High-resolution imaging of CaF_2/Si (111) surface using atomic resolution NC-AFM

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Non-contact Atomic Force Microscopy (NC-AFM) is the only experimental method which is capable of imaging non-conducting surfaces with atomic resolution. Chemical resolution of different species at surfaces of binary compounds, such as NaCl, KBr, TiO_2, InAs, Al_2O_3, and CaF_2, remains among the main challenges for NC-AFM. In these cases, the image contrast depends qualitatively on the sign of charge and/or spatial distribution of the electrostatic potential produced by the tip apex structure and/or composition. The chemical identity of atomic features observed on surfaces still remains unclear, mainly due to the uncertainty in the structure and chemical composition of tips.

We have investigated the surface structure of CaF_2/Si (111) on atomic scale for clarify the contribution of the electrostatic potential between the tip and the surface atom species using NC-AFM operated at room temperature in ultrahigh vacuum environment. Figure 1 shows the topographic images of this surface with the tip that is attributed to the (a) positive electrostatic potential and (b) negative one. According to a line profile (fig.1(c)) on the solid line in fig.1 (b), the atom positions of topmost three layers, Ca (1), F (2) and F (3), can be clearly recognized as the topographic images and the results is consistent with the case of (111) cleaved surface of CaF_2 [1]. This high spatial resolution in our system has the possibility of the chemical identification about the ionic surface by applying the mixed ionic system, $Ca_xSr_{1-x}F_2$/Si (111) for example [2].

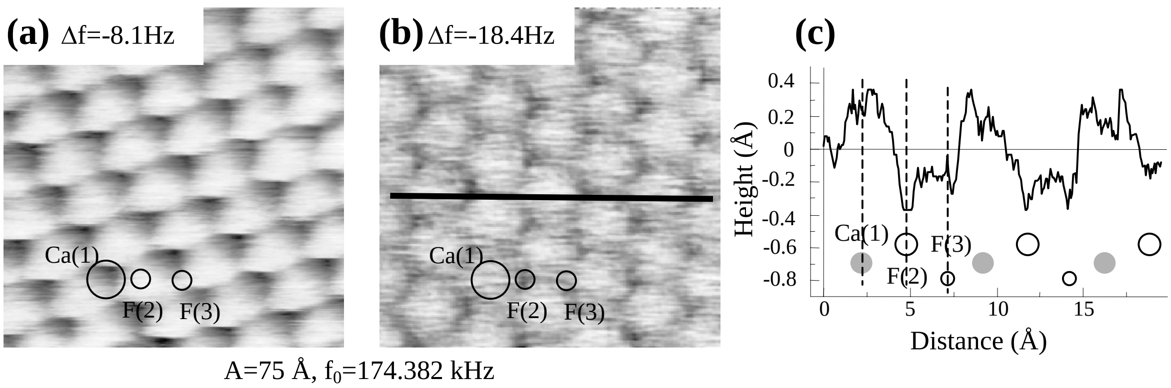

Figure1 Topographic NC-AFM images of CaF_2/Si(111) surface with (a) positive terminated tip and (b) negative terminated tip. Scanning size is both 2.1 x 2.1 nm^2. (c) Line profile on the solid line in (b). f_0, A, Δf are corresponding to the resonant frequency, the vibration amplitude, and the frequency shift of the cantilever, respectively.

[1] C. Barth, A. S. Foster, M. Reichling, A. L. Shluger, J. Phys.:Condens. Matter **13**, 2061 (2001).

[2] J. D. Denlinger, M. A. Olmstead, E. Rotenberg, J. R. Patel, E. Fontes, Phys. Rev. Lett. **43**, 7335 (1991).