Title: Decoding Atomic-Scale Functionality in Oxide and Nitride Materials for Electronics and Quantum Technologies

Baishakhi Mazumder, Associate Professor, University at Buffalo, Buffalo, USA

Oxide and nitride materials are poised to drive the next wave of innovation in electronic and quantum technologies. Their wide bandgaps, robust thermal and chemical stability, and rich defect chemistries make them ideal candidates for high-power electronics, RF devices, and quantum materials platforms. However, the performance of these materials is critically governed by atomic-scale phenomena such as defect structures, dopant distributions, and interface characteristics that remain challenging to fully resolve and control.

In this talk, I will present our recent advances in probing and designing functional oxides and nitrides through a synergistic combination of atom probe tomography (APT), transmission electron microscopy (TEM), and machine learning (ML). APT provides three-dimensional, near-atomic-resolution compositional maps that unveil dopant distributions, vacancy clustering, and interface chemistry. TEM offers powerful insights into crystallography, defect topology, and strain fields. When integrated with data-driven modeling, these techniques allow us to extract hidden correlations and generate predictive insights into material behavior.

Through selected examples, I will demonstrate how this integrated methodology is advancing our understanding of defect-driven behavior, interface phenomena, and chemical inhomogeneities that impact performance in wide-bandgap electronic devices and quantum materials. These insights open pathways for targeted materials engineering, supporting the development of scalable, high-performance systems for future electronics and quantum technologies.