NTEGRA

PROBE NANOLABORATORY

IT'S TIME FOR I**NTEGRA**TION!

NTEGRA

PROBE NANOLABORATORY

NTEGRA's name is derived from many sources.
It came from classical languages for ages associated with pure science. In Latin, word 'integer' means perfect, absolute, or complete. The concept of 'completeness' refl ects the NanoLaboratory concept: each system serves as a core for the whole laboratory. Moreover, ancient roots can be seen in the name of every model – from Solaris and Prima to Vita and Spectra.
The fi rst two letters in NTEGRA are closely connected with our company name, NT-MDT SI, which in turn refers to the initial letters in word NanoTechnology.

Over the last 28 years, NT-MDT has been involved in the development, production and support of research instrumentation, primarily, atomic force microscopes (AFM) and its combinations with ultrahigh resolution spectroscopy for nanotechnology and its applications. Our pathway has been marked by the creation of a large number of devices, whose functions and capabilities cover the broad range of customer needs in different areas: university education, academic and industrial research. NT-MDT pioneering efforts led to the impressive combination of scanning probe microscopy with Raman spectroscopy.

NT-MDT Spectrum Instruments is the result of the reorganization of NT-MDT corporate structure to maintain its lead in AFM and AFM – nano-Raman/IR. In the new form, NT-MDT's businesses are represented by companies in Russia, Europe, USA and China.

We are also proud to deliver to our customer's one the best after sales technical and applications support, in comparison to other manufacturers worldwide.

Customer, Technology, Integrity – this is the foundation of our company that helps us to be a leader in nanoscale analysis worldwide for decades.

"Over the last 25 years, we achieved spectacular results with NT-MDT team, by developing and manufacturing superior AFM systems for labs all over the word. As scientific community demands more and more comprehensive systems to explore nano-world, we decided to reorganize structure of our company into the NT-MDT Spectrum Instruments Group to expand our capabilities. This will help us to expand wide range of AFM modes, such as quantitative nano-mechanical, electrical and other measurements with methods of vibrational spectroscopy (nano-Raman, IR, s-SNOM and other). As the leader in Atomic Force Microscopy for the decades, we strive to deliver cutting edge technology systems to our customers and bring their labs to a new research level ".

Honorary President of NT-MDT Spectrum Instruments Group
The founder of NT-MDT Bykov V.A

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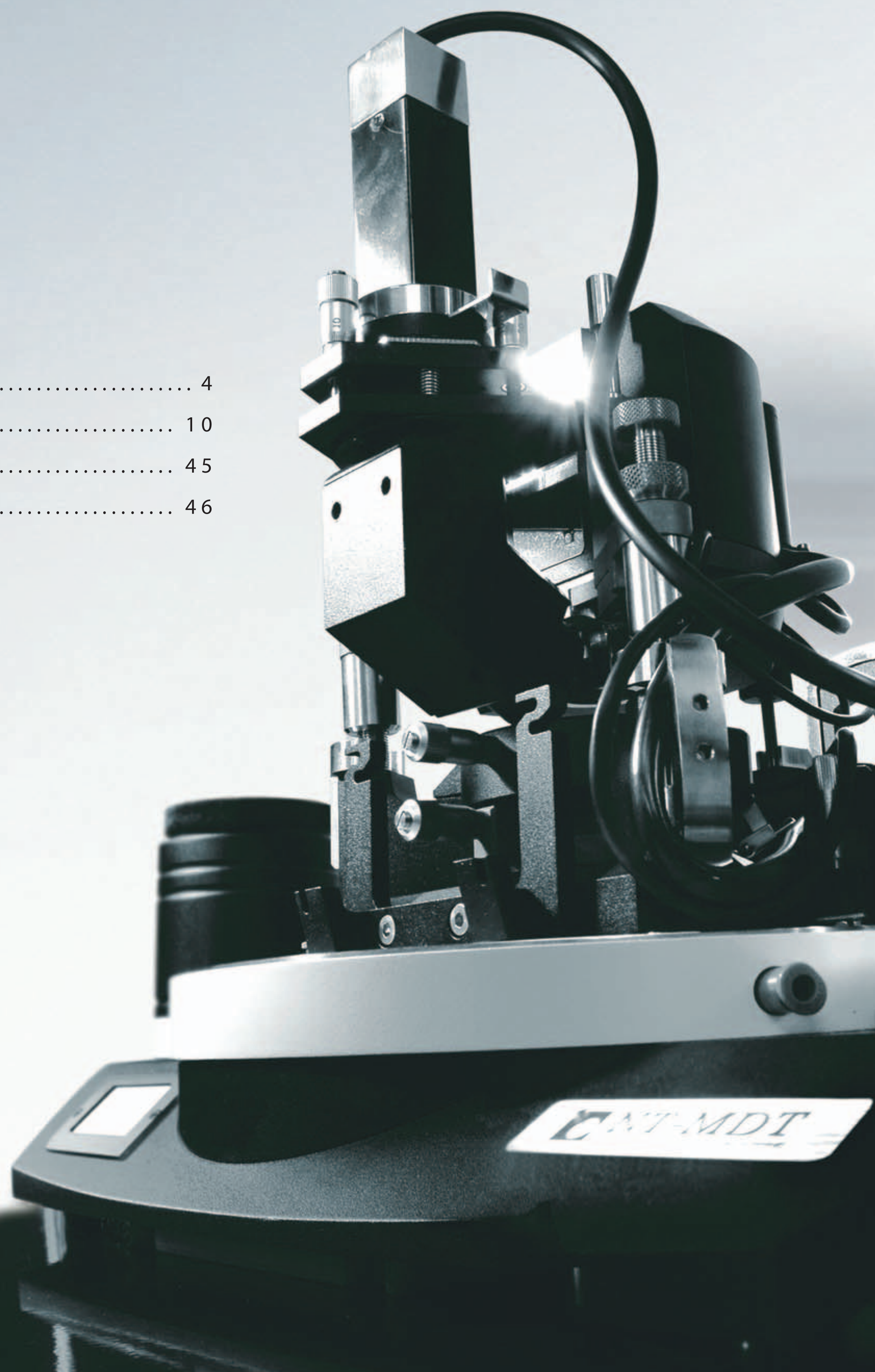


ntroducing **NTEGRA**

NTEGRA Prima

NTEGRA Spectra

NTEGRA Therma

NTEGRA Tomo

NTEGRA

NTEGRA Aura

NTEGRA Vita

NTEGRA Maximus

NTEGRA Solaris

Central to NT-MDT's philosophy of the integrated lab is NTEGRA line

NTEGRA concept

NTEGRA is a revolutionary technological concept. It was designed specifically to form an SPM based platform within which cutting-edge methods from other scientific analyses such as spectroscopy and sample preparation could be integrated. All the systems assembled on **NTEGRA** platform share the same SPM core, electronic controllers, and software. As a result, any **NTEGRA** base unit built for one particular application can easily be modified into a system suitable for another, very different application. The result: a complete solution for research and industry which provides a scientist with groundbreaking results.

One integrated concept, many built-for-purpose models

Currently NT-MDT SI offers eight versions of the systems assembled on the **NTEGRA** platform. For superior performance, each system has its own application specialization.

NTEGRA Prima is a high-resolution, low-noise SPM ideal for the multi-user labs. Integrated optics coupled to the SPM provides imaging of samples with almost continuous zoom from the millimeter to angstrom range.

NTEGRA Therma is an effective solution for SPM measurements either at constant temperatures from -30 °C to 300 °C or with changing temperature. Our low-drift THead™ maintains a drift of less than 10 nm/°C.

NTEGRA Aura is a high-sensitive system perfectly suited for measurements in vacuum up to 10^{-3} torr or under controlled atmosphere environments.

NTEGRA Maximus performs high throughput screening of multiple samples as well as measurements on large samples.

NTEGRA Solaris uses Scanning Near-Field Optical Microscopy (SNOM) to investigate optical properties beyond the diffraction limit.

NTEGRA Vita combines the strengths of the excellent SPM with perfect optical microscope for biological and medical applications.

NTEGRA Tomo, industry-leading NT-MDT SI invention, integrates the SPM with an ultramicrotome to perform AFM tomography and 3D reconstruction of biological and materials ultrastructure never seen before.

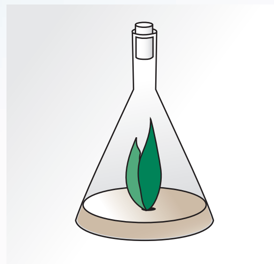
NTEGRA Spectra, the R&D 100 award winner in 2006, integrates the SPM with Raman spectroscopy and laser confocal microscopy to study the distribution of chemical properties with molecular resolution.

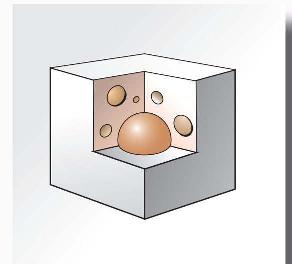
Combination of...

SPM

with

Spectroscopy

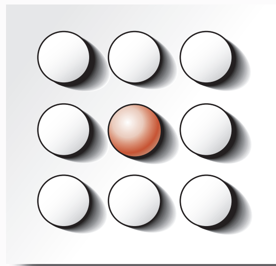

Controlled environment


3D tomography

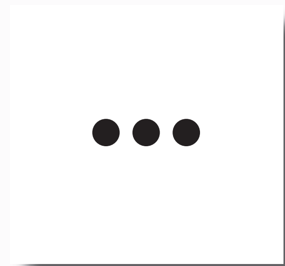
SPM was a method strictly oriented to a narrow sector of material sciences for many years. Times have changed. Today it is a part of the mainstream. There is hardly a branch of science from biology to chemistry, from physics to nanotechnology, where the SPM is not used. This wide-spread applicability dictates a new need for integration. The SPM has been called on to merge with the sophisticated infrastructure of the modern scientific laboratory.

