

The world's most flexible AFM

NANOWizard[®] 4 NANOSCIENCE AFM



Fast scanning up to 3 sec/image for tracking of dynamic processes

Easy and intuitive high-resolution quantitative imaging with QI™ mode

Unique solutions for mechanical and electrical characterization of samples

Widest range of modes and accessories of any AFM

Fully flexible and modular design for the widest range of applications

JPK
Instruments

we have joined Bruker



NanoWizard® 4 NANOSCIENCE AFM

HIGHEST PERFORMANCE MEETS UTMOST FLEXIBILITY

Today's research topics in nanoscience are complex and therefore require a highly flexible AFM system. With the new NanoWizard® 4 AFM you are well prepared for any future research project.

HIGH RESOLUTION AND FAST SCANNING – COMBINED WITH A LARGE SCAN RANGE

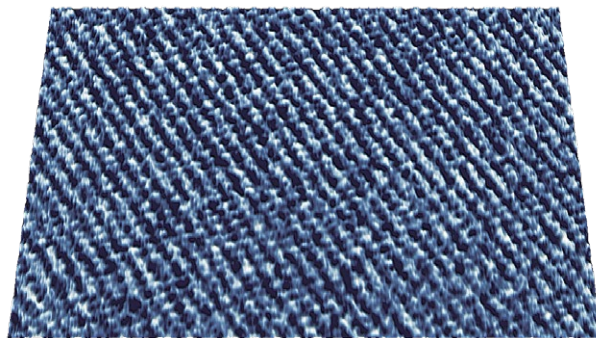
The NanoWizard® 4 NanoScience AFM combines closed-loop atomic resolution and fast scanning capabilities of up to 3 sec/image in a system with a large scan range of 100µm in XY. It has the lowest noise levels of the closed-loop scanner and of the deflection detection system. The powerful digital Vortis™ controller combines fast signal handling with lowest noise.

QI™ MODE – EASY IMAGING OF ANY SAMPLE

JPK's QI™ mode based on real force curves is perfect for obtaining quantitative data with highest resolution quickly and easily. The unmatched force sensitivity and perfect force control make the system ideal for any brittle, delicate, soft or sticky sample. Due to our wizard-technology, the system becomes more intuitive and easy-to-use for non-experts than any other AFM.

FLEXIBILITY AS A RESULT OF A MODULAR DESIGN

Due to JPK's leading tip-scanner technology and our consistent modular design philosophy, the NanoWizard® 4 is the most flexible system available on the market today. Perfect for optical integration and with the largest number of accessories and modes, it is the most versatile AFM system yet.



Atomic lattice resolution on calcite measured on inverted microscope in liquid. Scan size: 30 nm × 15 nm, XY closed-loop



Hexacontane C₆₀H₁₂₂ on HOPG. Adhesion image (range: 2 nN) measured with QI™ Mode in 3D. Stripes are monomolecular layers of Hexacontane. Scan size: 250 nm × 250 nm, XY closed-loop



NanoWizard® 4 NanoScience with TopViewOptics™ in JPK's table-top acoustic enclosure.

FAST SCANNING CAPABILITIES FOR INCREASED PRODUCTIVITY

THE BENCHMARK FOR FAST SCANNING WITH A LARGE SCANNER AFM

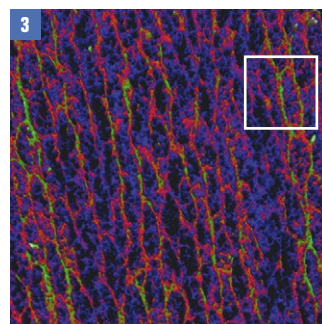
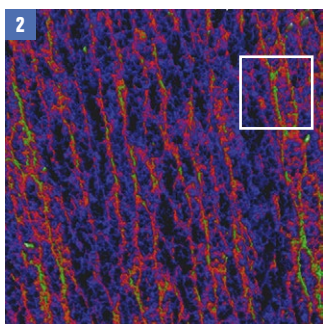
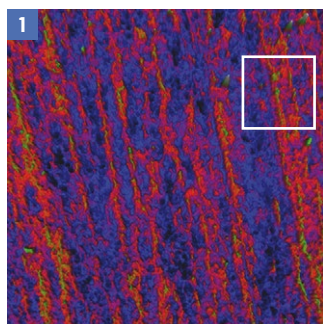
Thanks to the proven NanoWizard® ULTRA Speed scanner technology option, now available for the NanoWizard® 4, the 3 sec/image makes the new system more than 30 times faster than other AFMs with a large scan range.

