Novel Microscopes and Molecular Interaction Measurement Devices
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Abstract

The measurement of intermolecular forces provides valuable information about molecules, ions, and atoms. Atomic force microscopy (AFM) has been widely used in mapping topographic structures and their mechanical properties. Unfortunately, the accuracy of intermolecular interaction AFM measurements is limited by mechanical instability, and intermediate states of intermolecular interactions (like unbinding) are not detectable using AFM. Electrical detection methods, such as interfacial force microscopy (IFM) can also measure surface phenomena, but have low sensitivity and are technically complex. AFM force-modulation techniques allow for topographic, elastic, and viscous images to be obtained at the same time, yet these can be difficult to interpret. DC-measurement techniques are more easily interpreted, but a “double-spring effect” due to the elastic behavior of both the sample and probe complicates the studies. Boise State University has invented a suite of technologies that overcome many of the limitations of currently available microscope devices and techniques.

- A CANTILEVER-BASED OPTICAL INTERFACIAL FORCE MICROSCOPE (COFIM) with force-feedback has been invented which allows both normal and friction forces to be measured simultaneously, while eliminating the double-spring effect and snap-to-contact problems of AFM.

- Additionally, deflection, topographic, and force images are obtained from a single scan using the novel HIGH-SPEED ATOMIC FORCE MICROSCOPE (HSAFM) developed at Boise State, allowing scientists to view the behavior of molecules on a nanometer scale at physiologically relevant time scales.

COIFM Advantages

- Imaging mechanical properties of local structures, such as small impurities and domains at the nanometer scale
- Optical detection technique used with feedback mechanisms to self balance the cantilever
- Eliminates double-spring effect and snap-to-contact problems
- Enhanced sensitivity to interfacial forces
- Ability to measure interfacial forces and intermolecular interactions in a liquid environment
- A sample substance, such as water, can be laterally modulated while measuring interfacial forces
- Both normal and friction forces can be measured

HSAFM Advantages

- Uses normal size cantilever tip
- High-speed imaging of one frame per ten seconds for large biological systems, like bacteria
- Measures intermolecular forces using any interfacial force measurement tool as a biosensor (such as AFM, SFA, etc.)
- Self-actuating system follows topographic features simultaneously and cooperatively at high speed
- Force-feedback scheme used for imaging large biological samples
- Obtains deflection, topographic, and force image, simultaneously
- Ability to view dynamic behavior of individual biological and bio-relevant molecules at a molecular-level resolution under physiologically relevant time scales
Applications of COIFM

- Imaging various soft materials: living cells, fibers, epoxy composites, self-assembling monolayers, super alloys, plastics
- Future applications include development of micromechanical machines

Applications of HSAFM

- Understanding large-scale biological phenomena, like the roughening variation of bacteria that happens within seconds in response to an antimicrobial
- Studying molecular dynamic behavior, like polymer structural changes, on surfaces used in industry

Stage of Development

Both microscopes, and the associated techniques, have been developed and tested in a laboratory, and the described advantages have been validated. Patents for the technologies are currently pending. Additional refinements are required before application to biological and medical applications.

Boise State is looking for a Licensee for this technology.

About the Inventor

Dr. Byung Kim is a Professor of Physics at Boise State University. Dr. Kim's research areas include force-feedback force microscopy of biological systems, scanning tunneling microscopy of chiral recognition system, rapid biosensing and analysis, nanotribology of chemically modified interfaces, and magnetic force microscopy of magnetic thin films.

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