Low-Temperature Atomic Layer Deposition of Crystalline MoS_2

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Molybdenum disulfide (MoS_2) is a widely studied 2D material, which has shown promise in electronics, opto-electronics, and catalysis, for example.[1] However, production of high-quality, large-area MoS_2 films, preferably at low deposition temperatures, remains a challenge.

Atomic layer deposition (ALD) is an industry-approved thin film deposition technique, which is based on self-limiting surface reactions of alternately pulsed, gaseous precursors. The characteristic self-limiting growth of ALD allows for unmatched large-area uniformity and conformality, often combined with good film quality at low deposition temperatures.[2,3]

In this work, a new, volatile molybdenum precursor $Mo(thd)_3$ (thd=2,2,6,6-tetramethylheptane-3,5-dionato) was synthesized. 2H-MoS_2 films were deposited at 300 °C using H_2S as the second precursor (Figure 1). Facile thickness control and cm^2-scale uniformity (limited by substrate size) as well as relatively good crystallinity (Figure 2) were demonstrated. In addition, film morphology, composition, and optical properties were characterized.

References

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[3] M. Leskelä, J. Niinistö, M. Ritala, in Comprehensive Materials Processing, Ed. D. Cameron, vol. 4 (2014) pp. 101–123
[4] S. Mignuzzi, A.J. Pollard, N. Bonini et al., Phys. Rev. B 91 (2015) 195411

Figures

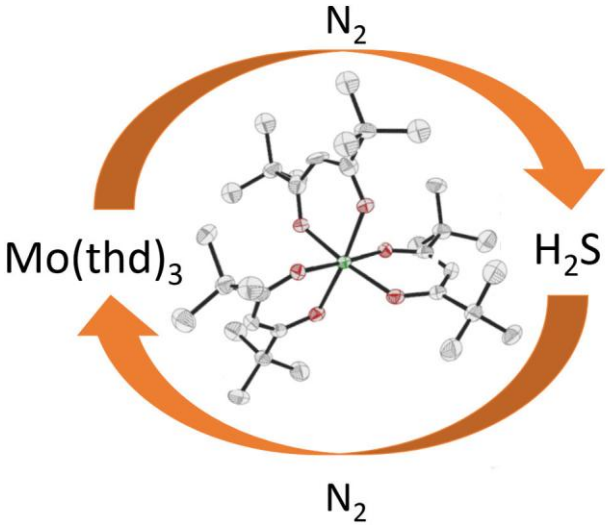

Figure 1: ALD-cycle, which consists of $Mo(thd)_3$ and H_2S pulses separated by N_2 purging steps. The crystal structure of $Mo(thd)_3$ is shown in the middle (hydrogen atoms have been omitted).

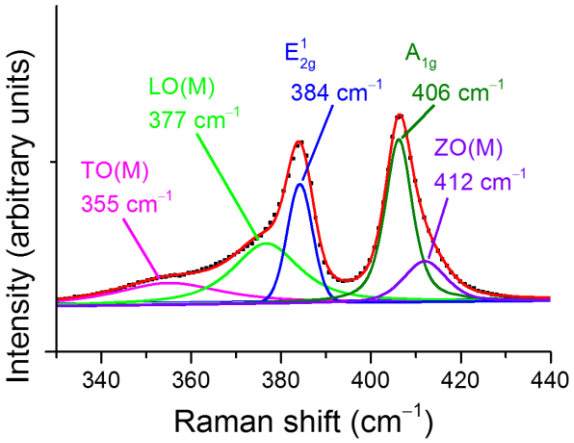

Figure 2: Raman spectrum of an approximately 2 nm MoS_2 film. TO(M), LO(M), and ZO(M) are disorder-induced modes.[4]