The highest bandwidth for all system components, accurate force control and fast feedback – even with a large scanner – are the core elements of the new system. By using the movie creator function, data processing is easier than ever before.

OBSERVE SAMPLE DYNAMICS IN REAL-TIME

The fast scanning capabilities of the new generation NanoWizard® 4 deliver the speed and accuracy to understand phenomena such as crystallization, growth, melting, phase separations, domain building or island formation in real-time with highest spatial resolution.

With the unique tip-scanner, the system can perform heating, cooling, gas/fluid exchange and external mechanical force applications to study sample property changes in real-time.



Dynamic morphology changes of human dental enamel through acid interaction (10 mM HCl). Marked region shows the vanishing enamel prisms and the remaining dentin framework. Z-range: 250 nm. Scan size 50 μ m $\times$ 50 μ m, 600 μ m/sec tip-velocity. Sample courtesy: Dr. Christine Müller-Renno, TU Kaiserslautern, Germany, Prof. Dr. Matthias Hannig, Uniklinikum des Saarlandes, Germany



Phase images show a dynamic growth front of a polyhydroxybutyrate-co-valerate (PHB/V) spherulite crystallization. Scan size: 1.5 μ m $\times$ 1.5 μ m. Line rate: 21 sec/frame

FAST SCANNING BENEFITS

- Enhance productivity, probe more sample areas in the same time period
- Obtain a quick survey of your sample
- Observe changes and follow sample dynamics in real-time
- Perform time-lapse studies on polymers, thin films, advanced materials, capsules and others

FASTER SCANNING MEANS MORE THROUGHPUT

With the fast scan option and the ExperimentPlanner™ software module, the user can probe more spots within the scanning range and move with a motorized stage to the next scanning area.

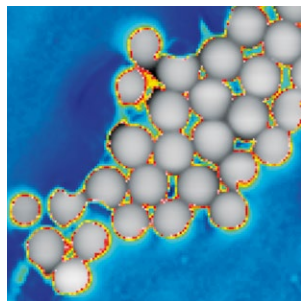
This is possible in a fully automated way to have a survey of the sample and find a region of interest quicker.

NANOMECHANICS IN PARTICULAR FOR SOFT AND ADVANCED MATERIALS

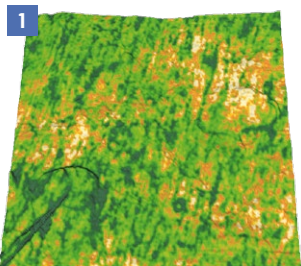
As an expert in force measurements, JPK provides a complete set of methods for characterizing mechanical properties such as hardness, viscoelasticity, deformation and adhesion. We provide the right solution, in particular, for very soft or delicate samples or for samples under external mechanical load.

QUANTITATIVE CHARACTERIZATION OF MECHANICAL PROPERTIES

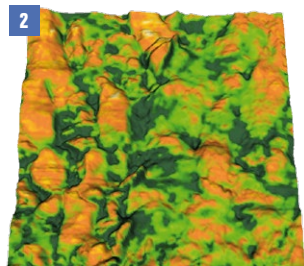
The new system comes with enhanced quantitative imaging capabilities for mapping mechanical parameters accurately and easily. JPK's QI™ Advanced mode, with its linear Z-movement and a full set of quantitative data in every pixel, allows the extraction of quantitative parameters such as elasticity, adhesion, dissipation, chemical forces or conductivity. The automated large Z-adjustment has been specifically developed for swelling samples or those with a rough topography. The enhanced data analysis capabilities – in particular for modulus



