Atomic-scale investigation of the structure-property correlation in emerging 2D quantum materials

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Two-dimensional (2D) materials are considered candidates for future nanoelectronics, optoelectronics, and spintronic applications. Understanding the structural origin of the novel physical properties in 2D materials is a key step toward functionality engineering and improved device performance.

In this talk, I will first show the latest development of quantitative intensity analysis techniques in scanning transmission electron microscopy (STEM) imaging, and its applications in revealing the atomic-scale structure-properties correlation in emerging 2D materials. Secondly, I will introduce the universal strategy to overcome the structural degradation problem of air-sensitive 2D quantum materials. We developed a home-built, interconnected inert-gas protection system compatible with atomic STEM and Cryo-TEM imaging. I will present recent breakthroughs in the structure-property relationships of various air-sensitive 2D materials. Examples include, but are not limited to: monolayer amorphous carbon where the high-density distorted defect network contributes to its ultrahigh mechanical toughness; intrinsic defect structures in air-sensitive WTe_2/$MoTe_2$ monolayer and their heterostructures with enhanced defect states; superlattice reconstruction in 2D ferromagnetic heterostructure with exotic magnetic responses, etc. Lastly, I will discuss the atomic-resolution Cryo-HRTEM technique for handling dually air- and dose-sensitive material systems, such as 2D perovskites and charge density waves (CDWs) in 2D TaS_2.