Almost any of today's serious commercial SPM can be adapted to work in vacuum or in controlled gaseous or liquid environment, but to date, none have achieved real integration of multiple methods, including non-SPM techniques, within a global and convenient interface. NT-MDT SI has answered the call, launching the new **NTEGRA** Probe NanoLaboratory. **NTEGRA** allows the sample of interest to be studied by powerful and up-to-the-minute non-SPM methods without compromising SPM quality. It uniquely integrates SPM with optical observation, chemical composition mapping, and even nano-tomography, opening a new universe of correlative analyses applicable to all areas of modern science. Furthermore, its open architecture in hardware, software, and signal integration provides a portal for you to customize and expand this list to fit your applications.

Optical methods



High throughput screening



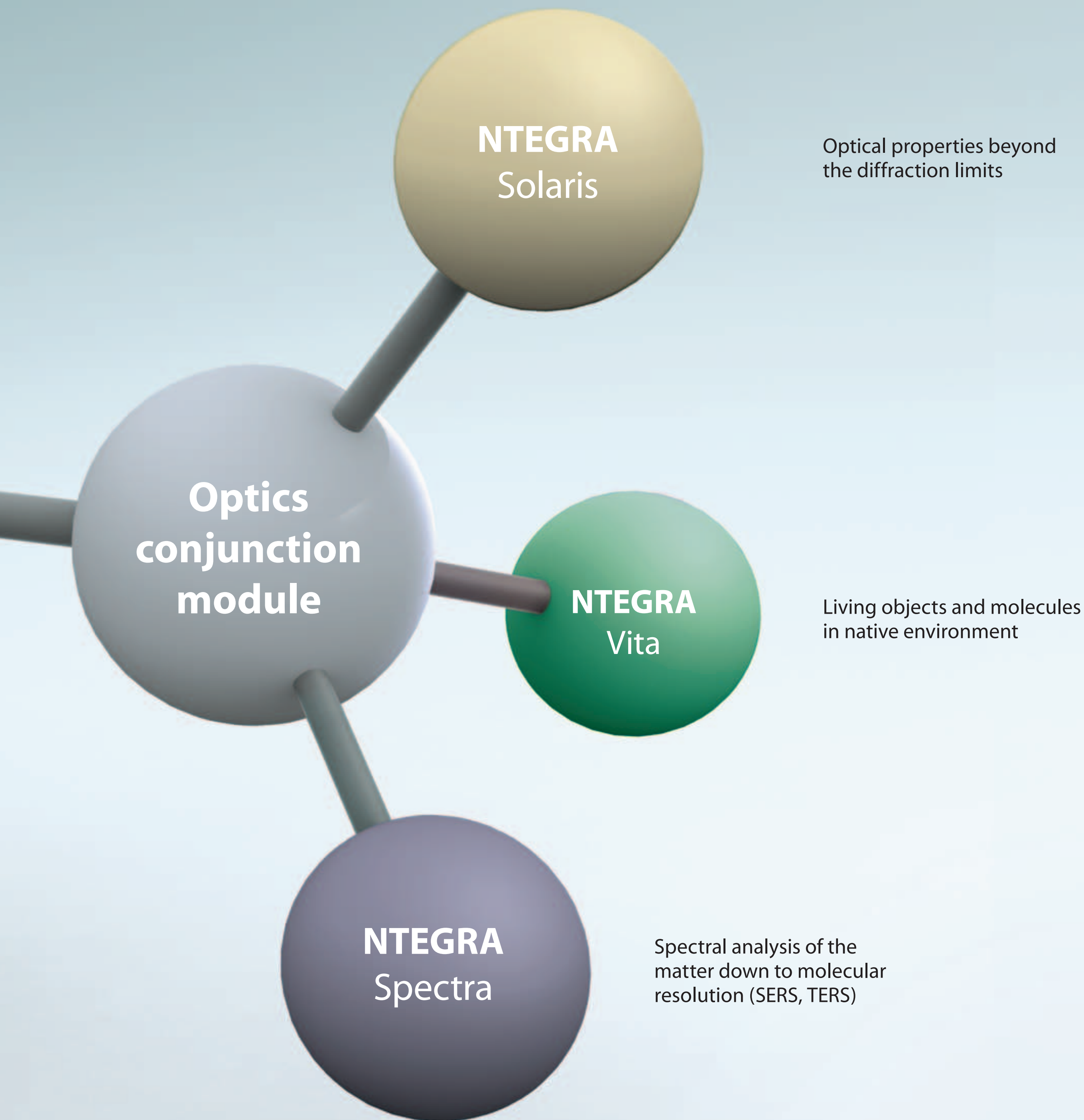
Other non-SPM methods

Smart solution for instrument re-specialization

What do you do when your lab is involved in multiple distinct projects requiring SPM-based instruments with radically different focus? Should you invest in multiple devices? Should you spend the time learning multiple pieces of software? Relinquish space for multiple instruments? Contact multiple service teams for support and tuning? And what happens when still another researchers joins you? Add still further complexity?

NTEGRA offers an elegant solution. Universal platform design, universal electronics, universal software — all you need to convert one **NTEGRA** model into another is to add the necessary accessory. No matter what the configuration, **NTEGRA** will retain its excellent quality and performance. Find your area of interest on the pages below and contact us to set up the most versatile system for you.

NTEGRA Probe Nanolaboratory: SPM that grows as your lab grows.



Optical properties beyond the diffraction limits

Living objects and molecules in native environment

Spectral analysis of the matter down to molecular resolution (SERS, TERS)

odel line

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Benefit from precise motion

Integration + Precision =

Quality measurements, Comfort, and Confidence

NTEGRA Prima couples exquisite scientific precision with unsurpassed flexibility to give you the ultimate power in scanning probe applications and measurements. Try NTEGRA Prima. Feel the quality of its superior engineering. See the exceptional imaging quality. Test drive the powerful but easy-to-use software and investigate its expandability. Enjoy the comfort and confidence of working with the highest quality scientific instrumentation.

One Core, unlimited functionality

NTEGRA Prima brings extraordinary freedom to your research. Now, one system can be used to investigate tiny, large, even massive samples. NT-MDT SI DualScan™ mode extends the conventional scanning range to 200 µm. The scanning head can also be used as a portable, stand-alone device, making it possible to measure samples of unlimited size.

NTEGRA Prima's standard configuration includes everything necessary for atomic resolution imaging in ambient and even in fluid environment. Start with a simple scanner and base then, as your needs grow, choose from dozens of techniques available in **NTEGRA** Prima to analyze your sample surface.

Not only does **NTEGRA** Prima provide all of the conventional techniques such as topography, phase, and magnetic force measurements, it extends to techniques that are unique to NT-MDT SI. For example, NT-MDT SI scanning capacitance microscopy (SCM) maps variations in electron carrier concentration across the sample surface with the unprecedented sensitivity (1 aF), setting the international standard for capacitance measurements.

Another advanced technique – piezoresponse force microscopy (PFM) for high spatial resolution imaging is based on the deformation of the sample surface due to the converse piezoelectric effect and the analysis of the resulting surface displacement.

Quality and Precision — accurate, reproducible measurements

When working at the atomic scale, precision positioning is critical. To guarantee that precision, the full **NTEGRA** line features specifically engineered, built-in, closed loop capacitive sensors. Even when scanning areas are as small as 50x50 nm, their exceptionally low noise levels (down to 0.1 nm typically) allows **NTEGRA** to image and modify the surface with the sensors engaged. The reliable scanner feedback assures high accuracy in the quantitative measurements of interaction forces between the probe and sample surface

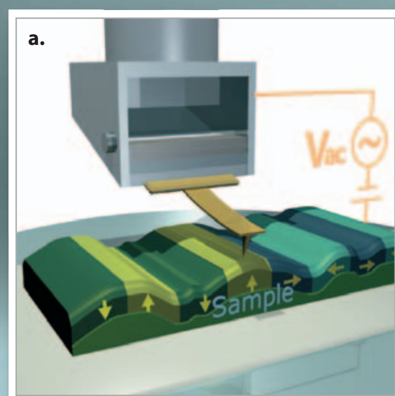
Focus on what's important

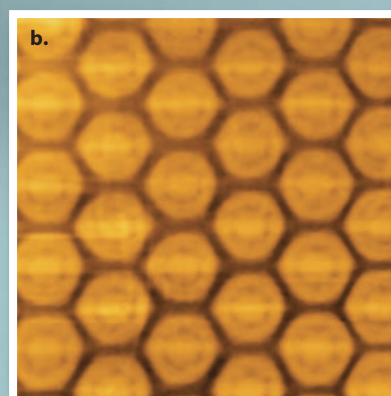
Using the integrated optical viewing system, find just the right area to measure. Zoom in to target your SPM tip on that exact area then control the scanning process in real time and compare optical image to the SPM information. Need still higher resolution? Drop the optical resolution on the **NTEGRA** Prima to 0.4 µm with the unique HRV (High Resolution Viewing) system. By combining the optical viewing system with either an STM or AFM head into one module, the HRV allows you to peer under the working probe. Interested in going to the next level? The same head provides laser input/output and focusing of the laser spot under the probe, expanding conventional scanning probe technology to include TERS[1] or apertureless SNOM[2] experiments on opaque samples.

