

Wetting on heterogeneous surfaces observed by atomic force microscopy

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Abstract

Wetting of liquids on surfaces enables to reveal various heterogeneities of a substrate. Contact lines of drops can be distorted by these heterogeneities as observed by optical microscopy at the scale of several tens of micrometers. At smaller scales, we show that Atomic Force Microscopy is able to image and record, without detectable perturbation, a quantitative profile of drops having small contact angles. This contact angle is found to vary strongly with the size of the drops which lie on silanized substrates, thus showing a very low hysteresis. Still, calculations and numerical simulations show that the variation of angle is controlled by the minute residual heterogeneities of the substrate and not by effects related to the contact line energy. The latter effect probably necessitates the use of still more homogeneous substrates than those used in this study. We show that there is also a lot of interest in the observation of liquids at such a small scale on very heterogeneous substrates.

AFM study of capillary wave fluctuations on - and spinodal dewetting of thin polymer films

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Abstract

The natural roughness of thin polymer films was characterized by IC-AFM. Polystyrene and poly(vinyl pyridine) spin-coated films with thickness ranging between 1 to 16 times R_g were annealed for various times well above T_g and quenched to room temperature. Different molar masses were used to probe the ratio of film thickness to R_g . The power spectral density was determined from images obtained at different cell sizes. These results show that the free surface of polymer melts follows laws of capillary wave fluctuations as do surfaces of low molar mass liquids provided films are thick enough. Thinner films are unstable or metastable depending on the absolute thickness of the film and not the molecules confinement. Unstable films present the amplification of selected spatial frequencies in the roughness spectral density which is most likely the manifestation of spinodal dewetting. Metastable films dewet by the classical mechanism of nucleation and growth of holes.

Direct imaging of aqueous lysozyme adsorption onto mica by atomic force microscopy

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Abstract

The adsorption dynamics of lysozyme onto mica was followed using in situ tapping mode AFM in aqueous solution. Under stagnant conditions and at a bulk concentration of 2 $\mu\text{g/mL}$, lysozyme clusters were imaged on mica several minutes after exposure to the protein solution. Experiments with ^{14}C -labeled lysozyme, in conjunction with the AFM images of the submonolayer, reveal that lysozyme, once adsorbed, diffused on a time scale of minutes or less on the surface, and formed clusters consisting of about five molecules. At a protein concentration of 5 $\mu\text{g/mL}$, surface coverage increased uniformly until a complete monolayer was established after two hours. Multilayer formation occurred at longer times. Washout experiments indicated that the protein was irreversibly adsorbed. Our data can be interpreted by considering that once adsorbed, lysozyme may undergo a conformation change. Previously buried hydrophobic residues of neighboring proteins could interact resulting in cluster formation.

Rheological measurements of thin polymer films

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Abstract

Results of tan delta measurements of thin polymer samples (thickness <0.13 mm) will be presented. The results will be compared to measurements of polymer films 20 times thicker measured by a Rheometric Data Analyzer (RDA). For the AFM measurements, a thin polymer sample was oscillated sinusoidally by a piezo transducer at amplitudes below 0.125 microns. A 25-micron glass sphere that was attached to an AFM cantilever was brought into contact to the oscillating polymer sample. The response of the AFM cantilever (as measured by the photodiode signal) and the piezo input signal were fed into a lock-in amplifier and the amplitude and phase shift were used to calculate the tan delta of the polymer material as a function of the measured oscillatory frequency (0.01 Hz to 500 Hz).

Direct patterning of solid state and organic materials by dip-pen nanolithography

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Abstract

Dip-Pen Nanolithography was used for the direct patterning of solid state and organic nanostructures on silicon and oxidized silicon substrates. For solid-state materials, the approach works by the hydrolysis of metal precursors in the meniscus between an AFM tip and a surface. The inks used here are the hybrid composites of inorganic chlorides with amphiphilic block copolymer surfactants. Three proof-of-concept systems involving structural-controlled Al₂O₃, SiO₂, and SnO₂ were patterned successfully. For the organic part, four typical organic dyes (rhodamine 6G, coumarin, fluorescein, and acid red) were used to demonstrate the idea of colored ink dip pen nanolithography. Arrays of dots and lines can be written easily with control over feature size and shape on the sub-200 nm level. These artificial structures have been well characterized by various methods. These works are important as it opens up the opportunity for using DPN to deposit solid-state materials and functionalized organic materials on surfaces with the resolution of an AFM without the need for a driving force other than chemisorption.

Atomic force microscopy measurements of colloidal surface forces during sorption of copper ions

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Abstract

A methodology based on atomic force microscopy (AFM) is presented to directly measure colloidal surface forces between a silica particle and a glass plate during sorption of copper ions. The force measurements demonstrate that when sorption is insignificant, the surface force is repulsive and its magnitude decreases with increasing ionic strength and decreasing pH. In such conditions, the surface force is calculated based on the Derjaguin-Landau-Verwey-Overbeek (DLVO) theory for constant surface charge and is found to compare well with the AFM force measurements. When sorption is significant, it causes charge reversal for the silica particle from negative to positive and, thus, in-situ force measurements using AFM demonstrate that the force between the silica particle and the glass plate changes from repulsive to attractive. The transient zeta potential of the silica particle during sorption of copper ions is determined by representing the experimental data with the DLVO theory.

Characterization of carbon nanotube composites via magnetic force microscopy and force spectroscopy

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Abstract

The use of carbon nanotubes as structural reinforcements in composites is dependent on their ability to efficiently disperse in the composite matrix. The characterization of such dispersion is limited by the lack of available tools to visualize the quality of the matrix/carbon nanotube interaction. The work reported herein demonstrates the use of magnetic force microscopy to characterize the dispersion of the carbon nanotubes in a composite matrix. Additionally conventional force spectroscopy measurements give insight into the nanotube/matrix interfacial adhesion properties. This data will lead to a better understanding of the forces at work in the composite and will aid in the design of future nanotube composites.