Micro rheology on silica beads ($d = 2 \mu\text{m}$) partially embedded into PDMS: Overlay of topography (grayscale) and loss modulus G'' (color texture) recorded at a modulation frequency of 100 Hz. Scan size: $15 \mu\text{m} \times 15 \mu\text{m}$



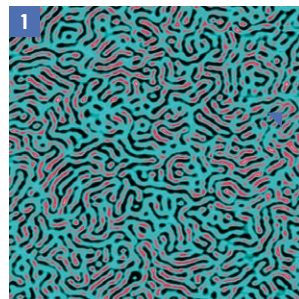
NanoWizard® 4 head on StretchingStage



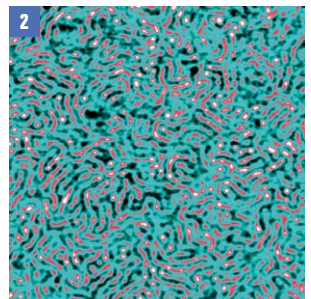
QI™ images of plastic film (1) before (color texture, range: 40 MPa) and (2) after (color texture, range: 400 kPa) stretching. 3D height image is overlaid with Young's modulus information. After stretching the plastic film shows a 100 times lower E-modulus and strong changes in topography. Scan size: $8 \mu\text{m} \times 8 \mu\text{m}$

FULL SET OF NANOMECHANICS MODES

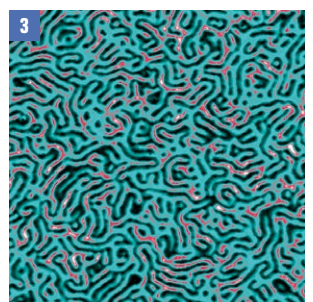
- QI™ Advanced mode with Contact Point Imaging (CPI)
- Contact resonance imaging mode
- Amplitude Modulation (AM), Phase Modulation (PM) and Frequency Modulation (FM)
- Higher harmonics techniques
- MicroRheology
- Force modulation
- Friction force microscopy
- Fast force mapping
- Single molecule force spectroscopy with ramp and clamp
- Colloidal probe
- NanoIndentation
- NanoManipulation
- Sample property changes under external mechanical tension with StretchingStage



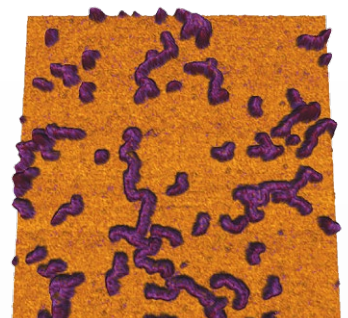
Kraton (styrenic block-copolymer) measured with QI™ mode



- 1 Height image (Z-range: 15 nm)
- 2 Adhesion image (range: 400 pN)
- 3 Young's modulus image (range: 160 MPa)
Scan size: $1 \mu\text{m} \times 1 \mu\text{m}$



Dendronized polymer (PG3, third generation) measured with QI™ mode on mica in ethanol. The JPK SmallCell™ was used to measure in a closed liquid volume smaller than $150 \mu\text{l}$. 3D height image with overlay of elasticity (color texture, range: 1 N/m). Scan size: $1 \mu\text{m} \times 1 \mu\text{m}$.



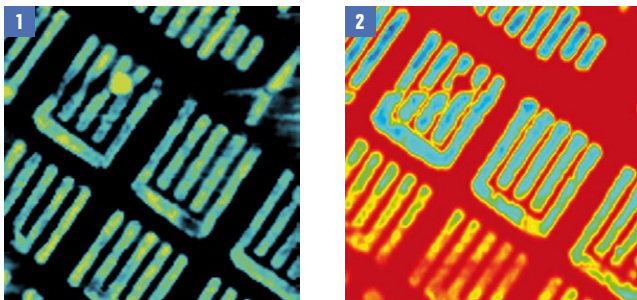
Sample courtesy: Prof. A.D. Schlüter, Institut f. Polymere, ETH Zürich, Switzerland

ENHANCED MATERIAL PROPERTIES MAPPING

The characterization of electrical, electro-mechanical or magnetic sample properties was always a difficult task, particularly on loosely attached, brittle or soft samples. The enhanced QI™-Advanced mode capabilities now makes this easy and straight forward. The new NanoWizard® 4 can be combined with a new Conductive AFM and Kelvin Probe (KPM) module with enclosed-volume for the investigation of samples in a controlled gas environment. In addition, the NanoWizard® 4 system comes with enhanced STM, Piezoresponse Force Microscopy (PFM), Scanning-Thermal AFM and electrochemistry options.

