Energy dissipation in flexible C-Nanotube tips and Nanoneedles

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Today, a promising application of Carbon Nanotubes (CNTs) and focussed ion beam (FIB) structured nano-needles (fig. 1) is the use as probes in scanning force microscopy, where their small radii allow good spatial resolution, while the high aspect ratio makes them suitable for analyzing rough surfaces with steep edges. Another promising application will be the probing of soft materials with a better defined geometry than those of standard cantilever tips. However, the knowledge of the mechanical properties and of the mechanism of energy losses of these particular tips is of primary importance.

In order to have a better understanding of the dissipation processes, experiments have been done using Single-Wall C-Nanotube tips and Needles of silica carved with a FIB. A PLL-controlled FM-AFM has been used to perform force distance measurements.

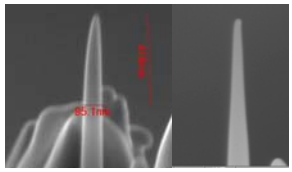

Fig 1: SEM Image of a nanoneedle

Based on the understanding of the general mechanical response of the CNTs [1], it was possible to distinguish different damping contributions either related to the interaction of the nanotube with the sample surface (adhesion, viscoelastic contributions at the interface…) or related to intrinsic losses within the nanotube itself.

In general, the damping of a CNT is dominated by energy losses related to the interaction of the tube with the surface, while intrinsic energy losses during tube deformation was a major contributions observed for the nano needles (fig. 2). This difference can be explained with the fact that a FIB creates a lot of defects with a sizeable amount of amorphous material in the nano-needle. Nevertheless, similar effects can also be observed in CNT-Cantilever tips. It was possible to see the transition from a well defined and undamaged NT to a defected Nanotube. In this case the defects do not only affect the damping of the system but also go together with a modified mechanical response of the nanotube.

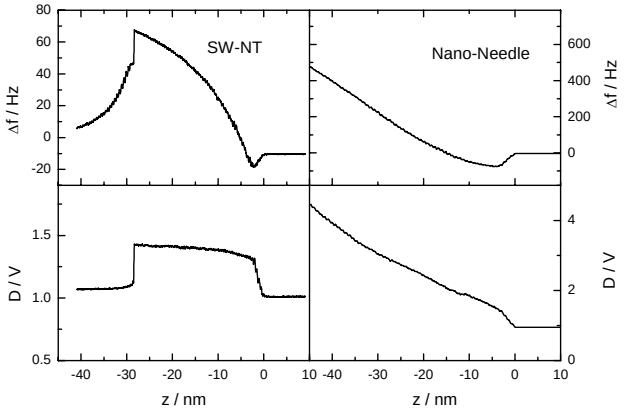

Fig. 2: Comparison of frequency shift and damping with SW-NT and Nano-Needle. While the damping increase of the NT remains constant in the IC-Situation, the damping of the Nano-needle increases considerably, indicating intrinsic losses

[1] D. Dietzel et al Nanotechnology 16, S73-78 (2005)