Atomic Resolution nc-AFM imaging in a closed liquid cell: New potentials in Chemistry & Molecular Biology

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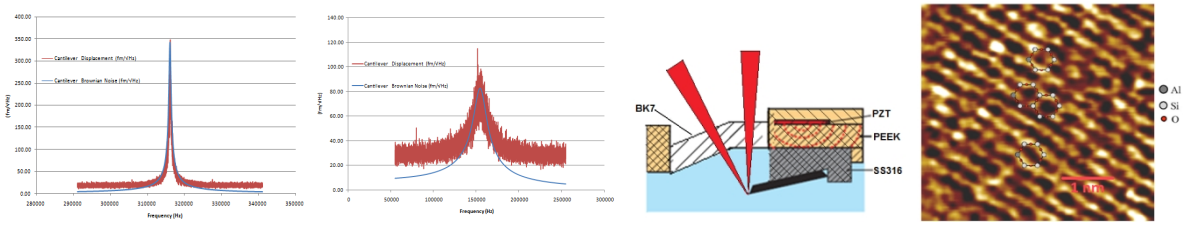
We have designed a non-contact Atomic Force Microscope, which can achieve true atomic resolution in a closed liquid cell, which does not suffer from evaporation of fluids during imaging. Non-contact Atomic Force Microscope (nc-AFM) in liquid environment offers the potential of visualization of individual molecules in real space under physiological environments at atomic resolution opening up very interesting possibilities from chemistry to molecular biology.

A High Resolution nc-Atomic Force Microscope(AFM) system from NanoMagnetics Instruments Ltd.[1] is used during the experiments. We added a band-pass filter(BPF) after the quadrant photodetector amplifiers and before the PLL. The frequency shift signal from the Phase Locked Loop(PLL) is fed into the feedback electronics which controls the high voltage signal applied to the custom made piezotube scanner. We have designed a closed liquid cell where we can flow the fluid using a syringe or a peristaltic pump. The AFM cantilever holder was designed as described in [2] to eliminate acoustical resonances. We can obtain resonance curves without spurious acoustic peaks in liquid using a piezoactuator. We have used an RF modulated 635 nm low noise diode laser. RF modulation is effective to reduce the optical feedback noise and the optical interference noise[3]. Deflection noise density of designed system is 20 fm/√Hz in air and 25 fm/√Hz in liquid as shown in Figure 1 (a) and (b). The observed frequency noise at the PLL output was ~1Hz_{pp} in liquid. Force sensitivity of our system is demonstrated by imaging cleaved mica surface in liquid environment as shown in Fig.1.(d) with Δf = +50Hz, A=0.9nm, k=32N/m & Q ~11.



(a) (b) (c)

(d)

Fig. 1. (a)Thermal Noise Spectrum of the cantilever in air and (b) in pure water. The red lines show experimentally measured values while the blue lines show theoretically calculated values for thermal Brownian motion. (c)Schematics of the cantilever holder. (d)The atomic resolution AFM image of the cleaved clean mica taken in PBS solution.

[1] AQUA nc-AFM, NanoMagnetics Instruments Ltd. Oxford, UK. www.nanomagnetics-inst.com

[2] H. Asakawa & T. Fukuma, "*Spurious-free cantilever excitation in liquid by piezoactuator with flexure drive mechanism*", Rev. Sci. Instrum. **80,** 103703(2009)
[3] T. Fukuma *et. al.* "Development of low noise cantilever deflection sensor for multienvironment frequency-modulation atomic force microscopy, Review of Scientific Instruments **76**,053704(2005)