The NEXT Group

The NEXT group (**N**anoscienc**E** e**X**periments for **T**echnology) has worked in nanoscience, focusing on technological innovation, for 13 years.

WHAT IS NANOTECHNOLOGY?

The word Nanotechnology identifies all the techniques and methods to manipulate matter – nano or atomic scale - in order to obtain materials with higher, or completely new, chemical and physical properties, compared to the properties of bulk matter. In the following diagram (Fig.1) you can get the idea of the size of the matter concerned.

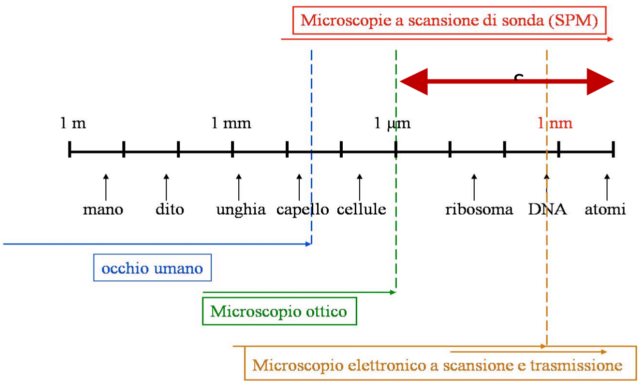

Fig. 1 – Size scale and microscopic techniques used to observe matter at different scales.

Two approaches are possible when synthesizing nanostructures: the first entails starting form materials of macroscopic dimensions and " grinding " them until the size desired is achieved. This method is called Top - Down (Fig. 2a)

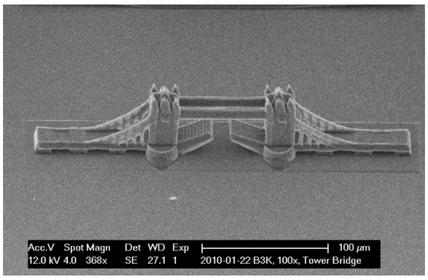

Fig. 2a - Top-down approach: scanning electron microscope image of a polymer block, dug by the electrons to make a reproduction of the London Bridge.

The second method, called Bottom - Up (Fig. 2b) combines individual atoms or molecules together until the designed structures are achieved.

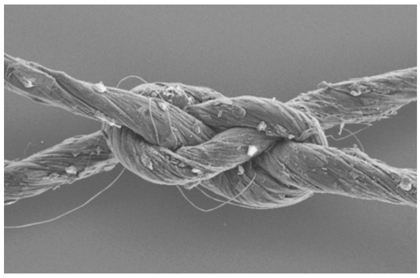

Fig. 2b - Approach Bottom - Up: Scanning electron microscope image of Cotton fibres and Carbon nanotubes, twisted together to build a new kind of fabric for jeans.

CARBON NANOTUBES , GRAPHENE NANOPLATES AND GRAPHENE.

In the last few years, the NEXT group has acquired a thorough experience in synthesizing and engineering nanostructured carbon materials - carbon nanotubes, graphene and graphene nanoplates - and in creating "sheets of twisted carbon nanotubes" called buckypapers .

The carbon nanotubes were discovered in 1991 by chance by Japanese researcher Sumio Iijima, who noticed their presence among other secondary products in the production of fullerenes. They represent one of the allotropic forms of the carbon, like diamonds, graphite and fullerenes themselves are. They are defined as one-dimensional structures, since their diameter is of the order of nanometres, while their length is of the order of microns. They are made up of one or more sheets of carbon atoms twisted to form a cylinder, or more concentric cylinders, that create the walls of the tube. In the NEXT Laboratory, they are synthesized either by arc discharge (Top-Down method) or by chemical vapour decomposition of hydrocarbon (Bottom-Up method), as shown in Fig. 3.

The graphene, on the other hand, is a two-dimensional crystal consisting of a single sheet of carbon atoms and it's the basic element of graphite. It is synthesized by chemical decomposition of hydrocarbon or exfoliation of graphite or graphene nanoplates. The Graphene nanoplates are formed by several layers (from 2 to 30) of graphene sheets, close to each other. They have been synthesized using an original method designed by researchers of the NEXT Laboratory. These carbonaceous nanostructures are outstanding and have unique properties: high electrical conductivity (a thousand times higher than copper), no warming, high thermal conductivity (about 3-4 times higher than copper).

