SCALABLE GROWTH OF LARGE-AREA 2D TRANSITION METAL DICHALCOGENIDES AND HETEROSTRUCTURES VIA SODIUM-MEDIATED CHEMICAL VAPOR DEPOSITION

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ABSTRACT

Chemical vapor deposition (CVD) has emerged as a pivotal technique for the production of two-dimensional (2D) materials, particularly 2D transition metal dichalcogenides (TMDs), following the discovery of graphene. In this study, we present novel CVD recipes utilizing a sodium metalate precursor ($NaMO_4$, M = transition metal) in conjunction with sulfur vapors at elevated temperatures to facilitate the growth of 2D TMD materials. Our findings reveal that the incorporation of sodium significantly enhances crystal growth rates, enabling the transition from a vapor-vapor reaction to a vapor-liquid-solid mechanism [1-2]. This advancement has enabled the fabrication of continuous 2D TMD films encompassing monolayer and few-layer domains, with exceptional lateral dimensions exceeding 500 μm. Moreover, by adjusting precursor concentration ratios, we have successfully synthesized exceedingly large 2D TMD heterostructures both vertically and laterally. Specifically, we demonstrate the production of 2D MoS_2 and WS_2, along with their heterostructures, using these innovative CVD recipes. Comprehensive characterization via optical, atomic force, and scanning electron microscopies, as well as Raman and photoluminescence spectroscopies, validates the high quality and structural integrity of the synthesized materials. Our approach represents a significant advancement in the scalable production of large-area 2D TMDs and their heterostructures, paving the way for their integration into diverse applications in electronics, optoelectronics, and beyond.

KEYWORDS: Two dimensional materials, Transition Metal dichalcogenides, Chemical Vapour Deposition

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