TRANSPORT STUDY OF CARBON NANOTUBE NETWORKS WITH DIFFERENT RATIOS OF SEMICONDUCTING AND METALLIC NANOTUBES

X. Wang, S. Nanot, E. H. Hároz, and J. Kono
Department of Electrical & Computer Engineering, Rice University, Houston, TX, U.S.A

An important goal of current nanotechnology research is to obtain a quantitative understanding of how electrons drift and tunnel through junctions of nanostructures and how the overall electrical conductivity of networks of nanostructures is determined. Such knowledge is crucial for a broad range of future applications of macroscopic assemblies of nanostructures. Here, we present a comprehensive study of DC transport properties of macroscopic single-walled carbon nanotube (SWNT) networks with different ratios of metallic and semiconducting nanotubes. Our temperature-dependent transport measurements show that when the length of SWNT is orders of magnitude smaller than the dimensions of the network, the resistance mainly comes from inter-tube junctions, which can be well explained by hopping (or tunneling) models. Particularly, we found that the probability of hopping (or tunneling) through a metal-metal junction is higher than that of a metal-semiconductor or semiconductor-semiconductor junction, leading to a much higher conductance in a metal-enriched network than the others at low temperature. However, the conductance of semiconductor-enriched network starts to catch up at higher temperature when the hopping probability starts to saturate. This is because accidental doping in semiconducting SWNTs increases the available number of carriers for hopping through the junctions and thus increases the overall conductance.