CONDUCTIVE AFM (C-AFM) WITH QI™ ADVANCED MODE

- Current measurement options from 0.1 pA to 10 µA
- Noise limit 100 fA RMS in imaging bandwidth
- Suitable for fragile or loosely attached samples thanks to QI™ mode
- C-AFM enclosed-volume module for controlled inert gas atmosphere

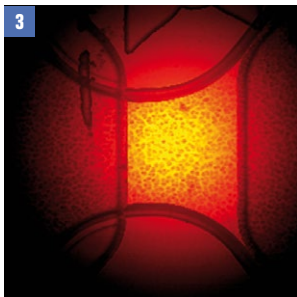
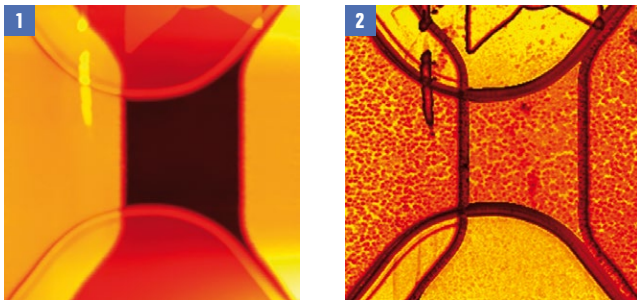


Conductive Atomic Force Microscopy (CAFM-QI™) on higher metal layer (core I5 processor, Intel)

- 1 Height image (Z-range: 10 nm)
- 2 Current image (range: 15 nA). Scan size: 1.4 µm × 1.4 µm

SCANNING THERMAL AFM WITH QI™ ADVANCED MODE

- Probes thermal properties of the sample with highest resolution
- Uses nanofabricated thermal probes to achieve unprecedented high spatial and thermal resolution and sensitivity



Scanning thermal microscopy measurement with VertiSense™ module on thermal calibration sample from Applied NanoStructures, Inc., imaged in QI™ mode with VertiSense™ Thermal Probes.*

- 1 Height image (Z-range: 600 nm)
- 2 Adhesion image (range: 9.5 nN)
- 3 Temperature information
Range: 55 °C
Scan size: 20 µm × 20 µm

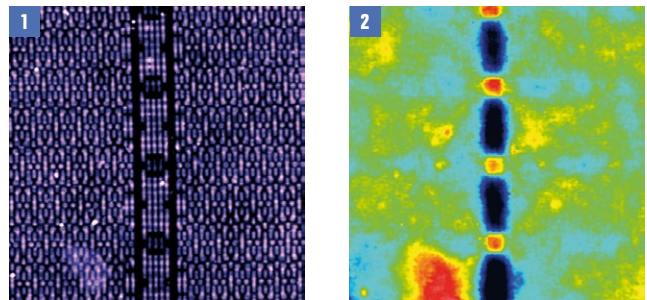
* VertiSense is trademark of Applied NanoStructures, Inc.

SCANNING TUNNELLING MICROSCOPY (STM)

- Measures surface electronic states using a tunneling current between a conductive tip and sample
- Tunnel currents with a noise limit of 100 fA RMS in imaging bandwidth

KELVIN PROBE AFM (KPM-AFM)

- Electrical surface potential measurements
- Optional enclosed-volume electrically connected cantilever holder for controlled inert gas environment

