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# Some Recent Developments in SPM Probing of Ferroelectrics: Crackling Noise Microscopy, Phonon-Nanoscopy and Optically Manipulated Ferroelectricity in BiFeO3

*Monday 1 December 2025 14:30 (30 minutes)*

I will discuss our recent work on various ferroelectric and multiferroic oxide material systems using scanning probe microscopy (SPM) as the main investigative tool, with a focus on nanoscale functional property measurements of individual topological defects and new SPM instrument capability developments.

The nanoscale phonon properties of $BiFeO_3$ structural variants have rarely been investigated at the nanoscale. Here, we combine nano-Fourier transform infrared spectroscopy (nano-FTIR) and scattering scanning near-field optical microscopy (s-SNOM) imaging to report on the first direct mid-IR imaging of such nanoscale phase variants in mixed-phase BiFeO3 based on their distinct vibrational signatures. The noninvasive optical reading in the infrared, i.e. 'phonon-nanoscopy'can further successfully detect electrical switching of ferroelectric BiFeO3, providing insight into future infrared photoelectric applications. Our work demonstrates that scanning near-field techniques are versatile and sensitive for probing the structural and physical properties of nanoscale entities with subtle distinctions.

Other types of optical control of polar order in ferroelectric and multiferroic materials include photostriction, i.e. optomechanical coupling in $BiFeO_3$ thin films. We demonstrate a strong photostrictive response in nanocrystallite $BiFeO_3$ thin films synthesized through cost-effective, scalable spray pyrolysis under relatively low optical power (˜1.7 W cm-2). This response is accompanied by synchronous light-driven enhancements in piezoelectricity and polarization switching. The effective separation of photogenerated excitons, facilitated by a high density of domain walls characterized through piezoresponse force mapping, leads to an effective screening of the depolarization field and compensation for the built-in field induced by charged defects. A photostriction coefficient of $4.5\times10^{-7}$ m² W-1 - five times higher than bulk $BiFeO_3$ and comparable to leading halide perovskites - was measured using scanning probe microscopy, offering new opportunities to integrate these materials into innovative devices.

The discussion will include a newly-developed SPM method to investigate crackling noise of domain walls in ferroelectrics with an AFM system.

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**Session Classification:** Focus Session - From edge states to emergent phases

**Track Classification:** Focus sessions: From Edge States to Emergent Phases: Advances in Topological and Strongly Correlated Materials