Park System NX10 Atomic Force Microscope (AFM)

Characterization of surface roughness, adhesion and friction in silica glass

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Working principle

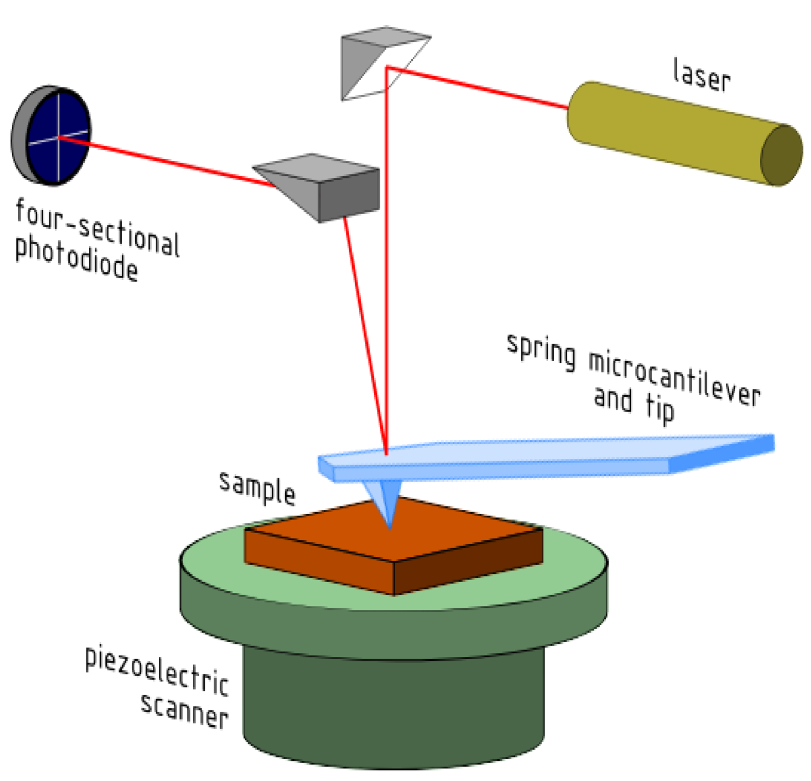

Figure 1. Schematic of an AFM.

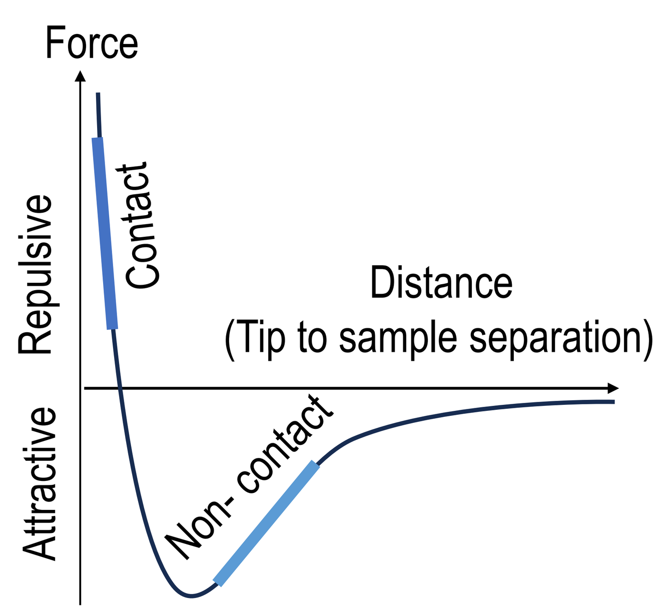

Figure 2. Interatomic force vs distance as approximation for the tip-sample separation.

Atomic force microscopy (AFM) is a type of scanning probe microscopy with resolution of less than a nanometer. The information about the surface is gathered using the deflection of the cantilever following surface interaction, detected from the laser light reflected of cantilever onto the photodiode (see Figure 1). The tip-sample interaction is based on Lennard Jones intermolecular potential, resulting in repulsive (contact) and attractive (non-contact) forces (see Figure 2).

