Growth of Frost Column-like Carbon Nanotube Forest on Alumina Layer

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1. Introduction

Carbon nanotubes (CNTs) and graphene have attracted the attention to the application because of their superior electrical, thermal and photonic properties. Various applications in optical devices for photonic metamaterial[1], solar cells[2] and emission from floating graphene[3] are expected. The frost column-like CNT forest[4,5], a carbon film of the two-dimensional structure supported by CNT forest of one-dimensional structure, is expected as a floating mirror or a floating thin film on substrate. In previous reports anisotropic optical properties of the frost column-like CNT forest on th-SiO (t100nm) substrates in those anisotropic infrared absorption and light interference between the carbon film and the substrate[6,7] were observed. Growth of the frost column-like CNT forests on various substrates is required to develop further optical and electric applications. However, frost column-like CNT forest growth on a AlO layers with underlying metal film as electrode and mirror have not been reported yet. In this report, growth of the frost column-like CNT forests on alumina layer was investigated.

2. Experimental

RF sputtering deposition of alumina was conducted on the Cu(100nm)/th-SiO/Si and th-SiO/Si substrate with Ar gas flow rate of 25 sccm, 1.4 Pa pressure at RF power of 50W with the base pressure less than 0.5 mPa. Copper metal film of 100nm thickness has been prepared on thermal CVD SiO_2/Si (th-SiO/Si) substrate by DC magnetron sputtering deposition. Ni catalyst films were deposited on these alumina layers by DC magnetron sputtering method at discharge current of 20 mA, voltage of 290 to 300 V with Ar gas flow of 10 sccm, and 0.8 Pa pressure with the base pressure less than 3 mPa. Using these catalysts of Ni/AlO(30nm)/Cu(100nm)/th-SiO/Si and Ni/AlO(30nm)/th-SiO/Si, the frost column-like CNTs were grown by thermal CVD using C_2H_2 source gas flow of 10 sccm, 54 Pa at 730°C. Structure of sample was observed by FE-SEM (JEOL JSM-7401F).

3. Result and Discussion

Figure 1 shows cross-sectional SEM images of samples. On the Ni/AlO_x catalyst frost column-like CNT forest with very low density CNT forest were obtained. Frost-column structures were not grown on Ni/AlO(30nm)/Cu(100nm) with underlying Cu layer, and it was observed that copper film was peeled off and nickel catalyst on alumina formed agglomerated particles as shown Fig.1(b) and (c). It is considered that nickel catalysts were agglomerated due to high-temperature process of CVD.

4. Summary

Frost column-like CNT forest were successfully grown on alumina layers on the th-SiO/Si substrate. Although frost column-like CNT forests were not grown on alumina films with underlying Cu films due to peeling off of Cu films by heat shock. Further research is required for the growth of frost column-like CNT forests on alumina buffer layers with underlying metal films for the optical applications, including choosing of suitable metal layer and sufficient thickness of the metal films.

References

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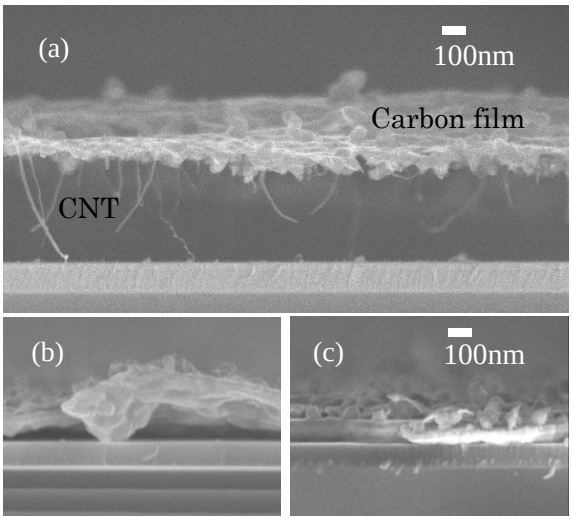

Figure 1. Cross sectional SEM images of (a) frost column like CNT forests grown on (a) Ni/AlO(30nm)/th-SiO/Si, and (b, c) carbon film deposits on Ni/AlO(30nm)/Cu(100nm)/th-SiO/Si.