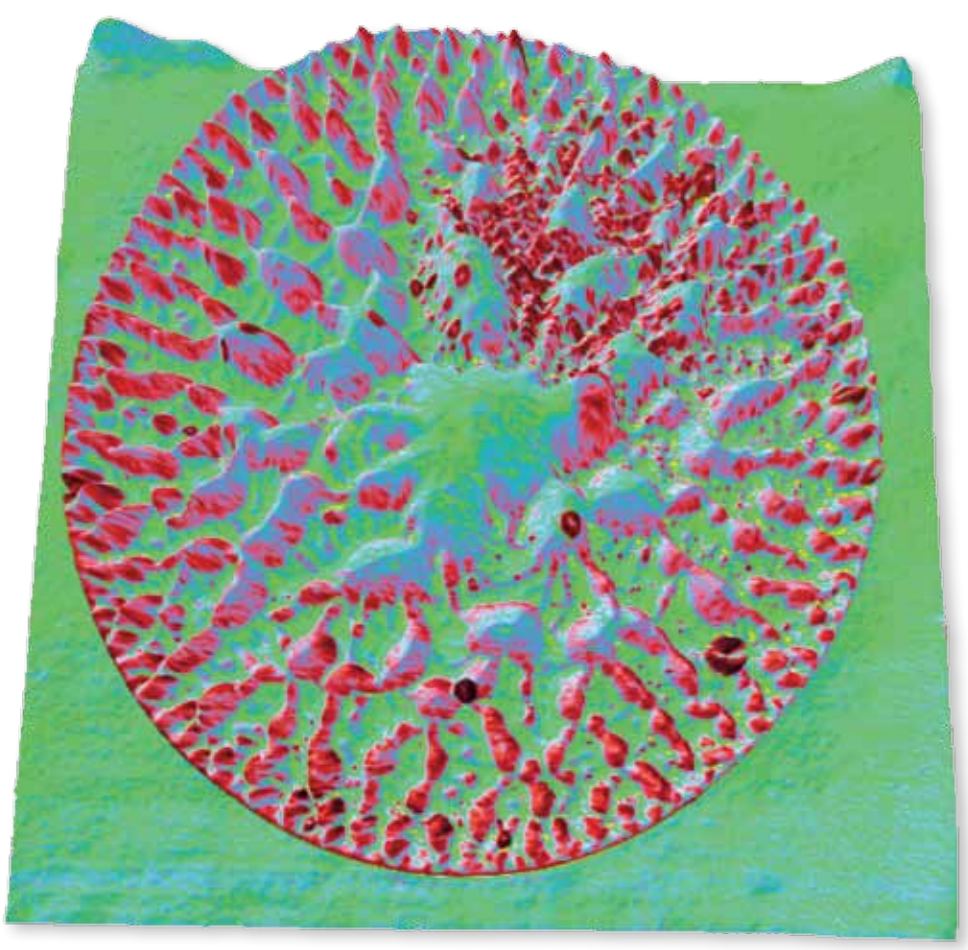

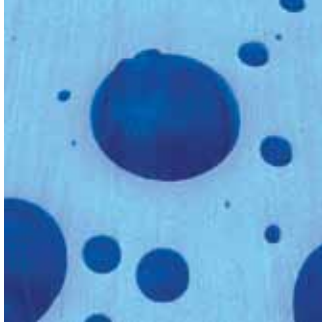

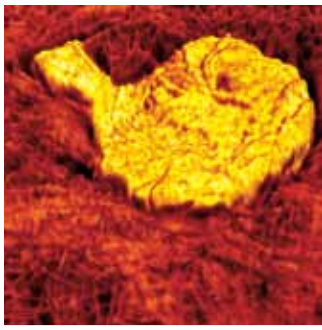

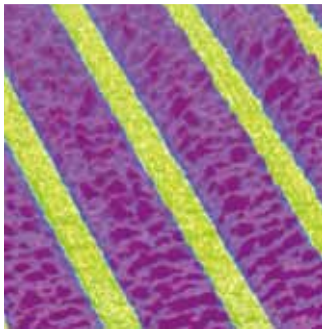

PeakForce QNM

Quantitative Nanomechanical Property Mapping

- High-Resolution Mapping of Modulus and Adhesion
- Direct Force Control Keeps Indentations Small for Higher Resolution and Non-Destructive Imaging
- Widest Operating Range for Samples from Soft Gels (~1 MPa) to Rigid Polymers (>20 GPa)

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PeakForce QNM

Go Beyond Topography

PeakForce™ QNM™ is a patent-pending, groundbreaking atomic force microscope (AFM) imaging mode that provides AFM researchers unprecedented capability to quantitatively characterize nanoscale materials. It maps and distinguishes between nanomechanical properties, including modulus and adhesion, while simultaneously imaging sample topography at high resolution. PeakForce QNM operates over an extremely wide range, approximately 1 MPa to 50 GPa for modulus and 10 pN to 10 µN for adhesion, enabling characterization of a large variety of sample types.

Because it is based on Bruker's proprietary Peak Force Tapping™ technology, the forces applied to the sample are precisely controlled and a variety of probes can be used. This allows indentations to be limited to several nanometers in most cases, which both maintains resolution and prevents sample damage.