Contact mode AFM slides and scans across the surface using a cantilever with a relatively low spring constant to avoid sample damage. Repulsive contact force causes the cantilever to bend and deflect vertically, detecting changes in topography. Lateral force microscopy (LFM), a type of contact mode AFM, determines the friction force acting on a colloidal probe which causes torsion and lateral deflection in the cantilever as the tip scans the surface (see Figure 4, 7).

Tapping mode AFM scans the surface with an oscillating cantilever driven close to its resonance frequency which shifts as it approaches a surface due to tip-sample interaction (see Figure 3). Roughness data is obtained from changes in the oscillation amplitude. Material-specific mechanical properties are obtained from phase lag between drive and detected signals.

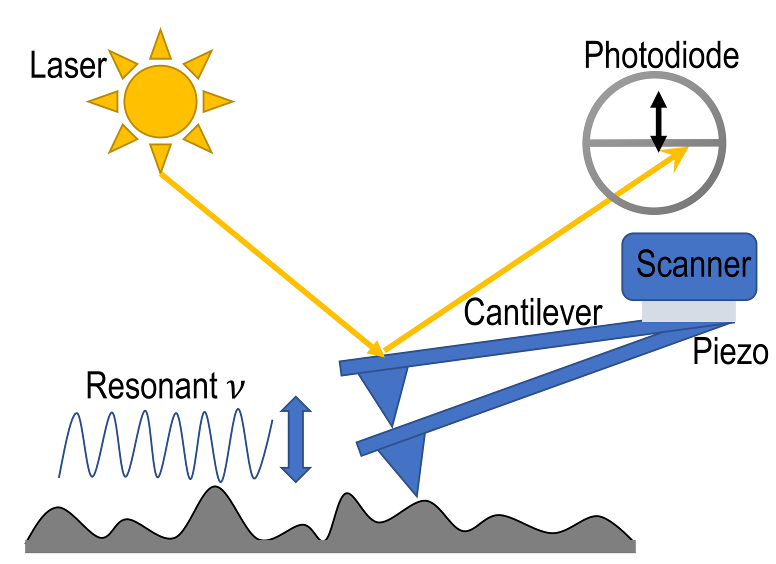

Figure 3. Tapping mode in AFM to measure surface topography.

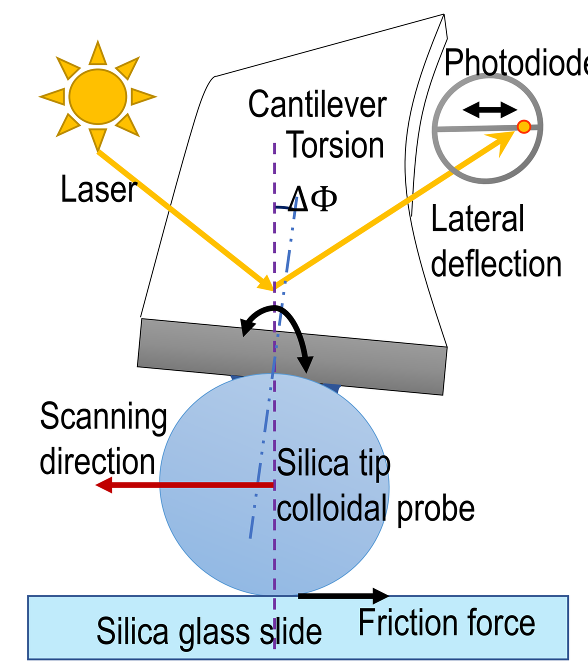

Figure 4. LFM with AFM to measure friction.

