Non-contact determination of the mechanical properties of viscoelastic soft condensed matter using AFM.

Erik Abegg*[1], Elisabeth Charlaix[2], and Joel Chevrier[1]

[1]Laboratoire Interdisciplinaire de Physique [Saint Martin d'Hères] (LIPhy) – Université Joseph Fourier - Grenoble 1, Centre National de la Recherche Scientifique : UMR5588 – 140 Av. de la physique,BP 8738402 Saint Martin d'Hères, France

[2]Laboratoire Interdisciplinaire de Physique – Univ. Grenoble Alpes, CNRS, LIPhy, 38000 Grenoble – France

Abstract

Precise determination of the elastic properties of soft condensed matter at the nanoscale is important in many situations, from substrate characterization to cancer cell differentiation. When measuring these properties at the nanoscale through contact mechanics, adhesive effects dominate the interaction and prevent obtaining quantitative results. As a solution to this problem, a non-contact measuring mode in liquid has previously been developed for the surface force apparatus (SFA). [1] Advantages of this technique are the non-invasiveness of the measurement and the prevention of probe contamination. SFA measurements are however limited by the macroscopic size of the probe, requiring homogeneous samples and introducing substrate effects in soft films thinner than 300 nm.
To surpass these limits our project has moved the technique to the AFM platform where microscale probes can be utilized, allowing for lateral resolution below the micron scale. In contrast to conventional AFM, the technique is not limited to the resonance frequency of the cantilever, allowing the investigation of frequency dependent viscoelastic effects with a single probe. This was previously demonstrated by investigating the mechanical response of a water nano-meniscus over multiple frequencies. [2]

A difficulty of conventional piezo-acoustic excitation in liquid is the inconsistent transfer function due to parasitic resonances. We have applied an alternative excitation method to circumvent this, using electrostatic coupling between probe and substrate, which allows for clean excitation over a broad range of frequencies.

Using the formalism previously described in [3], the linear response of our system allows us to quantitatively determine the dissipative and elastic components of the interaction. This opens the door to the investigation of a wide range of surface interactions in liquid.

We report on the demonstration of this technique in silicone oil using a silicon wafer substrate.

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*Speaker

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