One Core, Next-generation integration

NTEGRA Prima is just the beginning. Designed with totally open architecture for hardware, software, and signal integration, this nanolaboratory forms the platform for interfacing with advanced spectroscopy, microtomy, high-throughput screening and thermal accessories to form the next generation of integrated analytical instrumentation. Whether your SPM needs are simple or bleeding edge, **NTEGRA** Prima can form the foundation for successful imaging and measurement in your lab.

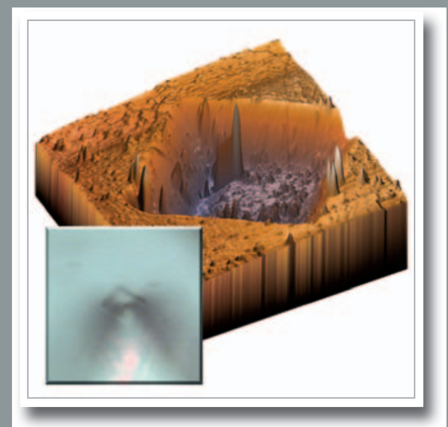
[1] Tip Enhanced Raman Scattering
[2] Scanning Near-Field Optical Microscopy



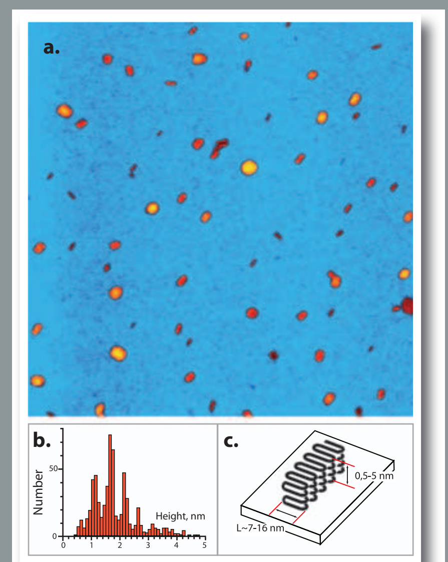


a) Piezoresponse force microscopy (PFM) b) Hexagonal domains in lithium niobate. PFM. Scan size 64x64 µm.
Image courtesy of T. Jungk, A. Hoffman, E. Soergel, University of Bonn

Silicon Test Echeloned Pattern STEPP. Monatomic step image with closed-loop on. Step height 0.31 nm. Scan size 7x7 µm



AFM image of a 5 µm crater and its optical image captured during the scanning process. The probe tip looks as a transparent "ghost" and does not obstruct optical imaging



a) UHMW-PE single-molecule nanocrystallites on mica. AFM Topography image. Scan size 800x800 nm
b) Typical histogram of the nanocrystallites height distribution for the population of 614 nanoparticles. The height is quantized with a step of approximately 0.5 nm (PE-chain diameter)
c) Simplified model of the nanocrystallite structure

Scanning probe microscopy

In air&liquid: AFM (contact + semi-contact + non-contact) / Lateral Force Microscopy / Phase Imaging/Force Modulation/Adhesion Force Imaging/ Lithography: AFM (Force)

In air only: STM/ Magnetic Force Microscopy/ Electrostatic Force Microscopy/ Scanning Capacitance Microscopy/ Kelvin Probe Microscopy/ Spreading Resistance Imaging/ Nanosclerometry/ Lithography: AFM (Current), PFM (optional)

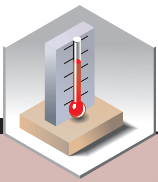
Specification \ Scan type		Scanning by sample	Scanning by probe*
Sample size		Up to ∅40 mm, up to 15 mm in height	Up to ∅100 mm, up to 15 mm in height
Sample weight		Up to 100 g	Up to 300 g
XY sample positioning range, resolution		5x5 mm, 5 μm	
Positioning sensitivity		2 μm	
Scan range		⩾ 90x90x9 μm ⩾ 10x10x4 μm ⩾ 1x1x1 μm	⩾ 90x90x9 μm
		Up to 180x180x18 μm ** (DualScan™ mode)	
Non-linearity, XY (with closed-loop sensors)		⩽0.1%	⩽0.15%
Noise level, Z (RMS in bandwidth 1000 Hz)	With sensors	0.04 nm (typically), ⩽0.06 nm	0.06 nm (typically), ⩽0.07 nm
	Without sensors	0.03 nm	0.05 nm
Noise level, XY*** (RMS in bandwidth 200 Hz)	With sensors	0.2 nm (typically), ⩽0.3 nm (XY 90 μm)	0.1 nm (typically), ⩽0.2 nm
	Without sensors	0.02 nm (XY 90 μm) 0.001 nm (XY 1 μm)	0.01 nm
Optical viewing system	Optical resolution	3 μm (1μm optional; 0.4 μm optional, NA 0.7) ****	3 μm
	Field of view	4.5–0.4 mm	2.0–0.4 mm
	Continuous zoom	available	available
Vibration isolation	Active	0.7–1000 Hz	
	Passive	above 1 kHz	

* Scanning head can be configured to serve as a stand-alone device for specimens of unlimited sizes.
** Optionally can be expanded to 200x200x20 μm.
*** Built-in capacitive sensors have extremely low noise and any area down to 50x50 nm can be scanned with closed-loop control.
**** High Resolution Viewing system (HRV head) is optional and provides additional functionality making it possible to generate and detect tip-localized aperture less near-field effects.

Papers:

• *Shahgaldian P., Sciotti M.A. Pieles U. Amino-Substituted Amphiphilic Calixarenes: self-Assembly and Interactions with DNA // Langmuir. 2008. N 24.*
• *Mahmood I. A., Moheimani S.O.R. Making a commercial atomic force microscope more accurate and faster using positive position feedback control // Review of scientific instruments. 2009. N 80.*
• *Hu Zhijun, Tian Mingwen, Nysten B., and Jonas A.M. Regular arrays of highly ordered ferroelectric polymer nanostructures for non-volatile low-voltage memories // Nature materials. 2009. Vol. 8.*

Heating and cooling



Changing temperature plus mechanical stability? Now it's a reality.

Your images and measurements will tell the tale… the rock solid stability of drift less than 10 nm/°C

The great barrier to high temperature measurements has been breached! Thermal drift is no longer an issue! NTEGRA Therma's unique design reduces thermal drift to less than 10 nm/°C, translating into incredible stability for your long-term experiments.

Change temperatures quickly and smoothly. Maintain temperature precisely (±0.005°C). With NTEGRA Therma, enter the world of thermal measurement with new confidence. Precise thermal control and mechanical drift so low you'll forget that it used to be a problem.

Rigidity and stability

High temperature measurements are always a challenge. Different components of the system respond differently to heat, creating a mechanical drift that confounds long term measurement. **NTEGRA** Therma solves that problem, providing unprecedented low thermal drift and high stability.

Therma's design and composition are the keys. First, the THead™ construction separates a working cell with a measuring part and includes an independent registration unit. The tight construction of the cell provides negligible temperature difference while temperature variations. This compact unit is very proof against external vibrations. The temperature of probe and sample are the same as the temperature of the cell. The scanner with integrated capacitive sensors is confined to a separate block made of invar alloy carefully formulated with coefficient of thermal expansion near zero. Moreover, placed outside a working cell the scanner stays at room temperature.

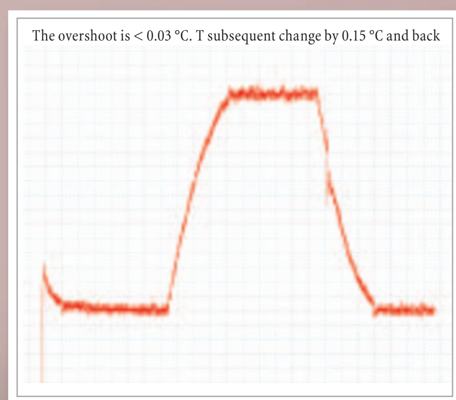
The ultimate test: your results. Whether you are working at constant, elevated temperatures over long time periods or are running variable thermal programming, **NTEGRA** Therma provides the stability for impressively clear images and precise, repeatable measurements.

A new level of thermal control

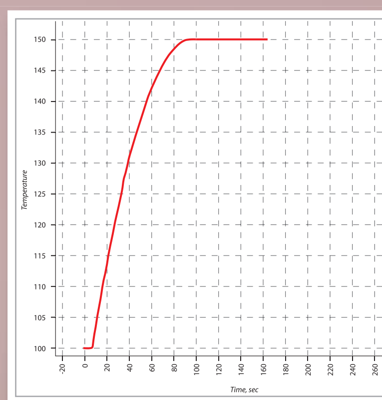
The special smart heating algorithm ramps the temperature quickly and precisely to a given value with minimal overshooting. This algorithm provides much less overshooting comparing to the common PID (Proportional Integral Differential) control, thus ensuring no unwanted overheating.

