

# Innova

- Superior AFM Research Performance and Versatility

# Innova – Superior Research Performance and Versatility

The Bruker Innova® Atomic Force Microscope (AFM) delivers accurate, high-resolution imaging and a wide range of functionality for the physical, life, and material sciences. As a highly configurable and customizable system, Innova also offers application flexibility for the most demanding scientific research at a moderate cost. Its unique state-of-the-art closed-loop scan linearization system ensures accurate measurements and noise levels approaching those of open-loop operation. Innova delivers atomic resolution with great ease and scans up to 90 microns in closed-loop without the need to change scanner hardware. The integrated, high-resolution color optics, open stage, and new software with experiment selector make setting up each new experiment fast and easy.

## High-Resolution System

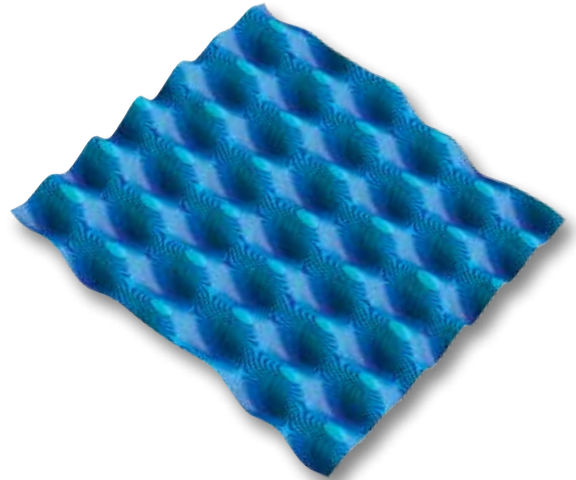
- Utilizes an innovative design optimized for lowest closed-loop noise and drift
- Ensures accurate measurements at all scales and in all dimensions
- Delivers highest resolution results with great ease.

## Fast Setup for Every Experiment

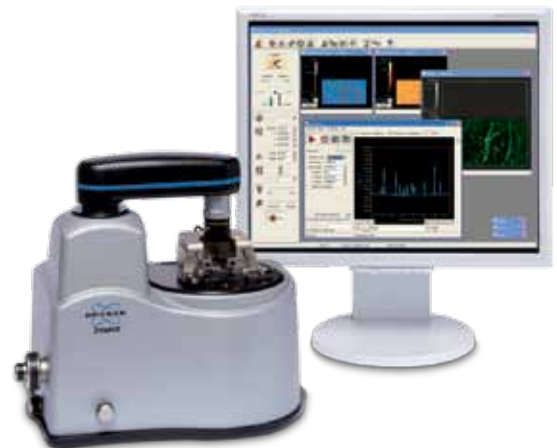
- Ergonomic open stage and premounted cantilever option provide fastest hardware setup
- Software controlled high NA optics ensure fast and precise region of interest identification
- Experiment selector distills decades of AFM expertise into preconfigured software settings
- System performance and workflow enable seamless operation from survey to atomic resolution

## Powerful Research Flexibility

- Addresses all advanced measurements with full range of SPM modes
- Customizes research with configurable signal access and physical access to tip-sample junction
- Offers nano-optics with TERS-enabled AFM-Raman integration



Atomic resolution STM image of highly oriented pyrolytic graphite (HOPG). Image size 1.3 nm.



## Routine High Resolution

All aspects of the Innova electromechanical design have been optimized, from the rigid microscope stage with a short mechanical loop and low thermal drift to the ultra-low noise electronics. The result is a unique combination of high-resolution performance and closed-loop positioning. Innova uses Bruker's proprietary ultra-low noise digital closed-loop scan linearization for accurate measurements in all dimensions, regardless of size, offset, speed, or rotation in air and liquid. With closed-loop noise levels approaching those of open-loop operation, superior image quality is achieved from the full 90 micron scan range down to submicron images on any sample, whether it is a semiconductor, a soft and nanostructured material, or DNA. In addition, closed-loop scan linearization can be activated and deactivated on-the-fly. This incredible flexibility allows zooming down to atomic resolution on any selected portion of a full size scan, without changing scanner hardware and without withdrawing the probe from the surface. With Innova, high-resolution imaging is routine.