Results and discussion

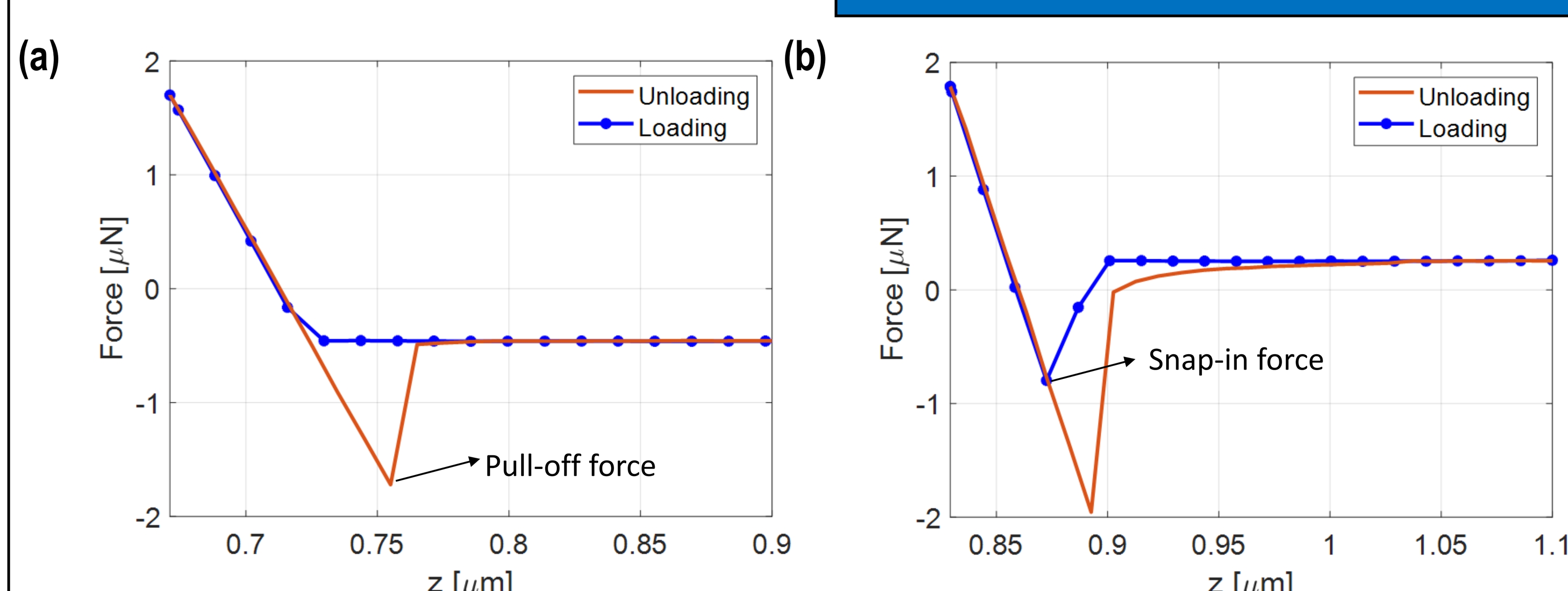

Figure 5. (Un-)Loading experiments with contact mode AFM on silica glass cleaned (a) with solvents in the ultrasound and (b) in ozone.

