

DST-SATHI Centre on In-situ and Correlative Microscopy: a cornerstone to cutting-edge characterisation across multiple length scales

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Since its advent, Microscopy has been used extensively to characterise materials across all disciplines, from physical to life sciences. In these areas, information from various length scales was obtained using optical, surface probe, or electron microscopy. With most of the research these days being interdisciplinary, it is essential to establish facilities that can promote and nurture this form of research. Currently, in-situ electron, optical and scanning probe microscopy techniques are at the helm of interdisciplinary research. To realise this latest paradigm in microscopy, it is essential to have a platform that enables the acquisition of information from materials using complementary techniques at different length scales. At the same time, the sample is subject to external stimuli. This will be the first such centre in India to cater to advanced sample analysis in real-time across multiple length scales using complementary imaging and spectroscopic techniques while the sample is subjected to a stimulus.

To realise this, IIT Hyderabad and five other partner organisations, namely University of Hyderabad, ARCI, CCMB, IICT and CBIT, submitted a proposal in September 2022. In April 2023, the cluster from IIT Hyderabad was shortlisted for a presentation at JNCASR Bengaluru and in the meeting, IIT Hyderabad was advised to identify more partner organisations, particularly industrial partners and suggested expanding the cluster beyond the local Telangana region and making this a national facility. This led to several discussions with industrial partners and R&D labs across the country, and today, the IIT Hyderabad cluster has 10 academic partners, 4 R&D labs and 4 Industrial partners[1]. This effort of bringing together people across multiple disciplines and raising a financial contribution of 20 Cr INR from the cluster has paved the way for the success of the SATHI proposal. In December 2023, the IIT Hyderabad cluster was awarded the SATHI grant to set up a Centre on In-situ and Correlative Microscopy (CISCoM).

While much pioneering work has been done in India in Electron Microscopy, Surface Probe Microscopy, and Optical Microscopy, correlating these three fields and extracting complementary information to gain a complete understanding of a specimen at different length scales and in real time has been very limited. Even globally, very few centres of excellence focus on in situ correlative microscopy. To sustain cutting-edge interdisciplinary research at IITH and establish ourselves as a centre of excellence locally and globally. In line with this vision, along with our partner institutions, pertinent scientific topics which are of mutual interest and can potentially be tackled by carrying out correlative in-situ microscopy studies have been identified and categorised into three broad verticals, namely structural, functional, biomedical & pharmaceutical applications, as summarised in Table 1.

Among these, we have defined twelve research themes that foster interdisciplinary research among the partner institutes and the local industries and institutions.

[1] A complete list of partners institutes is given at the end of this article.

Verticals	Themes	Techniques
SATHI CISCoM R&D Activities	Novel Processing Routes	S/TEM APT SPM TERS FTIR
	Phase Transformations in Advanced Steels	
	Mechanical Behaviour of Advanced Alloys	
	Assessment of Cements and Concrete Mixtures	
	Energy Storage Materials	S/TEM SPM TERS FTIR MOKE
	2D Materials	
	Neuromorphic Computing	
	Magnetic Materials & Devices	
	Transplantation Therapies	Super-resolution optical microscopy S/TEM TERS FTIR
	Insights into Infectious Diseases	
	Cellular Dynamics	
	Rheological Paradigms for Materials Design	

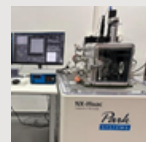
Table 1: Proposed R&D Activities at the SATHI Centre on In-Situ and Correlative Microscopy (CISCoM) at IIT Hyderabad

This centre will house nine state-of-the-art facilities and sample preparation facilities in a class 100000 cleanroom. The details and specifications of the equipment procured and installed are given in Table 2. This centre at IITH on “In-situ & Correlative Microscopy (CISCoM)” will be the cornerstone to cater to cutting-edge sample analysis.

By enabling such a centre, we are bringing people across various scientific disciplines ranging from materials science and metallurgical engineering, physics and chemistry, biology, biomedical and pharmaceutical studies, and geology as well as expertise in computational techniques, artificial intelligence and machine learning together to address common scientific goals which can only be solved using such sophisticated techniques.