These capabilities dramatically exceed those of any other technique for nanoscale materials characterization. Established quantitative techniques, such as conventional nanoindentation, make much larger indentations and are therefore low resolution and destructive. Techniques that operate at higher resolution, such as phase imaging, higher harmonic imaging, and Dual AC imaging, generate contrast related to material properties, but don't readily distinguish between modulus and adhesion, and are not quantitative even when the sources of the image contrast are understood.

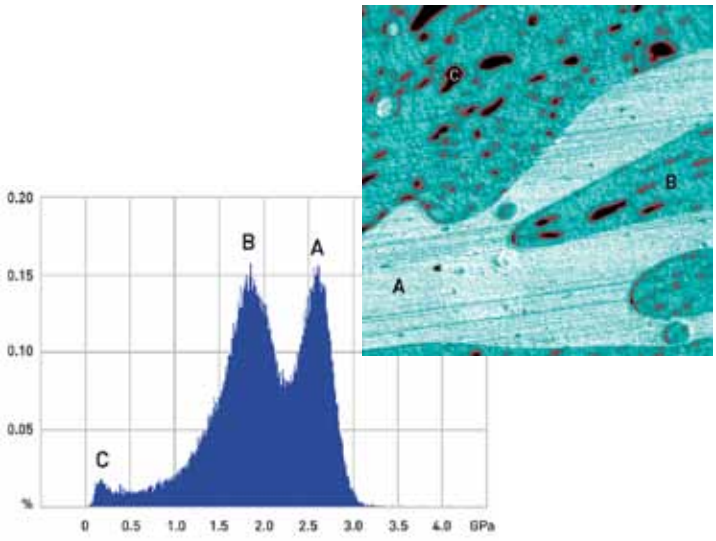
This exclusive imaging mode exceeds even HarmoniX® mode, surpassing its range of applicability. No other AFM technique on the market today approaches the power and flexibility of Peakforce QNM.

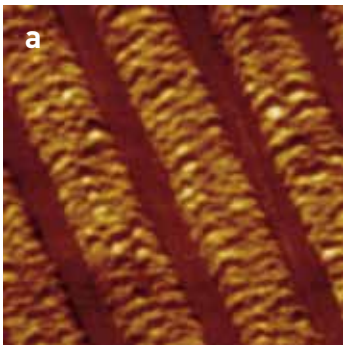
Discover More with PeakForce QNM

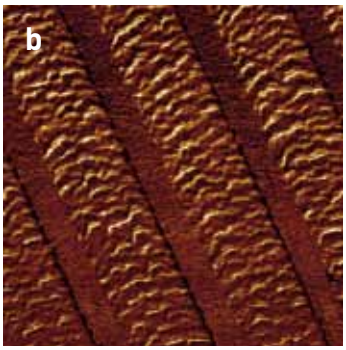
- **Obtain maps of sample modulus and adhesion simultaneously along with high-resolution topography images**
- **Exclusive Peak Force Tapping technology precisely controls imaging force, keeping indentations small to deliver non-destructive, high-resolution imaging**
- **Material properties can be characterized over a very wide range to address samples in many different research areas**

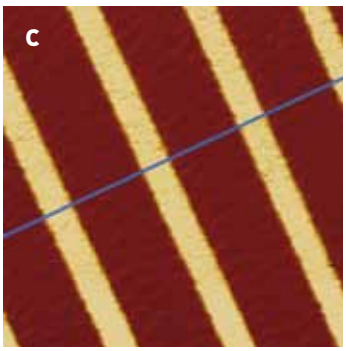
Easily Visualize and Quantify Materials in Multi-Component Polymer Blends

The properties of multi-component polymer blends depend not only on the individual components, but also on how they are distributed in the bulk material. The image to the right is a PeakForce QNM modulus map (scan size 7 µm) of a polymer blend with three components. The contrast directly reflects different moduli, where A is stiffest, C is most compliant, and B has an intermediate stiffness. These components can be quantified by bearing analysis, yielding both the average modulus of each component as well as its proportion of the total area.







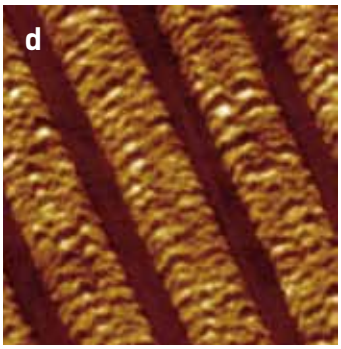


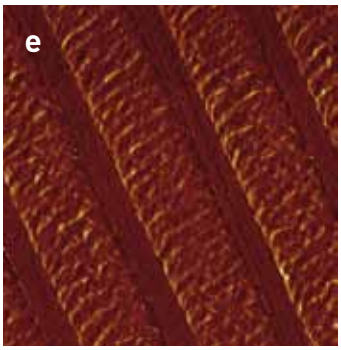
Unambiguously Distinguish Adhesion Variations from Modulus Variations

