Prof. Srin Manne's AFM lab

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Overview

The behavior of supermolecular structures and assemblies under spatially confined conditions is a central problem in the physics and chemistry of "soft matter." As the degree of confinement approaches a relevant supramolecular length scale, significant deviations from bulk behavior are generally observed. These deviations often play a central role in both technological and biological processes, in applications as diverse as lubrication, liquid spreading, filtration, mesoscopic materials synthesis, and biological pattern formation.

Technical Documents

Circuit Board Manufacture

DI File format info

Dimension stage limit switches

Dimension heat/cool stage

Current Research

Interfacial Surfactant Aggregation

An interesting area of supermolecular confinement is the aggregation of surfactant molecules at the solid/liquid interface. The adsorption of surfactants is essential in many commercially important processes such as detergency, lubrication, water purification and ore flotation. Despite the importance of surfactant aggregation at the solid/liquid interface, very little was known about the structure of these aggregates until recently. Interfacial surfactant structure had been indirectly studied by a variety of techniques such as calorimetry, solution depletion methods, neutron and x-ray scattering, ellipsometry and fluorescence probes. AFM, however, has the unique ability to directly visualize the structure of surfactant aggregates at the solid/liquid interface. AFM is able to directly visualize the structure of surfactant aggregates at the solid/liquid interface by mapping the electric double layer or stearic repulsion forces between the adsorbed micelles and the AFM probe.

AFM development

The Atomic Force Microscope (AFM) can be modified and extended to study a wide variety of phenomenon at nanometer length scales and pico-newton force scales. The following sections are some modification we've made to our microscopes.

Heatstage

The variation of temperature allows us to probe structural changes associated with critical phenomena and to measure activation energies associated with interfacial reactions. Since critical phenomena and surface reactions often take place in a liquid (and often aqueous) environment, a temperature controlled liquid environment for AFM is desirable. In particular, such an environment allows us to study phase transitions in "soft condensed matter" such as proteins, surfactant micelles, model membranes, and desorbed polymers.
We have developed a stable, temperature controlled stage, which is capable of operating over the entire temperature range of aqueous solutions. This stage uses a thermoelectric cooler for both cooling and heating. It has demonstrated lattice resolution in fluids from -15 °C to more than 130 °C.

Environment control

The AFM tip-sample environment has a direct impact on the resulting images. For imaging in air, the ambient relative humidity leads to capillary condensation around the tip, which modifies the imaging forces. Additionally, some samples may be sensitive to atmospheric moisture, and the surface may change its topography in response to changes in humidity.

Tip modifications

Future: high electric and magnetic fields

Imaging a sample under an applied external electric or magnetic field offers opportunities to study...

Self assembly: experimental models

A central preoccupation of condensed matter physics is the emergence of material properties, such as crystal structure, lattice dynamics, and phase transitions, from the local interactions between constituent atoms. In real materials, however, this connection is incomplete because exact interatomic potentials generally cannot be derived ab initio, or readily be measured in isolation, or freely be varied to investigate their effects on material properties. The advent of colloidal crystals, prepared from particles with simple and tunable interactions, has helped bridge this gap.

However, colloidal crystals have some limitations as model systems for real materials and as reliable test-beds for statistical theories. Experiments on charge-stabilized colloids have revealed unexpected long-range attractions between like-charged particles and the effective pair potential for these systems is now a matter of some controversy. Using dipole-dipole interactions between paramagnetic colloidal particles circumvents this problem, although hydrodynamic coupling and electrostatics can still play a role. Colloidal systems require extensive sample preparation, and long equilibration times (several days) to form the delicately ordered lattices. Kinetic traps and prohibitively slow approach to equilibrium may pose special problems for binary colloid mixtures (the mesoscopic analogue of alloys or compounds), for which few results have been reported to date.

A new and conceptually simple experimental model for condensed phases has been developed, which combines accurately known and tunable pair potentials, equilibration times of a few seconds, an independently adjustable “temperature,” and collective behavior visible to the naked eye. We use this system to quantify lattice and interfacial structures, phonon velocities, binary phases and phase transitions; these results are quantitatively related to the known pair potential, confirming the applicability of statistical theories to this ensemble.

Self assembly: theoretical models

Micelles can be modeled...

Non-Covalent microcontact printing

Microcontact printing is a technique developed by **Prof. George Whitesides' group** at Harvard. It is conceptually very simple: An uncured silicone rubber is cast onto a "master" surface that has the desired surface features. The silicone is cured and removed from the master surface. The now embossed silicone "stamp" is "inked" with molecules and stamped down on a surface just as you would use an office rubber stamp. This technique is able to reproduce patterns on length scales below 100 nm. This technique is typically used to stamp molecules which covalently bond to a surface, such as thiols on gold. We are interested in "softer" materials which form non-covalent bonds with a surface, such as lipids and proteins.
More information about microcontact printing

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Past research

Past research has included crystal growth and dissolution, electrochemistry, molecular crystals.

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