Large-area synthesis of MoS_2 thin films by atomic layer deposition

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MoS_2 has been received great attention as a potential channel material because of its high mobility and relatively large band-gap. A MoS_2 monolayer which has been extensively studied has been mostly formed by a mechanical exfoliation method. However, the exfoliation method is not suitable for mass-production of MoS_2 layer because the exfoliation method cannot precisely control thickness and form uniform MoS_2 in a large-area. Therefore, the large-area synthesis of MoS_2 thin films is essential for a wide range of applications in the industry. Atomic layer deposition (ALD) is a thin film deposition method based on self-limiting mechanism. ALD can control the film thickness at an atomic scale and form very uniform and conformal thin films on the large-area.

We deposited MoS_2 thin films on SiO_2 substrates by ALD using $Mo(CO)_6$ as a Mo source and H_2S as a S source. The self-saturation behavior was confirmed and the growth per cycle is 0.24 Å/cycle at 160 ^oC. The temperature window of the ALD of MoS_2 films was observed in the range from 160 to 180 ^oC. The growth per cycle abruptly increased above 180 ^oC. Although the XRD spectra of the as-grown MoS_2 films show no crystalline peak, the Raman spectra clearly show E_{2g} and A_{1g} peaks of MoS_2 even at < 1 nm-thick MoS_2. (Fig. 1). It was also verified from the XPS analysis that the as-grown films have Mo-S chemical bindings. After annealing at 500 ^oC under N_2 atmosphere, the crystallinity of the MoS_2 films was improved, as evidenced by the XRD analysis. We examined the initial growth behavior of MoS_2 films to reduce the film thickness down to few MoS_2 layers. The details on the growth behavior and the properties of the MoS_2 films will be presented.

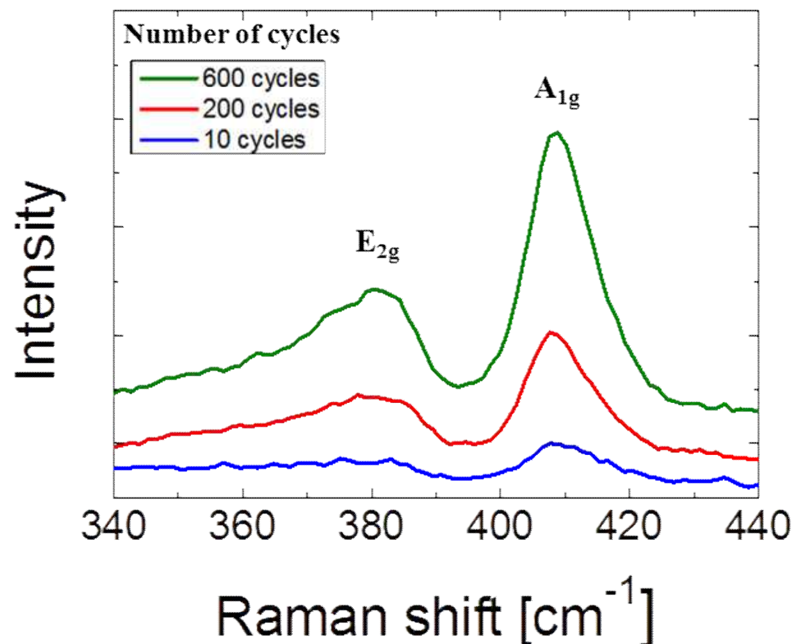

Figure 1. Raman spectra of as-grown MoS_2 films by ALD