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Development of a tuning fork based sensor for *in-situ* force measurements during nanomanipulation inside a high resolution SEM.

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Abstract – We describe the development of a force sensor to be coupled to a home-built manipulator operating inside a scanning electron microscope. We aim to perform force measurements during *in-situ* manipulation of nano-objects. The sensor is based on a quartz tuning fork due to its high quality factor which provides a very good sensitivity. The experimental setup is presented as well as preliminary results on sensor's characterization and measurement tests.

Many research efforts are at present concentrated in the nanotechnology field, where there are still many opened questions related to elementary physics applied to nanoscale phenomena. Some of the fundamental problems are associated with the controlled mechanical manipulation of nano-objects and the quantification of the involved forces. Effects like adhesion and friction may be dominant in this size regime; then, studies of mechanical properties and forces have huge technological interest. Here, we describe the design and construction of a home-built SEM sample holder [1], where manipulation of nano-objects is coupled to a sensor to force measurements.

The force sensor is based on a quartz tuning fork. They have a very well defined resonance frequency of 32.7 kHz, high quality factor Q (10^3-10^5) and high spring constant (~kN/m). These features just make them very sensitive, allowing subhertz changes on the resonance frequency to be detected. It is possible to obtain the force exerted during a manipulation, by attaching the probe tip of the sample holder to a tuning fork and measuring the variations on the resonance frequency during the experiment. Forces on the order of 10^{-12} N have already been achieved [2].

We aim is to quantify the forces applied during the manipulation of nano-objects like carbon nanotubes and semiconductor nanowires. We show the developed experimental setup for *in situ* experiments, together with the sensor characterization and the first tests inside the electron microscope. The electrical properties, spring constant and quality factor of the forks have been carefully determined and, preliminary force results are presented.

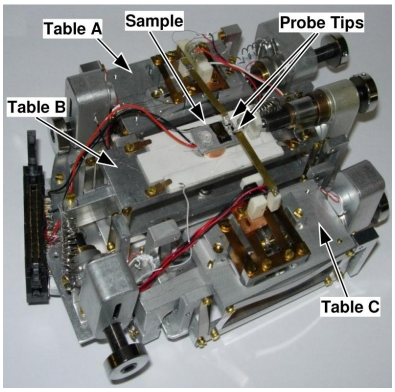

Figure 1: Sample holder developed for manipulation. Tables A, B and C are responsible for moving the two probe tips on six independent axes [1].

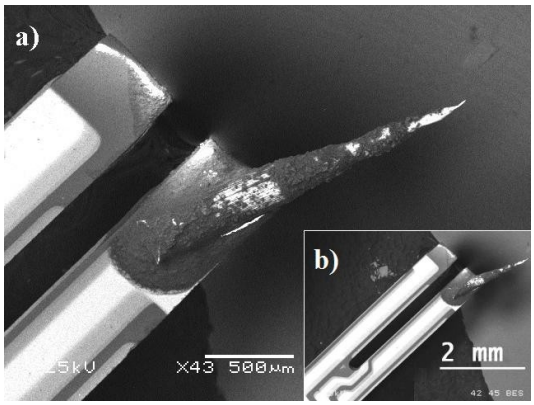

Figure 2: Scanning electron pictures of a tungsten tip glued to the end of one of tuning fork's prongs. They show the end of the fork (a) and the complete view (b) of it.

References

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