NanoRack™ Sample Stretching Stage for the MFP-3D™ AFM

Asylum Research

Introduction

The **NanoRack** Sample Stretching Stage provides the first direct measurement method for observing nanoscale features and effects of materials under stress control. The NanoRack stage is available as an option for **MFP-3D** AFMs.

The NanoRack stage (Figure 1) is a high-strain, high-travel manual tension and compression stage that provides two-axis stress control of samples under different loads. It integrates force measurements with AFM images or other measurements and returns both stress and strain data. The stage is compatible with a wide variety of imaging techniques including Phase and Dual AC™ for enhanced contrast of material properties, as well as our Ztherm™ option for localized thermal analysis. The height-adjustable stabilizing pillar can be removed to provide bottom access to the test sample. The NanoRack is ideal for a wide range of applications including measurements of adhesive strength in polymers and stress-induced deformations and cracking in a variety of biological and inorganic materials.

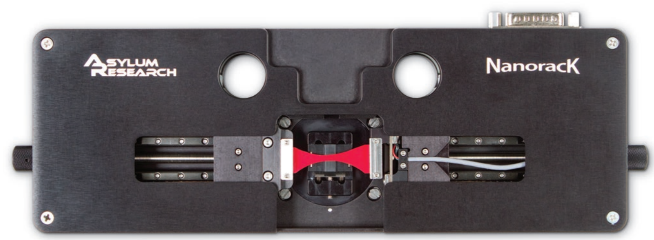

Figure 1: The MFP-3D NanoRack Sample Stretching Stage is a high-strain, high-travel manual stretching stage that provides control of tensile and compressive loaded samples up to 80 N.

Features/Benefits

- High-strain, high-travel manual stretching stage provides two axis tensile stress control
- Returns both stress and strain data
- Can be used under tension or compression
- Allows control of the sample image region under different loads
- SmartStart™ automatic load cell calibration provides integrated force measurements with MFP-3D images or other measurements
- Compatible with a wide variety of Asylum Research imaging techniques including Phase and Dual AC, as well as Ztherm Modulated Thermal Analysis

Impact Copolymer Example

A commercial impact copolymer (ICP), a multicomponent material typically used in automotive and appliance applications where a balance of stiffness and toughness is needed, was studied with the NanoRack accessory on the MFP-3D AFM to investigate material deformation and interface adhesion as a function of tensile stress. Effects of deformation were observed within both the polypropylene (PP) and ethylene-propylene (EP) components, as well as at the interface between the two materials.

There are no other direct measurement methods available to determine interfacial adhesive strength of polymer blends, and so AFM investigations of micro-domain deformation such as the one described here could be used ultimately to provide a direct determination of interfacial adhesion in complex polymer-containing materials such as ICP. Studies of this kind improve our understanding of material structure-property relationships, ultimately enabling manufacture of better quality products.

Figure 2 shows real-time stress vs. time curves of the ICP as the sample is being pulled in the NanoRack. Note that the force spikes immediately upon pulling and is followed by a lengthy relaxation process that is strongly material dependent. As the copolymer stretches, the individual components (PP and EP rubbers) deform accordingly in response to the tensile

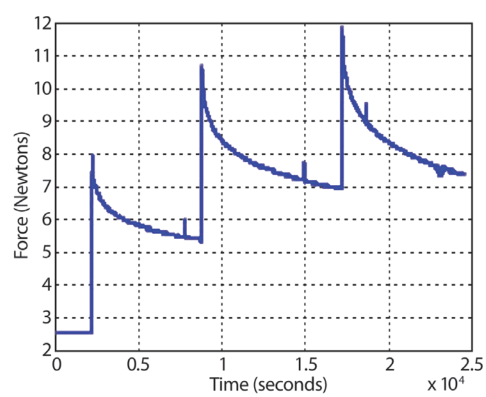

Figure 2: Stress (Newtons) vs. time (seconds) curve of ICP as it is being stretched on the NanoRack.

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stress. Figure 3 shows before and after images of the EP component for a 3% elongation. For additional information, see our application note "Applications of the NanoRack Sample Stretching Stage to a Commercial Impact Copolymer" by D. Yablon, et al., ExxonMobil.

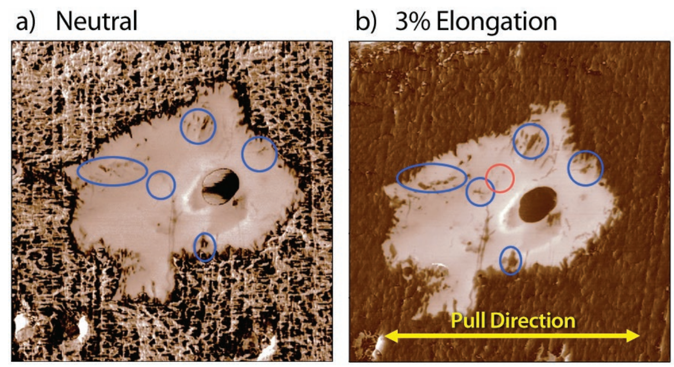

Figure 3: Amplitude mode 2 images of identical EP domain within ICP material at (a) neutral position on NanoRack and (b) 3% elongation on NanoRack. 5 µm scans.

Crack Propagation in Bone Example

Due to the hierarchical structure and complexity of bone, the uncovering of structure-function relationships, i.e. the origin of material properties such as strength, toughness, and fatigue resistance, is usually a non-trivial task. The NanoRack Sample Stretching Stage, in combination with AFM imaging, offers an approach to overcome some of these difficulties. Because AFM allows for imaging in ambient – even hydrated conditions – it is feasible to perform *in situ* micro-mechanical testing experiments while conducting imaging. Figure 4 shows cracking generated in a cortical bovine bone. As expected, due to the underlying lamellar structure, such cracking under stress is generally deflected towards the long beam axis. For additional information, see our application note "Crack Propagation in Bone Captured with *In Situ* Mechanical Testing During AFM", O. Katsamenis, et. al, University of Southampton.

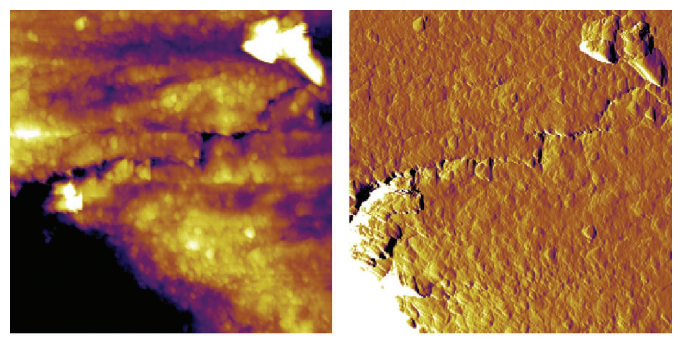

Figure 4: AFM height (left) and amplitude (right) images showing a crack in cortical bovine bone deflecting and eventually breaking through a lamella. 24 µm scan.

Specifications

- Sample Size: 12 mm wide maximum, 41 mm long minimum, 6 mm thick maximum
- Sample is supported by a height-adjustable stabilizing pillar that can be removed to provide bottom access to the test sample
- Maximum range of motion: 120 mm (30 mm relaxed to 150 mm fully stretched)
- Maximum 80 N load (strain gauge limit)
- Strain (force) gauge can be swapped from a 80N (±0.8N) version to 20 N (±0.2 N) version for higher resolution at lower forces
- Knobs adjust sample 500 µm per revolution
- Can discretely adjust to 5 µm encoder resolution

Compatibility

- Compatible with all MFP-3D AFMs except MFP-3D Origin.™

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