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Structure dependence of Optical Properties of Frost Column-like Carbon Nanotube Forest

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1. Introduction

Carbon nanotubes (CNTs) have been of interest to researchers because of their superior electrical, thermal and photonic properties. Applications of the energy saving devices and optical devices are expected. In the field of optical device applications, for example CNT has the applicability to an photonic metamatateriral[1], field emitter elements[2] and solar cells[3]. However, it is known that optical properties depend on the density and structure of CNT forest[4]. Therefore, the precise control of structure and optical properties is essential to utilize the CNT forest for optical applications. The frost column-like CNT forest, a carbon film supported by low-density CNT forest, is expected as a floating mirror or a floating thin film on substrate. In this report, the optical properties of frost column-like CNT forest were investigated.

2. Experimental

Sputtering deposition of Ni was carried out on thermal CVD SiO_2/Si substrate at discharge current of 20mA, voltage of 290 to 300V with Ar gas of 10sccm flow rate, and 0.8 Pa pressure in the base pressure around 3mPa. The frost column-like CNTs were grown by thermal CVD using C_2H_2 source gas of 10sccm, 54Pa at 730°C. Height of the frost-column like CNT forests[5] was controlled by the synthesis time from 5 to 20sec. Height of sample was observed by SEM (JEOL JSM-7300F), followed by measurement of optical reflectance by UV-VIS spectrophotometer (HITACHI-U3900).

3. Results

Figure 1 shows cross-sectional SEM images of frost column-like CNT forests. At each growth condition, CNT forests coated with carbon layers were obtained at different growth heights. The carbon films does not shape the perfect flat surface, but slightly curves gradually, below which CNTs grow at different height gradually. Figure 2 show specular and diffusion reflectance spectra for each sample. Patterns of optical interference were confirmed both in specular and diffusion reflectance, in which pitch of the oscillation was reduced with increasing CNT height. CNT forests is a material of highest absorption coefficient in the axial direction[6], however, frost-column like CNT forest has 10-20% specular reflectance, due to the low density of CNT forest in frost-column. The diffusion reflectance of 1-5 % is relatively high 25% of specular reflectance. The specular reflectance and diffusion reflectance did not show clear dependence on the height of frosts, which suggested that the absorption on the CNT body is relatively small in these frost-columns like structures. This might be due to the low CNT density of frost column-like CNT forests; therefore it shows the properties of a floating thin film.

4. Conclusions

Different heights of frost column-like CNT forests were obtained by changing the synthesis time. And then subjected to reflectance measurements, a pattern of the interference was observed and increase in height of frost column like CNT that pattern became shorten. CNT forests has high absorption, however frost column-like CNT forests showed the properties such as thin films. Further modification of the frost-column like forests, including growth density and conductance of films, and their optical properties will be discussed.

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Reference

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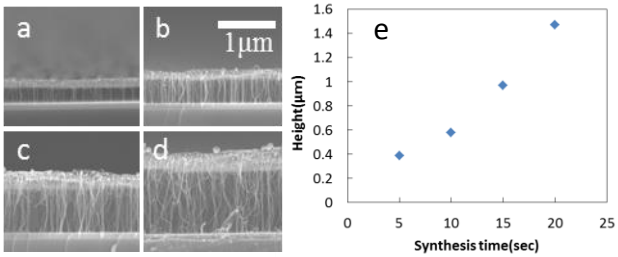

Figure1. SEM image of frost column like CNT forests. Synthesis time is (a) 5sec (b)10sec (c)15sec (d)20sec. Synthesis time VS Average height by using SEM images and Image J(e).

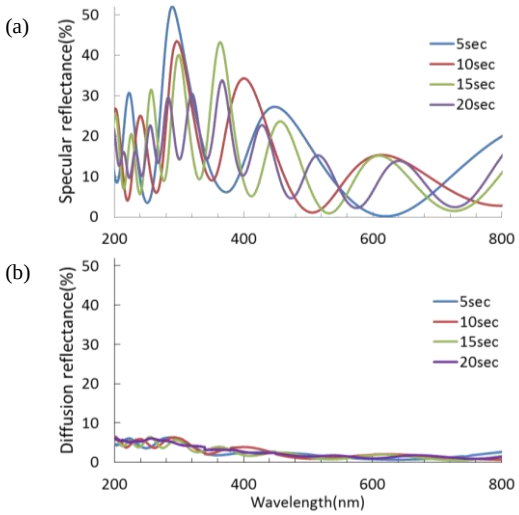

Figure 2. Reflectance of forest column like CNT forest about each synthesis time (a)specular reflectance (b)diffuse reflectance.