Atomic step structure formed by nanoscratching on alkali halide surface using an AFM

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The atomic manipulation studies using an AFM have been actively studied for last several years, and the remarkable results have been then presented unceasingly in the Si(111) and the Ge(111) systems. Besides the manipulation on the semiconductor surfaces, the manipulation on insulator surfaces is very important for a future atomic device. Ionic crystals, which have been studied energetically, are one of the typical insulators. Gnecco et al [1] recently reported the results of the lateral force imaging in contact mode after the scratching on the KBr(100) surface using UHV-SFM of beam-deflection type. In this study, we report formation of atomic step structure on the alkali halide surface by nanoscratching using the AFM.

The $KCl_{0.9}I_{0.1}$(100) clean surface was fabricated by cleaving the single crystal in air and immediately introducing to the vacuum chamber. Then the cleaved sample was heated at 200°C for 1 hour. The AFM experiment was performed using the Si cantilever with the spring constant about 40 N/m at room temperature in UHV. Nanoscratching was performed by scanning under the condition that the amplitude was reduced to almost zero in the constant excitation mode. By the nanoscratching, we have achieved formation of atomic step structure with terraces. Figure 1 shows the topographic images of the atomic step structure created artificially. The difference in the step height between the terraces is 0.6 nm, which closely corresponds to the lattice constant of the KCl crystal. It should be noted that we could achieve the AFM images with atomic resolution even after the nanoscratching. Both forming atomic step structure and imaging the structure with atomic resolution after the nanoscratching could depend on the condition of the tip apex, but we are not able to control enough the tip condition at present.

The present nanoscratching technique provides a possibility to modify the surface structure of the insulator as well as of the semiconductor with atomic resolution, thereby playing an important role as one of the atomic manipulation technique in the near future.

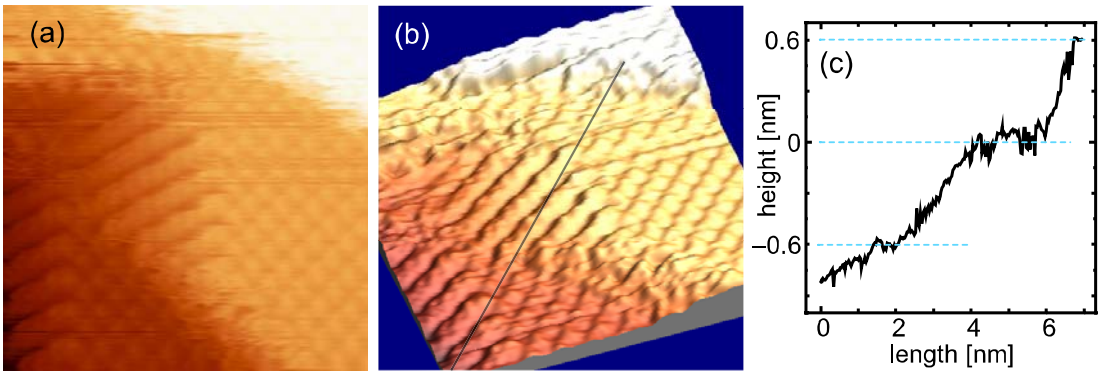

Fig.1. The atomic step structure formed by nanoscratching (a) the 2D topographic image of the $KCl_{0.9}I_{0.1}$ cleavage surface (Δf= -18.6Hz, A_0=1.4 nm, scan size 6×6nm^2), (b) the 3D image of (a), (c) the line profile of (b) along the diagonal line in a black color

[1] E. Gnecco, et al, Phys. Rev. Lett., **88** (2002) 215501