From Atoms to Applications – Our Journey in Materials Characterisation

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It gives me both joy and quiet pride to present this issue of KirITH, centered on "Materials Characterisation" — a subject that lies at the very heart of our Department's vision.

In the Department of Materials Science and Metallurgical Engineering, materials characterisation is not simply a branch of our research — it is the very lens through which we engage with the world. It is how we dialogue with matter, engaging it in a quiet conversation across scales and phenomena where each measurement is a question and each signal is an answer. This is how we trace the lyric in the crystal's symmetry, the whisper of strain in its lattice, and witness the dance of atoms as they transform. Our motto, "Atoms to Applications", reflects this poetic arc: from the hidden to the harnessed, from signal to solution.

We've come a long way. I still remember when we first moved to our new campus — the road to Academic Block A was unpaved and uneven, and we had to set up our first TEM on the ground floor. A colleague rode in the truck transporting the TEM crate, shielding it from every bump and jolt. That care mattered — it was our only TEM, and its safe arrival marked a quiet victory.

Before that, in our ODF makeshift campus, we had just one SEM and a PPMS, both housed in the same corrugated shade where metallography, etching, and sample preparation were done side by side. The air carried the sting of chemical vapours slowly corroding the instruments we couldn't afford to replace.

And yet, we dreamt big. With no excess space, no safety net — just conviction, collaboration, and a refusal to settle — we built. That indomitable spirit, alive in every student and colleague, has brought us to today: a modern, beautiful campus, equipped with ultra-modern instruments, national-scale facilities, and a thriving research ecosystem. The dream has taken shape — and it grows with each passing year.

Today, the campus is a very different place — physically, yes, but also in spirit. Characterisation is now not just a facility we have; it is a philosophy we live. At MSME, we believe that to characterise is to accompany materials — to walk with them, listen to them, and uncover their inner narratives.

We observe materials through their entire journey. SEM and TEM help us resolve defects and microstructure. *In situ* TEM lets us watch change as it happens. AFM allows us to feel the topography of the invisible, while PFM makes electromechanical interaction audible in its own way. Nanoindentation shows us resilience in numbers. EBSD reads orientation like a topographic map. Every tool not only tells a story — it changes what we choose to ask next.

We began by establishing platforms like SEM–EBSD, PPMS, Raman, AFM/PFM, and XRD — laying the groundwork for advanced materials characterisation at IIT Hyderabad. With XRD, we began decoding the symmetry hidden in structure, setting the stage for deeper insights into phase and orientation.

Today, our faculty, together with colleagues from other departments and partner institutes, have built on that early foundation to secure the prestigious SATHI grant. From this collaboration has grown the SATHI–CISCoM national facility — a vibrant hub for correlative and in situ microscopy, and for pushing the frontiers of atom probe tomography (APT). With APT, we now do what once felt like science fiction — mapping matter atom by atom, revealing clusters, segregation, and the chemistry of the infinitesimal.

What began as a modest suite of instruments has evolved into a shared, state-of-the-art infrastructure for cutting-edge research. This transformation has been driven by persistence, foresight, and a conviction that India must lead — not follow — in characterisation science. That belief continues to shape the identity and ambition of our department.

What makes this work truly distinctive is our correlative approach. We refuse to silo observations. Instead, we trace across length, time, and modality — connecting diffraction patterns with microstructural evolution, impedance arcs with thermoelectric behavior, symmetry with properties and performance. We embrace the hierarchy of materials, from atoms to grains, and build the bridges between them.

Our scope extends further: XRD, UV–Vis, Raman, electrical and thermal transport, thermoelectric profiling, and electrochemical impedance spectroscopy allow us to probe the full physical life of a material — not just how it looks, but how it behaves, transforms, and endures.

And then there's the virtual mirror. Using first-principles calculations, phase-field models, and our in-house MicroSim GPU platform, we simulate microstructures and generate synthetic observables. We don't just characterise what exists — we explore what could.

At MSME, characterisation is never a full stop. It's the first sentence of every material's story. Through this issue, I invite you to explore that story with us — to see, to question, to imagine, and to build.
We do not just observe materials. We accompany them — through microscopes, through models, through minds.

Acronyms: AFM – Atomic Force Microscop(e)y; APT – Atom Probe Tomograph(y); EBSD – Electron Backscatter Diffraction; PFM – Piezoresponse Force Microscop(e)y; PPMS – Physical Property Measurement System; SEM – Scanning Electron Microscop(e)y; TEM – Transmission Electron Microscop(e)y; UV–Vis – Ultraviolet–Visible Spectroscop(e)y; XRD – X-ray Diffraction

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