Vertical to lateral transition of growth of MoS_2: Effect of precursor partial pressure

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Transition metal di-chalcogenides hold promise for next generation electronics due to their unique electronic and optical properties. Due to presence of dangling bond-free surfaces, they enable atomic-level scaling and provide great electrostatic control. Various bottom-up techniques such as PVT, CVT etc. [1] have been used to obtain thin layers for proof-of-concept devices. However, for large scale commercial applications, there is a need for pure CVD method wherein the individual precursors are directed to the reaction chamber in a controlled amount. Though lateral grains in the range of 1-100 µm [2] has been grown by MOCVD techniques, the underlying growth mechanism is relatively less understood. Herein, we report the importance of the partial pressure of the reacting species in the controlled growth of atomically thin films. Using molybdenum hexacarbonyl ($MO(CO)_6$) and hydrogen sulphide (H_2S) as the precursor, we have obtained films of different morphologies and stoichiometry. The film morphology can be tuned by changing the precursor concentration and/or the pressure of the reaction chamber. A shift from vertically oriented flakes to lateral islands is observed on reducing the partial pressure of the molybdenum species. Increased nucleation density and reaction rates stifle the lateral growth of the film at higher partial pressure of the precursor. The control over the different morphologies during growth enables the use of MoS_2 for diverse applications.

References

[1] Y. Xie et al., Nanotechnology, 8 (2017), 1-11
[2] V. Kranthi et al. ACS Applied Nano Materials, 4(7), (2021), 6734-6744

Figures

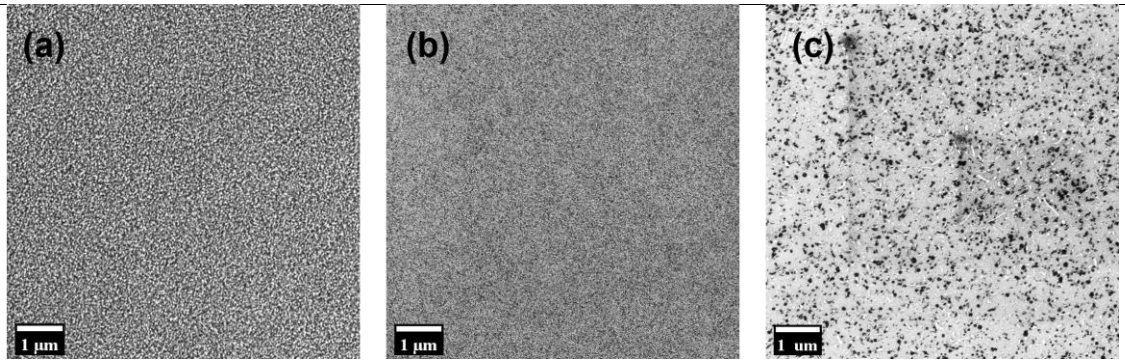

Figure 1: SEM image showing vertical to lateral transition of growing film with reducing partial pressure. (a) $4.5x10^{-2}$ Torr (b) $5.0x10^{-2}$ Torr (c) $2.4x10^{-4}$ Torr (Scale bar - 1µm)

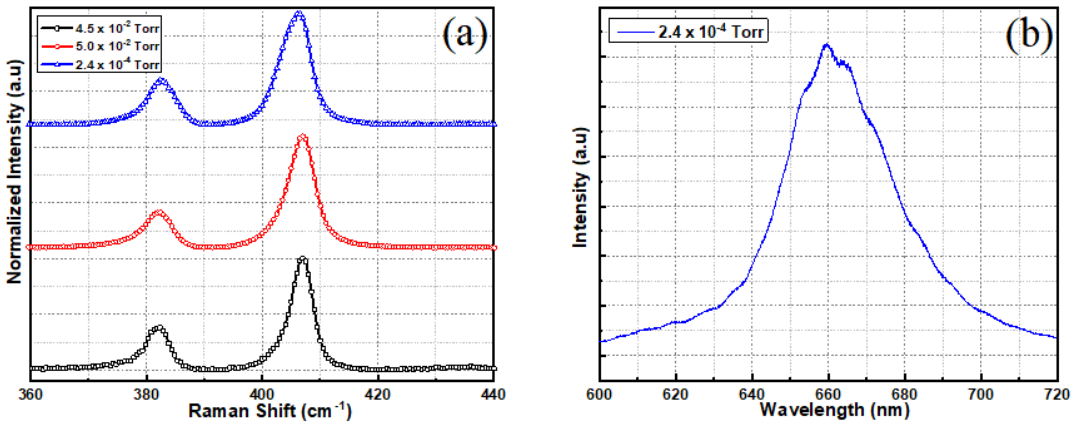

Figure 1: (a) Raman spectrum confirming the presence of MoS_2 (b) PL corresponding to a monolayer of MoS_2 (grown at a low partial pressure)