Different Morphological Growth of Molybdenum Disulfide *via* Aerosol-Assisted Chemical Vapour Deposition

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Transition metal dichalcogenides (TMDCs) are versatile two-dimensional (2D) materials that have unique optical and electronic properties. Amongst these, molybdenum disulfide (MoS_2) has attracted attention due to its potential applications in high performance transistors as a result of its semiconductor nature and high current on/off ratio (10^8) [1]. Remarkably, MoS_2 possesses a thickness-dependent bandgap that ranges from 1.2 eV for bulk (indirect bandgap) to 1.9 eV for monolayer (direct bandgap). This spans the near infrared to a visible range of the electromagnetic spectrum and potentially makes it suitable for photodetectors and photovoltaics [2]. Due to its layered structure, MoS_2 exists in three known polytypes (1T, 2H, 3R). The most stable and comprehensively studied being the 2H configuration which is particularly abundant in the earth's crust [3]. Ranging from material synthesis to property exploration, both bulk and 2D MoS_2 have been extensively investigated. Various deposition techniques such as, physical vapour deposition (PVD) and chemical vapour deposition (CVD) have been proven be successful growth methods of monolayer MoS_2 [4]. In addition, solution based methods, such as hydrothermal synthesis and solvothermal synthesis have also shown great promise [5]. However, there are still great challenges on scalable production in terms of large-area uniform growth. Moreover, there are further challenges on controlling the phases of the layers as different phases may coexist within a same flake which can result in a vast discrepancy in optical and electrical properties. Here we demonstrate the epitaxial growth by an Aerosol-Assisted Chemical Vapor Deposition (AACVD) method [6] results in large area coverage (~1 cm^2) of MoS_2 on both glass and Silicon dioxide (SiO_2) substrates. The morphology and thickness can be tuned by precursor concentration and/or growth temperature allowing us to engineer different MoS_2 structures, such as nanorods, snowflake-like structures (Figure 1) and 2D layers. The as-grown MoS_2 structures are characterized using X-ray diffraction (XRD), Raman and electron dispersive X-ray spectroscopies, which confirmed the presence of 2H-MoS_2. The XRD results show that the MoS_2 structures grown on SiO_2 substrates are under strain compared to the growth obtained on glass substrates, which also confirmed by the Raman shift observed in E^1_{2g} and A_{1g} modes. However, it is apparent that this substrate induced strain does not significantly affect the growth of different morphologies. The successful growth of 2H-MoS_2 with different morphologies offer the prospect for large-area device fabrication that exploit distinctive optical and electronic properties.

References

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Figures

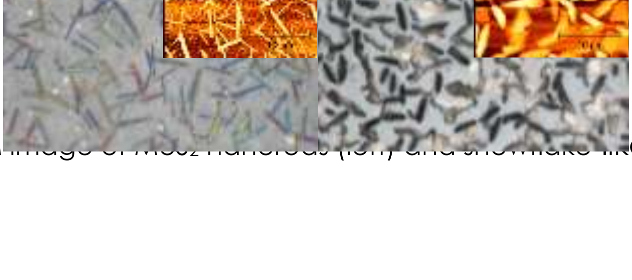

Figure 1: Optical and AFM image of MoS_2 nanorods (left) and snowflake-like structures (right) on glass substrates