Synthesis and Doping of 2D Semiconductors by Metalorganic Chemical Vapor Deposition

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Abstract

Two-dimensional (2D) transition metal dichalcogenides (TMDC) exhibit exciting semiconductor properties and versatile material chemistry for transistors, optoelectronic devices, quantum information science, and energy missions. Metalorganic chemical vapor deposition (MOCVD) has emerged as a promising technique to grow 2D TMDC thanks to its ability to carry out high-temperature epitaxial growth and to maintain steady precursor flows during the process. First, I will discuss our MOCVD process for growing 2D TMDC on sapphire and graphene substrates and its capabilities for low-temperature deposition on functionalized surfaces or a damascene structure. [1,2] Second, I will talk about our recent progress on the substitutional doping of TMDC with Re [3] and V during TMDC growth. Some dopants can modulate carrier concentrations, introduce magnetism, and even heal defects in TMDC. Third, few-layer TMDC semiconductors might be of interest for near room-temperature device applications due to their reduced thermal ionization energy compared to their monolayer counterparts. I will present our epitaxial 1-to-3-layer MoS_2, layer-by-layer grown by MOCVD and the results. And finally, using TMDs as the building block we can create symmetry-breaking 2D materials with an intrinsic dipole moment. The recent results [4,5] including the conversion of 2D WS_2 and MoS_2 into 2D Janus WSSe and MoSSe and charge transfer study of heterobilayers comprised of Janus TMDs and standard TMDs will be presented.

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