

Multifunctional approaches for exploring 2D materials and their device integration via Atomic Force Microscopy

Atomic force microscopy (AFM) represents a powerful toolbox for exploring the physics of two-dimensional (2D) materials and accelerating their integration into next-generation optoelectronic devices. In this talk, we demonstrate how advanced AFM (including Kelvin probe force microscopy KPFM, electrostatic force microscopy EFM, and conductive AFM C-AFM) provide key insights into the structure–function relationships in MoS₂ and Te nanosheets grown via chemical or vapor-phase techniques. Three case studies are presented. First, KPFM reveals how substrate induced ripple morphologies in CVD-grown MoS₂ generate directional anisotropy and localized charge doping, which are crucial for anisotropic optoelectronic responses. [1] Secondly, EFM measurements show that the choice of molecular seeding promoters drastically modulates the electronic polarizability of monolayer MoS₂, significantly impacting photoluminescence and critically altering charge transport in back-gated field-effect transistors. [2] Finally, C-AFM enables direct nanoscale mapping of resistive switching behavior in vapor deposited 2D tellurium, demonstrating its integration in memristor devices for neuromorphic computing. [3] The use of gold substrates enhances the switching efficiency by facilitating interfacial reconfiguration and reducing energy consumption. In perspective, these studies illustrate how AFM techniques are not only indispensable for fundamental characterization, but also for correlating local physical properties with device performance, paving the way for the rational design of 2D material-based transistors and memory elements.

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