## Fast Setup for Every Application

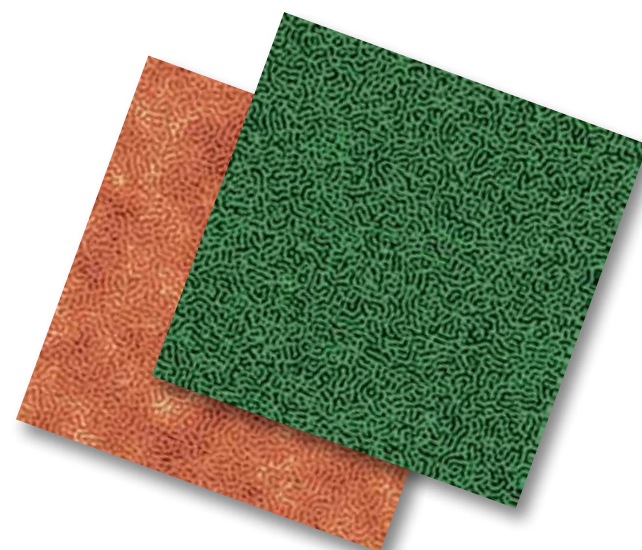
### *Accurate Region of Interest Identification*

The patented top-down optics of the Innova integrate seamlessly with all imaging modes. With software-controlled optical zoom, they provide a broad range of magnification, allowing for a direct view of the cantilever and sample with better than 1 micron resolution to identify the smallest sample features and ensure precise probe positioning. With the optics positioned entirely inside the protective instrument cover, probe and sample can be viewed at any time while insulating the instrument from the environment. The ergonomic integration of the optics with the microscope also contributes to the ease and accuracy of tip exchange and laser alignment. The user can simply drop in a new tip and swing the optics back into place. The pre-aligned cantilever will always remain in focus.

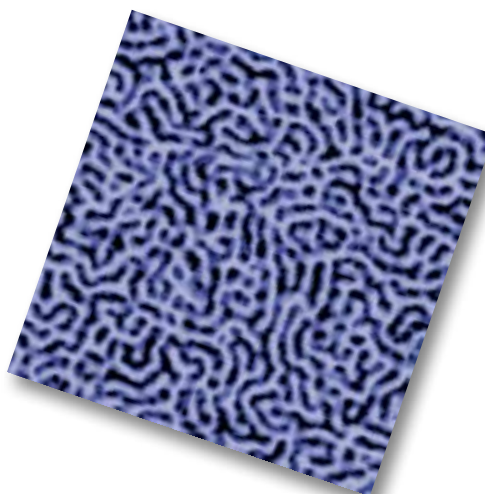
### *Streamlined Software*

Innova now enables research-quality results even faster, thanks to all new NanoDrive™ version 8 software. Through the Experiment Selector user interface, the system configures itself instantly for any targeted application. From there it is a short, intuitive path to the acquisition of optimized high-resolution images with up to eight different simultaneous channels, followed by immediate analysis of partial data without interrupting ongoing acquisition, and ultimately to publication.

Real-time navigation is fast and efficient with an AFM canvas overlaying acquired images. Innova comes standard with a complete NanoScope® Analysis software module that is completely independent of the real-time control yet is integrated seamlessly with single-click data transfer.



High-resolution topography (orange) and phase image (green) revealing the microphase separation in a poly(styrene-b-butadiene-b-styrene) (SBS) triblock copolymer. Raw data (unfiltered), 1k x 1k data points, 2µm image size, closed-loop scan linearization active.

