EFFECTS OF NITROGEN ION BOMBARDMENT ON CARBON NANOTUBES

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Carbon nanotubes (CNT) have shown to posses most remarkable electronic and mechanical properties [1,2]. It is very interesting to study the effects produced on these properties after ion bombardment. Although a few works are related to the theoretical studies of ion irradiation on nanotubes [3,4], little progress has been reported on experimental results [5,6]. In fact, only the effect of Argon ions is reported until now [3-6] showing the amorphization of the nanotubes but also this kind of ions has been proposed to join CNT [3] and control the shape of the CNT [5].

The aim of this work is to explore the effect of the low energy region of a reactive ion, like nitrogen, on the carbon nanotubes. We want to study not only the mechanical effect of the ions on the CNT but also the possible chemical effects.

The CNT used in our experiments were prepared using no intrusive methods [7] and deposited on silicon and mica substrates. The specific procedure for sample preparation is described in [8]. An End-Hall ion source was used for the low energy nitrogen ion bombardment of the carbon nanotubes at room temperature. The sample holder was rotating at 2 rpm during the process and the beam direction was perpendicular to the sample surface. The nitrogen ion energy and current density was varied between 60-92 eV and 0.015-0.068 mA/cm^2 respectively. This process was performed using different bombardment time at the same ion current and energy conditions.

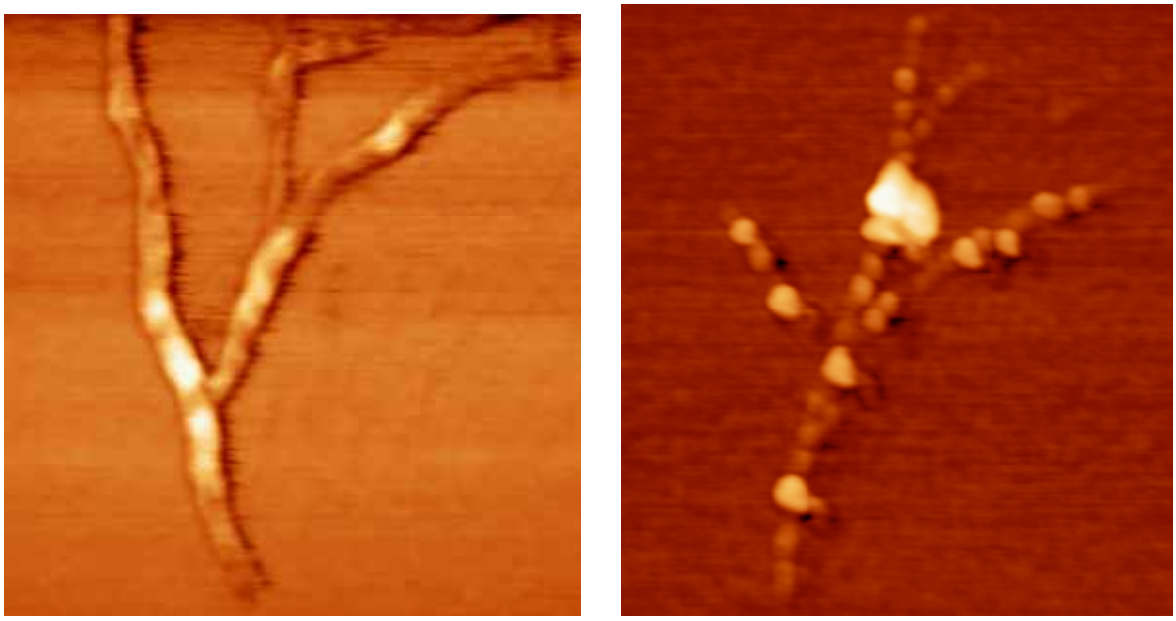
The morphology, mechanical stability and hardness properties of the carbon nanotubes have been studied by means atomic force microscopy (AFM), before and after ion bombardment (Fig.1). The AFM was working in tapping mode and using silicon nitride cantilevers when the surface morphology was studied, whereas nanoindentation and nanoscratching experiments were performed using a stainless steel cantilever (k_c =179.8Nm^{-1}) with a diamond tip. Using the diamond tip it was possible to resolve the nanotubes and to perform nanomechanical experiments on them. For completeness a chemical characterization was also performed.

We present the morphologic and nanomechanical properties of the CNT as a function of the energy and current density of the nitrogen ion beam and also as compared with the non-bombarment CNT.

References:

[1] P. M. Ajayan and T.W. Ebbesen, Rep. Prog. Phys. **60** (1997)1025.
[2] H.Dai,Surface Science **500** (2002) 218.
[3] A.V. Krasheninnikon, K. Nordlund, J. Keinonen and F. Banhart, Physical Review B **66** (2002) 245403.
[4] A. A.V. Krasheninnikon, K. Nordlund, M. Sirviö, E. Salomen and J. Keinonen , Physical Review B **63** (2001) 245405.
[5] H. Lim, H. Jung and S.K. Joo, Microelectronic Engineering **69** (2003) 81.
[6]M.M. Brzhezinskaya, E.M. Baitinger and V.V. Shnitov, Physica B **348** (2004) 95.
[7] M. Burghard, G. Duesberg, G. Philipp, J. Muster, and S. Roth, Adv. Mater. **10**, (1998) 584.
[8] P. J. de Pablo, M. T. Martínez, J. Colchero, J. Gómez-Herrero, W. K. Maser, A.M. Benito, E. Muñoz, and A. M. Baró, Adv. Mater. **12** (2000) 573 .

Figure 1:



AFM images (1.2µmx1.2µm) of CNTs before (left) and after (right) nitrogen ion bombardment at low energy