Separation of Metallic From Semiconducting Single-Walled Carbon Nanotubes

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We have developed a method to separate metallic from semiconducting single-walled carbon nanotubes using alternating current dielectrophoresis. The experimental setup consists of a microelectrode array which provides a strongly inhomogeneous electric field driven by a radio-frequency generator. The array is exposed to a drop of an aqueous solution of individual single-walled carbon nanotubes (not bundles!). As a result metallic tubes are attracted towards the microelectrode array leaving the semiconducting tubes in the solvent. The opposite movement of metallic and semiconducting tubes along the electric field gradient is due to different polarizabilities of metallic and semiconducting tubes and of the solvent. The separation is proven by a comparative Raman-Spectroscopy study on the dielectrophoretically deposited tubes and a reference sample.

Illustration of the experimental set-up showing microelectrodes wired to a chip carrier. The metallic nanotubes (black) are deposited from a drop of nanotube suspension onto the electrodes by ac-dielectrophoresis, leaving the semiconducting tubes (white) in suspension. Gold electrodes are 30 nm thick, 50 µm wide with a 50 µm pitch on a p-type silicon substrate with 600 nm thermally oxidized SiO₂. A thin titanium adhesion layer has been used.

Rayleigh scattered light from the dielectrophoretically deposited metallic SWNTs and the electrodes, recorded with an incident-light dark field microscope. The scattered light from the aligned SWNTs appears green to the eye and is polarised perpendicular to the electrodes.

Raman spectra of SWNTs deposited via ac-dielectrophoresis with the incident light polarization parallel (0°) and perpendicular (90°) to the deposited SWNTs. Radial breathing mode region (left), G-mode region (right).

References: