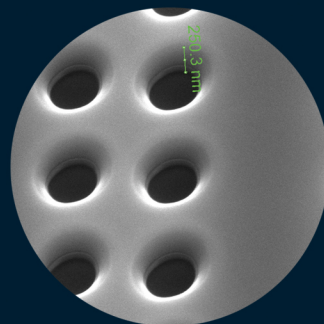
# MATERIAL CHARACTERIZATION

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
- Cathode Luminescence 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  $15\mu\text{m}$  and  $\sim 10\text{nm}$  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)



◀ FIB



| INSTRUMENT                          | VENDOR / MODEL            | SPECIFICATIONS                                                                                                                                            |
|-------------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| FOCUSED ION BEAM DUAL COLUMN SYSTEM | FEI / Helios Nanolab 600i | Electron beam resolution: $\sim 1.4\text{nm}$<br>5 GIS ports: Platinum, Tungsten, Carbon, Iodine, $\text{XeF}_2$<br>Circuit edit<br>Omniprobe manipulator |





▲ FESEM

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



MATERIAL  
CHARACTERIZATION

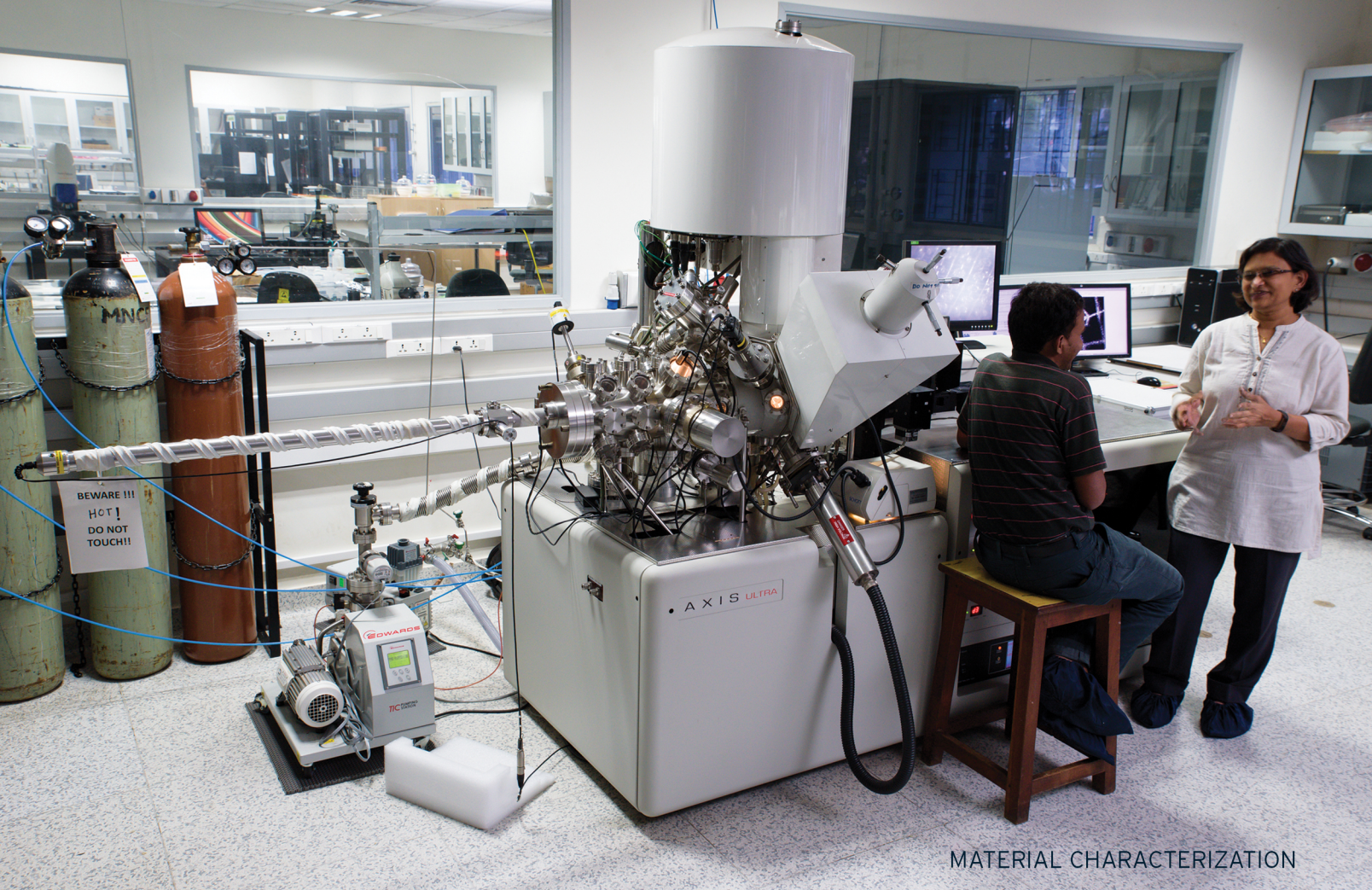
Transmission  
Electron  
Microscope ►



TITAN THEMIS

| INSTRUMENT                       | VENDOR / MODEL          | SPECIFICATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TRANSMISSION ELECTRON MICROSCOPE | FEI / Titan Themis 3391 | <p>Ultra-bright XFEG gun<br/>60-300kV, suitable for beam-sensitive samples<br/>4K x 4K CMOS camera<br/>Single tilt and double