Production of single layer transition metal dichalcogenides and their heterostructures

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ABSTRACT

Significant research efforts have been dedicated to refine and develop efficient production methods of 2D-Transition Metal Dichalcogenide crystals. By far, the most scalable and appropriate for the industry appears to be the atmospheric pressure Chemical Vapor Deposition method (CVD). In a typical reaction scheme, a transition metal precursor, commonly a metal oxide reacts in vapor phase with sulfur at elevated temperatures (800°C).

An atmospheric pressure, eco-friendly CVD method for the production of large area MoS_2 and WS_2 2D crystals is presented. The method is based on the reaction between a sodium metalate precursor (Na_2MO_4, M = Mo, W), predeposited on the growth substrate, and sulfur vapors at high temperatures. As has been observed recently the presence of sodium enhances the growth rate of the crystals moving from a vapor-vapor reaction to vapor-liquid-solid scheme. We find that by this method, continuous MoS_2 films with monolayer and few layer domains, isolated triangular MoS_2 monolayers or very large WS_2 monolayers with lateral dimensions exceeding 300 μm can be readily obtained. The impact of the growth conditions on the crystal shape is studied and it is shown that the chalcogen concentration can significantly impact the crystal's growth. Moreover, the possibility of blending the precursors in various concentration ratios to fabricate ternary alloys of the $Mo_xW_{1-x}S_2$ form is finally discussed.