Noise in nc- Dynamic Atomic Force Microscopy in humid environment

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Generally, either statistical or quantum noise limits the ultimate resolution. In the first case, according to the dissipation-fluctuation theorem, noise is related to dissipation within a physical system. Here, we measure and discuss noise in tip-sample interaction for non-contact Dynamic Atomic Force Microscopy (nc-DAFM). We show that in humid environment it is possible to acquire "noise" images with a well-defined pattern (Fig. 1d), different from topography or other acquisition channels. This noise is attributed to the interaction induced by liquid necks forming between tip and sample [1]. While previous analyses identified thermal noise as the dominant contribution to frequency fluctuations (see, for example, [2]), experimental evidence reveals the presence of an additional and significantly stronger source when operating in humid environment in nc-DAFM regime.

Using different AFM techniques (Force Spectroscopy, Kelvin Probe Microscopy, 3D modes, etc), we analyze this noise for amphiphilic molecules (SDS) adsorbed on graphite. Our experiments show that different materials induce different noise, leading to an image with "chemical" contrast (Fig. 1d), which we relate to the nanoscale wetting properties of the sample. This interaction-induced noise carries therefore valuable information about the chemical nature of the sample [3], turning what is conventionally regarded as a limiting factor (noise) into an interesting signal.

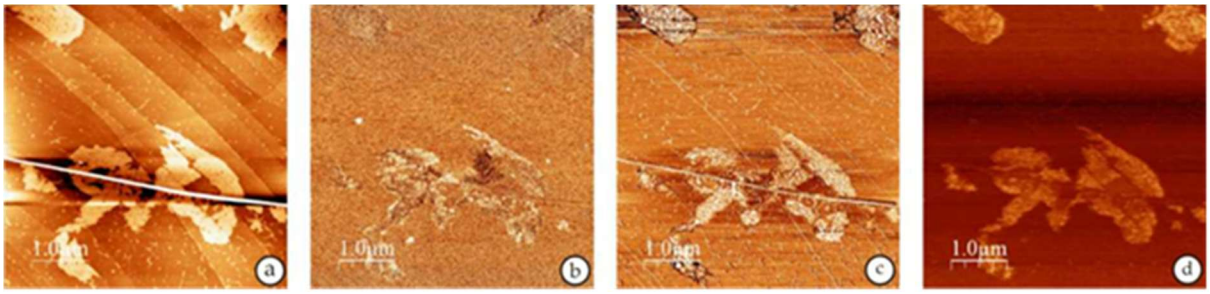

Figure 1. Topography (a), Frequency Shift (b), Contact Potential (c) and Noise (d) images acquired simultaneously in nc-DAFM with topography feedback performed at constant oscillation amplitude.

References

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[3] L. Almonte et. al., "Rose petal effect: A subtle combination of nano-scale roughness and chemical variability", Nano Select, 3 (5), 97–989 (2021).