



POSTER #36

NEW METHOD TO OBTAIN VISCOELASTIC CONTRAST OF POLYMERS USING ATOMIC FORCE MICROSCOPY

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We have discovered a new method for extracting nanoscale viscoelastic information from an atomic force microscope (AFM) without the use of a lock-in amplifier. The information needed for this is hidden within a typical AFM tip deflection trace like the one shown in Figure 2. By auto-correlating several of these curves using the snap-to-contact feature as a reference, and then subtracting an averaging background slope, it becomes apparent that a damped oscillation exists between the snap-to-contact and peak force as seen in the panel to the right of the deflection trace. The tip end of the cantilever is in contact with the sample during these oscillations. Thus, they carry mechanical information of the sample. By modeling this data with, for example, a damped harmonic oscillator, it is possible to extract stiffness and viscosity from these oscillations.

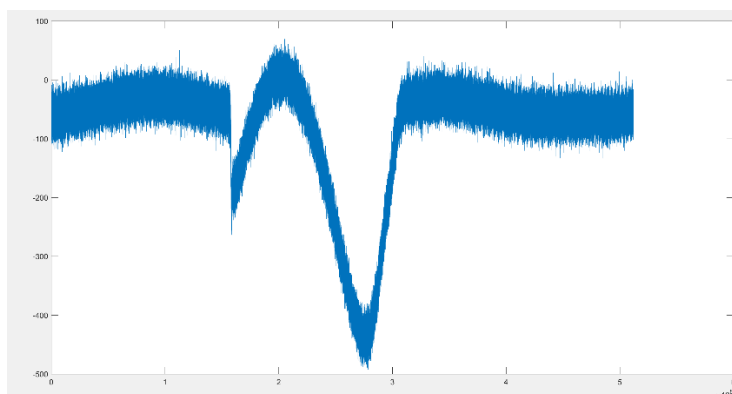


Figure 1. Typical Voltage-time trace showing the snap-to-contact at about 1.6 time units.

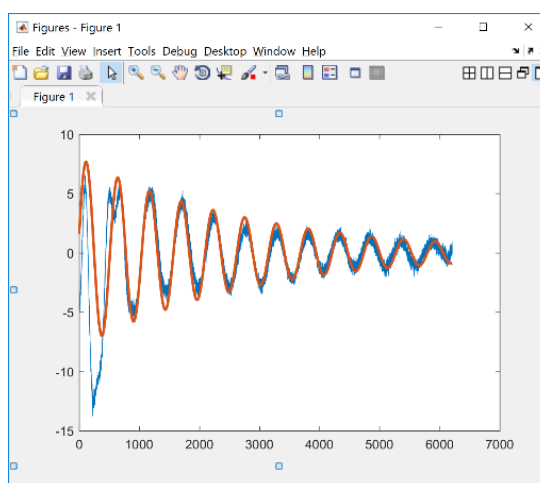


Figure 2. Oscillation immediately after snap-to-contact (largely amplified from Figure 1).



We propose the use of sample stiffness and sample viscosity as contrast agents for imaging. As a model system we use a polystyrene (PS)-embedded low density polyethylene (LDPE) surface. Bruker provides such a surface as a calibration reference for nanoscale mechanical mapping. The two polymers phase-separate in the melt and when they are spin cast, make a thin film where the LDPE appears as small micron or sub-micron diameter discs in a "sea" of polystyrene.

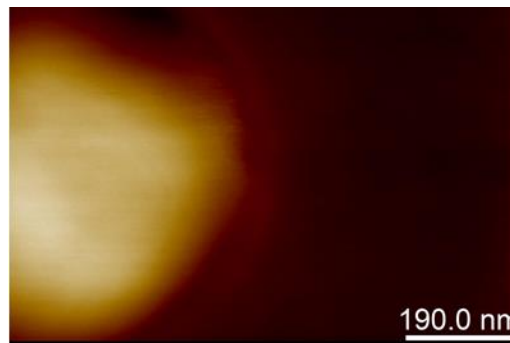


Figure 3. Topographical image of a portion of a bright LDPE feature surrounded by darker PS.

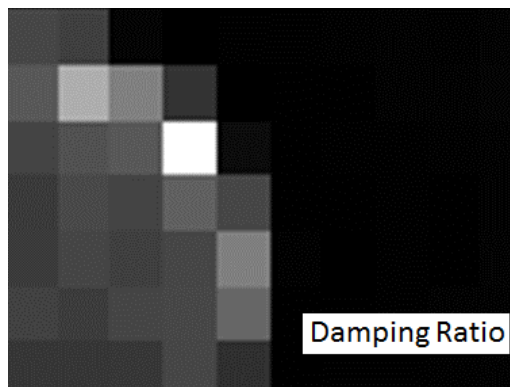


Figure 4. Image obtained by assigning a damping coefficient to each pixel.

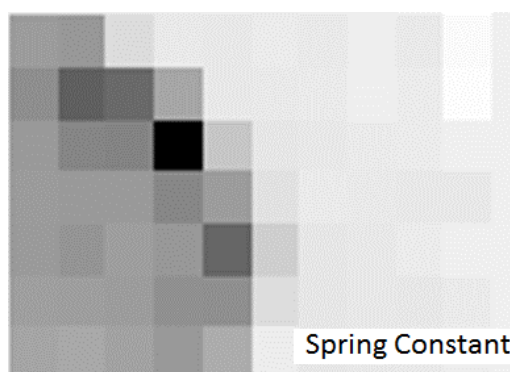


Figure 5. Image obtained by assigning a stiffness to each pixel.

These mechanical constants show clear contrast. Although better modeling algorithms than the simple one used here are called for, this work shows the proof of concept and underscores the relevance of using the, thus far ignored, post jump-to-contact oscillations for imaging.

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