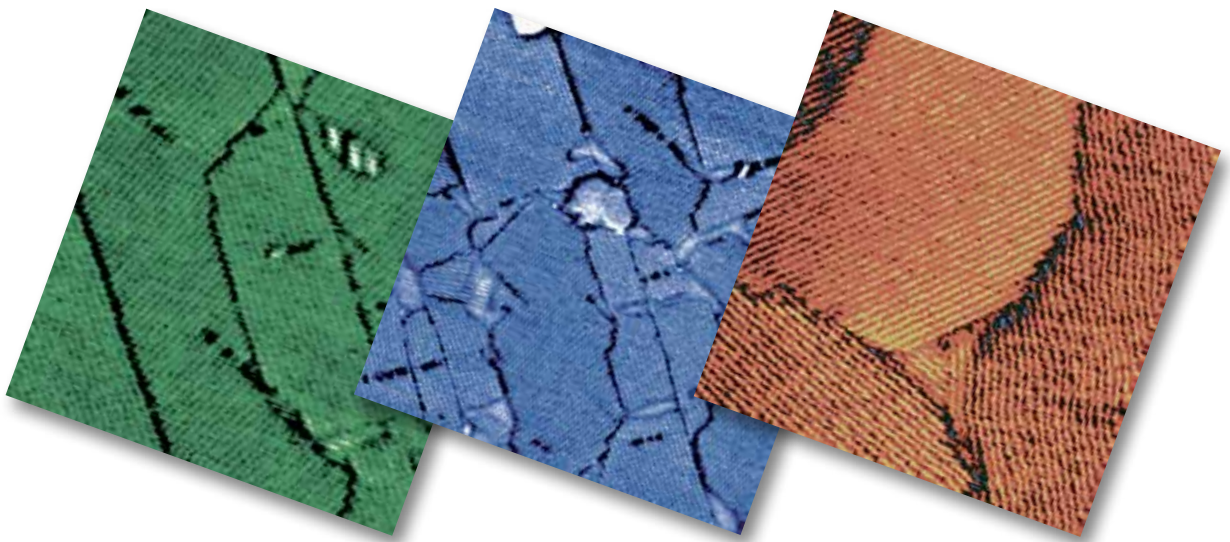


High-resolution phase image revealing the microphase separation in a poly(styrene-b-butadiene-b-styrene) (SBS) triblock copolymer. Image size 750nm, closed-loop scan linearization active.

### *Fast and Easy Tip and Sample Exchange*

Innova has been specifically designed to provide quick and easy tip exchange and alignment. The Innova head rests kinematically on three independently controlled motors that allow height, pitch and tilt adjustments relative to the sample, and user-defined positions can move the head in sub-micron increments. In addition, the system comes complete with a universal chip carrier that accepts almost any unmounted cantilever. For even faster and easier tip exchange, our series of precision premounted cantilevers ensure the laser is automatically and precisely focused on the same spot from one tip to the next.





High-resolution phase image of  $C_{60}H_{122}$  alkane on graphite Image size 420nm (green image), 700nm (blue image), 380nm (red image). Closed-loop scan linearization active. Note the clear lamellar structure with its approximately 7.5nm periodicity proving outstanding force control and closed-loop performance.

### Powerful Research Flexibility

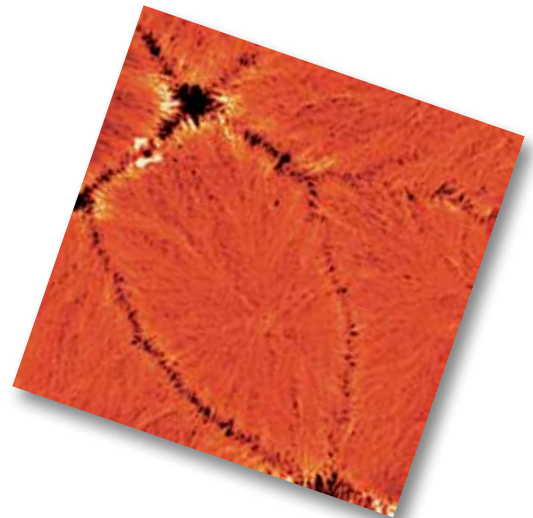
Innova's modern state-of-the-art electronics not only provide exceptionally low noise and outstanding closed-loop performance but also enable a full suite of advanced modes. Core performance and advanced features go hand-in-hand. All advanced modes offer single point spectroscopies, where the precise spatial targeting enabled by low noise and drift is critical. Innova's core architecture makes even advanced modes straightforward. Two integrated configurable digital lock-in amplifiers enable advanced SPM modes such as scanning capacitance microscopy (SCM), Kelvin probe force microscopy (KPFM), electric force microscopy (EFM), piezo response microscopy and many more without the need for external hardware or third-party software. Innova's advanced modes come with unique features that offer true applications solutions. KPFM comes in two implementations, to provide the highest sensitivity for small potential variations yet also elimination of topographic artifacts for large potential variations. SCM comes with closed-loop constant dC/dV mode to ensure a constant excitation volume.

