NEW ROUTES FOR PRODUCING NANOWIRES AND NANOTUBES AND THEIR PHYSICAL PROPERTIES

Luc Piraux, S. Matefi-Tempfli, L. Vila, M. Darques, F. Elhoussine and S. Michotte

Unité de Physico-Chimie et de Physique des Matériaux
Université Catholique de Louvain – Belgium
E-mail: piraux@pcpm.ucl.ac.be
http://www.mapr.ucl.ac.be/Fr/PCPM/pcpm.html

Nanowires and nanotubes are central elements in nanoscience and nanotechnology for various applications such as electronic and optical components, nanowiring, mechanical reinforcement, energy storage, near field probes, electromechanical systems, super lubricating surfaces, biotechnology expands, data storage, field emission, etc

Nanochemistry fabrication methods have improved remarkably over the last few years. Among the different strategies developed to elaborate nanomaterials, the templating method is one of the most attractive as it has proven to be reliable for the synthesis of arrays of nanowires and nanotubules of desired composition, sizes and aspect ratios. Chemical and electrochemical techniques are used for synthesizing arrays of nanowires and nanotubes inside the voids spaces of nanoporous host materials. To date, most of the work in this area has entailed the use of two types of templates : track-etched polymer membranes and nanoporous aluminas. These two types of templates are produced at the lab-scale at the Materials Science Department at UCL and exhibit well-defined nanoporosity with geometrical parameters controllable to a large extent [1]. A variety of nanowired materials including noble metals, ferromagnets, superconductors, semimetals, oxydes, carbon nanotubes and conducting polymers have been fabricated via chemical and electrochemical techniques. Also, complex structures such as organic/inorganic nanocomposites and multilayers composed of ultra-thin layers of magnetic and non magnetic metals have ben successfully fabricated by this method [2]. The resulting cylinders have diameters ranging between 10 nm and a few microns, a smooth surface, and the controlled length can vary from few nanometers up to 20 micrometers. Arrays of vertically aligned and free standing nanowires can also be formed by the selective dissolution of the supported nanoporous media. Such nanowires systems are intrinsically scientifically interesting systems with a lot of potential applications in various areas.

Numerous interesting properties have been identified in the group at UCL, in relation with the nanoscopic dimensions of the materials. For the magnetic nanowires, there comes original transport and magnetic properties such as giant magnetoresistance [2], magnetization reversal in a single nanowire [3], domain wall magnetoresistance [4], spin transport in nanoconstrictions [5] and other phenomena due to dimensions comparable or smaller to scaling lengths in magnetism, spin polarized transport … In addition, high frequency studies are favoured in magnetic nanostructures as their dimensions are smaller than the skin depth. These nanowires exhibit very interesting properties such as resonance frequency tunability and zero field ferromagnetic resonance absorption [6]. Also, interesting results were recently obtained on superconducting nanowires [7]. An increase in the thermodynamic critical field H_c is observed and is attributed to the small transversal dimension leading to an incomplete Meissner effect. A non-zero resistance occurs below T_c in these 1D-superconductor due to fluctuations of the superconducting order parameter (phase slips). The destruction of superconductivity observed in the V-I characteristics may be explained by the formation of phase slip centers. Finally, preliminary results on field emission properties of vertically aligned metallic nanowires will be presented [8].

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Figure:

(a) well-ordered nanoporous alumina as template; (b) superconducting nanowires after selective dissolution of the template; (c) magnetic multilayered nanowire for spin transport studies; (d) single wire measurement using a multi-probes technique; (e) array of vertically aligned nanowires for field emission studies.