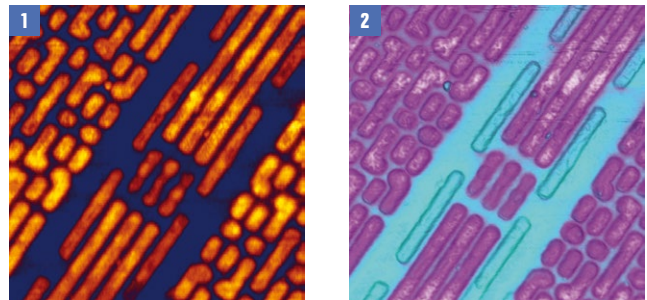


Kelvin Probe Microscopy (KPM, one-pass) on SRAM (Core I5 processor, Intel)

- 1 Height image (Z-range: 10 nm)
- 2 Surface potential (range: 50 mV). Scan size: 4.5 µm × 4.5 µm

ELECTRICAL FORCE MICROSCOPY (EFM)

- Electrical force gradient measurements between tip and sample
- State-of-the-art electrically connected cantilever holder with enclosed-volume for controlled inert gas environment

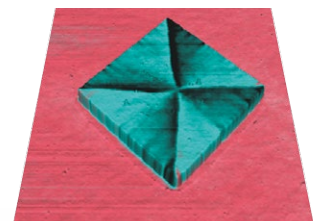


Electrostatic force microscopy (EFM, one-pass) on SRAM (Core I5 processor, Intel)

- 1 Height image (Z-range: 10 nm)
- 2 Overlay of electrostatic force signal (color texture range: 30 mV) and 3D topography
Scan size: 1.4 µm × 1.4 µm

MAGNETIC FORCE AFM (MFM)

Local magnetic force gradient distribution measurements between magnetic cantilever tip and sample.



Overlay of magnetic force information and 3D height image on NiFe square structure. Magnetic domains and Landau pattern are clearly visible. Scan size 8 µm × 8 µm. Sample courtesy: Dr. Katrin Schultheiss, Institute of Ion beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Germany

A NEW LEVEL OF USER-FRIENDLINESS

HIGH QUALITY IMAGES WITH “JUST 4 CLICKS”

The improved QI™ mode with lowest noise level delivers outstandingly clear, quantitative images at the highest resolution with “just 4 clicks”. Due to the wizard-technology, every user can easily obtain high-quality data. QI™ is based on real force curves, so mechanical, electrical, magnetic, chemical and bio-functional interactions are now more precise and easier to measure than other methods.

AUTOMATED WORKFLOW WITH HYBRIDSTAGE™

The HybridStage™ is a newly developed modular, piezo-based sample scanner stage with motorized coarse XY sample movement. Large area mapping of micro-spheres or capsules, printed 3D structures and micro/nano structured surfaces over millimeter distances is now easily possible. The HybridStage™ in combination with the ExperimentPlanner™ software module guarantees an automated and streamlined workflow.

The new ExperimentControl™ feature on a tablet



FULL CONTROL OVER EXPERIMENTS DELIVERS RESEARCH QUALITY RESULTS

With the RampDesigner™ and the ExperimentPlanner™ software features, the user can easily design complex experiments. The ExperimentControl™ feature simplifies setting up the instrument, remotely controls and monitors complex and long-term experiments via the internet (by a computer, tablet or smartphone), delivers a continuous status update. A comprehensive data analysis package with advanced calibration algorithms, visualization routines and expanded usability supports the user.

ERGONOMICS AND EASE OF OPERATION FOR A STRESS-FREE WORKFLOW

The newly developed graphical user interface with ergonomic design and “optical-style” GUI enables better contrast. This prevents eyestrain and makes operation more intuitive during long term optical experiments.

A large single screen ensures a compact and streamlined workflow. Fully packed with easy-to-use features and with our legendary customer support the NanoWizard® 4 is perfect for beginners and experts.



◀ NanoWizard® 4 on HybridStage™

EXPANDED USER-FRIENDLINESS

- Easy and straight-forward highest resolution imaging of any sample with QI™ mode for beginners and experts
- Highest quality mechanical and electrical sample property mapping by QI™ Advanced mode
- Unique design of force curve patterns with the RampDesigner™ for force spectroscopy applications
- Advanced algorithms for experimental workflow with the ExperimentPlanner™
- ExperimentControl™ feature for remote control of experiments
- Automated workflow with the motorized stage or the HybridStage™
- Fast batch-processing of data and images with comprehensive fitting routines

HIGHEST FLEXIBILITY AND MODULARITY

JPK's NanoWizard® 4 delivers the flexibility and modularity necessary for all future applications.