Beyond providing advanced modes for carrier profiling or conductivity mapping, Innova comes with Bruker's Dark Lift function. Building on Bruker's intelligent LiftMode™, Dark Lift performs electrical measurements while the AFM feedback diode is turned off. Only Dark Lift can truly ensure photoelectric artifacts are eliminated, rather than relying on model predictions.

### Applications

No matter your application—Innova is ready

- Materials Science
- Nanolithography
- Life Sciences
- Polymer Chemistry
- Solar and Semiconductor Devices

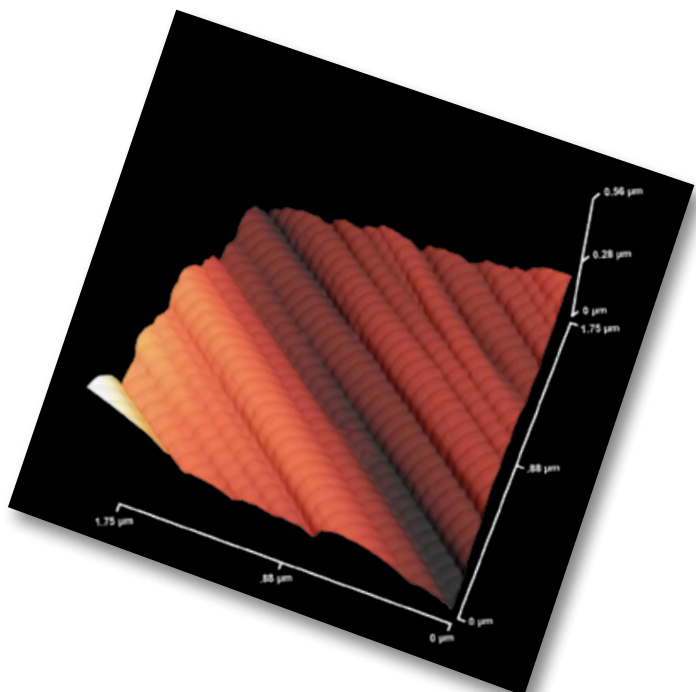


Topography of syndiotactic polypropylene showing fibrillar fine structure within large spherulites. 35µm image.

## Full Range of SPM Modes Available

The Innova offers a full complement of SPM techniques, making it ideal for applications ranging from photovoltaics to energy storage, from surface science to device characterization, and from biomolecules to semiconductors. A host of standard and optional scan modes provides complete surface characterization of samples in both air and liquid.

