Water footprints in tip-sample force reconstruction for dynamic atomic force microscopy in ambient conditions

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Since its advent, Atomic Force Micorscopy (AFM) has enabled probing single nanostructures, mapping heterogeneous compositional variation in surface properties or studying molecular interactions. Initially the AFM was developed to operate in the quasistatic or DC mode but dynamic modes of operation where introduced to reduce lateral forces while imaging and enhance versatility. In terms of nanoscale processes and properties, a main advantage of dynamic AFM modes over DC modes relates to their capacity to simultaneously probe both conservative and dissipative forces while tracking the topography for imaging. Tip-sample force reconstruction maps in DC modes suffer from stability resulting in so-called "jump-to-contact" where information for a range of distances before mechanical contact is lost. This is crucial in ambient conditions measurements, where the formation of a water neck between the tip and the sample induces instability at long-range distances. On the other hand, interpreting data acquired from the dynamic modes of operation requires detailed modeling and care as the tip follows a non-monotonic force trajectory during each oscillation cycle. We have applied a model to reconstruct, from simple amplitude and phase versus distance curves, the interaction forces between the AFM tip and a sample in ambient conditions [1]. We will show our results on tip-sample forces on ionic crystals where water layers adsorbed on the surface can be controlled and imaged [2]. We will relate features of the reconstruction forces to different tip-sample interactions before mechanical contact between the tip and the sample occurs. That would include capillary forces, long-range van der Waals forces and forces arising from the formation of chemical bonds. Tip-sample force interactions reconstructed from measurements on BaF_2 and CaF_2 (111) faces reveals the ability of BaF_2 to structure water layers even at room conditions [3].

References

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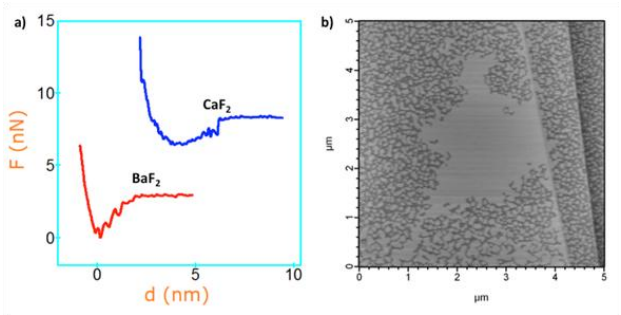

Figure 1. a) Tip-sample interaction reconstruction on water patches adsorbed on BaF_2 and CaF_2. b) AFM image of a 1 nm height water patch on BaF_2.