COMPREHENSIVE MATERIAL PROPERTIES CHARACTERIZATION

- Mechanical properties (visco-elasticity, hardness, adhesion, deformation)
- Electrical properties with Electrical Force Microscopy, Conductive-AFM, Kelvin Probe AFM (KPM), Scanning Tunneling Microscopy (STM)
- Magnetic properties with MFM
- Electro-optical properties with photo-conductive AFM
- Local thermal properties by scanning thermal AFM (SThM)



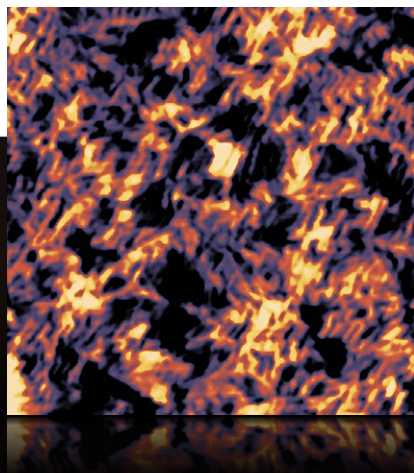
◀ Cantilever holder with electrical tip connection (enclosed volume)

IN-SITU AFM DURING CHANGE OF SAMPLE PROPERTIES BY EXTERNAL LOADS

- Piezoresponse Force Microscopy with high voltages (PFM)
- Observe samples under external load with the new StretchingStage
- Apply external magnetic fields
- NanoLithography and NanoManipulation
- Electro-chemistry & scanning electrochemistry (SECM)

SAMPLE ENVIRONMENTAL CONTROL OPTIONS

- Sample heating from ambient to 300 °C
- Sample cooling from ambient to -35 °C
- Cryo-AFM down to -120 °C with CryoStage
- Defined sample humidity
- Perfect for experiments in fluids, even harsh or aggressive ones, with the SmallCell™
- Experiments with controlled gas flow
- Experiments under demanding environments in a glove box



◀ Topography image of crystalline polyethylene (Z-range: 15 nm) measured at -120 °C with JPK CryoStage, Scan size: 2 µm × 2 µm

OPTICAL INTEGRATION FOR CORRELATIVE RESULTS

- Inverted optical microscope integration
- Optical side-view of the samples with high resolution
- Upright optical microscope integration with Upright Fluorescence Microscopy (UFM) Kit or BioMaterials™ workstation
- Fluorescence and confocal laser scanning integration (CLSM)
- Optical Superresolution combination (STED, TIRF, PALM/STORM)
- Fluorescence spectroscopy techniques (FLIM, FRET, FCS, FRAP...)
- Raman experiments even TERS
- Near-field optical experiments



▲ The new Sample Humidifier module



▲ Piezoresponse Force Microscopy (PFM) of ferroelectric polymer (P(VDF-TrFE)) on gold backelectrode on silicon. A sequence of voltage pulses was generated from the grayscale of the JPK-logo bimap template (black = -20V, white = +20V) to write the logo into the samples piezoelectric polarization. 3D vertical PFM-phase (range: 180°), scan size: 12 µm × 30 µm

EASY AND COST EFFECTIVE UPGRADABILITY BY CONSISTENT MODULAR DESIGN

- Different head options
- Vortis™ controller to Vortis™ Advanced or Vortis™ Combi controller
- Powerful software modules
- Largest number of accessories and modes of any AFM system



