XPS CHARACTERIZATION OF NITROGEN-DOPED CARBON NANOTUBES

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The electronic structures of CNTs are closely correlated with their morphological properties. In this manner, CNTs can be either metallic or semiconducting depending on their size and chirality. Numerous methods have been proposed to change and control these properties in the synthesis process, but it is not easy because several parameters contribute to it. One excellent way to tune and optimize the electronic properties of CNTs is by atomic substitution, i.e. atomic doping. Due to the small difference in atomic radii between nitrogen and carbon atoms, N atoms are god candidates to substitute C atoms in the hexagonal graphene structures of CNTs. Although there are abundant theoretical results for N-doped CNTs to date, few works have been reported on the chemical binding configurations of nitrogen in N-doped CNTs. The aim of this work is to study the nitrogen bonding of CNTs before and after nitrogen ion bombardment by means of X-ray Photoelectron Spectroscopy (XPS).

Single-wall carbon nanotubes were deposited on Si substrates by non intrusive methods. The samples were imaged by Atomic Force Microscopy (AFM) to confirm that only isolated nanotubes were produced. The same CNT solution was used to deposit several droplets on silicon substrates to achieve a major concentration of nanotubes on the surface and then to perform photoemission measurements of them. In order to incorporate nitrogen atoms, the samples were further exposed to nitrogen ion bombardment at room temperature. Two different ion sources were used to study the effects of ion current and energy on the CNTs. XPS was performed to study the incorporation of nitrogen in the carbon nanotube and to address the chemical nature of the C-N bonding. Annealing in vacuum at 500ºC has been performed to remove contamination from the ambient atmosphere and residual solvent.

C1s, N1s and Si2p XPS spectra were recorded, before and after each accumulative ion bombardment. All C1s spectra showed asymmetric line-shapes consistent with previous studies and with the presence of sp^2 and sp^3 bonds. Annealing at 500ºC did not produce decomposition, neither on CNT nor on CNTs after ion bombardment, since there were no new features related to the presence of Si-C bonds. Chemical shift and changes in the shape of the C1s and N1s spectra indicate that some nitrogen atoms are bonded with carbon in the CNT after N_2^+ bombardment. In conclusion, from XPS measurements we can obtain clear chemical information on the changes produced on CNT after nitrogen incorporation.