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Table 2: Proposed R&D Activities at the SATHI Centre on In-Situ and Correlative Microscopy (CISCoM) at IIT Hyderabad

SNO	Facility	Technical Details	Key Specification	Photograph
1.	Cameca LEAP 6000XR (installed & functioning)	An advanced microscopy and spectroscopy tool that delivers atomic-scale, 3D reconstructions of metals and inorganic solids. It combines time-of-flight mass spectrometry	spatial resolution $\Delta x \approx \Delta y \approx 0.3\text{--}0.5\text{ nm}$; $\Delta z \approx 0.1\text{--}0.3\text{ nm}$ ppm-level element sensitivity	
2.	JEOL NEOARM 200F – Probe Corrected TEM (installed & training due)	Aberration-corrected Scanning Transmission Electron Microscope with Energy Filtering and Imaging to enable atomic resolution EDS and EELS, making this a state-of-the-art Analytical TEM	30 – 200 kV STEM 0.82 Å spatial resolution 160 mm ² EDS detector STEM-SAAF detector 4d-STEM CEFID EELS	
3.	JEOL NEOARM 200F – Image Corrected TEM (installed & training due)	Aberration Corrected High Resolution Transmission Electron microscope equipped with an electric biprism to perform electron holography	30 – 200 kV HRTEM 0.7 Å spatial resolution STEM-HAADF/ABF Electron Holography	
4.	JEOL JIB-4700F (yet to be installed)	Focused-ion-beam/Scanning Electron Microscope for site-specific specimen preparation for APT and TEM analysis	1.6 nm resolution @ 1kV In-lens Schottky-emission Max probe current (SEM): 300 nA, Ga-ion source: 90 nA probe current	
5.	Park NX-Hivac AFM (installed & functioning)	A high vacuum multimode AFM for precise semiconductor failure analysis and highly sensitive nanomaterials science research in ambient & vacuum	Multimode AFM with LFM, EFM, DC-EFM, KPM, EFM, IV Spectroscopy	
6.	NTMDT – NTEGRA Spectra II, AFM with Tip-Enhanced Raman Scattering (installed & functioning)	AFM with confocal Raman spectroscopy, enabling simultaneous topographical and chemical analysis at the nanoscale, supporting a wide range of AFM modes	mechanical, thermal, SECM, and electrical measurements combined with high-resolution Raman mapping with spatial resolution of 20 nm and spectral resolution of 0.1 cm ⁻¹	
7.	Nikon AXR with NSPARC High resolution confocal imaging system (installed & functioning)	Confocal microscope equipped with Nikon Spatial Array Confocal detector for super-resolution fluorescence imaging	100 nm lateral and 300 nm axial resolution 25 mm field of view with 8k x 8k scanning 6 laser lines: 405, 445, 488, 514, 561, 640 nm sCMOS detector	
8.	ThermoFisher Scientific RaptIR+ with iS50	An FTIR spectrometer for bulk measurements and a microscopy platform for detailed micro-analysis for a wide range of sample types	Spectral range: 350–7800 cm ⁻¹ Spectral resolution: 0.09 cm ⁻¹ ATR crystals: Monolithic diamond (main compartment), germanium tip (microscope)	

9.	Anton Paar MCR 302e – Modular Compact Rheometer	A versatile rheometer designed to characterise viscoelastic properties in complex fluids and soft materials precisely.	Storage modulus, loss modulus and viscosity across varying frequencies, strain, shear rate and temperature Rotational & oscillatory modes Digital microscope with glass Peltier plate	
10.	10. Vertis Magvision Kerr Microscopy System	Designed for spintronics and magnetic materials research, the Magvision 18001 enables fast, non-destructive imaging of magnetisation through polarisation rotation detection.	400 nm resolution 6MP 60 FPS camera with >80% QE >10 electrical contact sample stage with high precision piezo control 400 mT electromagnet in two axes Liquid nitrogen cooled stage down to 90K	
11.	11. Specimen preparation facilities	Preparation techniques for inorganic and organic materials tailored for multiple length-scale microscopic studies.		

Annexure: List of partners at SATHI-CISCoM:

Academic Institutions:

1. Indian Institute of Technology Hyderabad (Host Institute)
2. University of Hyderabad
3. Visvesvaraya National Institute of Technology, Nagpur
4. National Institute of Technology, Raipur
5. National Institute of Technology, Warangal
6. National Institute of Technology Andhra Pradesh, Tadepalligudem
7. Telangana State Council for Higher Education
8. Chaitanya Bharati Institute of Technology (CBIT), Hyderabad
9. Sri Vishnu Educational Society, Hyderabad
10. Veltech University, Chennai

R&D Labs:

1. International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad
2. Centre for Cellular & Molecular Biology (CCMB), Hyderabad
3. Indian Institute of Chemical Technology (IICT), Hyderabad
4. LV Prasad Eye Institute, Hyderabad

Industries:

1. Dr. Reddy's Labs, Hyderabad
2. Bharat Biotech, Hyderabad
3. Amara Raja Group, Tirupati
4. TATA Steel, Jamshedpur



Transmission Electron Microscopy

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