tilt specimen holders<br/>New computerized 5-axis specimen piezo-stage</p> <p>Super-X quad EDS detector for super-fast elemental analysis</p> <p>Atomic resolution in TEM and STEM mode</p> <p>Field-free imaging in Lorentz mode for magnetic property studies</p> <p>Low dose imaging for sensitive samples</p> <p>HAADF (High Angle Annular Dark Field Imaging) and triple Dark Field/Bright Field (DF/BF) detectors for simultaneous imaging in STEM mode</p> <p>SAED (Selected Area Electron Diffraction)</p> |





MATERIAL CHARACTERIZATION

### ▲ X-Ray Photoelectron Spectroscopy

| INSTRUMENT                       | VENDOR / MODEL             | SPECIFICATIONS                                                                                                                                                                                                                           |
|----------------------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| X-RAY PHOTOELECTRON SPECTROSCOPY | Kratos /<br>Axis Ultra DLD | Monochromatic source: Al K $\alpha$ (1486.6eV)<br>Dual source: Al K $\alpha$ and Mg K $\alpha$ (1253.6eV)<br>Charge neutralizer<br>Ar-ion sputtering<br>Ultra-Violet Photoelectron Spectroscopy (UPS)<br>XPS Imaging & Elemental mapping |

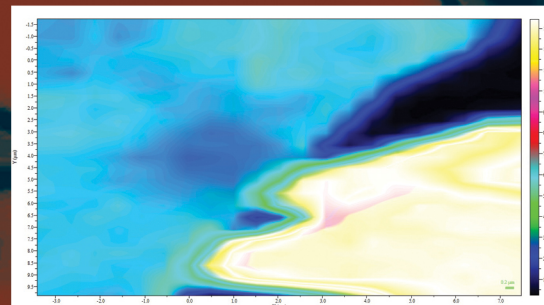
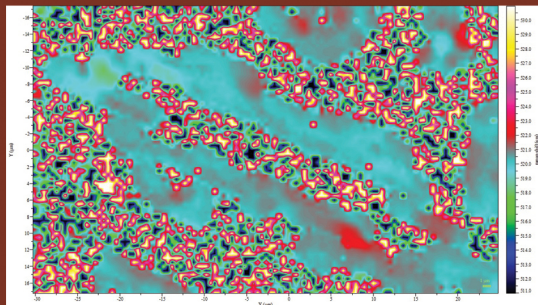


