Research Project: Nano particle reinforced composites for critical infrastructure protection

Research Topic: Atomic Force Microscopy (AFM)

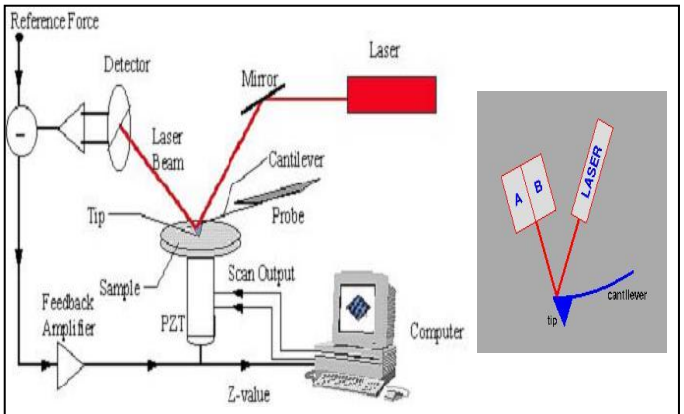
Problem

Multi-scale research starting from molecular dynamics simulation to developing continuum theory of nanocomposite material systems, and to develop a material database for nano-particle reinforced composites and other low-cost, high-strength, innovative materials, such as fly ash and polymer enhanced concrete. Supporting experiments, including Atomic Force Microscopy AFM) will be used to validate numerical results.

Atomic Force Microscopy will be used as an imaging tool to evaluate dispersion of nano particles in various matrices, study the topography of fractured surfaces to get qualitative measure of particles adhesion. Also it will be used to study local properties (modulus and hardness) of nano composites using indentation technique.

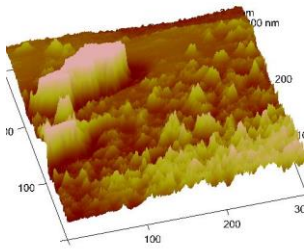
Approach

The atomic force microscope (AFM), which is based on sensing of interaction between the atomically sharp tip and surface, has become the instrument of choice for the characterization of the surface nano-mechanical properties. The dynamic mode of the AFM, such as force modulation (FM), or scanning acoustic microscopy, by employing different character of tip-surface contact (constant or periodic) or cantilever dynamic regimes, have greatly expanded the capability of nano-mechanical mapping in comparison with static mode AFM. In FM-AFM the cantilever base is low frequency modulated while the tip is in contact with the surface. The cantilever exerts a force on the surface; the stiffer the area, the higher the cantilever deflection magnitude. The surface topography is determined from the feedback circuit, which tries to keep the average cantilever deflection constant. This procedure will be used to measure quantitatively the Young's modulus of CNT, nanoclay, graphite platelet or other polymer composite materials. Statistical analysis will be used to identify modulus values associated with the matrix, fiber and interphase. In this study, two sets of samples will be used: undamaged sample, and preloaded (pre-cracked) sample. This procedure, combined with numerical simulation, will be used to quantify the amount of damage. The atomic force microscopes that will be used in this study are Digital Instruments multimode scanners with Nanoscope IIIa and Nanoscope 5 controllers equipped with a variety of tips which are housed in the Department of Chemical Engineering at the University of Mississippi. Topographic and phase images will be captured simultaneously by using tapping mode AF.



Schematic diagram of Atomic Force Microscopy Technique

Findings



polymer nano composites obtained by University of Mississippi Researchers

This work is at its initial stage. A graduate student is hired on this project and is being trained to use Nanoscope IIIa AFM. Topographic image of 2.5% MWCNT/ Nylon 6,6 with tapping mode AFM was collected.

Impact

The Atomic Force Microscope is well suited for the characterization of nano-composite polymer materials when compared to traditional microscopes such as the electron and optical microscopes. Atomic force microscopes give direct 3-D measurements of the surface structure of polymers. Further, using materials sensing modes such as lateral force and phase contrast, it is possible to differentiate the types of materials at a polymer surface which will help improve or validate theoretical modeling procedures.

Researcher:
John O'Haver is an Associate Professor in the Department of Chemical Engineering and Swatsi Gupta is a Graduate Student in the Department of Mechanical Engineering at University of Mississippi.

(*Last update: July 2007*)

Contact: Dr. Alex Cheng acheng@olemiss.edu