Ga 蒸気触媒 CVD 法におけるグラフェン初期成長過程の観察

Observation of the growth of graphene at initial stage synthesized by gallium vapor assisted chemical vapor deposition

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Graphene is a single, tightly packed of carbon atoms. Because of its remarkable carrier mobility, graphene has been expected to be applied in next-generation field effect transistors. At the present, the chemical vapor deposition method using Cu catalyst is proved to be the most promising way to the synthesis of high-quality, large-scale graphene. It is, however, required to transfer the synthesized graphene layer to an insulating substrate for electronics device applications. The direct synthesis of the large area graphene on insulating substrate such as quartz and SiO_2/Si substrate by CVD using Ga vapor catalyst has been reported in our previous study (K.murakami et al., Appl. Phys. Lett. 106, 093112(2015).). However, the growth mechanism of graphene by Ga vapor catalyst has not been entirely clear. In this study, the growth of graphene at initial stage synthesized by Ga vapor assisted CVD were observed by atomic force microscope (AFM).

Sapphire plate was employed as the substrate. The substrate was introduced to the quartz tube furnace and exposed to the mixture of Ga vapor catalysts, CH_4 (2 sccm), H_2 (12 sccm), and Ar (100 sccm) at 1050℃ for 30 min to 120 min. The graphene grains were synthesized over the entire surface of the substrate during this period.

Figure 1(a) is Raman spectra of graphene synthesized for time ranging from 30 min to 120 min, respectively. With the increase of synthesis time, the I_G/I_D ratio and the I_{2D}/I_G ratio both increased. These results indicate the improvement of crystal quality of graphene grains with longer synthesis time. Figure (b) and (c) show the deformation images of graphene synthesized for 60 min and 120 min measured by a force curve mapping using AFM. The dent depth of graphene areas corresponding to the darker contrast is deeper than the substrate. The grain size increases with the synthesis time. In addition, each grains of graphene is connected and has a tendency to cover the whole surface of the substrate, which is the reason for the crystal quality improvement of the graphene with longer synthesis time in Raman spectra.

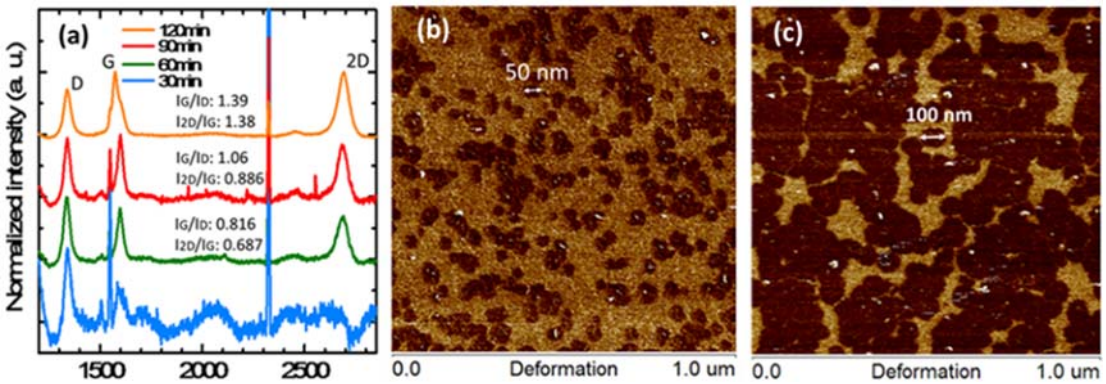

Figure 1(a). Raman spectra of graphene synthesized for 30-120 min, respectively. Deformation images of graphene synthesized for 60 min (b) and 120 min (c) measured by AFM.