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Chemical vapor deposition of MoS_2 films

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The two dimensional materials such as graphene, and transition metal dichalcogenides are became alternative and attracted for use in next generation nanoelectronic devices due to their rich physics and excellent electrical properties. Graphene is promising material for use in flexible and transparent device owing to planar nature and mechanical flexibility. Many researchers tried to improve mobility and some device which suspended on graphene were showed ultrahigh electron mobility (K. I. Bolotin, et al., 2008) compared to conventional devices based on amorphous silicon. Despite of all these excellent electrical properties, graphene has no bandgap that makes impossible to fabricate on/off and photoelectronic devices. In contrast, transition metal dichalcogenides such as molybdenum disulfide that normally used for lubricant have 1.8 eV direct bandgap when they fabricated onto monolayer (K. F. Mak, et al., 2010). Although monolayers of MoS2 have a large intrinsic bandgap, reported mobility in the 0.5 to 3 $cm^2V^{-1}s^{-1}$ that similar with amorphous silicon are too low to use as a practical electronic device. However, B. Radisavljevic, et al. and H. Wang, et al were achieved over 200 $cm^2V^{-1}s^{-1}$ mobility by using HfO_2 as a dielectric material. There are various ways to obtain or growth MoS2 monolayer using mechanical exfoliation (B. Radisavljevic, et al., 2011), sulfurization (Y. Zhan, et al., 2012), chemical vapor deposition (Y. H. Lee, et al., 2012; Y. Shi, et al., 2012). Although exfoliated monolayer of MoS2 shows excellent electrical properties than that fabricated other methods, there is limitation of mass production. CVD method is typical method to synthesize thin film. Some researchers reported synthesize method monolayer of MoS_2 using CVD, but need high temperature over 800℃, or pretreated substrate.

In this work, we analyze decomposition condition of molybdenum hexacarbonyl as a precursor and deposit the thin film of MoS2 directly on the various substrates of silicon, silicon oxide, and platinum using Mo precursor and hydrogen sulfide as a reaction gas in CVD chamber. The analysis result of molybdenum hexacarbonyl using Fourier transform infrared spectroscopy (FT-IR, NICOLET 6700, thermo scientific) shows 2000 cm^{-1} vibrational frequency that matched exactly same with simulation result using conventional Gaussian program and previous research (Y. Ishikawa and K. Kawakami, 2007). The molybdenum hexacarbonyl was decomposed about 200℃ at low pressure conditions (figure 1). The hydrogen sulfide plasma deposited film were analyzed using scanning electron microscope (SEM, figure 2), energy disperse X-ray spectroscopy (EDS), X-ray photoelectron spectroscopy (XPS), and X-ray diffraction (XRD).

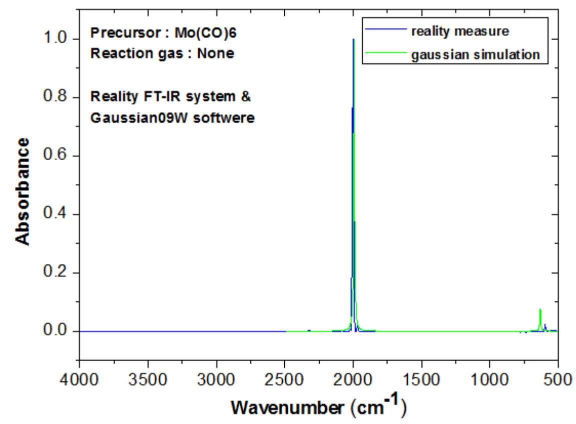

Figure 1. Comparison result of FT-IR measurement and simulation result.

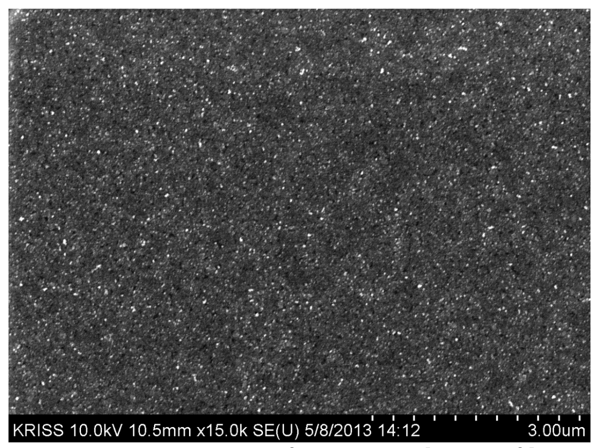

Figure 2. SEM image of CVD growth MoS_2 film.

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