Defect and defect dynamics in novel 2D materials

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Exciting the evolution of defects and simultaneously imaging the dynamical process can be realized with an aberration corrected electron beam inside the ultrahigh vacuum scanning transmission electron microscope (STEM). This method offers time-resolved direct tracking of the atomic motion during the structural changes induced by the high energy electrons. By controlling the scanning pattern of the electron beam, manipulation of defect to create new nanostructures is achievable. I will first show the atomic scale characterizations of defect structures in various emerging 2D materials by low-voltage STEM, including monolayer amorphous carbon, air-sensitive $NbSe_2$ monolayer and 1T' phase Te-based alloy monolayer, and elaborate how they affect the physical properties of the materials by combing density functional theory (DFT) calculations. Then I will demonstrate the atom-by-atom structural evolutions in 2D materials as monitored by sequential low voltage Z-contrast STEM imaging and the related underlying physics. Examples include Se vacancy-induced inversion domain nucleation in $MoSe_2$, the origin of novel 2D Pd_2Se_3 phase driven by interlayer fusion in layered $PdSe_2$, and the in situ observation of electron beam induced synthesis of hexagonal $MoSe_2$ from square FeSe. At the end of the talk, I will discuss the in-situ fabrication of highly stable metallic nanowires with MX stoichiometry within the transition-metal dichalcogenide (TMD) monolayers by steering the electron beam with atomic precision.