Scalable ALD MoS_2 process and its applications

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In the race for commercially viable transition metal dichalcogenides (TMD) 2D materials, Atomic Layer Deposition (ALD) stands out as an excellent example of how the future of TMDs will look like. 2D materials have grown beyond replacing other materials, into working alongside them and by enabling emerging applications by heterogenous integration [1]. As 2D materials have moved away from the simple depiction of concepts, there is a need for accurate control of the properties alongside the ability to grow at a large scale. Here we present a scalable process to grow MoS_2 and some of its current applications. The method uses thermal ALD to grow a template MoO_3 layer offering excellent uniformity and thickness control, preserved as the number of layers when converted to MoS_2. Vapour sulphurisation at an intermediate temperature is used to define the stoichiometry of MoS_2 followed by a high temperature crystallisation anneal. This stepped process offers decoupled control over the number of layers, stoichiometry and crystallinity of the film while resulting in uniform large area growth (Figure 1). It has enabled applications such as flexible transistors [2] and ferroelectric arrays [3], low energy phase change memories [4], flexible nanogap temperature sensors [5], and heterostructures for energy storage applications [6]. It is currently developed further to include other n and p-type TMDs to cater further applications such as for flexible solar cells and battery electrodes demonstrating the vast versatility of the process.

References

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Figures

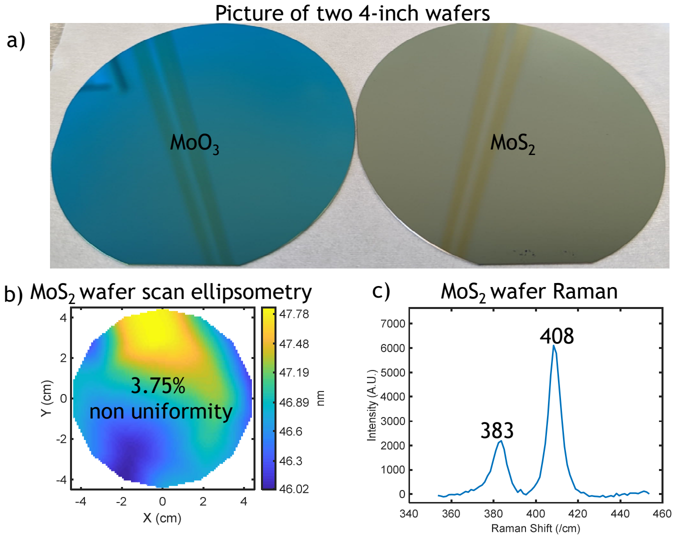

Figure 1: 4-inch wafer MoO_3 and MoS_2 films. b) Wafer-scale MoS_2 ellipsometry thickness profile c) Raman spectroscopy of the ALD MoS_2