Development of NC-AFM operating in a magnetic field

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The magnetic properties emerging at a surface is thought to be different from behaviors in the bulk. However, there are few experimental results to investigate the properties at atomic level in a magnetic field. To investigate it we designed and developed the noncontact atomic force microscope (NC-AFM) which can operate at temperature down to 5 K and in magnetic field up to 9T.
Our NC-AFM apparatus is comprised of three ultra-high vacuum (UHV) chambers below $3x10^{-11}$Torr. The observation chamber has a compact body to be inserted into superconducting solenoid. Miniaturized NC-AFM unit settled in the observation chamber was specially designed to reduce thermal noise and to suppress thermal drift under AFM measurements. Samples and cantilevers are transferable between the chambers without breaking UHV. The tip-surface interaction is detected from Si cantilever oscillation as a force sensor by frequency modulation (FM) technique utilizing optical fiber interferometer method.
The performance of NC-AFM imaging is so high to detect the subatomic structure. Figures 1 show a set of NC-AFM images of a Si(111)-7x7 obtained at 78 K by three different attractive interaction conditions. Si adatoms appeared as small humps at weak short range attractive interaction condition in Figure 1(a). As the tip approaching to the surface the attractive interaction was enhanced so that the Si adatoms were imaged as brighter humps as shown in Figure 1(b). Further tip approach led to appearance of small protrusions indicating Si rest atoms and the adhesion of the adatom humps. These features indicate the tip apex Si atom is so close to the Si surface atoms and chemical bonding between the dangling bond of the tip and the surface atoms was perturbed each other. We will present this in detail with latest results.

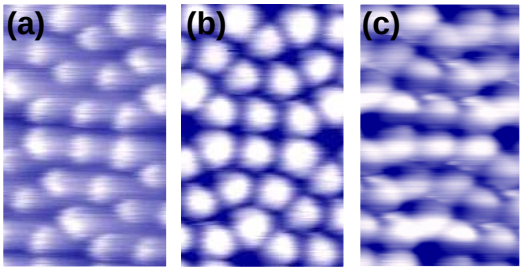

Figure 1 A set of AFM images of a Si(111)-7x7 obtained at 78K from the same area of $30x45A^2$ when changing the tip-surface distance. The frequency shifts of cantilever oscillation are (a) Δf =-30Hz, (b) Δf =-50Hz and (c) Δf =-70Hz.