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CHARACTERIZATION OF CARBON NANOTUBES THROUGH PES, SEM AND RAMAN SPECTROSCOPY

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Carbon Nanotubes (CNTs) are systems of a very high scientific and technological interest due to their specific properties [1]. Large efforts are being currently made both in the improvement of the methods of synthesis of CNTs and in the application of characterization techniques. In this sense, Photoelectron Spectroscopy (PES) supplies data for the study of their electronic structure, electron microscopy (SEM) images provides local information on the structure of the synthesized CNTs and Raman scattering has been shown to be the dominant experimental technique for studying phonons in CNTs, which evidence the one-dimensional (1D) behavior and special characteristics of these systems[2]. Thus the Raman spectra allow to characterize the samples in terms of the diameter distribution of single wall. nanotubes (SWNT), either isolated or in bundles, through the low-frequency Radial Breathing Mode (RBM), while the higher frequency Tangential Mode (TM) indicates their semiconducting or metallic character. Besides, the strong coupling between electrons and phonons in these 1D systems, gives rise to highly unusual Resonance Raman spectra.

A new experimental setup for growing CNTs is presented here. The carbon nanotubes were grown by catalytic chemical vapor deposition (CVD) in the controlled environment of a vacuum chamber with a background pressure of $1 \cdot 10^{-6}$ mbar on silicon substrates. Different amounts of iron catalyst up to 2 nm in thickness were deposited - by ion beam sputtering of an iron target - in some cases directly onto the Si substrate and in others on top of an intermediate layer deposited between substrate and catalyst whose function is to prevent interaction between Fe and Si that could deteriorate the catalytic efficiency of the process [3]. Two different diffusion layers were investigated: Al_2O_3 (20 nm thickness) and TiN (approximately 80 nm thickness), both deposited in the same chamber by reactive magnetron sputtering of an Al and Ti target respectively. After the Fe deposition the substrates were heated in vacuum to a temperature between 700 and 750°C in 10 minutes, after which acetylene (58 sccm flow rate and pressure 0.1 mbar) was introduced in the chamber. The growth time was 5 min in all cases. *In situ* PES monitors the chemical composition of both intermediate layers and iron catalyst after each step of the process, and allows to analyze the electronic structure of the CNTs. The samples are afterwards characterized *ex situ* by SEM and Raman spectroscopy.

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