High Sensitive Dynamic Force Microscopy in Liquids

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Dynamic force microscopy, which utilizes the resonance enhancement of the force sensitivity by vibrating the cantilever at or near the resonance frequency, is a very powerful operating mode for atomic force microscopy (AFM). In a vacuum environment, mechanical Q-factor of the cantilevers is very high, and hence many successful imaging with atomic and molecular resolution is reported. However, in a liquid environment, mechanical Q-factor of the cantilever is greatly reduced due to the viscosity of the liquid, and hence atomic resolution imaging is not achieved.

Electronic tuning of the effective quality factor is implemented for tapping mode AFM in liquids [1]. This technique increases the force sensitivity of the ordinary tapping mode AFM. It is reported that, by assuming 0.1 K fluctuations of pure water, the theoretical limit of the effective Q-factor for standard cantilevers is approximately 1000.

When the cantilever is driven by piezoelectric actuator attached to the cantilever holder which is a very common way to excite the cantilever in a commercially available AFM apparatus, the frequency spectrum has artificial resonance peaks corresponding to the resonance of various materials such as the liquid cell, cantilever base, liquid and so on. Actually, the effective Q-factor for standard cantilever is not increased very much by the artificial resonance.

In the present experiments, we will propose a novel method to prevent the artificial resonance and enhance the Q-factor of the cantilever even using the piezoelectric actuator excitation. High force sensitive imaging is successfully demonstrated in a liquid environment.

[1] J. Tamayo, A. D. L. Humphris and M. J. Miles, Appl. Phys. Lett., 77, 582, 2000.