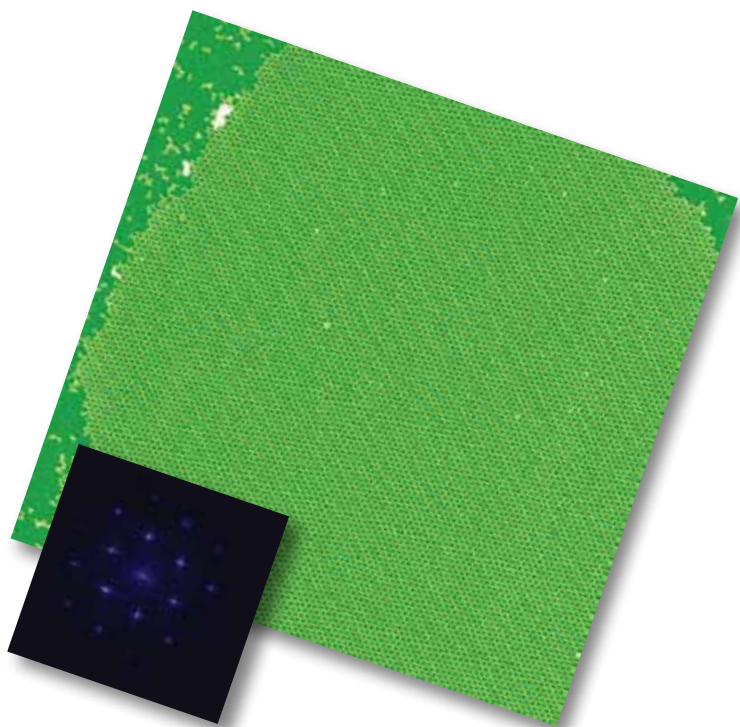
- Contact Mode
- TappingMode™
- PhaseImaging™
- LiftMode
- Dark Lift
- Nano-Indentation
- Nanolithography
- Open Hardware Access
- Device synchronization
- Piezo Response Microscopy
- Magnetic Force Microscopy (MFM)
- Electrostatic Force Microscopy (EFM)
- Force Modulation Microscopy (FMM)
- Scanning Tunneling Microscopy (STM)
- Low-Current Scanning Tunneling Microscopy (LC-STM)
- Electrochemical Scanning Probe Microscopy (ECSPM)
- Single & dual-pass Kelvin Probe Force Microscopy (KPFM)
- Conductive Atomic Force Microscopy (CAFM)
- Scanning Capacitance Microscopy (SCM)
- TERS-enabled AFM-Raman integration (IRIS™)
- Nano Thermal Analysis (VITA™)



Rat tail collagen clearly showing the characteristic 67nm banding. Image size 1.75µm. Closed-loop.



Individual triangular self-assemblies of origami-DNA on mica, imaged in liquid. Image size 250nm. Closed-loop. Revealing individual strands and fine structure at the connection points. (Sample courtesy of P. Rothmund, Caltech.)



1k x 1k pixel image of an engineered DNA network. Image size 3µm. Closed-loop. The fine detail visible due to the absence of noise or damage readily reveals the high symmetry and small but finite defect density. Individual building blocks can be discerned at the edge. The Fourier Transform (inset) shows the complete absence of distortion or drift. (Sample courtesy of A. Koyfman, UCSB.)

## Innova Design Features

### *Customizable with open access*

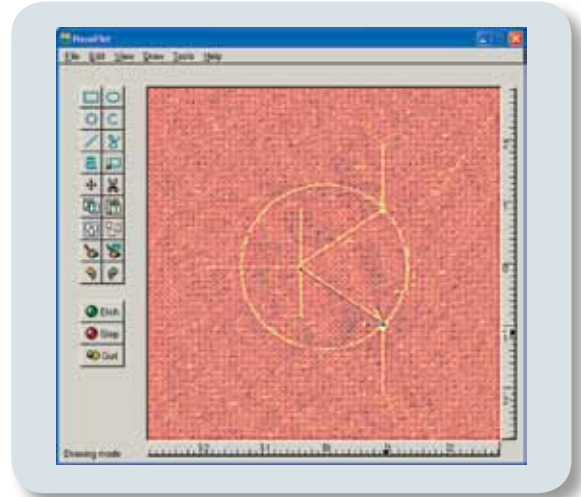
The Innova SPM provides excellent sample access, even when the microscope head is in place, without compromising the rigidity of the mechanical design. The physically open design provides flexibility for custom experiments, e.g., by allowing the easy insertion of electrodes for electrical and electrochemical sample characterization. The Innova control electronics provide built-in user access to I/O signals and software-configurable signal routing and processing.

