Measurement of Thermal Conductivity of Vertically Aligned Carbon Nanotubes/Parylene Composite by Photothermal Radiometry

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The vertically aligned carbon nanotubes (VA-CNTs)/polymer composite is commonly fabricated by infiltrating the polymer in the space between CNTs. One of the main difficulties for the fabrication of VA-CNT/polymer composite is the efficient infiltration of polymer in the very narrow gap (50~300 nm) between the CNTs. In addition, the crust of entangled nanotubes on top of the VA-CNTs prevents the polymer infiltrating. It is necessary to develop the method infiltrating the polymer into the CNTs with keeping alignment of CNTs and pinholes-free. The present study describes the fabrication VA-CNT/polymer composite by depositing the parylene polymer by chemical vapor deposition (CVD). We have applied the photothermal radiometry (PTR) to measure the thermal conductivity of VA-CNTs/Parylene composite. In this method, a sample is heated by laser beam (wavelength 790 nm) modulated by a function generator operating from 1 Hz to 1 MHz. The temperature response on the sample surface is detected by the signal intensity change of infrared radiation. There is a phase-lag including the information of thermal properties between the signal and the modulated laser beam. By analyzing the phase-lag data using curve-fitting procedure derived from heat conduction equations, it is possible to determine thermal conductivity. We have fabricated VA-CNTs/Parylene composite under various conditions, e.g., type of parylene, thickness of VA-CNTs. From the cross-sectional view of the composite, we have found that infiltration of parylene into the VA-CNT was improved by depositing parylene from the substrate side. We have compared the measured thermal conductivity with theoretically estimated value.