



Infrared and Terahertz Synchrotron Nanoscopy: Unlocking New Nanophotonic Phenomena in Emerging Van der Waals Materials

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Infrared (IR) and terahertz (THz) nanospectroscopy are rapidly evolving as key analytical modalities for exploring light–matter interactions beyond the diffraction limit, particularly in novel two-dimensional and quantum materials. In this presentation, I will discuss the transformative role of scattering-type scanning near-field optical microscopy (s-SNOM) when operated with high-brightness synchrotron radiation, enabling unprecedented sensitivity, broadband coverage, and momentum selectivity. Such capabilities are essential for accessing emergent optical responses and ultraconfined polaritonic modes that remain inaccessible to laboratory-based microscopy. We will highlight recent advances in IR–THz nanophotonics, including the discovery of a new material family supporting deeply subwavelength phonon-polariton modes in the deep-THz regime. These results are closely aligned with the scientific mission of IMBUIA, the first open-user IR nanospectroscopy station implemented at a 4th-generation storage ring. By revealing phenomena that bridge fundamental excitations and applied nanophotonic concepts, this work demonstrates the growing need for next-generation analytical tools capable of probing nanoscale responses in complex material systems. Finally, we will discuss upcoming opportunities enabled by TATU, the new open-user THz spectro-nanoscopy beamline currently under construction. TATU will provide researchers with unique access to ultrabroadband THz excitation, fueling new discoveries in strongly coupled polaritons, nonlocal optical responses, and functional materials for photonic circuitry. Together, these developments establish synchrotron-based s-SNOM as a powerful universal microscopy platform for guiding innovation in future optoelectronic and quantum technologies.