▲ NanoWizard® 4 setup with CryoStage

SPECIFICATIONS FOR THE NanoWizard® 4 NANOSCIENCE AFM

System specifications

- Atomic lattice resolution even on inverted microscope (< 0.030 nm RMS Z noise level)
- Ultra-low noise level of cantilever deflection detection system < 2 pm RMS free (0.1 Hz - 1 kHz) and high detector bandwidth of 8 MHz for high speed signal capture
- Tip-scanning, stand-alone system, with a rigid low-noise design and drift-minimized mechanics – the best choice for simultaneous AFM and laser scanning experiments
- IR deflection detection light source with low coherence for interference-free measurements
- The only liquid-safe AFM with integrated vapor barrier, special encapsulated piezo drives and tip-moving design
- Transmission illumination with standard condensers for precise brightfield, DIC and phase contrast
- Scanner unit
 - Best closed-loop AFM on the market for reproducible tip positioning and long time position stability
 - 100 × 100 × 15 μm³ scan range
 - Position noise level < 0.15 nm RMS in XY (in closed-loop) and 0.06 nm RMS sensor noise level in Z (3 kHz bw)

Vortis™ SPMControl electronics

- State-of-the-art digital controller with lowest noise levels and highest flexibility

SPMControl software

- True multi-user platform (perfect for imaging facilities)
- User-programmable software
- Fully automated sensitivity and spring constant calibration using thermal noise or Sader method
- Patented DirectOverlay™ for combined optical and AFM information
- Outline™ mode for precise selection of a new scan area in the optical image
- Improved ForceWatch™ mode for force spectroscopy and imaging for cantilever-drift-free measurements
- Comprehensive force measurement with TipSaver™
- Advanced spectroscopy modes such as various force clamp modes or ramp designs, e.g. for temperature ramps, pulling speed or force feedback
- Powerful Data Processing (DP) functions with full functionality for data export, fitting, filtering, edge detection, 3D rendering, FFT, cross section, etc.
- Powerful batch processing of force curves and images including WLC, FJC, step-fitting, JKR, DMT model and other analyses

Stages and sample holders

- Stages are available for all major inverted optical microscope manufacturers such as Zeiss, Nikon, Olympus and Leica
- Motorized precision stage with 20 × 20 mm² travel range with joystick or software control
- Manual precision stage with 20 × 20 mm² travel range
- Holders for Petri dishes, coverslips, microscope slides or metal SPM discs are available
- Special holders and liquid cells possible
- Ø 140 × 18 mm³ free sample volume

Optical configurations

- Fits on inverted microscopes from
 - Zeiss (Axio Observer, Axio Vert 200, Axio Vert A1)
 - Olympus (IX line)
 - Nikon (TE 2000, Ti line) and
 - Leica (DMI/DMI lines)
- for AFM simultaneously with optical microscopy
- Fully simultaneous operation with optical phase contrast and DIC using standard condensers
- Combine AFM with advanced commercial confocal microscopes and fluorescence optical techniques such as FCS, FRET, TIRF, FLIM, FRAP, STED, STORM/PALM, SIM and more
- Exact positioning and overlay of optical and AFM data with the unique JPK DirectOverlay™ software module
- Upgradeable for scatter-type SNOM, Raman, TERS measurements
- Superior stability when using immersion lens optics with highest NA in combination with a coverslip based sample holder
- TopViewOptics™ video optics for opaque samples
 - Maximum flexibility even if no fluorescence is needed (the sample stage can be mounted on an optical microscope within a minute)
 - Free access to the sample area for micropipettes or electrical connections
 - TopViewOptics™ with 12 × zoom

BioMAT™ option (see BioMat™ brochure)

- For high-NA upright fluorescence optics combined with AFM on opaque samples
- Supports upright research microscopes such as Zeiss Axio Imager and AxioScope, Olympus BX51/53 and BX FM as well as LEXT, Leica DM 4000/5000
- Upright Fluorescence Microscopy (UFM) Kit
 - Enables the combined use of AFM and optical fluorescence microscopes such as Zeiss Axio Zoom V16, Leica MacroScope Z16 ApoA, Olympus MVX 10 MacroView
- Large variety of camera options
 - High-end EM-CCD cameras such as models from Andor (iXon), Hamamatsu and Photometrics (Evolve)
 - sCMOS cameras from Andor (Zyla) or Hamamatsu (Orca)
 - CCD and CMOS cameras from Jenoptik, IDS or µEye

Temperature control options

- Ambient to 300 °C temperature range with 0.1 °C precision with the JPK High Temperature Heating Stage (HTHS™)
- 35 °C to 120 °C temperature range with 0.1 °C precision with the JPK Heating Cooling Module (HCM™)
- 120 °C sample cooling with JPK's CryoStage

