

Identification Mechanism of Atomic Species on Ge/Si (111)-(7x7) Surface

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Recently the ability of atomic species identification on Ge/Si (111)-(7x7) surface in noncontact atomic force microscopy (NC-AFM) was found [1]. In the NC-AFM image, the Si adatom was observed brighter than the Ge adatom. The NC-AFM image reflects electrostatic interaction force and chemical interaction force between tip and sample, which originates contact potential difference (CPD) or covalent bonding interaction between tip and sample, respectively. However, it has not been clarified how electrostatic force and chemical force contribute to the image contrast.

In this experiment, we investigate the identification mechanism of the atomic species on Ge/Si (111)-(7x7) surface using NC-AFM and Kelvin probe force microscopy (KPFM). Here, the KPFM is used to compensate the CPD between tip and sample.

Thermal drift between tip and sample, and thermal noise of oscillating cantilever becomes serious problem in simultaneous observation of NC-AFM/KPFM in atomic scale. In the present experiment, we used low temperature (LT) NC-AFM to reduce the thermal drift and the thermal noise.

Figure 1 (a) and 1 (b) show a topographic and a CPD images on Ge/Si (111)-(7x7) surface simultaneously obtained at 65K. In the topographic image of Fig. 1 (a), bright spot and dark spot indicate Si adatom and Ge adatom, respectively. This feature is in good agreement with the previous study [1]. On the other hand, in the CPD image of Fig. 1(b), Si adatom is imaged as bright spot (CPD is small), and Ge adatom is imaged as dark spot (CPD is large). The CPD at the Si adatom was found to be -0.08 eV lower than that at the Ge adatom. These experimental results suggest that both chemical force and electrostatic force contribute to the image contrast of Ge/Si (111)-(7x7) surface.

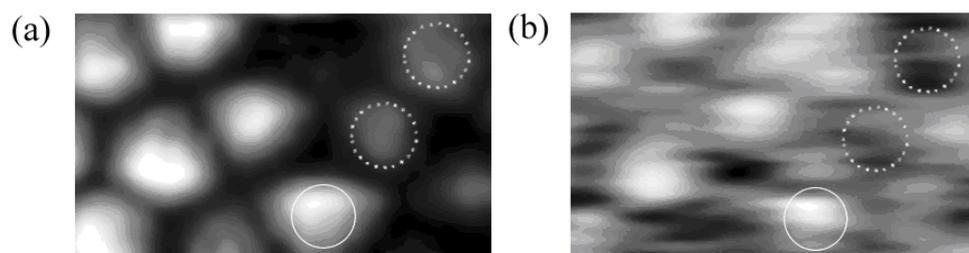


Figure 1 (a) Constant height mode topographic image and (b) Inversed CPD image of a Ge/Si (111)-(7x7) surface. Solid and dashed line circles indicate Si adatom and Ge adatom, respectively. Image size: 5 nm x 2.5 nm. f_0 : 165 kHz. Average of frequency shift: -11Hz. Sample bias modulation for KPFM: 1 kHz, 2V_{rms}. Spring constant of cantilever: 40 N/m. Temperature: 65K

- [1] S. Morita et al., Functions of NC-AFM on atomic scale, Scanning probe Microscopy: Characterization, Nanofabrication, and Device Application of Functional Materials, Kluwer Academic Publishers, 2005, pp.173-195