Thermal Conductivity of Cu-Carbon Nanotube Composite Film

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The thermal conductivity of Cu-carbon nanotube (CNT) composite film is measured and mapped out using time-domain thermoreflectance, an optical pump-probe method that measures the time-evolution of temperature change. We prepare the composite films with the thickness of ~450nm and a varying content (0 ~ 2.3 wt %) of CNT by electroplate-deposition of Cu and randomly dispersed CNT. Mapping the thermal conductivity of the film reveals highly non-uniform thermal conductivity. The non-uniformity increases with the larger loading of CNT until ~1.4 wt % of CNT; the thermal conductivity increases by nearly 50 % or higher on partial areas of the film and the area increases by loading more CNT. Nevertheless, the averaged value of the thermal conductivity remains relatively unchanged around 130 W/m/K. With the CNT loading of 2.3 wt %, the conductivity value is dramatically reduced to ~19 W/m/K in a relatively uniform distribution. The non-uniformity can be explained by the percolation of CNT across the film; high thermal conductivity of individual CNT leads to an increase of the conductivity. Due to the boundary thermal resistance between nearby CNTs in contact, however, the conductivity remains much smaller than the conductivity of CNT. The abrupt change in the thermal conductivity and its distribution for the film with ~2.3 wt % CNT can be accounted for by dominance of the boundary resistance in the thermal energy transport over the large region of the film.