### *Ready for nano-optics*

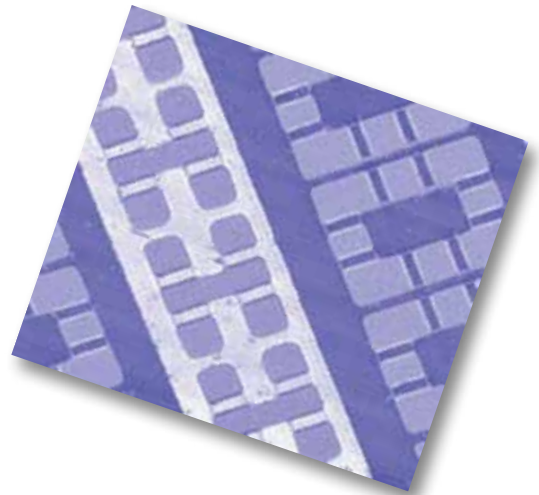
The physically open Innova head provides completely unobstructed optical access to the tip-sample junction, making Innova an ideal platform for near-field based nano-optics, including tip-enhanced Raman scattering (TERS). The optional Innova-IRIS accessory additionally provides an AFM head with even further increased optical access to the front of the AFM probe, optimizing the proven (opaque sample) off-axis TERS configuration, while also providing a near infrared feedback diode to eliminate spectral interference with Raman spectroscopy. Leveraging Innova's modular software, Innova-IRIS provides a handshaking communication protocol, enabling real-time point-and-shoot system control and data transfer with leading Raman spectrometers.

### *Flexible and versatile acquisition software*

The NanoDrive version 8 software incorporates a host of features to ensure real world productivity even in challenging experiments. Direct and intuitive access to all important scan and feedback parameters is combined with extensive real-time signal diagnostics and processing options to accelerate the scan optimization process. Imaging capabilities are enhanced by advanced features like LiftMode™ and Dark Lift and are complemented by several single-point spectroscopy modes and an easy-to-use nanolithography package. The interactive, closed-loop point-and-shoot positioning enables precisely targeted single-point spectroscopy, making it an ideal tool for semiconductor fault isolation as well as novel experiments such as the examination of local phase changes associated with electrical switching behavior. Designed from the ground up as modular code, the real-time control software offers many optional extensions, including an easy to use nanolithography package (NanoPlot), spectrometer control for AFM-Raman experiments (Innova-IRIS), as well as general-purpose device synchronization. Innova comes with the new complete, stand-alone NanoScope Analysis package with extensive analysis, processing, and display options for images and single point spectroscopy curves and a seamless link into real-time control. Data from partially acquired images can be fully analyzed at any time during the acquisition process without interrupting ongoing image acquisition.



Nanolithography with the new NanoPlot package.  
Anodic oxidation on silicon.

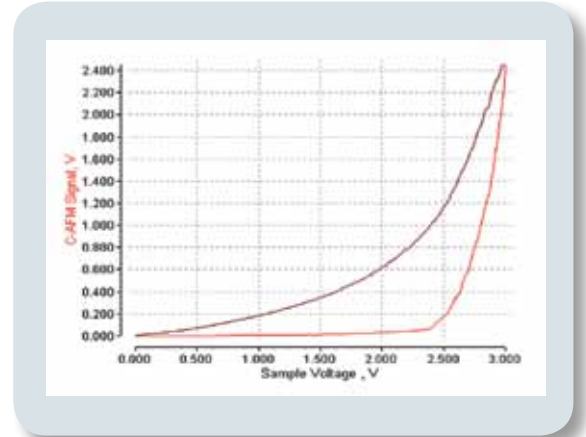


Scanning capacitance data of a silicon DRAM cell. The 2-D dopant profile provided by dC/dV measurements allows the visualization of device defects and the extraction of critical parameters, such as gate lengths. Image size 25µm. This image was acquired in CL-SCM-dark-lift mode, ensuring accurate and artifact-free dopant mapping.





