Effect of oxidation process on MoS$_2$ thin film growth
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[Introduction] MoS$_2$ have received considerable attention because of unique potential, such as controllable band-gap and high carrier mobility. Although significant efforts have been devoted to prepare MoS$_2$ thin film, technique to grow large and flat MoS$_2$ thin film is rare until now. A main purpose of this study is to explore a growth process of MoS$_2$ films in large area. For this purpose, a three-step procedure was investigated. Here, MoS$_2$ thin films were prepared through MoO$_3$ deposition, thermal annealing for oxidation and crystallization and sulfurization by CVD. Morphology and crystallinity were examined by XRD, AFM and Raman spectroscopy.

[Experimental] MoO$_3$ powder was thermally evaporated in vacuum to form MoO$_3$$_x$ thin film on a SiO$_2$/Si substrate. Subsequently, the film was thermally annealed at 400 °C in O$_2$ atmosphere for oxidation and crystallization. The MoO$_3$ film thus prepared was placed in a glass tube together with sulfur powder. Reaction between MoO$_3$ film and sulfur powder was induced instantaneously at 500 °C for 15 min, where the atmosphere in the tube was kept at 11kPa of N$_2$ gas.

[Results and Discussion] XRD patterns measured at each step are shown in Fig. 1. The oxidation process converted amorphous MoO$_3$$_x$ into crystalline MoO$_3$ with layered structure. After sulfurization, diffraction peaks from MoS$_2$ was clearly observed. Raman spectrum in Fig. 2 shows $E'_{2g}$ and $A_{1g}$ peaks to confirm successful growth of MoS$_2$ films. Fig. 3 shows XRD patterns measured from MoS$_2$ films fabricated with and without oxidation process. The oxidation process yielded an intensive diffraction peak from (002) MoS$_2$ lattice plane, emphasizing advantage of oxidation process. Uniformity of the MoS$_2$ films was confirmed over 12mm x 8mm size substrate. From these results, it can be concluded that three-step CVD technique is promising for growing MoS$_2$ film in large area.

In this study, the 15nm-thick MoO$_3$$_x$ film was initially deposited to enable XRD measurements. The final thickness of the MoS$_2$ film was 17 nm, which corresponds to 22 monolayers. Next plan is to decrease the thickness and refine the growth conditions for producing single layer MoS$_2$.

Fig. 1. XRD patterns measured after each process. Fig. 2. Raman spectrum obtained from MoS$_2$ thin film. Fig. 3. XRD patterns obtained from MoS$_2$ films with and without oxidation process.