AFM MECHANICAL CHARACTERIZATION AND FOUR-PROBE/SEM MEASUREMENT OF HYBRID METALLIC/INORGANIC NANOSPRINGS

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Abstract

Helical nanostructures [1,2] have attracted tremendous attention in the last decade. Their unique periodic geometry, chirality and high surface/volume ratio combine striking features from both 1D and 3D nano-objects.

This paper proposes a novel method to clamp and locally metallize in one step suspended inorganic nanosprings. Electron-beam and Ion-beam induced deposition (EBID/IBID) of platinum were carried out on silica nanosprings fabricated by sol-gel replication of organic self-assemblies[3]. We then performed 3-point bending tests with Atomic Force Microscopy[4] and 4-probe measurements inside a SEM/STM[5] along the length of the nanostructures to characterize both mechanical and electrical properties of our nanostructures. The results obtained show that the resulting nanoobjects exhibit stiffnesses ranging from 0.5 to 10N/m, and electrical resistance from 1 to 100 kΩ while keeping an ohmic behavior. COMSOL simulations were carried out and confirmed these results. This shows that our method can successfully be used to tune the properties of these hybrid nanosprings, which can thus be advantageously employed for fabricating highly sensitive NEMS with piezoresistive detection.

References

[1] D. N. McIlroy et al, APL, **79** (2001) 1540–1542
[2] Y. Wang et al, Chem. Soc. Rev., **42** (2013) 2930–2962
[3] T. Delclos, et al, Nano Letters **8** (2008), 1929-1935
[4] S. Houmadi et al, Appl. Phys. Lett. **102** (2013), 151904/151901-151904/151905
[5] M. Berthe et al, Atomic Scale Interconnection Machines (2012), pp107-118

Figures

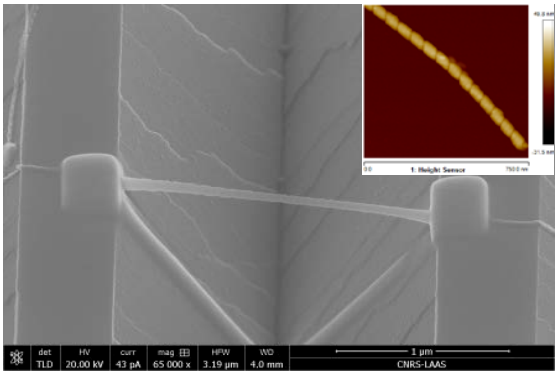

Figure 1: SEM image of a suspended nanospring after clamping and Pt IBID– inset: AFM image of a nanospring on a flat substrate

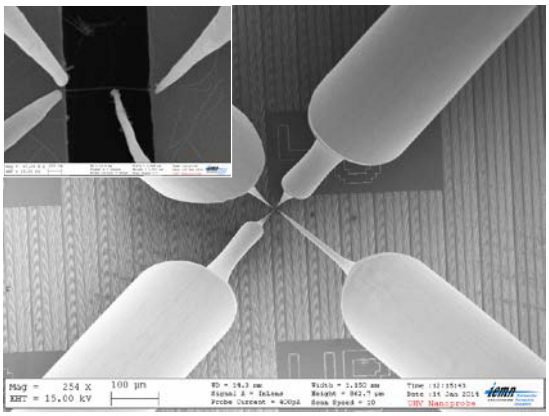

Figure 2: Setup inside the Nanoprobe. Inset: 4-probe measurement along one nanospring.

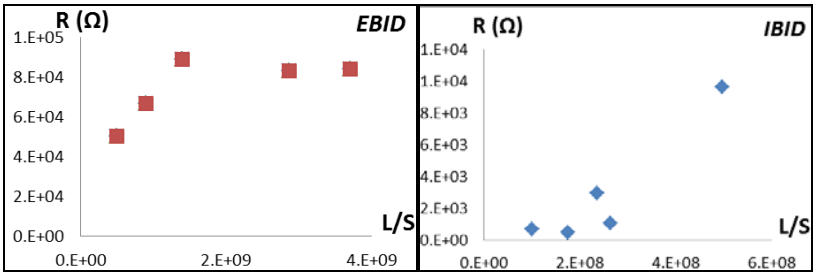

Figure 3: Resistances obtained with EBID (left) and IBID (right) metallized nanosprings. Thick layers (low L/S) show a linear resistance which agrees with a tubular modelling. Thin layers keep a helical structure