The role of van der Waals versus chemical forces in atom identification

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Atomic force microscopy (AFM) measures long- and short-range interactions. Sugimoto et al. [1] recently demonstrated chemical identification of atoms by AFM using the short range forces. Separation of long and short range forces was not necessary because the atoms under investigation all were lying in the top surface layer, such that the long range van der Waals (vdW) force was the same for all atoms. Previously, Lantz et al. [2] reported a chemical contrast between the corner adatom unfaulted and the center adatom faulted on the non-uniform Si(111)-7×7 surface. However, like the varying vdW forces at step edges, the corner holes on Si(111)-7×7 surface might lead to a spatial alteration in the vdW forces. Because the corner atoms are close to the corner holes, it is expected that the vdW attraction for corner adatoms is smaller than for center adatoms.

We therefore performed a simulation of the van-der-Waals force on the Si(111)-7×7 surface showing a small effect of the spatially varying vdW force. We investigated experimentally the contribution of the in-plane local spatial variation, e.g., the corner holes, to the long range vdW force with measurements on Si(111)-7×7 in constant height mode with oscillation amplitudes from the picometer to the nanometer range. The measurements revealed a chemical contrast that is much stronger than the varying vdW contribution and confirmed the results of Lantz, et al. In addition we found small variations among the other adatom types that are partially tip dependent.

[1] Y. Sugimoto, P. Pou, M. Abe, et. al, Nature, 446, (64), (2007)
[2] M. A. Lantz, H. J. Hug, R. Hoffmann, et al. Science, 291, (2580), (2001)