Poster

DIELECTROPHORESIS OF SINGLE-WALLED CARBON NANOTUBES: SURFACE CONDUCTANCE CONTROL

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Single-walled carbon nanotubes (SWNTs) have attracted considerable attention as promising building blocks for future nanoscale electronic applications. For the realization of nanotube-based electronics, it is necessarily needed to develop reliable approaches to disperse the bundles of nanotubes individually and sort by electronic type. Recently we have demonstrated a protocol to quantitatively evaluate the degree of dispersion. [1] Also, various approaches to separate nanotubes according to their eletronic stuructures have been demonstrated such as chemically selective functionalization, ion exchange chromatography and density-gradient ultracentrifugation. Among them, alternating current dielectrophoreis has attracted much interest for separation SWNTs. Dielectrophoresis has been demonstrated to separate metallic from semiconducting tubes by their opposite movement in a solvent when interacting with an external alternating electric field. [2, 3] The effect is based on the different electric-field-induced polarizabilities.

Here, we present electrical transport characteristics of the surface charge controlled, dielectrophoretically deposited nanotubes arrays. The modulation in surface conductance of nanotubes effects the polarizability of especially semiconducting nanotubes, resulting in more effective separation between metallic and semiconducting species. The surface conductance was controlled by cationic/anionic surfactant mixtures since the surface conductance is directly proportional to the surface charge. [4] A theoretical analysis about the influence of electrical double layer on nanotube electrokinetics is shown in Figure 1.[5] The Clausius-Mossotti factor (f_{CM}) represents the effective polarizability of the nanotubes. Nanotubes move toward the regions of high electric field strength (positive DEP) if the polarisability of the tube is greater than the suspending medium ($Re[f_{CM}]>0$) whereas nanotubes move in the opposite direction (negative DEP) when the polarisability of the tube is less than the suspending medium ($Re[f_{CM}]<0$). [5]

Experimental observation based on electrical transport measurement showed consistency with theoretical analysis, displaying different electrokinetic behaviors of semiconducting nanotubes depending on surface conductance, as shown in Figure 2. [5] The matted sheet of nanotubes deposited via dielectrophoresis usually did not show modulation under variable high field, indicating metallic dominent pathway. The current through metallic pathways should be greater than that through semiconducting species. In order to check out this possibility, preferential electrical breakdown of metallic species was performed by applying $V_G = 30$ V and $V_{SD} = 12$ V. The preferential electrical breakdown showed different resulting transport behaviors depending on surface conductance. Resulting transport behaviors demonstrated surface conductace modulation induced more effective separation. We will also present a more detailed theoretical study, using zeta potential measurement, and dielectrophoresis results carried out using sub-micron gap electrodes.

References:

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Figures:

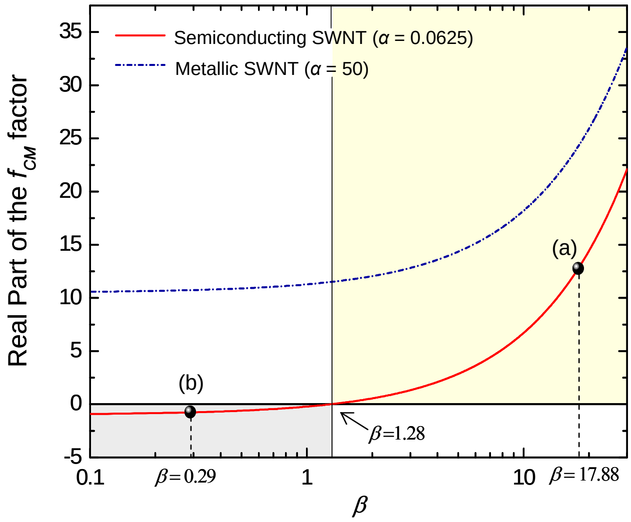

Figure 1 Theoretical plot showing the variation in the real part of the Clausius-Mossotti (f_{CM}) factor as a function of two parameters, $\alpha = \varepsilon_p/\varepsilon_m$ and $\beta = K_p/K_m$. The real part of f_{CM} was zero at β = 1.28 (a) β = 17.88 was calculated for the SDS suspended SWNT (ζ = 50 mV). (b) β = 0.29 was calculated for the CTADS suspended SWNT (ζ = 5 mV). [5]

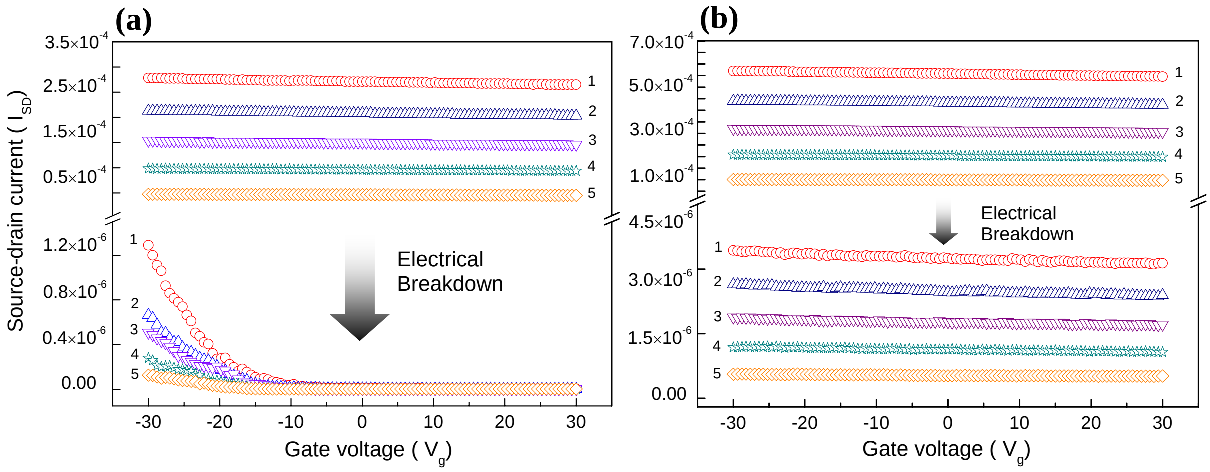

Figure 2 The electrical transport data before and after the preferential electrical breakdown procedure. The source-drain current was measured at 5 different source-drain biases (1: 2V, 2:1.6V, 3:1.2V, 4:0.8V, 5:0.4V) as a function of the back gate voltage. (a) dielectrophoretically deposited nanotubes from the SDS-SWNT suspension (b) dielectrophoretically deposited nanotubes from the SDS-CTAB-SWNT suspension. [5]