Advanced software solutions

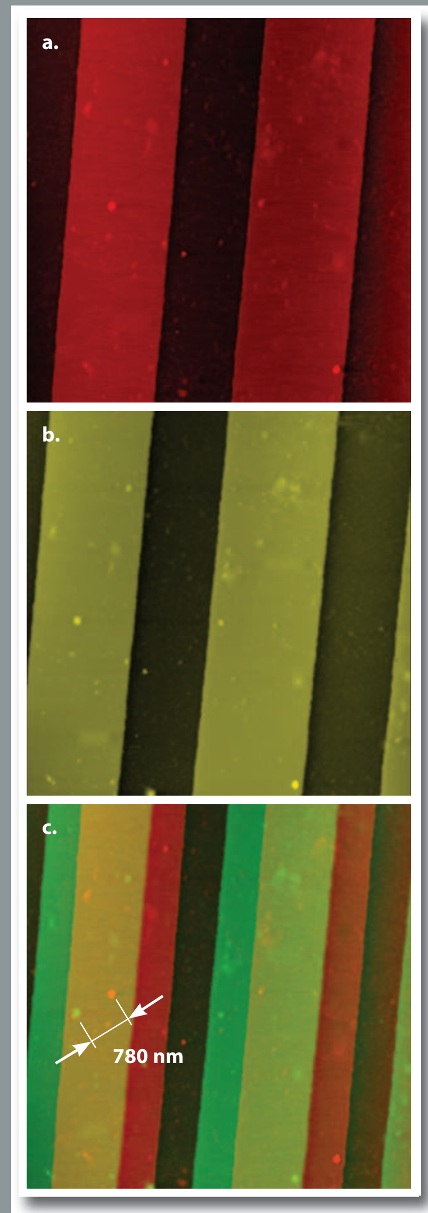
Taking the customers' wishes into account, NT-MDT SI has developed Nova™ software with user-friendly interface, which successfully integrates cutting-edge technologies and comprehensive functionality. Handy Nova™ provides a wide variety of functions, from full real-time control at the deep hardware level to image acquisition, from data management to scientific art creation. Your choice depends on the task. If you need external devices synchronization, choose Nova PowerScript™. TTL signal allows to initiate a number of devices, opening the interface to other applications. Nova PowerScript™: extend your possibilities! Image Analysis™ with nice and convenient GUI combines various techniques of analysis with multiple editing capabilities. Selection of powerful color palettes, filtration, light source positioning, 1D, 2D, 3D data representation, and many others that is what you get.



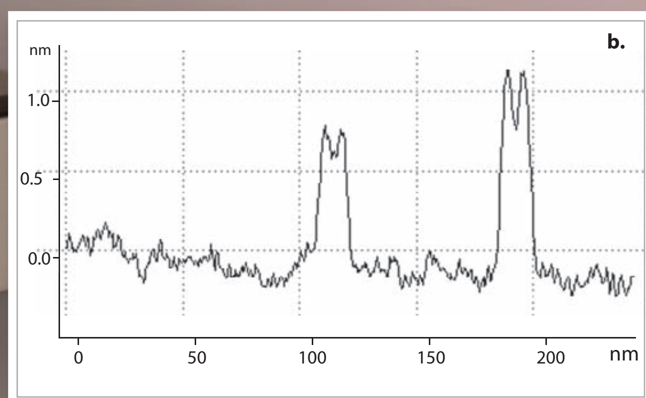
Temperature rise from 50 °C (beyond the plot range) to 100 °C



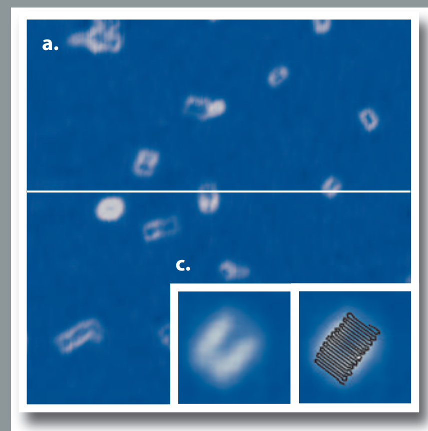
Temperature rise from 100 °C to 150 °C for ~ 90 sec

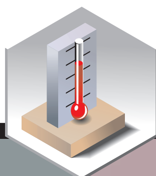


Silicon grating.
(a) Topography image at 28 °C
(b) Topography image at 130 °C
(c) Composed picture consisting of two images (at 28 °C and at 130 °C respectively), white arrows indicate initial (28 °C) and final (130 °C) position of the same feature. Thermal drift is less then 8 nm/°C. Scan size 7x7 µm



IPP single-molecule nanocrystallites on mica.
(a) AFM Topography image. Scan size 240x240 nm
(b) Height section drawn through the white line
(c) The interpretation of the intramolecular substructure seen on AFM images





Scanning probe microscopy

STM/ AFM (contact + semi-contact + non-contact) / Lateral Force Microscopy / Phase Imaging/Force Modulation/ Adhesion Force Imaging/ Magnetic Force Microscopy/ Electrostatic Force Microscopy/ Lithography: AFM (Force)

Specification	Scan type	Scanning by sample
Sample size	Ambient environment	Up to ∅40 mm, up to 15 mm in height
	Heating or cooling	10x10x1.5 mm 15x12x1.5 mm
XY sample positioning range, resolution		5x5 mm, 5 μm
Positioning sensitivity		2 μm
Temperature control	Range	From -30°C to +80°C/ from RT to +300 °C
	Stability	±0.005 (typically), better than ±0.01°C
Scan range	-30 °C ÷ +80 °C/ RT ÷ +200 °C	⩾ 10x10x6 μm
	Ambient conditions/ RT ÷ +150 °C	⩾ 90x90x9 μm ⩾ 1x1x1 μm
	RT ÷ +300 °C	⩾ 90x90x9 μm
Thermal drift* (typically)	XY	15 nm/°C
	Z	10 nm/°C
Non-linearity, XY with closed-loop sensors		<0.2%
Noise level, Z (RMS in bandwidth 1000Hz)	With sensors	0.04 nm (typically), ⩽0.06 nm
	Without sensors	0.03 nm
Noise level, XY** (RMS in bandwidth 200 Hz)	With sensors	0.2 nm (typically), ⩽0.3 nm (XY 90 μm) 0.025 nm (typically), ⩽0.04 nm (XY 10 μm)
	Without sensors	0.02 nm (XY 90 μm) 0.002 nm (XY 10 μm) 0.001 nm (XY 1 μm)
Linear dimension estimation error (with sensors)		±0.5%
Optical viewing system	Optical resolution	1 μm/ 3 μm
	Field of view	4.5–0.4 mm
	Continuous zoom	available
Vibration isolation	Active	0.7–1000 Hz
	Passive	above 1 kHz

* For temperature range –30 °C ÷ +80 °C and RT ÷ +200.
** Built-in capacitive sensors have extremely low noise and any area down to 50x50 nm can be scanned with closed-loop control.

Papers:
• *Wang W., Ciselli P., Kuznetsov E., Peijs T., Barber A.H. Effective reinforcement in carbon nanotube-polymer composites. Philos.Transact.A Math.Phys.Eng. Sci.2008; 18192168 (published online)*

Pure environment

NTEGRA Aura

Feel confident when everything is under control?

We'll worry about the environment… you concentrate on your experiment

Need vacuum? Exact, predefined temperature? Precisely controlled scan area? **NTEGRA** Aura understands the importance of reliable and efficient control and will create the perfect conditions for your experiment, according to your design, leaving you free to concentrate on science and masterful results.

Optimized conditions/Maximized outcome

Conducting SPM measurements in vacuum offers significant advantages in comparison to measuring under ambient conditions. Working in vacuum optimizes the resonance frequency or "Q-factor" of the cantilever, producing clearer, crisper, higher resolution images for semi-contact AFM modes and significantly increased sensitivity for non-contact modes such as MFM (magnetic force microscopy) and EFM (electrostatic force microscopy). On the other hand, working in vacuum can be a hindrance because of the long delays necessary when pumping down the system and the challenges in changing samples within bulky and very expensive pumping systems.

NTEGRA Aura solves these problems. Engineered in an economical, compact package, Aura's vacuum improves the Q-factor ten-fold after only one minute of pumping. For many experiments, 10^{-3} torr is sufficient to optimize the Q-factor.

Immediate readout of true sample environment

Built-in into the **NTEGRA** body and protected by a transparent crystalline sapphire plate, a compact LCD monitor constantly reports temperature and humidity inside the system enclosure. Need to dry out your sample before measuring? Or keep it at temperature? NT-MDT SI engineering maintains thermal stability to ± 0.005 °C (typically).

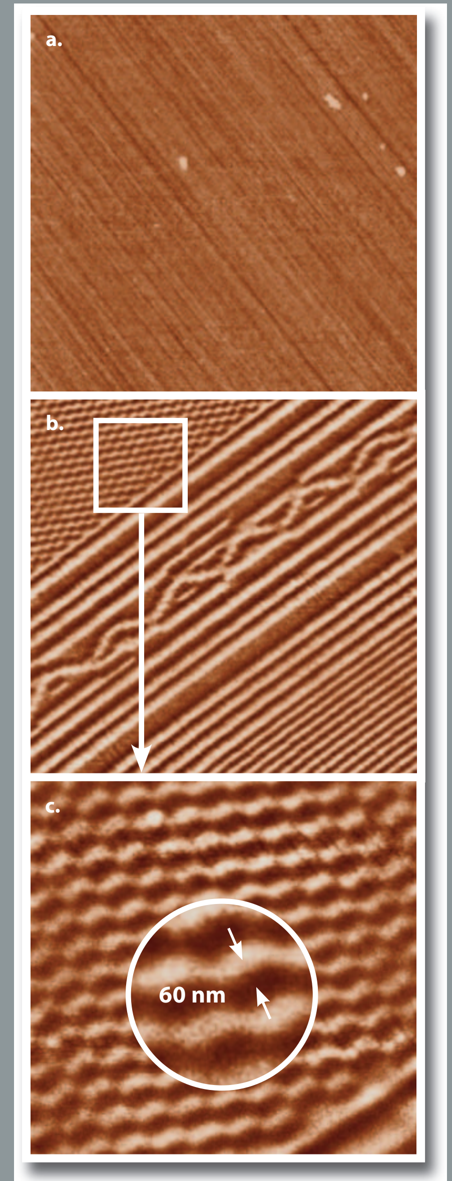
Also common to all **NTEGRAs**: the direct optical viewing system. Use it to scan for the right measurement area. Zoom in to target the tip. Record an optical image for documentation to correlate with your AFM images and measurements.

