Fishing for Carbon Nanotubes with a Plasmonic Metamaterial Net

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It has recently been shown that a strong light-driven near-field force is generated between an illuminated plasmonic metamaterial and a dielectric or metallic surface [1]. We experimentally demonstrate that plasmonic metamaterial efficiently collects carbon nanotubes (CNTs) when the metamaterial is illuminated with laser light through the fibre.

The metamaterials structures employed here were fabricated by focused ion beam milling in 50 nm gold films deposited on cleaved end faces of single-mode optical fibres. They comprise periodic square arrays of asymmetric split ring slits supporting a collective Fano type resonance in the near infrared range. Semiconducting CNTs (commercially synthesized using the electric discharge method and suspended in water with ionic surfactants) were utilized in dilute concentrations of order 10 μg/ml. The fibre was placed in the CNT solution and metamaterial illuminated for 20 minutes using a 1550 nm laser diode.

Figures 1(b)-(d) show optical microscope images of fibre/metamaterial samples after illumination in the CNT suspension at laser excitation level of 5 and 20 mW, alongside images of bare fibre and unstructured gold film control samples subjected to the same procedure. In the latter two cases CNTs are not deposited on the fibre tip, but on resonantly illuminated metamaterial samples, CNTs are deposited on the fibre core area to a density that increases with time and laser power. These depositions are explained by the mixed effect two forces: attractive near-field optical force and thermo-diffusive forces.

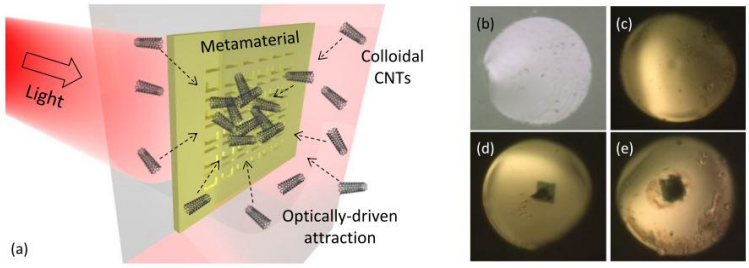

Figure.1: (a) Artistic impression of optically-driven carbon nanotube harvesting from suspension by a photonic metamaterial. (b-e) optical microscope image of fibre end faces after laser excitation in CNT suspension: (b) Bare cleaved fibre at 5mW laser power; (c) Fibre coated with unstructured 50nm gold flat film at 5mW; (d,e) Metamaterials on fibre cores at 5 and 20mW respectively.

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[2] J. W. Nicholson, R. S. Windeler, and D. J. DiGiovanni, *Optics Express*. **15** 8025 (2007)