Sub-Nanometer Resolution Dynamic Force Microscopy in Liquids

Y. J. Li, K. Fujii, Y. Naitoh and M. Kageshima Y. Sugawara**,**
Department of Applied Physics, Graduate School of Engineering, Osaka University,
2-1 Yamada-oka, Suita, Osaka 565-0871, Japan
liyanjun@ap.eng.osaka-u.ac.jp

In a liquid environment, mechanical Q-factor of the cantilever is greatly reduced due to the viscosity of the liquid, and hence high resolution imaging is difficult. 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. However, 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. So, actually, the effective Q-factor for standard cantilever is not increased very much by the artificial resonance.

Recently, we proposed a novel method using phase-locked oscillator to prevent the artificial resonance and enhance the Q-factor of the cantilever even using the piezoelectric actuator excitation. In the present experiments, high force sensitive and sub-nanometer resolution imaging is successfully demonstrated on ionic crystal $BaSO_4$(210) surface in a liquid environment.

Figure 1 shows AFM image of ionic crystal $BaSO_4$(210) surface obtained in water. In the AFM imaging, the effective Q-factor was set to be about 300. In Fig. 1, we can clearly observe the atomic feature of $BaSO_4$(210) surface. Thus, for the first time, sub-nanometer resolution AFM imaging in liquid was demonstrated with Q-control AFM using phase-locked oscillator method.

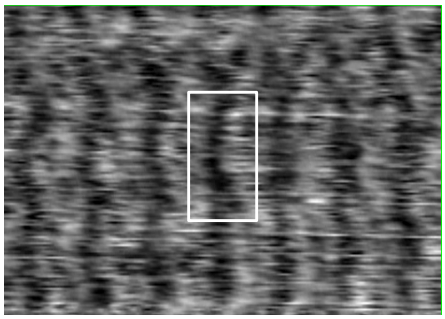

Figure 1 Sub-nanometer resolution AFM image of ionic crystal $BaSO_4$(210) surface measured in water. Scan size is 8 nm×5.6 nm. Rectangle is unit cell.

References

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