Spatial force spectroscopy on Ge(111)-c(2x8): theory and experiments

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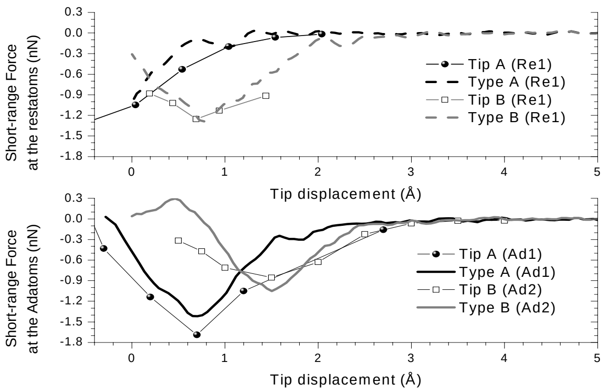
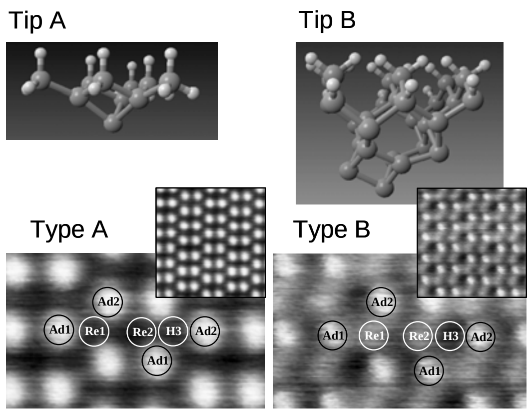
A combined experimental and theoretical work has allowed us to explain the different features obtained from spatial force spectroscopy (SFS) and imaging on the Ge(111)-c(2x8) surface. When probing this surface at low temperature, two typical topography patterns arise; in one of them (Type B) the restatoms of the surface are clearly imaged while in the other only the adatoms are apparent in topography (Type A). Such patterns have been observed also in room-temperature experiments [1]. Surprisingly, SFS performed at low temperature on specific positions on the surface when imaging at each topographic pattern reveals very similar tip-surface interaction force under exactly the same experimental parameters.
With the aim of explaining these differences, first principles calculations in a quite realistic approach for the tip description have been undertaken. Among a variety of different tip-apex configurations and orientations, two different tip terminations seem to closely reproduce the SFS experiments: a tip-apex ended in a single atom with a unique dangling bond (Tip A) for the Type A images, and a dimer-like tip termination (Tip B) for the Type B ones. Calculations reveal that not only the tip-apex structure is of fundamental importance, but also the orientation with respect to the surface for a given structure is crucial for a quantitative determination of experimental forces.
Furthermore, this combined work has allowed us to shed light on the dissipation phenomenon in semiconductor surfaces. After a tip change and for exactly the same experimental parameters, Type B image pattern showed contrast in the dissipation signal in both imaging and SFS, while no dissipation signal was obtained in previously acquired data under a Type A pattern. This behaviour points out to the tip-apex as fundamental dissipation channel in semiconductor surfaces, in agreement with previous observations [2]. The calculations have provided fundamental information on the dissipation mechanism in semiconductor surfaces.





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[2] H. J. Hug and A. Baratoff in Noncontact Atomic Force Microscopy, (S. Morita, R. Wiesendanger, and E. Meyer Eds. Springer-Verlag, Berlin, 2002), Chap. 20, pp. 395–432.