Poster

NANOMANIPULATION OF SMALL OBJECTS IN A FEG-SEM

Denise Nakabayashi[1,2], Paulo C. Silva[2], Juan C. Gonzalez[2], Daniel Ugarte[1,2]
[1]Instituto de Física Gleb Wataghin, UNICAMP, C.P. 6165, 13081-970 Campinas - SP, Brazil
[2]Lab. Nac. de Luz Síncrotron (LNLS), C.P. 6192, 13084-971 Campinas - SP, Brasil
E-mail: denise@lnls.br, ugarte@lnls.br

Nanometric objects attract huge interest due to their new and unexpected physical and chemical properties [1], which may allow the development of new technological devices. The study of these nano-objects is seriously limited by the fact that well-established conventional tools can not be easily applied in this size range. The development of new instruments and methodologies is necessary to allow the growth of nanoscience. The high-resolution capabilities of electron microscopy techniques render it a preferred tool to observe and characterize nano-objects. However, in most cases, electron microscopy methods are static, when it is frequently very interesting to perform dynamic in situ experiments.

In this work, we describe the development of a low cost sample holder containing a manipulation system (Figure 1), which allows the characterization and manipulation of nanometric objects during *in situ* Scanning Electron Microscopy (SEM) experiments. This system operates inside of a Field Emission SEM (FEG-SEM) whose resolution is 1.5 nm in optimal imaging conditions. The manipulation system has coarse and fine movements in three independent axes. The nanomanipulator tip can also be used to apply electrical potentials and measure induced currents.

The coarse movements of X and Z axes are based on elastic tables driven by commercial picomotors, whose minimum step is 30 nm. A ceramic trail, also driven by a picomotor, performs the Y movement with steps of 300 nm. The total range of X an Z axes is about 2 mm, but the Y-axis was designed to have a very large range (~ 20 mm) in order to be able to analyze several samples within the same experiment. Piezoelectric slabs are used to the fine adjust in Y and Z axes with total range of 50 μm at 100 V. A piezoelectric actuator is responsible to the X axis movement, with total range of 3 μm at 300 V.

The manipulation system has been applied to attach carbon nanotubes (NT) on Atomic Force Microscopy (AFM) tips [2] through an easy and controllable procedure. In fact, the high performance tips produce a significant improvement of the AFM image quality from the point of view of both lateral resolution and height range [3]. Using the nanomanipulator, we were able to apply an AC potential and to measure the vibration resonance frequency of one-dimensional nano-objects, like multi-walled NT and semiconductor nanowires (Figure 2). This frequency is subsequently used to calculate the elastic modulus of the material [4]. Finally, we have been using the system to pick up, displace and generate predefined arrangements of nanowires (Figure 3) and nanoparticles (Figure 4). These manipulation procedures are essential to render possible the bottom-up approach construction of nanocircuits [5].

References:

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[2] H. Dai et al, Nature, **384** (1996) 147.
[3] H. Gutiérrez et al, Phys. Stat. Sol. (a), **201**, No. 5 (2004) 888.
[4] P. Poncharal et al, Science, **283** (1999) 1513.
[5] Y. Huang et al, Science, **294** (2001) 1307.

Figures:

