Growth and characterization of singly-oriented single-layer transition metal dichalcogenides on Au(111)

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Abstract

In the recent past, substantial interest has been devoted to some of the single layer (SL) transition metal dichalcogenides (TMDs) as the semiconducting analogue to the 'original' two-dimensional (2D) material, graphene. Materials such as SL MoS_2 and WS_2 that, unlike graphene, possess a sizeable band gap are highly desired for their potential in next generation electronic and optoelectronic devices [1]. Furthermore, the lifting of the spin degeneracy due to the breaking of inversion symmetry (in the SL form) in these materials may form the basis of novel electronic devices utilizing their coupled spin [2] and valley degrees of freedom [3,4]. However, obtaining a crystalline layer and avoiding the mirror domain orientation is imperative for full exploitation of these exotic properties in applications and to suppress defects (such as grain boundaries), which are known to degrade the overall performances.

Here, we present a synthesis method based on physical vapor deposition of Mo/W (onto Au(111)) in H_2S environment, and an in-depth characterization of the synthesized SL MoS_2 [5] and WS_2 [6]. Synchrotron based X-ray photoelectron spectroscopy (XPS), in the fast modality, was used to follow the growth in real time. Thus, allowing the proper tuning of the parameters (found to be different for the two TMDs) and resulting in a highly crystalline growth. High-resolution XPS showed the complete absence of incompletely sulfided MoS_{2-x} and/or WS_{2-x} ($0< x <1$) species and indicated towards the interactions between Au substrate and TMDs overlayer. The presence of a unique spatial orientation of the MoS_2 and/or WS_2 crystalline domains was conclusively determined by x-ray photoelectron diffraction (XPD) measurements, also revealing the thermodynamically stable 1H polytypes of the grown SL TMDs. Scanning Tunneling Microscopy (STM), Low Energy Electron Diffraction (LEED) and Microscopy (LEEM) added further insight into the structural order and the lateral extension of the grown 2D TMDs.

References

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