USE OF HYDROPHOBICITY AS CONTRAST SOURCE IN ATOMIC FORCE MICROSCOPY

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In this paper, the energy dissipation process involved in the formation and rupture of a nanometer-sized capillary-condensed water bridge is theoretically analyzed [1]. With the help of numerical simulations, the dissipation contrast in amplitude-modulated (AM) atomic force microscopy is shown to be a result of a non-trivial interplay between the energy dissipated in each rupture process and the bi-stable motion of the cantilever. In the repulsive high amplitude regime, the dissipated power is a function of the tip and sample contact angles being independent of the elastic properties of the system. Working in this regime, energy dissipation images in air can be regarded as surface hydrophobicity maps.

In air ambient condition, the phase contrast in AFM is strongly influenced by capillary forces. When the tip approaches the sample, water condensation can induce the formation of a nanometer-sized water bridge. Understanding capillary contrast in AFM maps would be particularly interesting for biological applications, where the recognition of different species is frequently based on their hydrophilic or hydrophobic nature.

Our model is sketched in figure 1, whereas main findings are depicted in figure 2. We show that capillary dissipation contrast in AM-AFM strongly depends on the operation regime. In the attractive regime (phase shift $\phi>90$) the dissipated power changes as a consequence of the beating phenomena. Only in the repulsive regime ($\phi<90$) the energy dissipated per oscillation is independent on the amplitude and elastic properties of the system. For a given tip and RH, the dissipated power is just a function of the sample contact angle. As a consequence, only when working in the repulsive regime, energy dissipation images of biological samples in air can be regarded as surface hydrophobicity maps.

[1] E. Sahagun, P. García-Mochales, G.M. Sacha and J.J. Sáenz, Phys. Rev. Lett. 98, 176106 (2007)

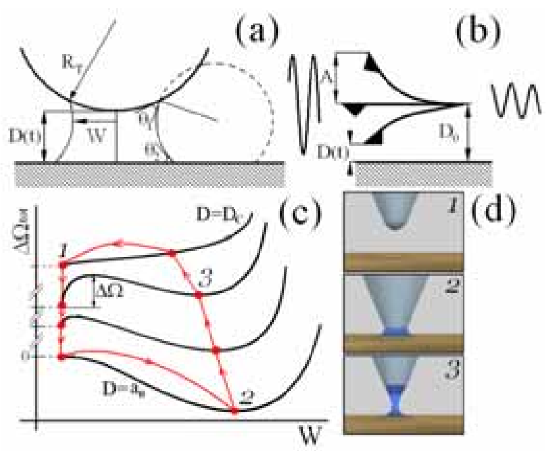

Fig 1. (1a) Sketch of the water bridge geometry. (1b) Tip-cantilever-driver system. (1c) Schematic representation of the formation/rupture process in tapping mode. (1d) Graphic representation of water neck formation/rupture.

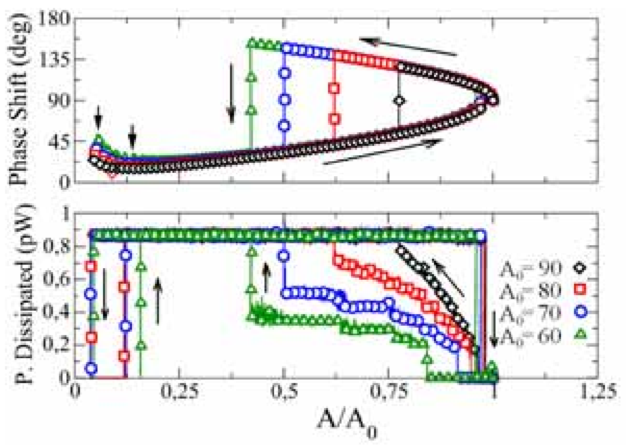

Fig 2. Phase (a) and power dissipated (b) vs normalized amplitude from simulated tapping mode operated AFM including capillary interactions.