Extending ultimate control to ultra small area

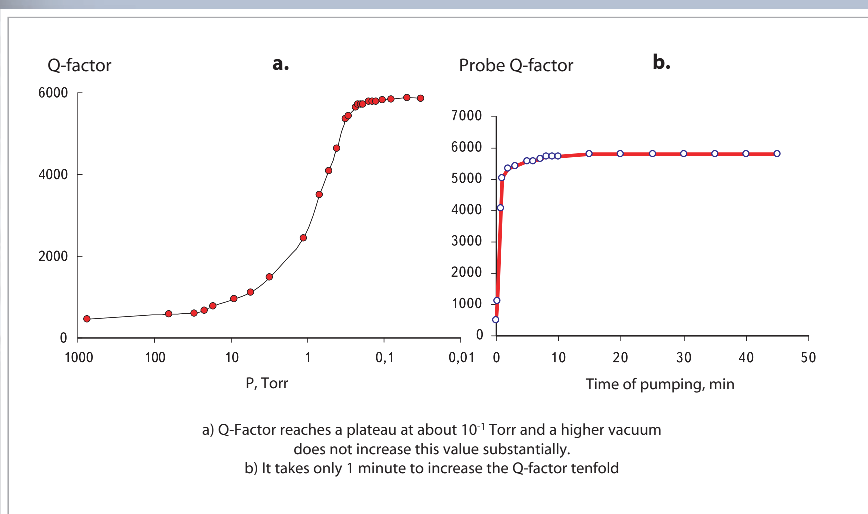
NTEGRA Aura incorporates the closed loop feedback sensors common to the full **NTEGRA** line. These sensors read the real scanner displacement and compensate for parasitic properties including non-linearity, hysteresis and creep. Proprietary NT-MDT SI sensors design produces exceptionally low noise level, a significant breakthrough in scanning technology. As a result you can scan the areas as small as 50x50 nm and even less with the closed loop feedback enabled.

Precise control — accurate influence

Precisely controlling the environment also opens a unique opportunity for controlled surface modification. **NTEGRA** Aura includes a wide range of tools and methods for mechanical, magnetic, and electrical surface modification. Raster or vector nanolithography is standard in all **NTEGRA** software. For example, without any preset sequence, length or patterning direction, the system can make a template from common graphic image files then translate the template to the sample surface, all using standard, included algorithms.

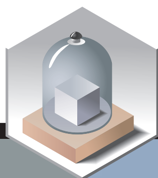


HDD topography (a) and MFM images (b, c). Distance between magnetic poles of a bit is about 60 nm (white pointers on the MFM image) Scan size a), b) 5x5 µm, c) 1.5x1.5 µm



a) Q-Factor reaches a plateau at about 10^{-1} Torr and a higher vacuum does not increase this value substantially.
b) It takes only 1 minute to increase the Q-factor tenfold

LCD monitor on the base unit panel



Scanning probe microscopy

Air/vacuum/gases

STM/ AFM (contact + semi-contact + non-contact) / Lateral Force Microscopy / Phase Imaging/Force Modulation/ AdhesionForce Imaging/ Magnetic Force Microscopy/ Electrostatic Force Microscopy / Scanning Capacitance Microscopy/PFM/Spectroscopy / Kelvin Probe Microscopy/ Spreading Resistance Imaging/ Lithography:AFM (Force, Current), STM, nano-manipulation

Specification \ Scan type		Scanning by sample	Scanning by probe*
Sample size		Up to ∅40 mm, up to 15 mm in height	Up to ∅100 mm, up to 20 mm in height
Sample weight		Up to 100 g	Up to 300 g
XY sample positioning range, resolution		5x5 mm, 5 μm	
Positioning sensitivity		2 μm	
Scan range		⩾ 90x90x9 μm ⩾ 1x1x1 μm	⩾ 90x90x9 μm
		Up to 180x180x18 μm** (DualScan™ mode)	
Non-linearity, XY with closed-loop sensors		⩽0.1%	⩽0.15%
Noise level, Z (RMS in bandwidth 1000Hz)	With sensors	0.04 nm (typically), ⩽0.06 nm	0.06 nm (typically), ⩽0.07 nm
	Without sensors	0.03 nm	0.05 nm
Noise level, XY*** (RMS in bandwidth 200 Hz)	With sensors	0.2 nm (typically), ⩽0.3 nm (XY 90 μm)	0.1 nm (typically), ⩽0.2 nm
	Without sensors	0.02 nm (XY 90 μm) 0.001 nm (XY 1 μm)	0.01 nm
Optical viewing system	Optical resolution	1 μm	3 μm
	Field of view	4.5–0.4 mm	2.0–0.4 mm
	Continuous zoom	available	available
Temperature control	Range	From RT to +150°C	
	Stability	±0.005°C (typically), ⩽ ±0.01°C	
Vacuum system	Pressure	10^{-3} Torr (sorption cryo pump)	
Vibration isolation	Active	0.7–1000 Hz	
	Passive	above 1 kHz	

Optional liquid scanning head – by probe (contact, semicontact, Lateral Force Microscopy, Adhesion Force Imaging, Phase Imaging, AFM spectroscopy)

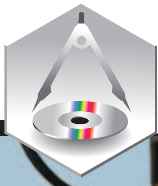
* Scanning head can be configured to serve as a stand-alone device for specimens of unlimited sizes.
** Optionally can be expanded to 200x200x20 μm.
*** Built-in capacitive sensors have extremely low noise and any area down to 50x50 nm can be scanned with closed-loop control.

Papers:

• *Tikhonenko F. V., Horsell D. W., Gorbachev R. V., Savchenko A. K.Weak localisation in graphene akes // Physical Review Letters. 2007. Vol. 98.*
• *Alexeev A., Loos J. Conductive atomic force microscopy (C-AFM) analysis of photoactive layers in inert atmosphere // Organic Electronics. 2008. N9.*

Large samples and automation

NTEGRA Maximus



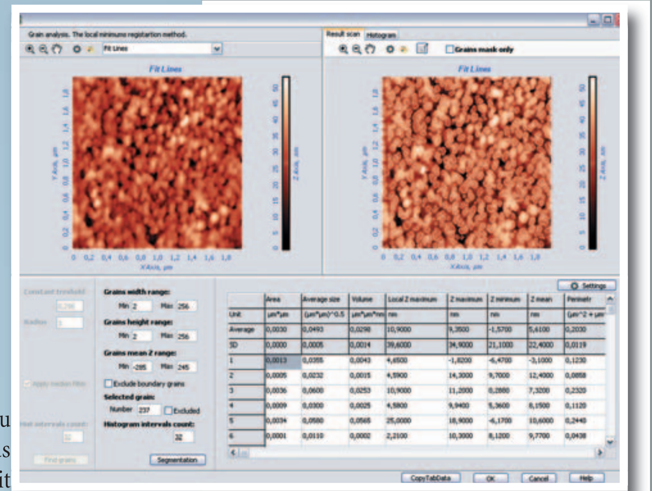
What is the profile of your ideal assistant? – Smart? Autonomous? Efficient? Processes mountains of work without complaining?

NTEGRA Maximus fits the bill

NTEGRA Maximus is the instrument of choice when you have large number of routine analyses to conduct and really need that knowledgeable robot assistant to take the work off your hands. You won't feel how easily it does its work. You'll just get what's important: dozens of high quality images and related measurements, all presented in neat, statistical format… the key information to draw your final conclusions.

Different applications… Universal effectiveness

Consider the following very different applications. Case A: you need to make multiple microscopic measurements in different regions on the surface of a large sample. Extremely useful, for example, in controlling roughness on optical lenses or wafers or testing magnetic properties on disk drives. Case B: you are working on a new formulation and need to characterize multiple properties on a large selection of microsamples. One example: the polymer industry where several parameters of a new material are optimized based on the microanalysis of a great number of samples. **NTEGRA** Maximus has the solution for these and many more similar applications.



