Very low oscillation amplitude NC-SFM in air

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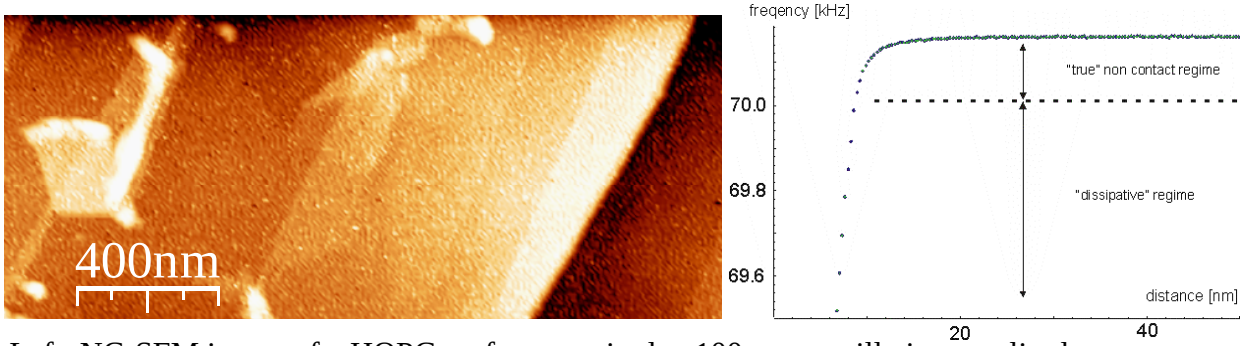
The use of sufficiently large oscillation amplitude has been fundamental for reliable and stable NC-SFM [1]. Sufficiently large oscillation amplitude results in increased detection signal, avoids sticking of the tip to the surface and puts sufficient energy into the tip-sample system to compensate for dissipation. However, oscillation amplitudes that are larger than the interaction length scale lead to non-linearity and call for elaborate algorithms for quantitative determination of tip-sample interaction.
In the present work we will discuss how low oscillation amplitude NC-SFM imaging can be implemented in air. To achieve this, first tip-sample interaction is determined with high precision to identify different interaction regimes [2]: a “true” non-contact regime where essentially only Van der Waals and electrostatic forces act, some intermediate regime with a strong dissipation and a “tapping” regime where intermittent contact is believed to occur. In the “true” non-contact regime we find that imaging is possible at very low oscillation amplitude, limited only by thermal noise of the cantilever. Images are acquired at constant frequency shift (main feedback) with constant oscillation amplitude. Stable imaging has been achieved at 250pm and 100pm (peak to peak) for cantilevers with force constants of 2 and 45 N/m respectively [3], about twice the motion induced by thermal noise. At lower oscillation amplitude our PLL-loop unlocks.
In conclusion we report very low amplitude NC-SFM in air and suggest that this imaging mode should also be possible in UHT environment resulting in simplified data interpretation. In particular for sufficiently low oscillation amplitude the tip-sample system could be treated as a harmonic oscillator leading to the decoupling of conservative and dissipative components of tip-sample interaction.



Left: NC-SFM image of a HOPG surface acquired at $100pm_{pp}$ oscillation amplitude.
Right: typical frequency-shift vs. distance curve in air.

[1] F.J. Giessibl, Science 267, 68-71 (1995).
[2] Elisa Palacios Lidón and Jaime Colchero, to be published.
[3] Olympus Optical Co. LDT, OMCL-AC series, see also www.olympus.co.jp/probe .