Fluid cell options

- Inert glass standard cantilever holders for experiments in droplets or custom fluid cells
- JPK's patented BioCell™ for high-NA immersion lenses and high resolution AFM down to the single molecule level, allows temperature control between 15–60 °C, perfusion and gas flow, made for standard cover slips
- CoverslipHolder offers the same performance as the BioCell™ for ambient temperature experiments
- Temperature controlled electrochemistry cell ECCell™ with transmission illuminations
- PetriDishHeater™ and PetriDishHolder perfect for living cells
- SmallCell™ small volume version for minimized volumes (< 60 μl) and with 3 perfusion ports
- SmallCell™ for harsh and aggressive media (< 150 μl)

Integrated flexibility from a wide range of accessories

- (see accessories handbook)
- Different sample holders, cantilever holders and stages for every application
- Large choice of temperature controls (for ambient, liquid and gas), liquid cells even for aggressive solvents
- JPK's ForceWheel™ handheld accessory for most sensitive experiment control
- Full experimental control by scripting functionality and access to all signals with the ExperimentControl™ feature
- JPK's sample StretchingStage
- CellHesion® module with extra 100 μm closed-loop Z-range
- TAO™ module with 100 × 100 μm² or 100 × 100 × 10 μm³ closed-loop sample scanning stage
- Vortis™ Advanced SPMControl station for maximum flexibility
- Comprehensive selection of electrical measurement modes
- Vibration and acoustic isolation from leading suppliers

Modularity and future upgrade pathways

- Simple and cost-effective upgrade paths are available for NanoWizard® 3 to NanoWizard® 4
- System can be upgraded to a NanoWizard® ULTRA Speed head, a CellHesion® 200 head or a ForceRobot® 300 head

NanoWizard® 4 AFM with ▶

Zeiss AxioImager and JPK BioMaterials Workstation



STANDARD OPERATING MODES

Imaging modes

- Easy-to-use QI™ mode for perfect imaging
- Contact mode with lateral force microscopy (LFM)
- AC modes with phase detection

Force measurements

- Static and dynamic spectroscopy
- Fast force mapping

OPTIONAL MODES

- Fast scanning option up to 3 sec/image
- QI™ Advanced mode for quantitative data
 - Mechanical properties such as adhesion, elasticity, stiffness, deformation
 - Conductivity and charge distribution mapping
 - Contact Point Imaging (CPI) with zero force
 - Molecular recognition imaging for binding site mapping
- HyperDrive™ mode for highest resolution imaging in fluid
- Advanced AC modes such as Frequency Modulation (FM) and Phase Modulation (PM) with Q-control
- Higher harmonics imaging
- MicroRheology
- Kelvin Probe Microscopy (KPM) and Scanning Capacitance Microscopy (SCM)
- MFM and EFM (see also QI™ mode)
- Conductive AFM (see also QI™ mode)
- Scanning Tunneling Microscopy (STM)
- Electrical spectroscopy modes
- Piezoresponse Force Microscopy (PFM)
- Electrochemistry with temperature control and optical microscopy
- NanoLithography and NanoManipulation
- Nanoindentation
- Scanning Thermal AFM (SthM)
- JPK ExperimentPlanner™ for designing a dedicated measurement workflow
- JPK RampDesigner™ for custom designed force curve segments for clamp and ramp experiments
- ExperimentControl™ feature for remote experiment control
- Environmental control options
- DirectOverlay™ for combined AFM and optical microscopy
- Additional XY or Z sample movement stages available with CellHesion®, TAO™ and HybridStage™ module

NanoWizard, CellHesion, TAO, BioMAT, NanoTracker, ForceRobot, Vortis, DirectOverlay, HyperDrive, ExperimentPlanner, ExperimentControl, RampDesigner, ForceWatch, TipSaver, HybridStage, BioCell, SmallCell, ECCell, HTHS, HCS, HCM, TopViewOptics, PetriDishHeater and QI are trademarks or registered trademarks of Bruker Nano GmbH.