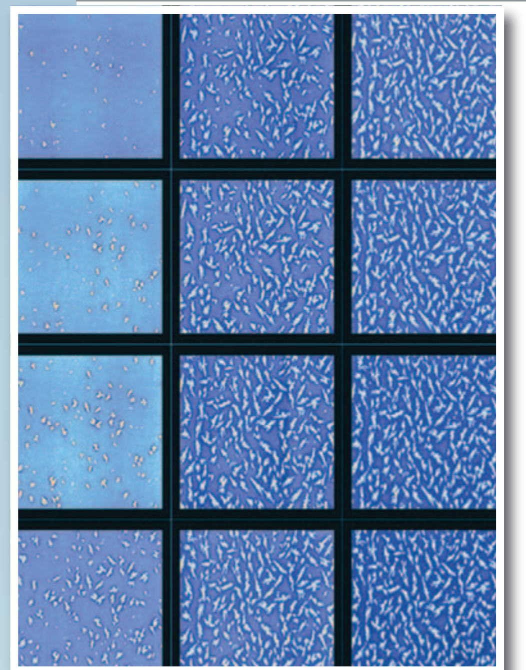
Grain analysis software

Expanded sample positioning

Clearly, to analyze either large samples or multiple small samples, you need more than XY motion. To meet that need, NT-MDT SI has designed an "RL" (Rotary-Linear) stage for **NTEGRA** Maximus. Rotate it to any angle (Rotary) and move the sample along a line (Linear) by software control. Fully motorized, the new RL stage is driven by software which includes mark-and-find programming, expanding your ability to measure automatically at dozens of locations.

Optical viewing to confirm just the right location

As with the full **NTEGRA** line, **NTEGRA** Maximus sports a zooming optical viewing system. Use the low magnification to find fields of up to 2 mm in diameter. After locating the general area, zoom in to mark specific small features or areas for measurement. This feature is especially useful when multiple microsamples are spotted onto one substrate or when locating test sites on single large substrates such as hard drives or wafers. Coupling a camera to the viewing system also provides light microscopy images which are stored along with your AFM images and measurements, providing important visual documentation of the areas analyzed.



Growth of lamellar aggregates from LB film of 5 bilayers melt at 75 °C

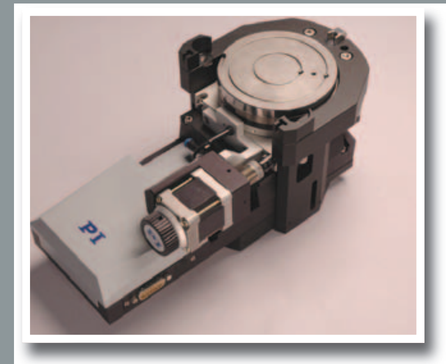
Flexible and efficient algorithms for the production process

NTEGRA Maximus optimizes your production cycles. Need to analyze large numbers of field for grain analysis? Apply NT-MDT SI proprietary Grain Analysis™ option for accurate and fast data processing. NT-MDT SI software solution provides automatic grains determination even for difficult surfaces and grains stuck together. You can calculate about 15 parameters for each grain, easily exporting results to Excel®. Need to crunch data from multiple surface properties on a large variety of microsamples? **NTEGRA** Maximus has an algorithm to track the trends, showing how properties changes from one sample to another. Use it to select the optimal combination of properties based on the analysis of your whole data array.

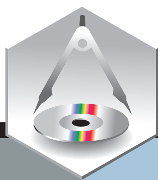
Customize your application

Need to drive **NTEGRA** Maximus according to your own analytical regime? Nova™ provides the maximum freedom for choosing the most effective tactics of your measurement then creating the macros to implement repeatedly and consistently. Acquire, archive, even filter… all hands-off and automatically.

Excel is a registered trademark of the Microsoft Corporation®



Design solutions. RL stage



Scanning probe microscopy

AFM (contact + semi-contact + non-contact) / Lateral Force Microscopy / Phase Imaging/Force Modulation/ Adhesion Force Imaging/ Magnetic Force Microscopy/ Electrostatic Force Microscopy / Scanning Capacitance Microscopy/ Kelvin Probe Microscopy/ Spreading Resistance Imaging/ Lithography: AFM (Force and Current)

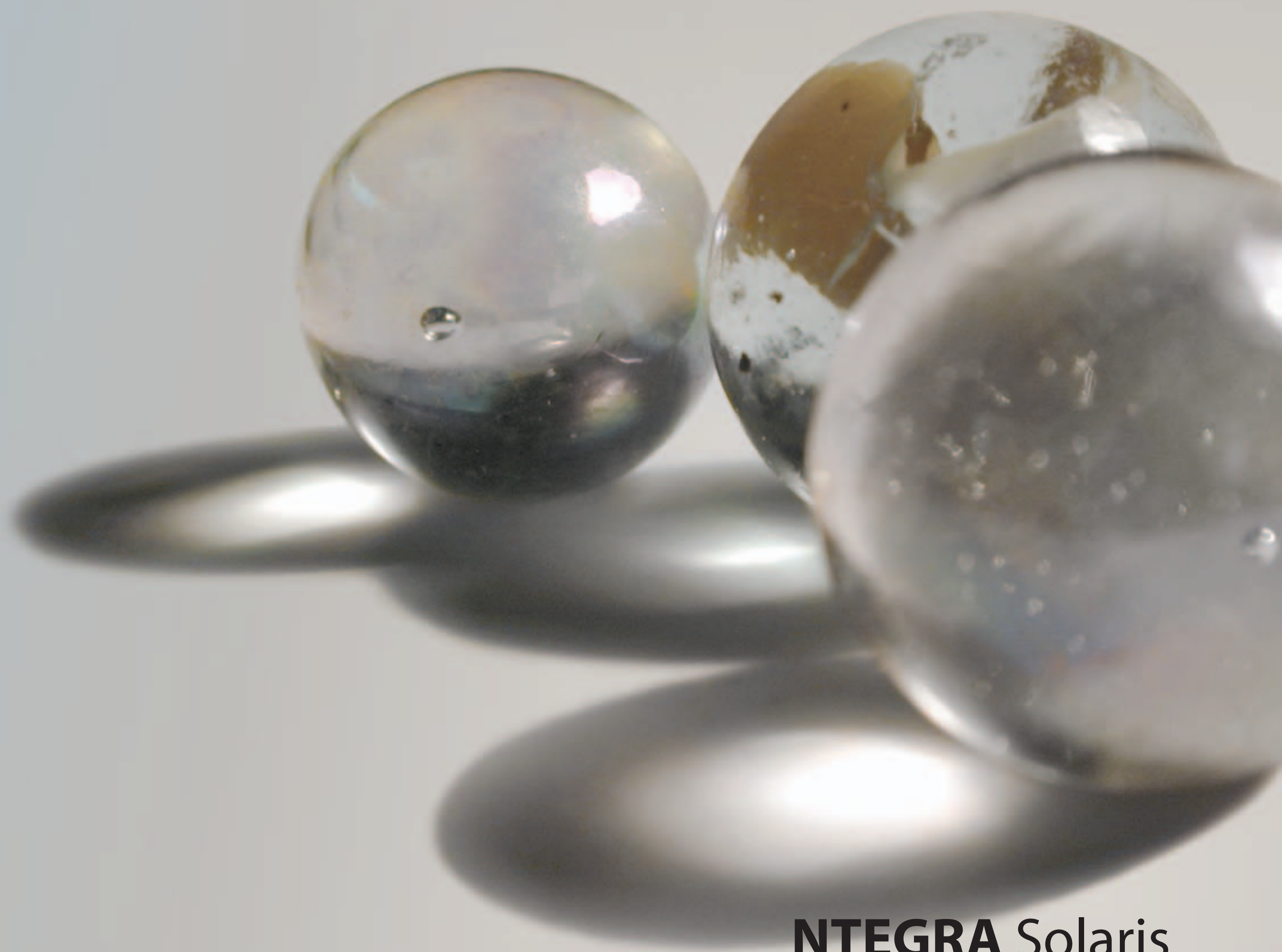
Specification

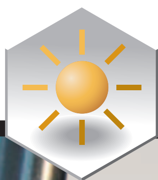
Sample size		Up to ∅100 mm, up to 20 mm in height
Sample weight		Up to 1 kg
XY sample positioning	Linear movement range	50 mm
	Positioning resolution	2.5 μm
	Rotary movement range	360°
	Positioning resolution	0.005°
Scan range		⩾ 90x90x9 μm
Sample holder		Vacuum chuck
Non-linearity, XY (with closed-loop sensors)		⩽0.15%
Noise level, Z (RMS in bandwidth 1000 Hz)	With sensors	0.06 nm (typically), ⩽0.07 nm
	Without sensors	0.05 nm
Noise level, XY* (RMS in bandwidth 200 Hz)	With sensors	0.1 nm (typically), ⩽0.2 nm
	Without sensors	0.01 nm
Optical viewing system	Optical resolution	3 μm
	Field of view	2.0–0.4 mm
	Continuous zoom	available
Vibration isolation	Active	0.7–1000 Hz
	Passive	above 1 kHz

* Built-in capacitive sensors have extremely low noise and any area down to 50x50 nm can be scanned with closed-loop control.

Papers:
- *R. Neffati et al. Automated Scanning Probe Microscopy as a New Tool for Combinatorial Polymer Research: Conductive Carbon Black/Poly(dimethylsiloxane) Composites. Macromol. Rapid Commun. 2003, 24, 113-117.*
- *Daan Wouters and Ulrich S. Schubert. Constructive Nanolithography and Nanochemistry: Local Probe Oxidation and Chemical Modification. Langmuir 2003, 19, 9033-9038.*

Collect the light





Rayleigh said the diffraction limit for light was $\lambda/2$.

Expect more!

In a nanoscale world, the optical diffraction limit of $\lambda/2$ presents a serious barrier to scientific progress. Now, ride the evanescent wave over that barrier with **NTEGRA** Solaris. Even more exciting: control the powerful system that observes a nanoworld which, until very recently, was invisible. Using the near-field effect, this scanning near-field optical microscope (SNOM) opens new investigations of optical properties far beyond the diffraction limit.

