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Effect of oxidation process on MoS_2 thin film growth

Sinae Heo[1, 2], Ryoma Hayakawa[1], Toyohiro Chikyow[1], Yutaka Wakayama[1, 2]

NIMS[1], Kyusyu University[2]

E-mail: HEO.Sinae@nims.go.jp

[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 ℃ 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^1_{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.

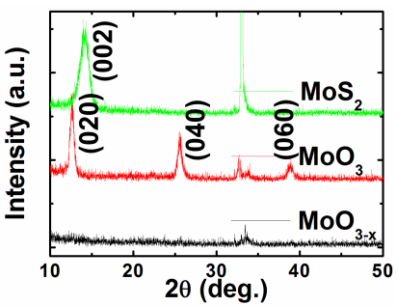

Fig. 1. XRD patterns measured after each process.

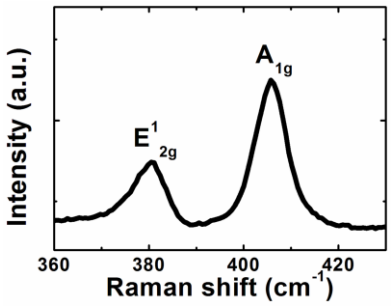

Fig. 2. Raman spectrum obtained from MoS_2 thin film.

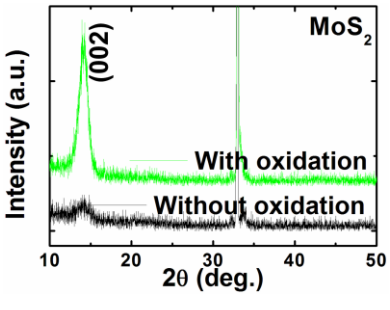

Fig. 3. XRD patterns obtained from MoS_2 films with and without oxidation process.