Photothermal Excitation for Reliable and Quantitative AFM

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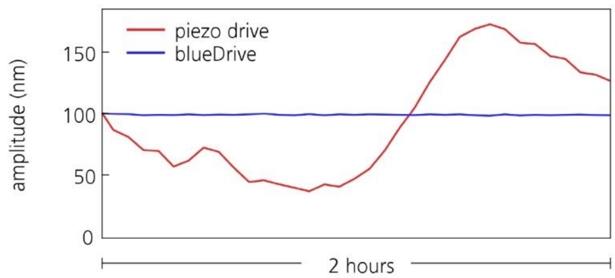
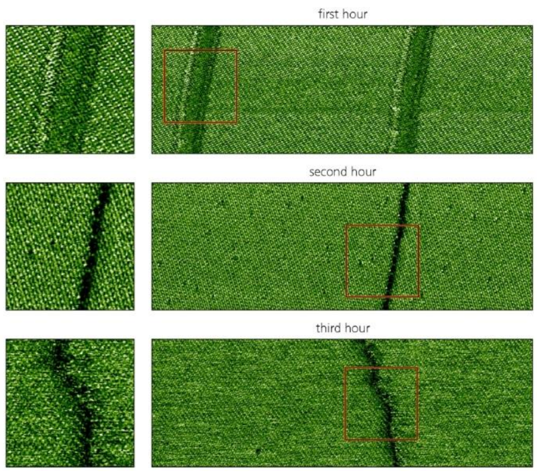


Since the advent of atomic force microscopy, cantilevers have predominantly been driven by piezos for AC imaging and data acquisition. The ease of use of the piezo excitation method is responsible for its ubiquity. However, the well-known "forest of peaks", which is clearly observed while tuning a cantilever in liquids, renders AC imaging in liquids problematically because the peaks move around with time (see Figure 1). Effectively, these shifting peaks result in a setpoint that changes with time causing stability problems while AFM imaging. Furthermore, the same "forest of peaks" prevents the quantitative interpretation of forces in liquids[1], air[2], and vacuum environments[3], even if the cantilever tune looks clean. Dissipation studies in all these environments have especially suffered due to piezo excitation of the cantilever.



Photothermal excitation is an alternative method for exciting a cantilever by heating/cooling the base of the cantilever to drive the cantilever. Photothermal excitation results in repeatable, accurate and time-stable cantilever tunes, as seen in the Figure. Therefore, the setpoint remains truly constant while imaging, preventing tip crashes, or unwanted tip retractions. True atomic resolution images of calcite in water, shown in Figure 2, were made for hours with no user intervention, testifying to the stability of photothermal excitation. Unlike other specialized drive methods, photothermal excitation is compatible with almost any cantilever and with all AFM techniques. The introduction of a blue laser into the AFM also enables several other functionalities, such as tuning the temperature of the cantilever. Furthermore, because the photothermal tune represents the true cantilever transfer function, existing AFM theories can be applied to accurately recover conservative and dissipative forces between the tip and the sample. This is especially important for force spectroscopy, dissipation studies, as well as the frequency modulation AFM techniques.

Our recent developments in perfecting photothermal excitation and its benefits to the AFM community will be shown.

[1] A. Labuda, K. Kobayashi, *et al.* AIP Advances **1**, 022136 (2011)
[2] R. Proksch and S. V Kalinin, Nanotechnology **21**, 455705 (2010)
[3] A. Labuda, Y. Miyahara, *et al.* Phys. Rev. B **84**, 125433 (2011)