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DOI: 10.1017/S1431927606064737
Microsc Microanal 12(Supp 2), 2006

Carbon Nanotubes Structure Modification and Synthesis of Nanocrystalline Diamond-Nanotubes Composites

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Carbon nanotube structure is strongly influenced by the synthesis method; its structure (morphology and chemistry) can be modified during the synthesis process or through a posterior treatment. Moreover, nanotubes can be combined with other carbon structures for the formation of nanocomposites. In this paper, first we report a new multiwalled carbon nanotube morphology, which presents a drastically altered surface made of branch-like structures. Secondly, the formation of nanocomposites made of two unique structures, nanotubes and nanocrystalline diamond, is reported.

Scanning and Transmission Electron Microscopy has been combined with Electron Energy Loss Spectroscopy for the characterization of the modified nanotubes morphology produced by a new two-step chemical vapour deposition method [1]. Figure 1, a) and b), illustrates SEM images of the as-prepared and modified nanotubes. A strong modification of the surface is clearly observed. In certain cases, such a modification becomes more pronounced at the tip of the nanotube. HRTEM images of the modified structure illustrate the presence of graphitic platelets (wings-like structure) covalently attached to the nanotube side walls (fig. 1c) and inset). The highly altered nanotube surface could improve the adhesion between the nanotubes and the nanocomposite component, as well as, it could change the electronic and emission properties of the carbon nanotubes.

Carbon nanotubes and nanocrystalline diamond [2] (UNCD) have been simultaneously grown using an adapted plasma-enhanced Chemical Vapour Deposition method [3] . It is important to remark that the pre-treatment of the substrate prior to growth has been found to be crucial in this process. Figure 2 a) illustrates a SEM micrograph of the nanocomposites. Isolated “supergrains” made of nanometre-sized crystalline diamond grains are connected with carbon nanotubes. Further studies need to be done in order to confirm if the nanotubes are covalently connected to UNCD or if such an interaction is a of Van der Waals type. Transmission Electron Microscopy images of the nanotubes (CNT) present at the nanocomposite show bundles made of multiwalled carbon nanotubes with a diameter in the range of 2 to 10nm, Figure 2b. The simultaneously presence of UNCD and CNT have been confirmed by EELS spectroscopy. Figure 2c, illustrates the characteristic C-K signal observed at two areas of the nanocomposite. The top-spectrum is similar to those observed in graphitic carbon nanotubes meanwhile the bottom-spectrum looks analogous to data obtained from high quality microcrystalline diamond or single-crystal diamond except for the presence of a π weak peak at 285.5eV. The produced hybrid structure (made of nanotubes and nanocrystalline diamond) could give rise to materials with novel properties that could be used in a wide range of applications such as electronic devices or MEMS/NEMS.

References

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[4] We acknowledge the financial support from the National Science Foundation (RPI), the European Commission IHP Network "Fullerene like-Materials" and the U.S. DOE Office. ST acknowledges the financial support from "Ministry of Education and Science of Spain Programa Ramon y Cajal". Electron microscopy imaging was carried out in the Electron Microscopy Center at Argonne National Laboratory, which is supported by the Office of Science.

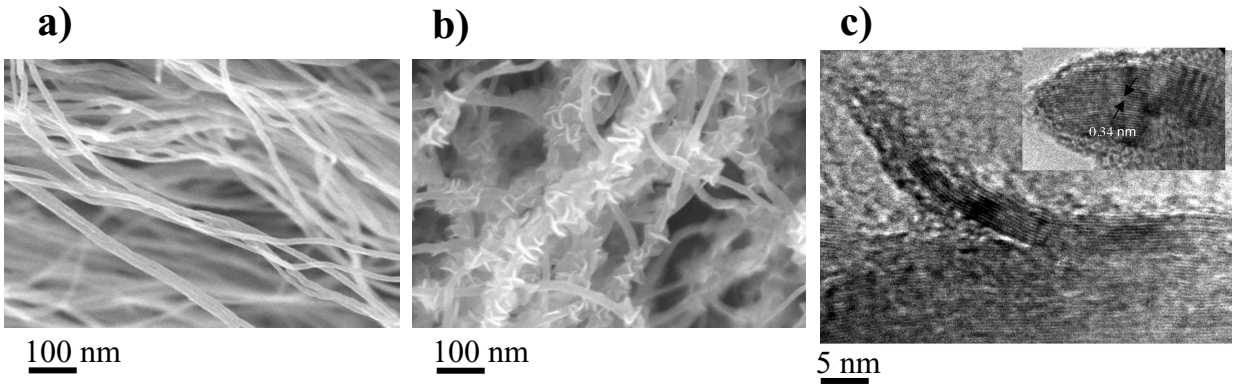

FIG. 1. Scanning Electron Microscopy micrograph of carbon nanotubes a) as-prepared and b) modified through a chemical-physical process. c) High Resolution Transmission Electron micrograph of the modified structure showing a unique graphitic wing-like structure.

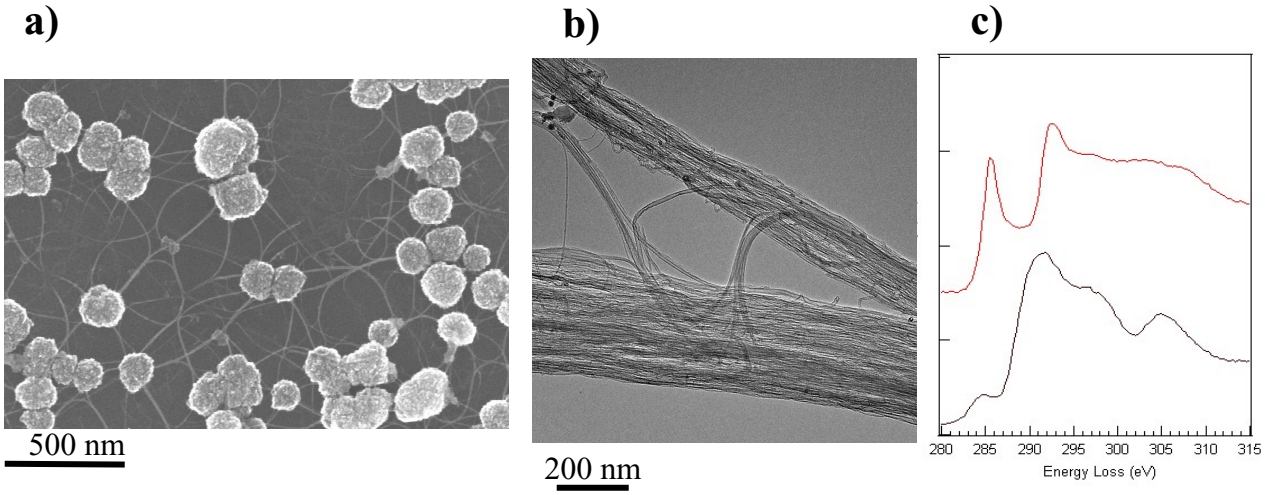

FIG. 2. a) SEM micrograph of the nanocrystalline diamond-nanotubes composite b) Carbon nanotubes TEM micrograph c) EELS corresponding to the nanocrystalline (bottom-spectrum) and nanotubes (top-spectrum) area on the nanocomposite.

https://doi.org/10.1017/S1431927606064737 Published online by Cambridge University Press