CVD-BASED PREPARATION ROUTES OF SINGLE-WALLED NANOTUBES WITH CONTROLLED ARCHITECTURES

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Among the novel forms of nanocrystalline carbon, the single-walled carbon nanotubes (SWNTs) have focused recently the attention of the scientific community [1,2], and the growth of organized arrays of carbon nanotubes is presently a challenging but critical task to obtain functional devices. The progress in fabrication of nanometer-sized structures needs easily scalable synthesis routes capable to produce aligned and oriented ensembles of tubular nanostructures.

Our approach to the production of carbon nanotubes relies on metal-catalysed reactions between "in situ" produced atomic hydrogen and carbon nanoparticles (diameter : 20-40 nm) which are carried by Ar fluxes and delivered inside the active area of a purpose-designed CVD reactor [3]. The carbon nanoparticles are prepared by laser-induced pyrolisis of hydrocarbon mixtures in a controlled-atmosphere flow reactor. The formation of nanotubes by reactions of atomic H with the C nanoparticles reflects the occurrence of a multi-step process which starting from amorphous carbon produces ordered graphitic nanostructures. The basic steps controlling the growth of SWNTs are :

I) etching of the C nanoparticles by atomic H; ii) formation of excited atoms and clusters of sp^2 – coordinated carbons in gas phase;

iii) condensation of such clusters into nanoscale graphene flakes;

iv) closing and wrapping of the graphene nanoaggregates.

In this communication we report details of the production of the nanopowders used as carbon feedstock and of the synthesis procedures which enables to generate nanostructered layers containing high percentages of SWNTs. The fundamental geometrical features of the produced SWNTs, i.e. helicity and radius, are routinely investigated by the combined use of SEM (Scanning Electron Microscopy) and Raman spectroscopy.

A proper choice of the process parameters and of the experimental arrangement allows to produce arrays of self-organized nanotubes joined together in bundles by Van der Waals forces (Figs.1-2).

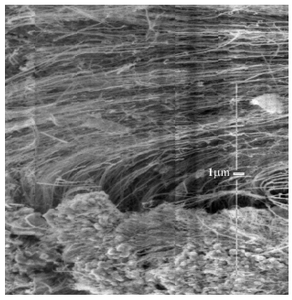

Fig.1 SEM image of straight ropes horizontally aligned bundles.

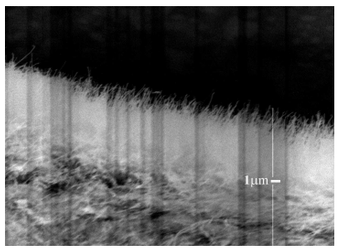

Fig.2 SEM image of straight ropes vertically horizontally aligned bundles.

The synthesis procedure allows to produce dense deposits consisting in straight bundles of nanotubes horizontally positioned, or densely packed arrays of nanotube oriented at variable angles with respect to the substrate surface. Such non-conventional approach can be employed also to realize specific architectures ,due to the feasibility to control the sites for nanotube growth and to produce deposits of pre-definite areas of the substrates (Fig. 3).

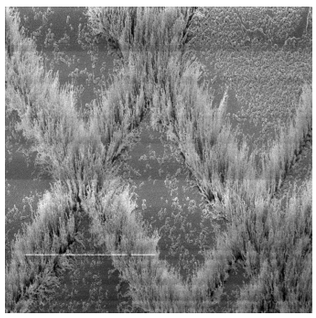

Fig.3 SEM images of nanotubes grown onto pre-defined locations of a Si/SiO_2 substrate.

This kind of organized depostis is very promising for the applications of carbon nanotubes as electron emitters and for the assembling of nanoscale electronic devices.

1 R.Saito, G.Dresselhaus and M.S.Dresselhaus: *"Physical Properties of Carbon Nanotubes"* ,Imperial College Press (1998)

2 M.Inagaki: *"New Carbons – Control of Structure and Functions"* , Elsevier Science 2000

3 M.L.Terranova, S.Piccirillo, V.Sessa, P.Sbornicchia, M.Rossi , S.Botti and D.Manno, *Chem.Phys.Lett.* 327, 284-290 (2000)