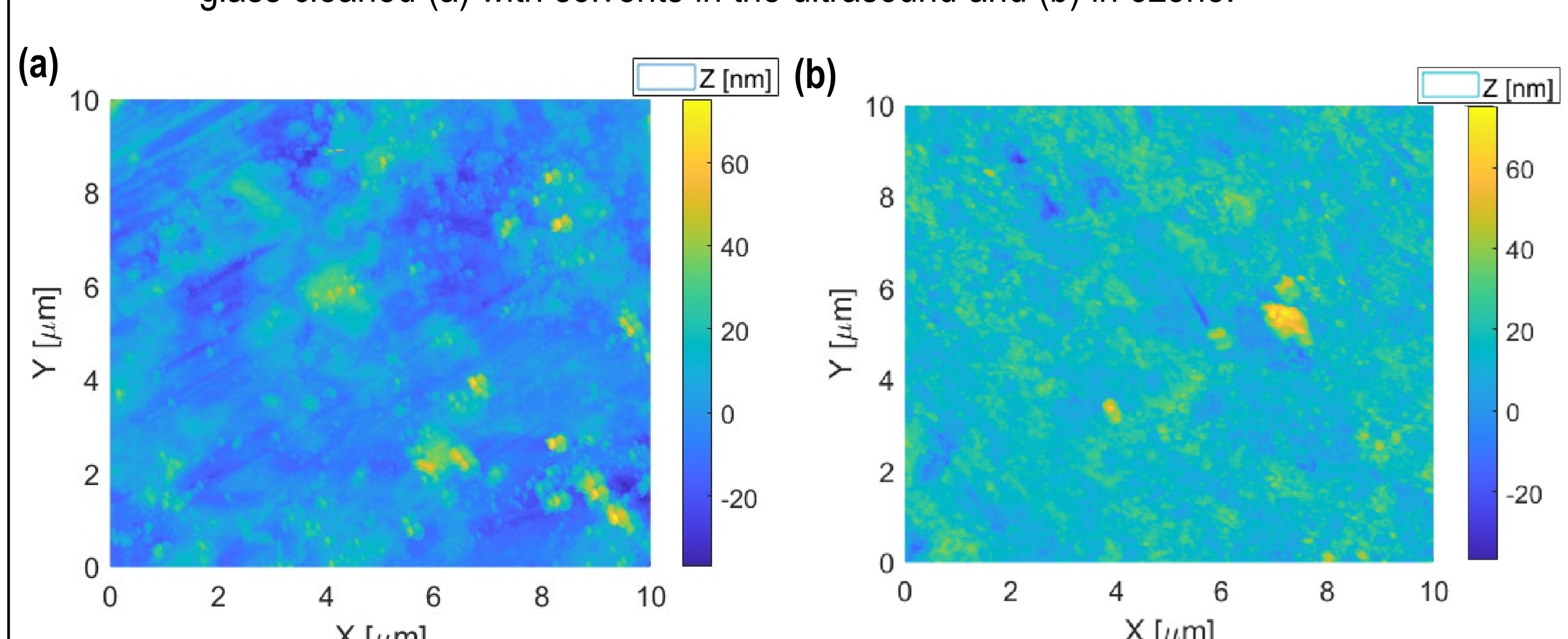

Figure 6. Surface height distribution with tapping mode AFM on silica glass cleaned (a)with solvents in the ultrasound and (b) in ozone.

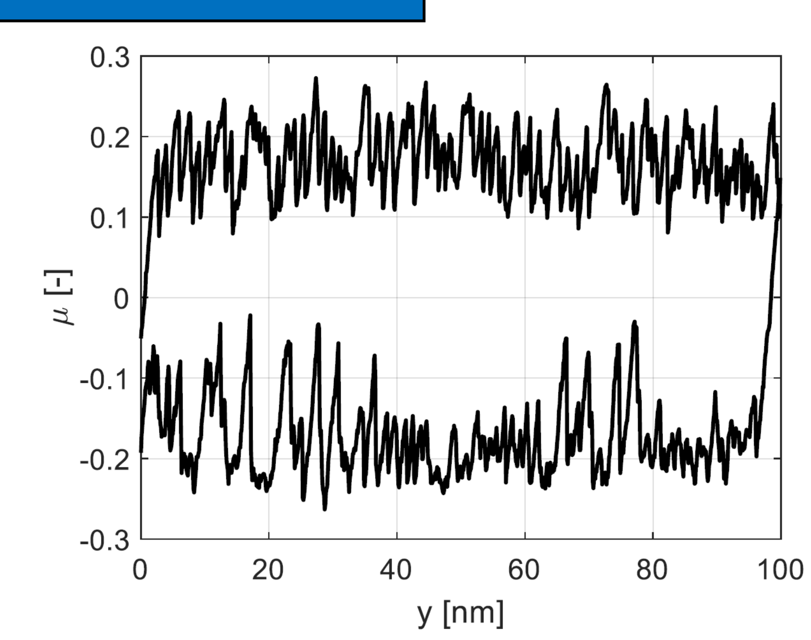

Figure 7. Coefficient of friction vs sliding distance for a colloidal silica probe of size 5μm slid across a silica glass slide with an applied load of 10μN using LFM.

Effect of cleaning methods on the surface energy and roughness of silica glass is studied using AFM. Two cleaning methods were used:

(1) Using polar and non-polar solvents in ultrasonic bath

(2) Using ozone and ultraviolet (UV) chamber

Cleaning the silica glass in ozone oxidizes the contaminants and the silicon-oxygen bonds on the surface and increases the surface energy, resulting in higher pull-off and snap-in forces compared to silica glass cleaned with solvents (see Figure 5). Root mean squared (RMS) roughness Rq of the silica glass is reduced from 14 nm to 8.6 nm with ozone cleaning and to 12 nm with solvent cleaning (see Figure 6).

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