Non-contact operation of Scanning Probe Microscope mediated by capillary condensation in humid environment

P. Sudersan,[1] and J. Colchero[1]
[1]*Department of Physics, University of Murcia, Murcia 30100, Spain.*

Presenting author's e-mail: p.sudersan@um.es

It is known that under humid conditions, an AFM tip close to a surface causes the spontaneous condensation of a water meniscus between the tip and the surface [1,2]. Interestingly, the resulting capillary interactions have both conservative and dissipative components that depend on the nano-scale contact angle of water with the surface. Typically, capillary force causes the tip to snap to contact. However, when the cantilever is oscillated, not only does the tip avoid snap-in, but rather, it manages to avoid any hard contact with the surface altogether. The temporary dissipative interaction experienced by the tip due to condensation, which occurs only when the instantaneous tip-sample distance during an oscillation cycle is below a particular length, causes the cantilever's oscillation amplitude to pulsate and avoid contact. This is shown by experimental amplitude-distance curves made on hydrophilic (mica) and hydrophobic (HOPG) samples, as well as numerically simulating the cantilever's non-linear harmonic response to such interactions (Figure 1). Operating the AFM at constant phase using a phase locked loop (PLL) allows separating the conservative and dissipative parts of the total interaction, where, the "frequency shift" channel contains information related to the local van der Waals and capillary interaction, while, the "amplitude" channel is related to the purely dissipative component of the capillary interaction. Using this mode, we show that the local nano-scale wetting property of the sample can be simultaneously mapped out, while avoiding tip-sample contact.

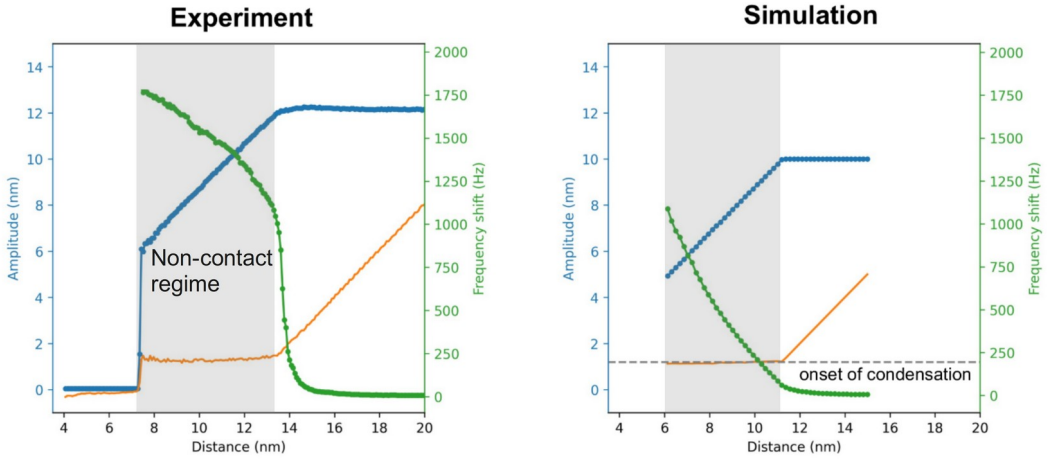

Figure 1. Interaction-distance curves on mica. Orange curves show that the tip-sample distance at the lower turning point of oscillation is not zero in the "non-contact" regime.

Reference

[1] J. Colchero et. al., Langmuir **14** (9), 2230–2234, (1998)

[2] E. Sahagún, et. al. Phys. Rev. Lett. **98**, 176106 (2007)