Agglomeration-suppressed Chalcogenization of Mo-metal Films Using Thermally Cracked Small S- and Se-molecules at Low Temperature

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Recently, for the large scale production and large area applications, large area growth methods of two dimensional (2D-) transition metal dichalcogenides (TMDCs) films utilizing chemical vapour deposition (CVD) techniques have been widely investigated. However, the conventional CVD methods require a high temperature and produce randomly distributed 2D-TMDCs crystallites on the substrate. Moreover, impurity incorporation from precursors cannot be avoided in the metal-organic CVD methods conducted at a relatively low temperature. Therefore, a facile and efficient fabrication method that can provide wafer-scale uniformity and low impurity incorporation as well as high film quality is required to enable the practical use of 2D-semiconductors.

In this study, we demonstrated a new strategy such as metal-agglomeration-suppressed growth (MASG)[1] to obtain high quality MoS_2 and $MoSe_2$ films on wafer-scale substrates using thermally cracked small sulfur (S-) and selenium (Se-) molecules at 570 °C or lower. Sulfur vapour passed through the high temperature cracking zone (≥900 °C), in which the large S-molecules were cracked to smaller molecules, after which they reacted with the Mo film to form MoS_2 films.

The growth procedure is illustrated in Figure 1. In the conventional sulfurization process (A), protruding islands were found on the films grown at a temperature of 500 °C or higher. On the other hand, in procedure B, the agglomeration of Mo precursor can be suppressed by pre-depositing S on the precursor film.

Figure 2(a) demonstrates the Raman spectra of MoS_2 films grown at temperatures as low as 400 and 500 °C for 30 min. Figure 2(b) shows the Raman spectra of points 1-9 (in inset) of MoS_2 grown on 6 inch SiO_2/Si wafer at 570 °C. The E^1_{2g} and A_{1g} peak intensities at all points were almost the same. The thickness variation was less than 3.3 % on the wafer.

The results on the growth at lower temperature will be also presented to demonstrate the usefulness of the MASG method for the growth of high quality TMDCs on transparent substrates.

References

[1] K. H. Jung, S. J. Yun, Y. Choi, J. H. Cho, J. W. Lim, H.-J. Chai, D.-H. Cho, Y.-D. Chung, G. Kim, Nanoscale, 10 (2018) 15213

Figures

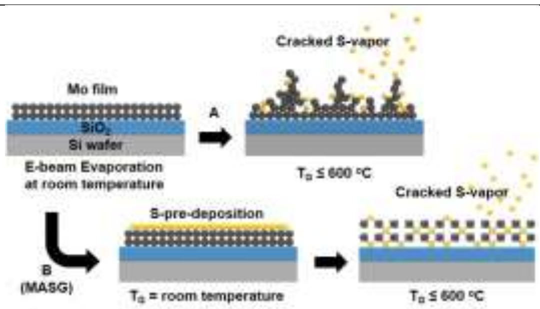

Figure 1: Procedures A (conventional) and B (MASG) for growing MoS_2 films from thin Mo precursors using cracked S-molecules

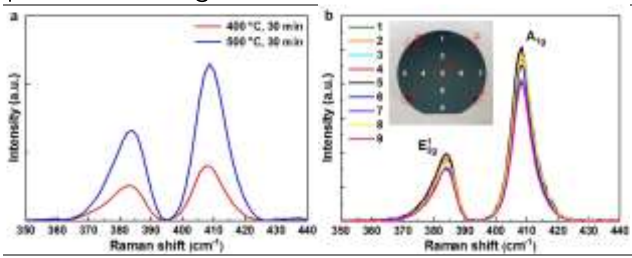

Figure 2: Raman spectra of (a) 6.1 nm MoS_2 films deposited at 400 and 500 °C for 30 min and (b) the high quality MoS_2 film deposited at 570 °C (the numbers indicate the points marked on the photograph in inset)