Two-Dimensional Transition Metal Dichalcogenides: Alloys, Directed Assembly, and Defect Identification

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Two-dimensional transition metal dichalcogenides (2D TMDs) [1] have emerged as key components in optoelectronic devices [2-3]. Large-scale synthesis of 2D TMDs with controlled atomic composition and physico-chemical properties have received attention. Chemical vapor deposition (CVD) offers rich opportunities to tune the properties of TMDs by varying precursors and substrates, and by engineering synthetic defects [4-6]. In this work, we show that by using mixed transition metal precursors, alloyed monolayers of $Mo_xW_{1-x}S_2$ islands can be synthesized exhibiting a compositional gradient and a tunable optical band gap [7, 8]. We further demonstrate that by adding tellurium into the transition metal precursors, it is possible to reduce the synthesis temperature of MoS_2 and WS_2 monolayers by 200 °C [9]. We also report a novel strategy to assemble and align CVD-grown TMD triangular islands on to a patterned substrate using electric-field-assisted assembly [10]. Besides insulating SiO_2 substrates, we are also able to grow 2D TMDs on one- and two-layer graphene substrates, forming vertical heterostructures [11]. Integrating WS_2 with two-layer graphene leads to a significant photoluminescence enhancement. Defect engineering is another key approach to tailor the performance of TMDs. Finally, I will present our recent effort on introducing, identifying, and eliminating atomic defects in CVD-grown 2D TMDs [12].

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