MAGNETOSTRICTIVE DRIVE OF AFM CANTILEVERS FOR LIQUID OPERATION

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Tapping mode atomic force microscopy (AFM) has proven to be a powerful technique for imaging soft biological samples with AFM [1]. In liquid environments, small oscillation amplitude tapping mode images can have 1 nm lateral resolution or less [2]. AFM cantilevers are often driven in liquid by either mechanical (with a piezoelectric ceramic) or magnetic excitation (applying an alternating magnetic field to a cantilever coated with a magnetic material) methods. It has been also shown that in liquid environments magnetic actuation allows easier identification of the cantilever resonant frequency [3].

In this work, a novel magnetostrictive drive of dynamic AFM cantilevers has been developed to obtain topographic images and force spectroscopy in liquid environment. This method overcomes some of the limitations inherent to operation in liquids: low quality factor (Q) and the shift of the resonant frequency to lower frequencies due to the large damping and the added inertial mass of the liquid. Commercial silicon nitride cantilevers were one side coated with sputtered thin magnetostrictive iron-boron films, opposite to the tip side. These amorphous magnetic alloys present excellent magnetic properties [4], good corrosion resistance in liquid environments, and nearly zero accumulated stress [5] when properly deposited.

A new AFM liquid cell, with a set of miniature solenoids, has been built that creates an AC magnetic excitation field. It is demonstrated that the field drives the mechanical resonance of the coated cantilever through the film magnetostriction. Due to the even effect of the magnetostriction, we can excite the cantilever with an AC current with the same frequency that the resonant frequency (f0) of the cantilever or with half of this resonant frequency (f0/2). As an operational example, topographic images of a gold surface obtained in water solution are presented, which show lateral and topographic resolution comparable with operation in air.

References:

[1] S. Kasas et al., Biochemistry, 36, (1997) 461.
[2] D. J. Müller et al., Biophys. J., 76, (1999) 1101.
[3] S. M. Lindsay et al., Jour. Vac. Sci. Technol. A, 11, (1993) 808.
[4] I. Fernández-Martínez et al,. JMMM, 320, (2008) 68.
[5] I. Fernández-Martínez et al,. JAP, (2008) 103.

Figures:

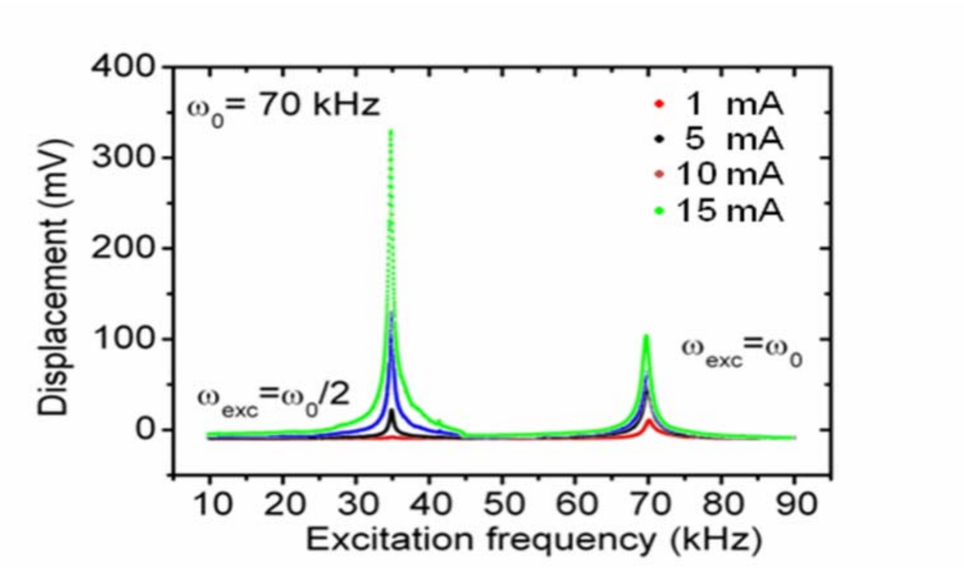


Fig. 1 Amplitude oscillation at different drive currents in air

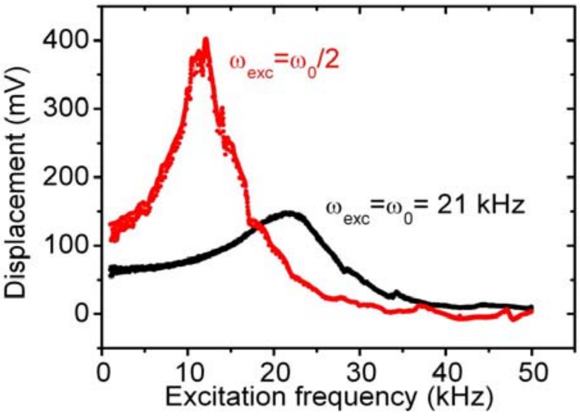
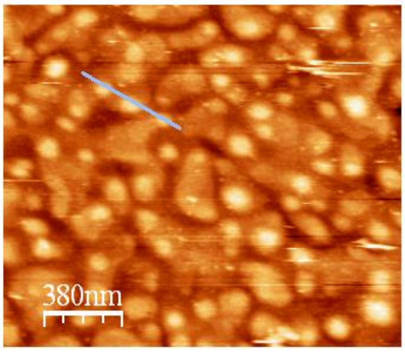


Fig. 2 Amplitude oscillation in liquid



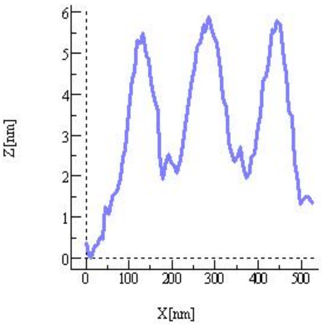


Fig. 3 Topographical image of a gold surface in water obtained with the magnetostrictive drive method. A topographic scan profile is shown.