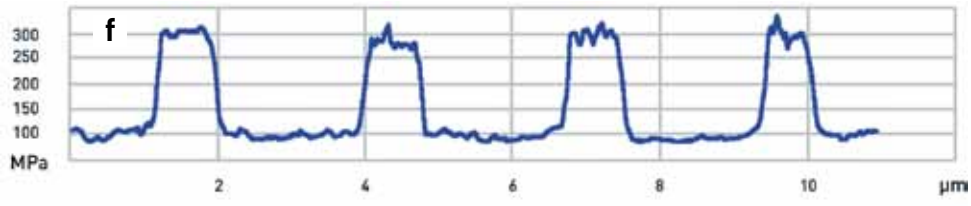
The images shown here are 10 µm scans of a multilayered polymer film, where a-c are PeakForce QNM images and d-e are TappingMode™ images. Peakforce QNM simultaneously generates height (a), adhesion (b), and modulus (c) data, while TappingMode yields only height (d) and phase (e) data.

Comparison of the images clearly shows that the phase image (e) is dominated by adhesion, not modulus as one might otherwise expect. This demonstrates that phase imaging is not always easily or clearly interpreted.

The PeakForce QNM data, however, is easily understood because adhesion (b) and modulus (c) are measured separately and unambiguously. Moreover, the data is quantitative, as shown in f, where one can easily see that the darker, wider strips in c correspond to a modulus of approximately 100 MPa while the lighter, narrower strips represent a modulus of approximately 300 MPa.



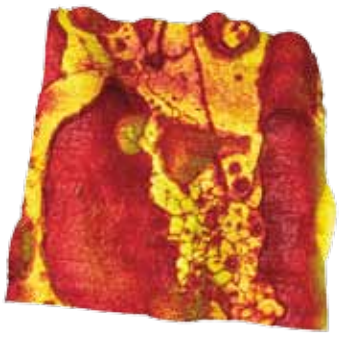




Explore Nanomechanical Properties of Biological Samples

PeakForce QNM can also be used to investigate the role of mechanical properties in biological structures and processes. It may even be used in liquids, opening the possibility of mapping not only modulus but also binding and recognition events.

The example at right is from a butterfly wing (500 nm scan size). The wings are covered by many tiny scales. The image is of the melanin layer underneath one of these scales. Quantitative modulus data has been overlaid on a 3D representation of the surface topography, making it easy to relate the mechanical properties to their corresponding structures.



PeakForce QNM

SPECIFICATIONS

AVAILABILITY	
Optional Feature	PeakForce QNM is an optional feature on all new Dimension® Icon®, MultiMode®8, and BioScope™ Catalyst™ SPM systems
PROBE RECOMMENDATIONS	
Modulus Range:	
<20 MPa	ScanAsyst-Air (k~ 0.4 N/m nominal, tip radius <10 nm typical)
5 – 500 MPa	Tap150A (k~ 5 N/m nominal, tip radius <10 nm typical)
200 MPa – 2 GPa	RTESPA (k~ 40 N/m nominal, tip radius <10 nm typical)
1 – 20 GPa	Tap525 (k~ 200 N/m nominal, tip radius <10 nm typical)
>10 GPa	DNISP-HS (k~ 350 N/m nominal, tip radius <40 nm typical, diamond tip)
	(A selection of these probes is included with the PeakForce QNM package)
STANDARD SAMPLES	
Modulus:	
1 MPa – 100 GPa	Several standard samples are included with the PeakForce QNM package, each covering approximately one order of magnitude of the specified range. These may be used for calibration and as training samples. Note that samples are not certified by any standards agency and may vary with aging.
TYPICAL PERFORMANCE	
General	Absolute accuracy, reproducibility, and resolution vary with the calibration method and measurement procedure. Absolute accuracy is also difficult to specify because of a lack of certified standards. Therefore, guaranteed performance specifications cannot be given at this time. Please refer to the data shown as a guide to typical performance.

Note: Specifications are subject to change without notice. Visit the Bruker website for most up-to-date specifications.

Cover images

Left: Anti-bacterial film consisting of poly(methyl methacrylate) and silver nanoparticles. Sample was imaged on a Dimension Icon using PeakForce QNM at a scan size of 13.5 µm. The data shown is adhesion data overlaid on topography. The dark red spots correspond to the location of silver nanoparticles, which are difficult to identify using the topography alone. (Sample courtesy of Mishae Khan and Daniel Bubb, Rutgers University.)

Top-right: Two-component polymer blend consisting of polystyrene and polyolefin elastomer (ethylene-octene copolymer) imaged on a Dimension Icon at a scan size of 10 µm. The data shown is modulus data overlaid on topography. The polystyrene component (light blue) is approximately 2 GPa while the copolymer inclusions (dark blue) are about 0.1 GPa.

Middle-right: Two-component polymer blend consisting of syndiotactic polypropylene (sPP) and polyethylene oxide (PEO) imaged on a MultiMode 8 with PeakForce QNM at a scan size of 2 µm. Quantitative modulus data map has been overlaid on a 3D image of the surface topography.

Bottom-right: A 3D representation of the data shown in figures a and c on page 3, where the modulus data has been overlaid on the surface topography. Scan size 10 µm.

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