Synthesis of MoS_2 atomic layers with PECVD

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Graphene has become to be the most spotlighted material because it has remarkable characteristics and advantages. Despite of these advantages, Graphene is difficult to apply to semiconductor devices because of low on/off ratio respectively with zero band-gap. However, since molybdenum disulfide (MoS_2) has the band gap of 1.96 eV in bulk state as well as the similar property with graphene, it can apply to semiconductor devices. Moreover single layer of MoS_2 has high mobility as $200cm^2/v^{-1}s^{-1}$ and on/off ratio over 10^8.

MoS_2 is usually synthesized by Chemical Vapor Deposition (CVD) under the relatively high temperature to get high quality property. However, the CVD method has limitation to synthesis of MoS_2 on flexible plastic substrate which has a melting point about 200°C. Therefore, it is very important to characterize the MoS_2 synthesis methods of low temperature.

In this study, MoS_2 was deposited by Plasma Enhanced CVD (PECVD) under the process temperature from 150 °C to 200 °C with Mo thin film and H_2S gas precursor. Mo was deposited on SiO_2/Si wafer with 1 nm thickness by e-beam evaporator firstly, and then decomposed H_2S gas by plasma was used for S precursors. Synthesized MoS_2 thin films at 150 °C exhibited the two characteristic MoS_2 raman peaks.

Table 1. Experiment conditions

Property	Conditions
Substrate Size	1 × 1 cm SiO_2/Si Wafer
Deposition Temperature	150, 200 °C
Deposition Pressure	200 mTorr
Precursor Source	H_2S
Plasma power	600w

In this experiment, synthesis of MoS_2 layer by 2 conditions and we confirmed the synthesis MoS_2 by raman spectroscopy. Raman spectroscopy has been widely used to determine the number of layers, as well as material property.

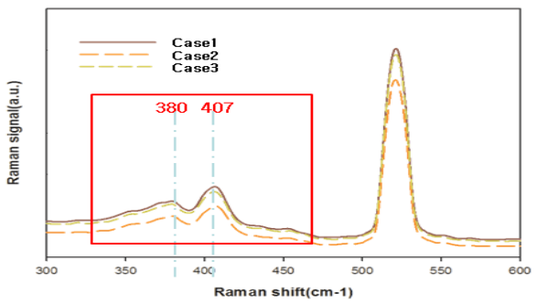

Fig. 1 Raman spectra for MoS_2 thin film layer on SiO_2/Si substrate at 200℃, 600w, 200mTorr. The film obtained exhibits two characteristic MoS_2 Raman peaks ($\mathbf{E_{2g}}$ ~380 and $\mathbf{A_{1g}}$ ~407 cm^{-1})

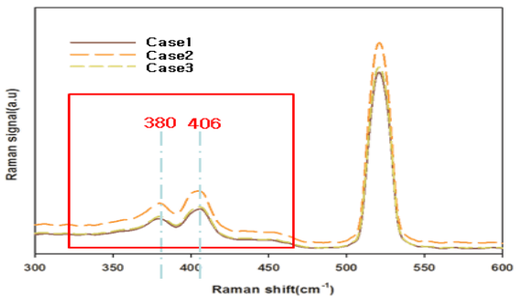

Fig. 2 Raman spectra for MoS_2 thin film layer on SiO_2/Si substrate at 150℃, 600w, 200mTorr. The film obtained exhibits two characteristic MoS_2 Raman peaks ($\mathbf{E_{2g}}$ ~380 and $\mathbf{A_{1g}}$ ~406 cm^{-1})

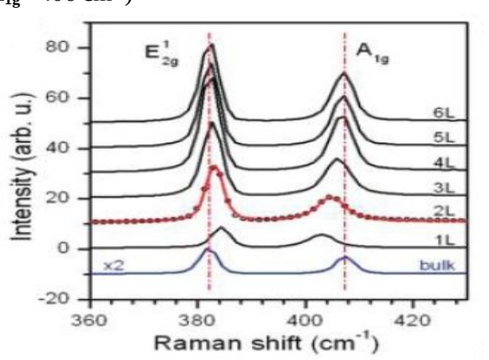

Fig. 3 Raman spectra of thin and bulk MoS_2 films(1)

Fig.1, 2 are spectra of MoS_2. Comparing fig.3 with them, we can confirm that both MoS_2 have 2~3 layers. Fig.1 and fig.2 have same distance of raman peak so it shows same layers of MoS_2.

Reference

1) Changgu Lee, Hugen Yan. Brus, Tony F.Heinz, James Hone, and Sunmin Ryu 2010 , ″Anomalous Lattice Vibrations of single and few-Layer MoS_2″, ACSNANO, Vol.4, No.5, 2695-2700