a

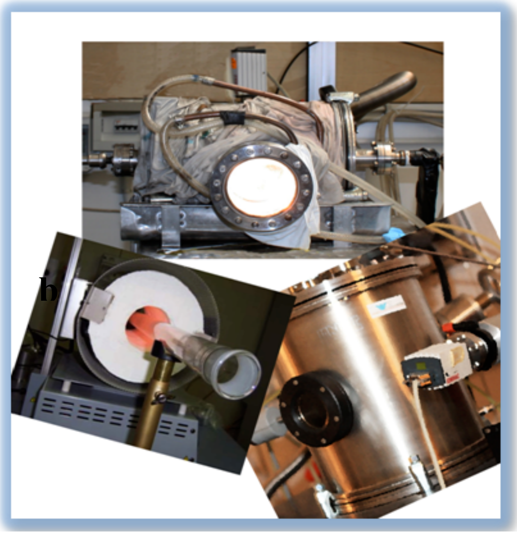

Fig .3 – Synthesis machines for nanostructures: a) vacuum chamber for the synthesis of carbon nanotubes by arc discharge technique; b) two types of reactors for chemical vapour deposition.

The employment of such nanostructures enhances significantly the electrical, mechanical and thermal properties of the matrices in which they are dispersed. The aim is to obtain novel electromagnetic shielding coating material for electronic devices which could be more ductile, flexible, mouldable and light than those currently available in the market.

The design and implementation of such kind of coating materials is based on in depth studies concerning their physical properties (electromagnetic, mechanical, thermal, chemical stability). Given the high presence of composite materials in electronic devices (PCs, tablets, smartphones, cars, etc.) and cables for data connection, there's a relevant demand for effective methods of light and flexible shielding. These materials find applications in various fields: cable data transmission, bio – medical devices, space-aeronautics, automobile industry. Regarding the use of nanostructures, great attention was also paid to the aspects concerning the toxicity and the impact on human health.

The studies of their effects on the environment and the human health proceed along with the knowledge of the physico-chemical properties of the nanomaterials. Indispensable for the characterization of these materials is the electron microscopy. The NEXT group is equipped with a Scanning Electron Microscope TESCAN - VEGAII and an Atomic Force Microscope APE - RESEARCH A100 .

The use of electron microscopy techniques and the interpretation of the images collected are now indispensable for the study and analysis in the field of new generation Technologies and Materials.

The Scanning Electron Microscopy (SEM) is a microscopic technique based on the use of electron beams, as a source, rather than light (photons beam). The use of the electrons increases the resolution power (the ability to distinguish in a clear and sharp way two or more neighbouring objects): it is several orders of magnitude higher than the resolution power which can be obtained with an optical microscope. This allows for very high magnification, giving the possibility to observe smaller and smaller objects. Moreover, thanks to a special detector - BRUKER XFlash123® - associated to the microscope, we are able to determine the chemical composition of the test sample (EDS) and it is possible to make a " x-ray " image of the materials through a detector in transmission (STEM) .

The Atomic Force Microscopy (AFM) uses a thin point, similar to an old record player's needle, made up by just a few atoms, and possibly only one, that oscillating allows to visualize the surface with a very accurate precision in thickness, in the range of Angstroms (0.00000001 cm) . The great importance and relative ease of use of this technique has allowed its popularity and application in many operating environments, ranging from materials science to medicine, biology and electronics.

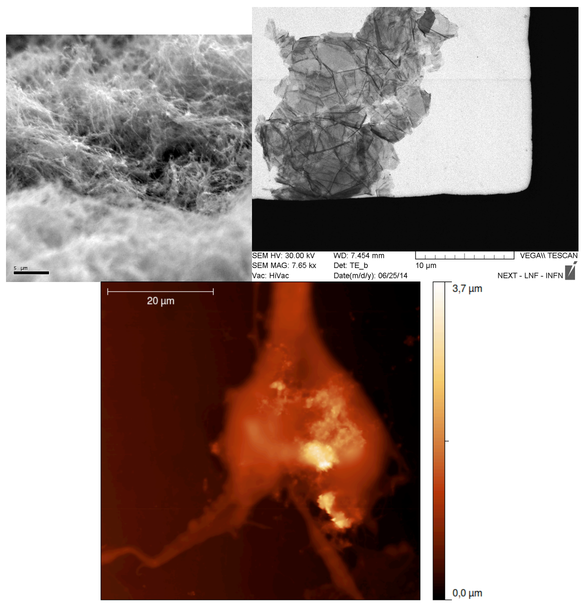

Fig. 4 - Clockwise, from top to bottom: SEM image of carbon nanotubes; image transmission graphene nanoplates; study of cell-nanotubes using AFM.