Once you begin to feel the rhythm of subwave breakthroughs, you will certainly agree:
NTEGRA Solaris is not only a good instrument, it is the new wave of scientific progress!

Three microscopes in one!

NTEGRA Solaris combines three different microscopy techniques: light, scanning nearfield optical microscopy (SNOM), and atomic force microscopy (AFM). Integration at this advanced level creates enormous design challenges because the conventional light microscope which uses standard optics and mechanics cannot provide the accuracy, precision of movement, and stability required for scanning probe microscopy or the efficiency necessary to collect the weak SNOM signal. When they invented **NTEGRA** Solaris, NT-MDT SI engineers took a unique approach. They built a stable, rigid light microscope objective right into the base of the SPM. The result: high resolution imaging with none of the optical microscope instability. Coupling this exceptional stability with a delicately sensitive detection makes **NTEGRA** Solaris perfect for advanced measurements, even at molecular scale.

Sensitive detectors + stray light elimination yield "pure" signal

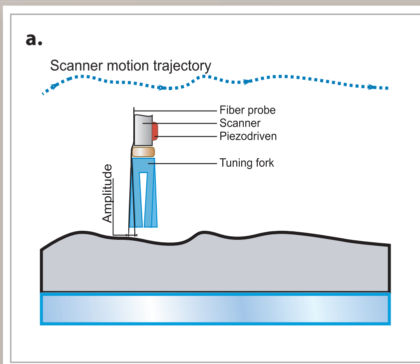
SNOM signals are much weaker than ambient light, demanding precise stray light control. Proprietary NT-MDT SI engineering and robust but elegant construction combine to guarantee that **NTEGRA** Solaris will provide you with superior protection from parasitic illumination. For the ultimate in sensitivity, Solaris incorporates the latest in PMT detectors. The proof is in the performance and validation tests confirm it: **NTEGRA** Solaris offers excellent high signal/noise ratio.

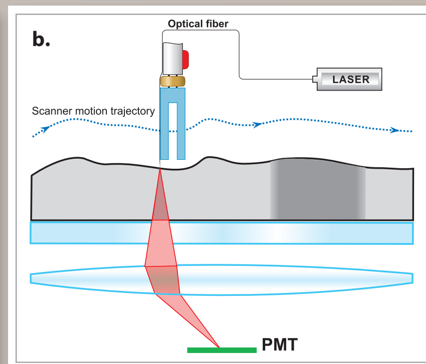
Reflected light + Transmitted light = Maximum characterization

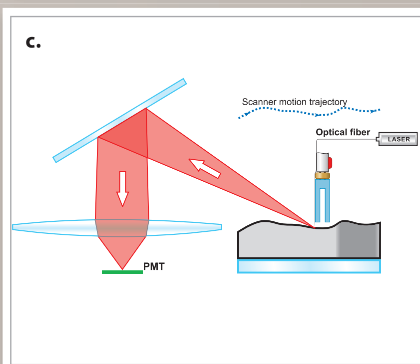
Every nearfield quantum carries critical information and, with weak SNOM signals, every quantum is precious. It is also well known that the transmitted and reflected light present different views of the sample. **NTEGRA** Solaris delicately detects the light from both channels simultaneously, instantly providing correlative images and measurements.

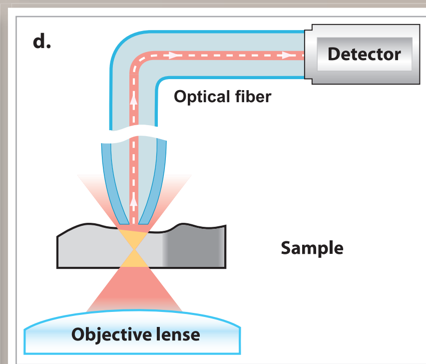
New engineering meets traditional quality

Successful nearfield microscopy rests on solving two problems: spatial resolution and detection efficiency. As a company, NT-MDT SI has grown from strong roots in physics and, as a result, our engineers and designers understand both these parameters and many others critical to SNOM. By consolidating all the traditional advantages of scanning probe microscopy with new directions in SNOM performance, they've built **NTEGRA** Solaris to take optical imaging and measurements on a whole a new level.

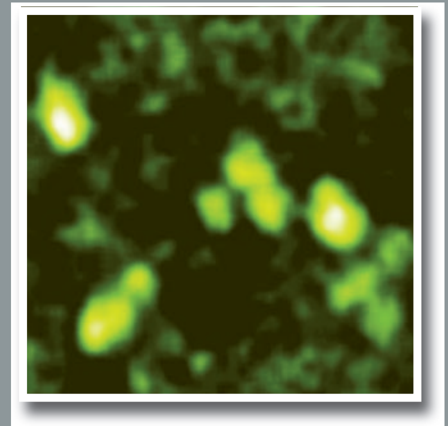




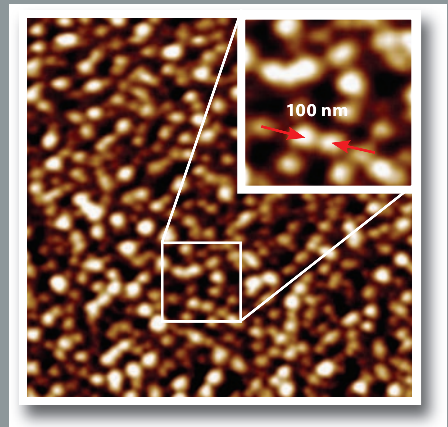




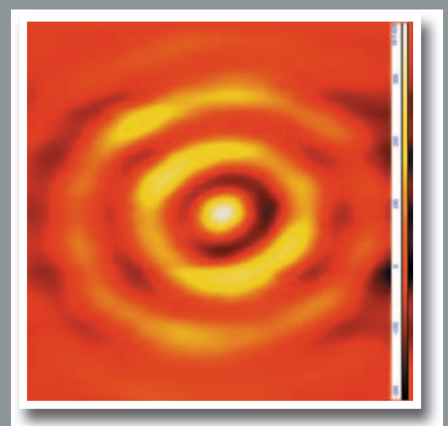
a) Shear force microscopy principle, b) SNOM Transmission mode principle, c) SNOM Reflection mode principle, and d) SNOM Collection mode principle



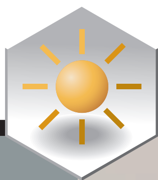
SNOM image of mitochondria dyed with FITC-labeled antibodies. Scan size 1.7×1.7 µm



SNOM image of polymer with globular structure. The enlarged scan area shows spatial resolution. Scan size 3.5x3.5 µm



Diffraction of light passing through an objective of standard optical microscope. Laser intensity corresponds to the color brightness. Scan size 4×4 µm



Scanning Near-Field Microscopy

Shear Force Microscopy / SNOM reflection, transmission, luminescence (optional)/ any AFM modes are available optionally

Specification

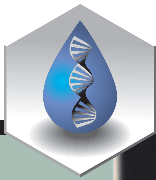
Laser module	Wavelength*	325, 355, 405, 442, 473, 488, 514, 532, 633, 785 nm	
	Coupling unit	X-Y-Z positioner, positioning accuracy 1 μm	
		V-groove fiber holder	
		Coupling 40X objective	
Shear Force Imaging	Sample size	Up to ∅100 mm, up to 15 mm in height	
	XY sample positioning range	5x5 mm	
	Readable resolution	5 μm	
	Positioning sensitivity	2 μm	
	Closed-loop operation	Capacitive sensors for 3 axes	
		Scanning by sample	**Scanning by probe**
	Scan range	⩾ 90x90x9 μm	⩾ 90x90x9 μm
	Non-linearity, XY	0.03 % (typically)	<0.15 %
	Noise level, Z	<0.2 nm (typically)	0.04 nm (typically), ⩽0.06 nm
	Noise level, XY	<0.5 nm (typically)	0.2 nm (typically), ⩽0.3 nm
	Quartz tuning fork base frequency	190 kHz	
	Optical fiber diameter	90 μm (for 480–550 nm), 125 μm (for 600–680 nm)	
	Aperture diameter	<100 nm	
Channels for simultaneous registration		Reflection	
		Transmission/Fluorescence	
PMT detectors (for each channel)	Spectral response	185–850 nm	
	Sensitivity at 420 nm	3x10^{10} V/W	
	Current-voltage conversion amplifier (built-in)	1x10^{6} V/A	
	Frequency band width	20 kHz	
	High voltage power supply	built-in	
Vibration isolation	Dynamic	0.7–1000 Hz	
	Passive	above 1 kHz	

* 488 nm laser is included as a default; other lasers can be supplied optionally.

Papers:
- *Fischer H., Nesci A., Leveque G., Martin O. J.F. Characterization of the polarization sensitivity anisotropy of a near-field probe using phase measurements //Journal of Microscopy. 2008.Vol. 230.*
- *Wang Q. Wang J. Zhang S. A nano-confined source based on surface plasmon Bragg reflectors and nanocavity // Optics Express. 2008.Vol. 16. N 24.*

Live and delicate

NTEGRA Vita



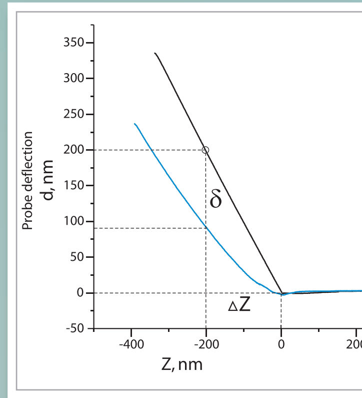
Life. Chemistry. Process.