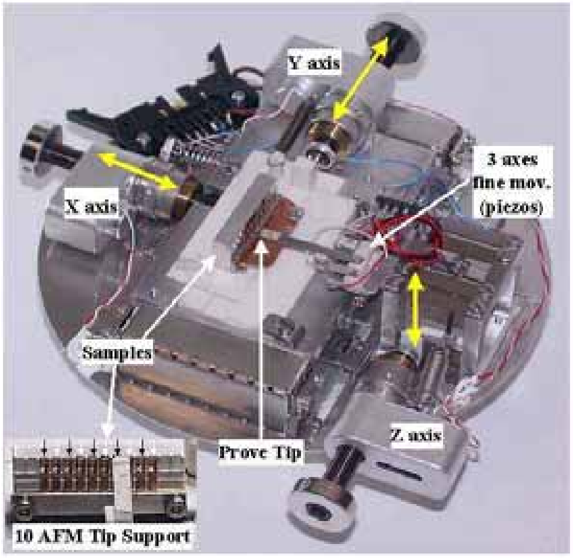

Figure 1: View of the Nanomanipulator

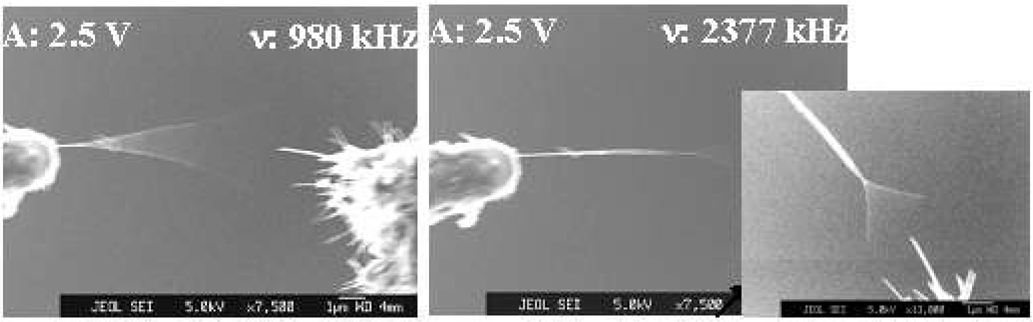

Figure 2: First and second vibration modes of an individual carbon nanotube.

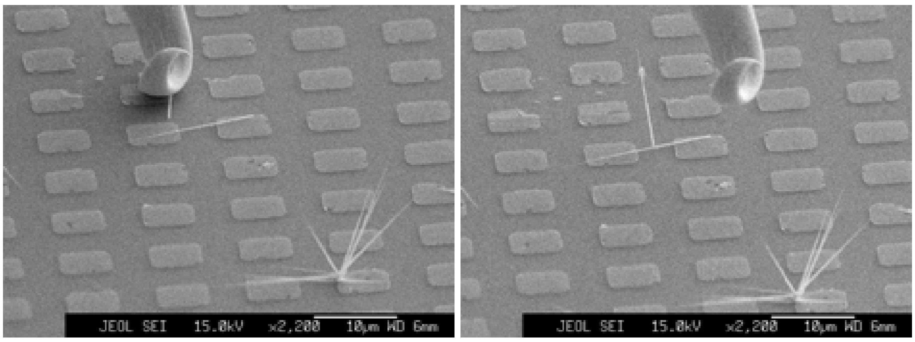

Figure 3: Manipulation of InP nanowires to form a “T” arrangement.

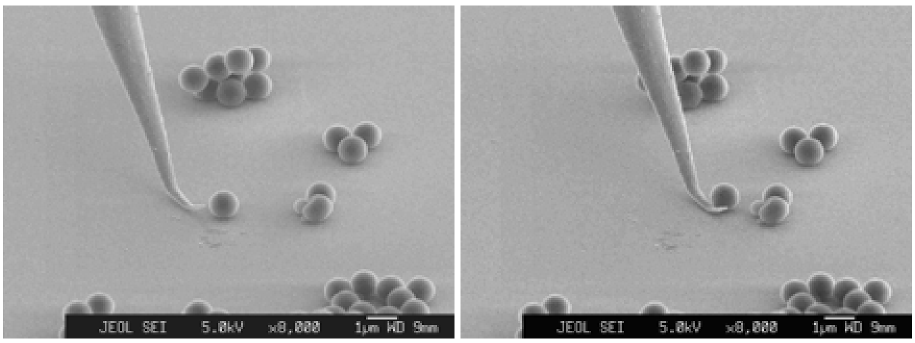

Figure 4: Example of latex particle manipulation.