Materials Science & Engineering Doctoral Defense

Atomic Scale Characterizations of Two-dimensional Anisotropic Materials and Their Heterostructures

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abstract

There has been a surge in two-dimensional (2D) materials field since the discovery of graphene in 2004. Recently, a new class of layered atomically thin materials that exhibit in-plane structural anisotropy, such as black phosphorous, transition metal trichalcogenides and rhenium dichalcogenides (ReS2), have attracted great attention. The reduced symmetry in these novel 2D materials gives rise to highly anisotropic physical properties that enable unique applications in next-gen electronics and optoelectronics. For example, higher carrier mobility along one preferential crystal direction for anisotropic field effect transistors and anisotropic photon absorption for polarization-sensitive photodetectors. This dissertation endeavors to address two key challenges towards practical application of anisotropic materials. One is the scalable production of high quality 2D anisotropic thin films, and the other is the controllability over anisotropy present in synthesized crystals. The investigation is focused mainly on rhenium disulfide because of its chemical similarity to conventional 2D transition metal dichalcogenides and yet anisotropic nature. Carefully designed vapor phase deposition has been demonstrated effective for batch synthesis of high quality ReS2 monolayer. Heterostructure fabrication proves to be a feasible route for controlling anisotropic directions. Scanning/transmission electron microscopy and angle-resolved Raman spectroscopy have been extensively applied to reveal the structure-property relationship in synthesized 2D anisotropic layers and their heterostructures.

June 9, 2018; 9:30 AM; ECA 219