MAGNETOSTRICTIVE DRIVE OF AFM CANTILEVERS FOR LIQUID OPERATION

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Dynamic 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 images can achieve 1nm lateral resolution or better [2]. AFM cantilevers are often driven in liquid by either electrical (with a piezoelectric ceramic) or magnetic excitation (applying an alternating magnetic field to a cantilever coated with a magnetic material) methods. However, it has been shown that the latter allows easier identification of the cantilever resonant frequency [3,4].

In this work, a novel magnetostrictive drive of dynamic mode AFM cantilevers has been developed for topographic images and force spectroscopy in liquid environment. This method overcomes further limitations superposed to those 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. In particular, those arisen from the difficulty to select from the various mechanical resonances of the cantilever/ cell system excited by an external piezo-actuator. Our direct magnetostrictive excitation method employs commercial silicon nitride cantilevers that were top side sputtered with amorphous iron-boron-nitrogen alloy magnetostrictive magnetic thin film.This amorphous alloy present soft magnetic properties and controlled anisotropy [5], good corrosion resistance in liquid environments, and nearly zero accumulated stress [6] when properly deposited. A new AFM liquid cell, with a set of miniature solenoids that create an in plane AC magnetic excitation field has been designed and built. It is demonstrated that this magnetic field drives the mechanical resonance of the coated cantilever through the film magnetostriction. The dynamic response of the magnetostrictive cantilevers and the ability to obtain topographic images of a surface in water are studied.

References:

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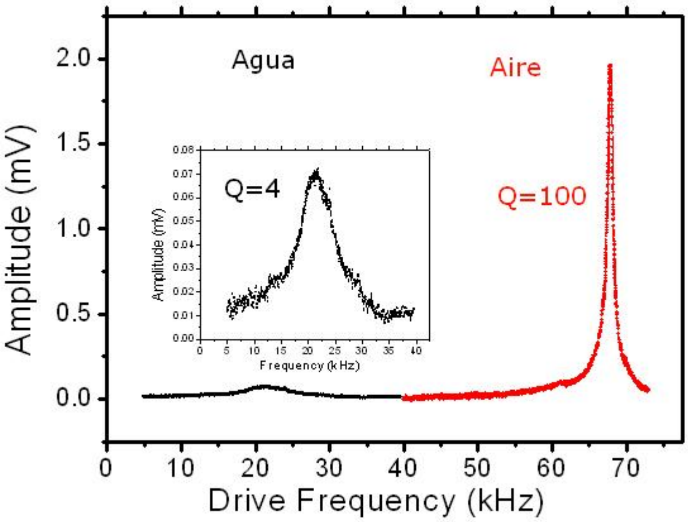
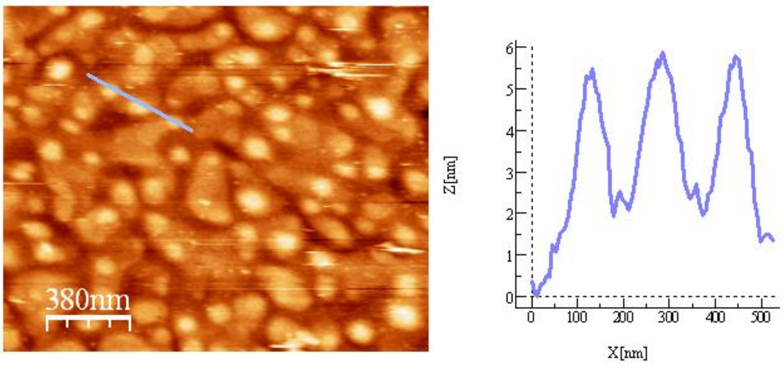
Figures:





Figures : Up: Cantilever oscillation amplitude versus drive frequency of the applied magnetic field. Inset shows the amplitude and Quality factor (Q) is reduced when immersed in water solution while the resonant frequency shifts to lower values. Down: Topographical image of a gold surface in water obtained with the magnetostrictive drive method. A topographic scan profile is shown.