Evaporation of Various Metals on Vertically-Aligned Single-Walled Carbon Nanotubes and Bonding Their Metal Surfaces to Bulk Metals

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For prospective electronics and thermal applications of Vertically-Aligned Single-Walled Carbon Nanotube (VASWNT) films, electronic contact resistance and thermal boundary resistance between metal and the VASWNT film is extremely important.

Aiming at obtaining low resistive contact, metal evaporation of different metals (Au, Ti, Al and Pd) onto VASWNT films was studied. Observations through Scanning Electron Microscopy (SEM) showed a clear metal-dependence of the deposition layer structure on the VASWNT film, reflecting the wettability and cohesive energy of each metal. These characteristics also influence the structures of the metal penetrated through the top surface into the VASWNT film, where metal forms particles inside the VASWNT film except for Ti, which wets the SWNT bundles. Furthermore, annealing of the Au-deposited VASWNT film was performed at different temperatures. As a result, the annealing was found to be effective to flatten the metal surface and to reduce the amount of penetrated metal particles. We also observed that, under certain conditions, the annealing results in peculiar morphology: rupture of the VASWNT films by the deposited metal.

In addition, we have attempted to bond the Au-deposited VASWNT film to bulk metal. This was done by connecting the Au-deposition layer to a metal block with a bonding material in between and annealing the whole system in argon gas. A systematic study was carried out for different bulk materials (brass and copper), bonding materials (gold foil and silver wax), and annealing temperatures (600-850˚C). The results show that the sufficiently firm connection can be achieved at around 750˚C for most of the tested combinations of bulk and bonding materials. The bonding technique opens up the possibility for various electronics and thermal device application of the VASWNT film.