GROWTH, MODIFICATION AND ELECTRICAL PROPERTIES OF MULTIWALLED CARBON NANOTUBES FOR FUTURE DEVICE APPLICATIONS

By

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ABSTRACT

Carbon Nanotubes (CNTs) are promising materials for future device interconnects due to their high electrical conductivity owing to their one-dimensional structure, and high current carrying capacity. However, many challenges exist for their integration in usable devices.

We have studied CNT growth morphology over constrained geometry non-planar substrates using SiO_2 microspheres. Aligned CNTs grow on spheres with diameters >~ 4 μm. Alignment is reinforced through attractive van der Waals interactions between CNTs. Low number density and high angular separation of CNTs on smaller, high curvature particles decrease inter-tube attraction and disrupt alignment.

Growing aligned CNTs on electrically-conducting and/or optically-transparent materials is potentially useful for accessing CNT properties through electrical and optical stimuli. We report a new approach to grow aligned bundles of multiwalled CNTs on a porous back-contact of optically transparent and electrically conducting indium tin oxide (ITO) films. These features can be harnessed to form CNT contacts with other substrate materials which, upon reduction by Si, result in a conducting interfacial layer.

Understanding carrier transport in CNTs and their networks is important. We have studied multishell carrier transport in individual multiwalled CNTs, and films of randomly dispersed multiwalled CNTs, as a function of electric field and temperature. Electrical measurements and first-principles density functional theory calculations indicate transport across CNT shells. Our results suggest that controlled

defect-creation could be an attractive strategy to induce electrical conductivity increase in multiwalled CNTs. Ozone exposure of individual multiwalled CNTs results in up to three-fold increase in CNT conductivity, and 50% decrease in carrier transport activation energy. CNT etch rate systematically increases with decreasing initial outer diameter and decreases with incremental ozone exposure, which could provide means to controllably tailor the CNT conductance.

High current densities, combined with air-exposure can slice, weld and chemically functionalize multiwalled carbon nanotubes (CNTs) with carboxyl and allyl moieties, and alter the electrical properties. The conductance of thin film assemblies of CNTs increases by 150%, indicating that the increase in the number of low-resistance pathways caused by CNT junction formation offsets the conductance decrease expected from defect creation, surface functionalization and fissure.