FRICTION FORCE MICROSCOPY AS A TOOL TO PROBE LOCAL PHASE TRANSITIONS

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We study local nanoscopic friction forces between an atomic force microscope tip and a glass sample in a humid environment [1, 2]. We show [1] how and why it is possible to tune friction forces in a predictable way by changing either the sample temperature, or the humidity in the experimental chamber. We relate the friction behavior to confined water phase transitions. We find that the water gas-liquid phase diagram is the same at the macroscopic scale as well as at the nanoscopic tip-sample contact.
Detailed friction measurements at varying sample temperature and humidity allow us also to extract information about kinetics of capillary condensation at the nanoscale [2]. At 40 % relative humidity we find that meniscus nucleation times increase from 0.6 ms up to 3.5 ms when temperature decreases from 332 K to 299 K. The nucleation times grow exponentially with inverse temperature 1/T obeying an Arrhenius law. We obtain a nucleation energy barrier of $7.8*10^{-20}$ J and an attempt frequency ranging between 10-100 GHz, in excellent agreement with theoretical predictions. These results provide direct experimental evidence that capillary condensation is a thermally activated phenomenon.

References:

[1] R. Szoszkiewicz, E. Riedo, submitted to Appl. Phys. Lett. (2005).
[2] R. Szoszkiewicz, E. Riedo, submitted to Phys. Rev. Lett. (2005).