Magnetostriction driven cantilevers for Dynamic Atomic Force Microscopy

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The development during the last decade of the Atomic Force Microscopy (AFM) technique focused on biological systems, has initiated a new form of biomolecular physics since this technique has introduced a new approach to the study biological processes. This success is largely due to the emergence of dynamic modes operated in physiological environments. Herein we present a novel cantilever mechanical excitation technique based on the magnetostrictive effect [1] that exhibits important advantages with respect to other methods. Commercial silicon nitride cantilevers were sputtered on the opposite side of the tip with magnetostrictive and soft magnetic thin iron-boron-nitrogen films. This amorphous magnetic alloy presents excellent magnetic properties [2], good corrosion resistance in liquid environments, and nearly zero deposition induced stress [3] for optimized sputtering parameters. In the presence of an alternating magnetic field the coated top side of the cantilever periodically extends, thus generating a mechanical oscillatory movement on the cantilever. This new actuation mode can be operated in physiological environments, lacks the unwanted heating of tip and/or sample, avoiding thermal drift problems. It also exhibits high resolution and stability, low noise and compatibility with the use of an inverted optical microscope. As an operational example we present low noise and high resolution topographic images acquired in liquid environment to demonstrate the method capability.

References:

[1] M. Penedo, I. Fernández-Martínez, J. L. Costa-Krämer, M. Luna and F. Briones, Applied Physics Letters, **95** (2009) 143505.
[2] I. Fernández-Martínez, M.S. Martín-González, R. González-Arrabal, R. Álvarez, F. Briones and J. L. Costa-Krämer, Journal of Magnetism and Magnetic Materials, **320** (2008) 68.
[3] I. Fernández-Martínez, J. L. Costa-Krämer and F. Briones, Journal of Applied Physics, **103** (2008) 113902.

Figures:

Figure 1: Scheme of the dynamic AFM driven by magnetostriction.

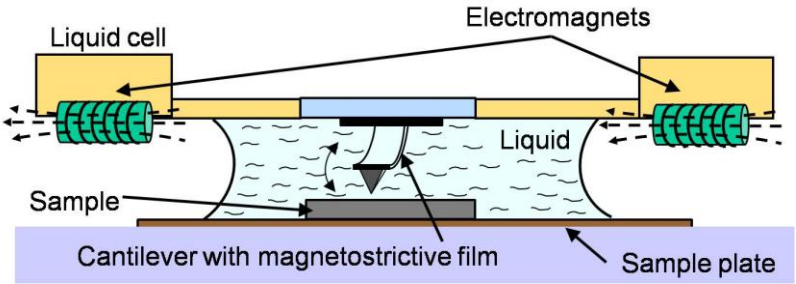

Figure 2: Oscillation amplitude spectra of a silicon cantilever immersed in water driven by the magnetostrictive effect. The first resonance peak is at 7.10 kHz, while the second is founded at 58.15 kHz. The inset shows the oscillation amplitude spectra of a silicon cantilever immersed in water driven by the magnetostrictive effect. The first resonance peak is at 21.60 kHz. In both cases, the current through the electromagnets is 25 mA while the thickness of the magnetostrictive coating is 50 nm

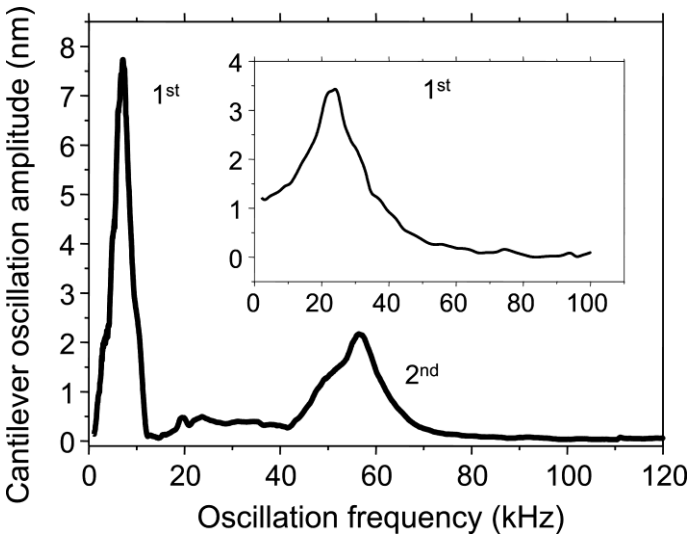

Figure 3: Dynamic atomic force microscopy topographic image of self-assembled maltoside neoglicoconjugate islands adsorbed on HOPG, obtained by means of magnetostrictive drive with the sample immersed in water. The organic molecules adsorb flat on graphite following the preferential crystallographic directions of the HOPG hexagonal symmetry. The black arrows guide the eye in the identification of the different domain arrangements. The profile in the inset corresponds to the white profile drawn in the image. A periodic pattern of 2.5 nm is observed (17.23 nm between the two points shown/seven peaks), which corresponds to the length of the molecule.