Towards multimodal all-optic UHV Atomic Force Microscopy

Denis Damiron[1,2], Mohammad Othman[1], Yoshihiro Obata[1], Dai Kobayashi[1], Hideki Kawakatsu[1]

[1] *Institute of Industrial Science the University of Tokyo, Tokyo, 153-8505, JAPAN;*

[2] *Laboratory for Integrated Micro Mechatronic Systems, the University of Tokyo, Tokyo, 153-8505, JAPAN.*

E-mail: *{othman,denis,dai,kawakatu}*@iis.u-tokyo.ac.jp

We are currently developing an "all-optic" Ultra High Vacuum Atomic Force Microscope for improvement in resolution of force gradient and mass detection. It incorporates a heterodyne laser doppler interferometer, photothermal excitation and a superheterodyne circuit with an intermediate frequency of 10.7 MHz. Photothermal cantilever excitation offers extremely clean excitation of the AFM cantilever at low amplitude (10 pm) and high frequency (~10 MHz), making the system a good approach for high frequency, small amplitude multimodal AFM with various control schemes. The system can be used for a conventional cantilever operating in its fundamental and higher modes, as well as for small or stiff cantilevers with high resonance frequency. Fundamental, second, or third mode of flexural, or torsional, can be confirmed by scanning a small laser spot with a diameter of 1.2 μm on the back side of the cantilever. Performing multi-modal excitation and detection modes allow selective detection of short-range interaction forces and acquisition of more details of the force curve in real time for 3D force gradient mapping. During experiments the gradient of frequency shift profiles could be obtained by using a lock-in amplifier operating at a dither frequency of 120 Hz. Figure 1 illustrates a real-time detection of Δf and its gradient using the lock-in amplifier during force curves acquisition on KBr(001) with a scanning frequency of 2Hz. Dither amplitude was 2 Å and self excitation amplitude was set at 4 Å. The excursion frequency along the Z axis was 0.5 Hz for an excursion range of 4 nm.

We will report on our recent results obtained with this new all optic AFM.

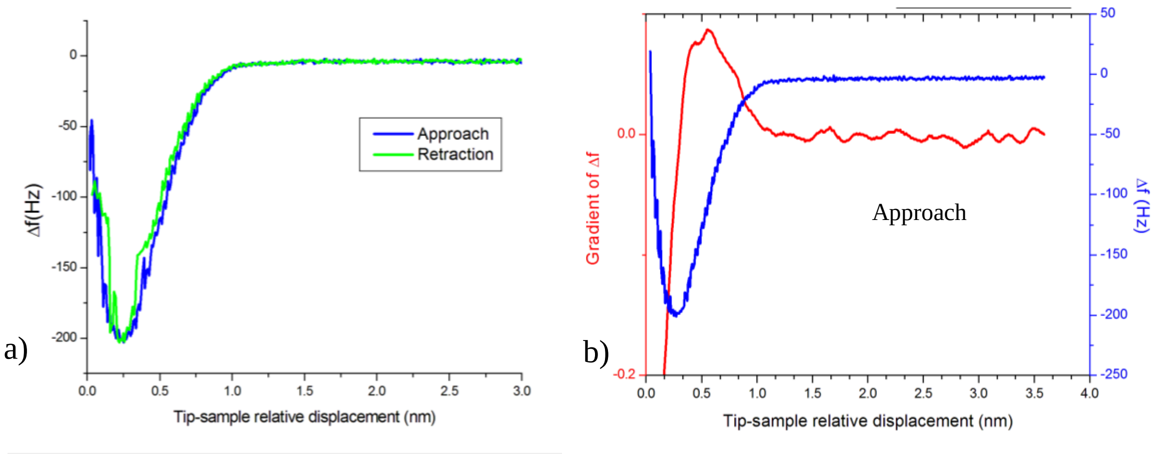

Figure 1: a) Preliminary results of measured frequency shift (Δf) versus distance during approach and retraction on KBr(001) using the second flexural mode at 1.7550 MHz.
b) Example of simultaneous detection of Δf and its gradient on KBr using a lock-in amplifier during force curve acquisition.