Evolution in Emerging 2D Functional Chalcogenides with CVD and Van der Waals Epitaxy

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Transition metal di-chalcogenides (TMDCs) such as MoS_2, $MoSe_2$, WS_2 and WSe_2 have become promising complementary materials to graphene sharing many of its attributes. They may however offer properties that are unattainable in graphene, in particular TMDCs offer a bandgap tunable through both composition and number of layers. This has led to use of TMDCs in applications such as transistors, photodetectors, electroluminescent and bio-sensing devices. The current challenge in this emerging research field is to provide a reliable process to fabricate large area of atomically thin 2D TMDCs on the desired substrate.

Chemical vapour deposition (CVD) technology has the advantage of offering conformal, scalable, and controllable thin film growth on a variety of different substrates. A unique CVD process has been developed for the fabrication of wafer-scale atomically thin TMDCs. [1] A typical CVD-grown MoS_2 on a 4" 300nm SiO_2/Si wafer has been demonstrated (Figure 1a) with a typical TEM image of layered MoS_2 grown on c-plane sapphire substrate by this CVD process (Figure 1b).

In addition, Van der Waals Epitaxy (VdWE) could provide the vapour phase epitaxy of these layered TMDCs on the substrates even with mismatched lattice constants. [2] VdWE technique has been successfully developed to fabricate large-scale monolayer MoS_2 and WS_2 on quartz and SiO_2/Si wafers. A typical VdWE-grown monolayer WS_2 on 300nmSiO_2/Si substrate (Figure. 2a) can be characterized by Raman spectroscopy (Figure 2b) and photoluminescence (PL) spectroscopy (Figure 2c). From the separation (60.1cm^{-1}) of two WS_2 Raman peaks (E^1_{2g} and A_{1g}) and PL, the monolayer behaviors can be identified.

In this talk, I describe the evolution in functional chalcogenide materials at the ORC and the recent development in emerging TMDCs materials using CVD technology and Van der Waals Epitaxy and discuss their properties and potential applications.

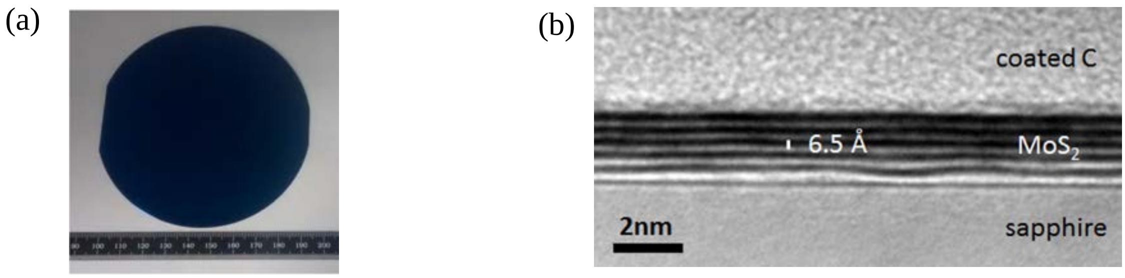

Fig1. (a) CVD-grown MoS_2 on 4" 300nm SiO_2/Si wafer (b) TEM image of CVD-grown MoS_2 on sapphire

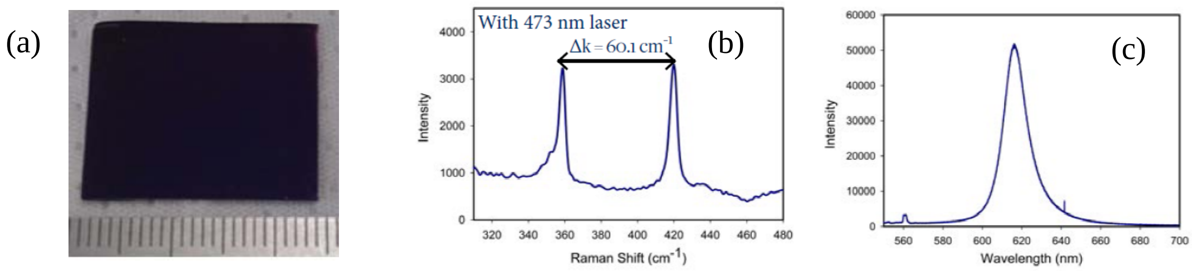

Fig2. (a) VdWE-grown WS_2 on 300nm SiO_2/Si wafer (b) Raman spectrum of VdWE-grown monolayer WS_2 (c) PL spectrum of VdWE-grown monolayer WS_2.

References:
1. C.C. Huang, *et al.*, Nanoscale, **6**, 12792 (2014).
2. A. Koma, Journal of Crystal Growth **201/202,** 236 (1999).

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