The experiment selector completely preconfigures the system for a wide range of selectable experiments. It is ideal for multi-user settings. The sophistication of the predefined experiments offers beginners a fast path to expert results, while at the same time advanced users can define and save specific configurations exclusively for their own use.



Closed-loop IV curve probing the phase change of a material with possible memory applications. Comparison of the ramp up (red) and ramp down (brown) curves reveals the field-induced change in electrical properties. Current signal is output of  $10^4$  V/A amplifier,  $5k\Omega$  resistor in series. (Sample courtesy of Prof. Wright, University of Exeter.)



Piezoforce lithography on thin PZT film.

# Innova Specifications

<b>Sample Size</b>	45mm x 45mm x 18mm
<b>Motorized Z stage</b>	Z travel: 18mm, with pitch and tilt capability
<b>Closed-Loop, Large Area Scanner</b>	XY > 90µm, Z > 7.5µm
<b>Open-Loop, Small Area Scanner</b>	XY > 5µm, Z > 1.5µm
<b>Noise Floor, Z</b>	<50 pm RMS, typical imaging bandwidth
<b>Closed-loop XY noise</b>	<1.2 nm RMS, typical imaging bandwidth
<b>Z-Linearizer noise</b>	<200 pm RMS, typical imaging bandwidth
<b>Open-loop XY drift</b>	<1nm/ min
<b>Closed-loop XY drift</b>	<3nm/ min
<b>Warm-up Time Open-loop</b>	15min
<b>Electronics</b>	20-bit DAC scan control, 8 x 100kHz +/- 10V ADCs Digital force and position feedback, programmable and controllable through external signals Integrated SW configurable signal access and routing 2 x Full digital lock-ins
<b>Optics</b>	On-axis, FOV 1.25mm - 0.25mm 5x motorized zoom, software controlled <2µm resolution (0.75µm resolution with 50x) 10x objective (50x optional)
<b>System Software</b>	NanoDrive v8 real-time control & NanoScope Analysis included
<b>AFM Modes</b>	<b>Standard:</b> Contact Mode, TappingMode™, PhaseImaging™, LiftMode™, Magnetic Force Microscopy (MFM), Electrostatic Force Microscopy (EFM), Dark Lift, Lateral Force Microscopy, Nano-Indentation, Force Spectroscopy, <b>Optional:</b> Scanning Tunneling Microscopy (STM), Low-Current Scanning Tunneling Microscopy (LC-STM), Force Modulation Microscopy (FMM), Piezo Response Microscopy, Electrochemical Scanning Probe Microscopy (ECSPM), Single & dual-pass Kelvin Probe Force Microscopy (KPFM), Conductive Atomic Force Microscopy (CAFM), Scanning Capacitance Microscopy (SCM), Nanolithography, Open Hardware Access, Device synchronization, TERS-enabled AFM-Raman integration (IRIS), Nano Thermal Analysis (VITA)
<b>Weights and Measures</b>	<b>Microscope:</b> 14" x 14" x 10" or 35.5cm x 35.5cm x 25.5cm (HxWxD); 26.5Lb or 12Kg Add 4" or 10cm in rear for cables <b>Controller:</b> 23" x 13.5" x 21" or 58.5cm x 34.5cm x 53.5cm (HxWxD); 73Lb or 33Kg Add 4" or 10cm in rear for cables
<b>EH&amp;S Compliance</b>	CE

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## Cover images

Foreground: Innova Atomic Force Microscope.

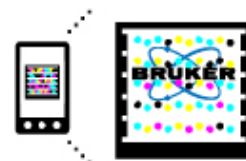
Background left: MFM phase image showing the magnetic domain structure on a rough nickel alloy surface. Innova's intelligent LiftMode™ enables the efficient acquisition of magnetic field information without topographic artifacts independent of sample roughness. Image size 22µm.

Background right: Topography of an oriented film of isotactic polypropylene, also known as the microporous membrane Celgard®. Oriented fibrillar regions are seen to be alternating with raised sections exhibiting a finer lamellar structure. Closed-loop scan linearization active. Image size 2.5µm.

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