Morphology Dependence on Thermal Transport Properties of Single-walled Carbon Nanotube Thin films.

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Single-walled carbon nanotubes (SWNTs) have gotten much attention as a highly promising material for the use of electronic devices such as transistors, solar cells and so on owing to the superior physical properties. However, in some cases, the performance of these devices can be limited by thermal properties of SWNTs. Therefore, understanding the thermal properties of SWNTs is significantly important.

In this study, we measured the in-plane thermal conductivity of randomly-networked SWNT films, whose optical transmittance are 86.4, 80.9, 63.7 and 53.5 % at 550 nm, as well as stacked films composed of two and three layers of 86.4 % transmittance films, made by aerosol chemical vapor deposition [1]. Micro Raman spectroscopy was employed, and thermal conductivities of the films were determined from excitation laser power dependence of Raman shift of the G^+ band [2]. In addition, optical absorbance spectra were used to investigate SWNT bundle network structure of the films. It was observed that the optical anisotropy decreased when the thickness of SWNT films increased, and the in-plane thermal transport properties of the films depended on the anisotropy. Figure 1 (a) shows the relationship between normalized density and in-plane thermal conductivity. The red dot-dashed and blue dashed lines show calculated in-plane thermal conductivity of perfect 2D (anisotropic) and 3D (isotropic) structure (Figure1 (b)), respectively, based on a soft core model [3]. The high transmittance films and the stacked thin films have high thermal conductivity, and they were regarded as almost perfect 2D structure (Left-side in Fig. 1 (a)). In-plane thermal conductivity suppression was observed for thick films (Right-side in Fig. 1 (a)). The result indicates that in-plane thermal conductivity of SWNTs can be drastically reduced by the difference of network structure between 2D and 3D because there is heat conduction perpendicular to in-plane direction in the case of 3D network structure.

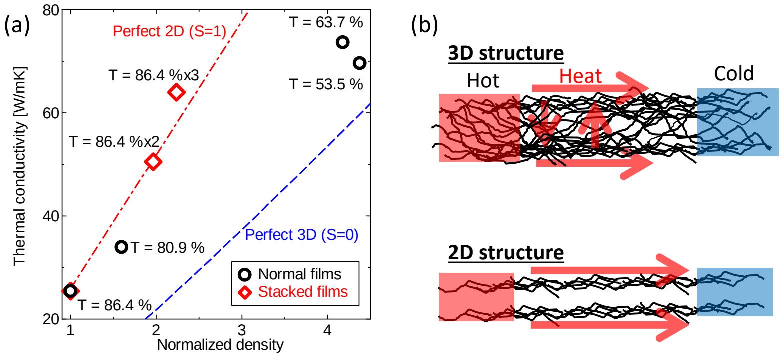

Fig. 1. (a) Relationship between density and thermal conductivity. (b) Schematic illustration of 3D and 2D random network structure.

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References

1. A. Kaskela et al., *Nano Letters*, Vol. 10 (2010), pp.4349-4355.
2. W. Cai et al., *Nano Letters*, Vol. 10 (2010), pp.1645-1651.
3. A. N. Volkov et al., *Applied Physics Letters*, Vol. 101 (2012), pp. 043113.