# OPTICAL CHARACTERIZATION

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

OPTICAL CHARACTERIZATION

| INSTRUMENT                                                                     | VENDOR / MODEL                                          | SPECIFICATIONS                                                                                                                                                                                                                                               |
|--------------------------------------------------------------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ZETA POTENTIAL ANALYZER<br>UTILIZING PHASE ANALYSIS<br>LIGHT SCATTERING (PALS) | Brookhaven<br>Instruments<br>Corporation /<br>Zeta PALS | <b>Zeta potential</b><br>Size range: 3nm to 30µm<br>Zeta potential range: -150mV to +150mV<br>Sample conc.: 10v/v%<br>Sample vol.: 1.5ml<br><br><b>Particle size</b><br>Size range: 3nm to 3µm<br>Sample vol.: 3ml to 4ml<br>Sample conc: 0.1mg/ml to 10v/v% |
| RAMAN AND MICRO<br>PHOTOLUMINESCENCE (PL)<br>SPECTROSCOPY                      | Horiba /<br>Lab RAM HR                                  | Spectral Resolution: 0.3cm <sup>-1</sup> per pixel<br>Spatial Resolution: 1µm<br>Wide range of scan: 200nm to 1500nm<br>Confocal microscope<br>Polarizers<br>Lasers: 532nm, 785nm and 266nm<br>Raman / PL mapping<br>Low temperature: 8K                     |
| FTIR                                                                           | Perkin Elmer/<br>Frontier MIR                           | Spectral range: 7800cm <sup>-1</sup> to 350 cm <sup>-1</sup><br>Spectral resolution: 0.5cm <sup>-1</sup> to 64 cm <sup>-1</sup><br>Detector: TGS and MCT<br>Modes: UATR, Diffuse reflectance, Specular reflectanc,<br>Transmission                           |
| STA                                                                            | Perkin Elmer/<br>STA 8000                               | Temperature range: 15°C to 1500°C<br>Heating rate: 0.1°C/min to 100°C/min<br>Calorimetric accuracy: ±5 %<br>Thermocouples: PT-PT/Rh (Type R)                                                                                                                 |

FTIR & STA ▼

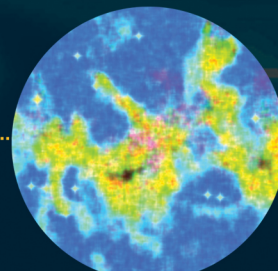
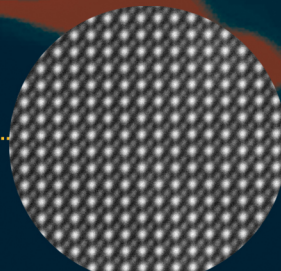
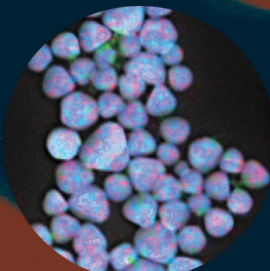
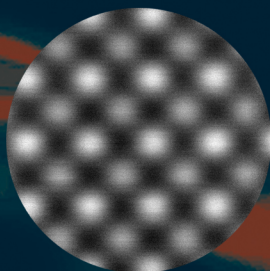
Raman & Micro PL ▼



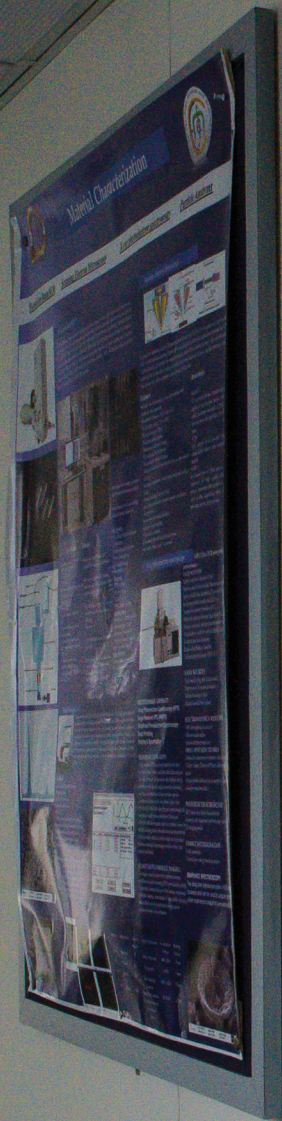


# MICROSCOPES

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













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