Good instrumentation makes it real

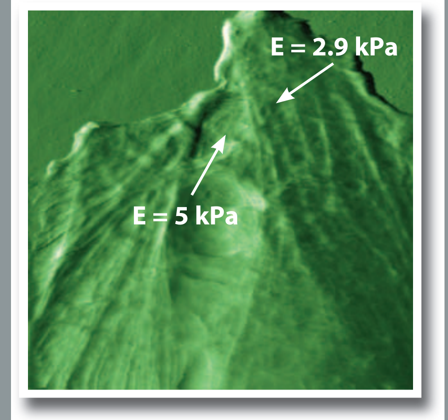
From molecules to living organisms, NTEGRA Vita opens the window to the world of biology and biochemistry. Especially designed to integrate seamlessly with your optical microscope, NTEGRA Vita preserves the in situ environment so that you can observe, image and measure what is really there. Turn on NTEGRA Vita and concentrate on your experiment. Enjoy your work and so much expected results. Our system is not the most important thing here. It is just you who can achieve everything with NTEGRA Vita.

Maintaining stasis

To maintain life and present the best conditions for measurement, most biological samples must be kept in fluid solutions. For conventional AFM biological imaging as well as biochemistry and bioorganic applications, **NTEGRA** Vita uses a unique sealed fluid cell which maintains an enclosed volume. Input/output pipes provide controlled flow of nutrient liquids and a heating element precisely maintains temperature, from room temperature to 60 °C, with an accuracy of ±0.005 °C (typically). Made of chemically stable materials, the fluid cell can withstand aggressive solutions, including acidic, alkaline, or salt solutions.



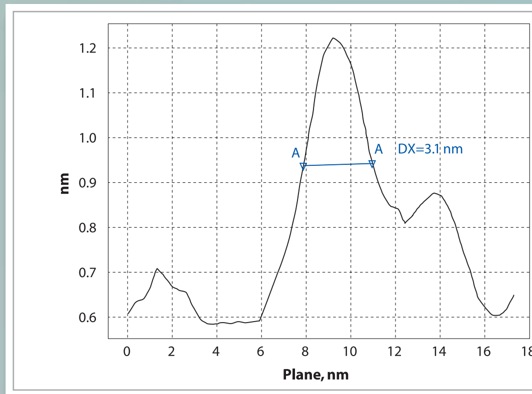
Two curves obtained from very stiff (black line) and rather soft (blue line) materials. Delta of probe deflection shows the sample deformation by the probe. It can be transformed into the Young's modulus



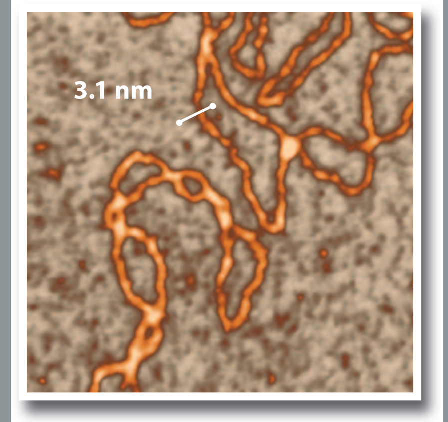
Porcine kidney living cell. Difference in rigidity within a cell is estimated by Young's modulus (for comparison the Young's modulus value for the Petri dish surface underlying the cell was 1.4 GPa). Scan size 28x28 µm

From millimeters to angstroms

Need to study live cells? **NTEGRA** Vita offers a special cell to hold standard Petri dishes. As with our sealed liquid cell, this system maintains liquid flow and temperature control. Most importantly, you can still use your inverted microscope for classic optical methods. With **NTEGRA** Vita, use fluorescence to image internal structures and the SPM to provide higher resolution surface detail or physical parameters such as membrane conductance or elasticity. Merge fluorescence and SPM images for further comparison.



DNA cross-section draft

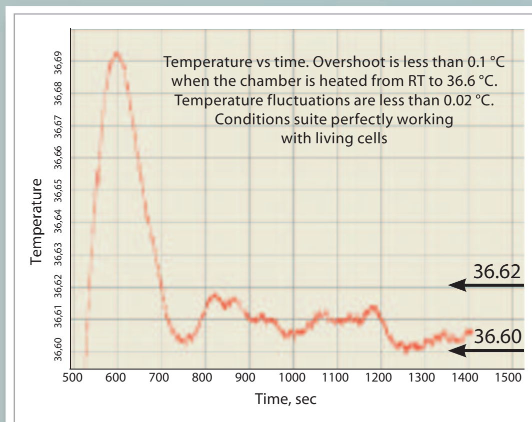


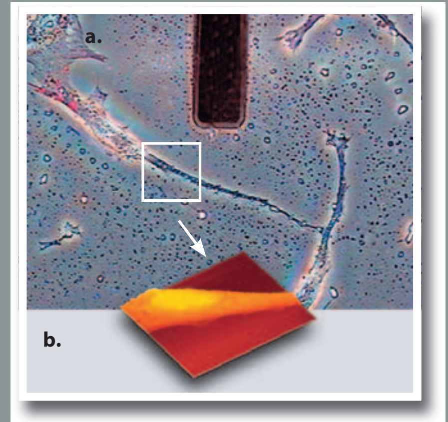
Unfolded DNA deposited on mica. AFM image obtained by DLC tip. DNA width 3.1 nm. Scan size 160x160 nm

Ultimate resolution requires ultra-small volumes

Need the ultimate in resolution? You need "scanning-by-sample", a mode in which a small sample is scanned with great precision under a fixed probe. Our engineers have developed a special little fluid cell specifically for this application. This cell is also helpful when using expensive chemicals.

From large format to ultrahigh resolution, **NTEGRA** Vita has a solution for your lab.

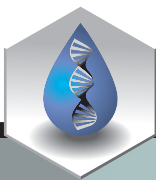




Human embryo fibroblast (primary culture).
a) Phase contrast optical image of the cells, obtained during AFM scanning.
b) AFM image of the framed area. Semicontact mode in air. Scan size 50x40x0.5 µm

Extremely small force measurements

Measurements and analysis of probe-to-sample forces in pico- and nano- Newton range provide new insight into cellular properties. "Pushing" a cell with the probe then evaluating the cantilever deflection provides quantitative information about the cell turgidity, cytoskeleton network rigidity, and cellular matrix density. "Touching" the surface-bound receptor molecules with a ligand-coated probe quantifies molecular interaction forces. **NTEGRA** Vita low noise closed loop sensors afford unprecedented accuracy of both probe movement and force measurements.



Scanning probe microscopy

		Scanning by sample	Scanning by probe*
SPM methods	in air & liquid	AFM (contact + semi-contact + non-contact) / Lateral Force Microscopy / Adhesion Force Imaging/ Force Modulation/ Phase Imaging/ AFM Lithography (scratching)/ Force-Distance curves	
	in air only	STM/ Magnetic Force Microscopy/ Electrostatic Force Microscopy / Scanning Capacitance Microscopy/ Kelvin Probe Microscopy/ Spreading Resistance Imaging/ Lithography: AFM (Current), STM	
Sample size	in air	Up to ∅40 mm, up to 15 mm in height	Up to∅ 100 mm, up to 15 mm in height
	in liquid	Up to 14x14x2.5 mm	Up to 15x15x3 mm
XY sample positioning range	in air	5x5 mm, 5 µm readable resolution, 2 µm sensitivity	
	in liquid	1x1 mm, 5 µm readable resolution, 2 µm sensitivity	
Scan range		⩾ 90x90x9 µm	⩾ 90x90x9 µm
Non-linearity, XY (with closed-loop sensors***)		<0.1%	<0.15%
Noise level, Z (RMS in bandwidth 1000Hz)	With sensors	0.04 nm (typically), ⩽0.06 nm	0.06 nm (typically), ⩽0.07 nm
	Without sensors	0.03 nm	0.05 nm
Noise level, XY** (RMS in bandwidth 200 Hz)	With sensors	0.2 nm (typically), ⩽0.3 nm (XY 100 µm)	0.1 nm (typically), ⩽0.2 nm
	Without sensors	0.02 nm (XY 100 µm) 0.001 nm (XY 3 µm)	0.01 nm
Temperature control (For operation in fluid environment)	Range	—	from -10 °C to +60 °C for liquid from -30°C to +120 °C for gas
	Stability	—	±0.005 °C (typically), ⩽±0.01 °C

* Scanning head can be configured to serve as a stand-alone device for specimens of unlimited sizes.
** Built-in capacitive sensors have extremely low noise and any area down to 50x50 nm can be scanned with closed-loop control.

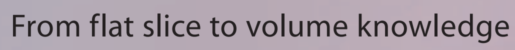
Optical microscopy*

		Upright viewing		Inverted viewing Scanning by probe
		Scanning by sample	Scanning by probe	
Objective lens	Magnification	x1/ x10	x1	x60**
	Numerical aperture	0.1/ 0.28	0.1	0.7
Continuous zoom		available		NA
Observation methods***	Bright field imaging	available		available
	Fluorescence imaging	NA		optional
	Contrast methods	Phase contrast imaging, Polarization, DIC	NA	optional

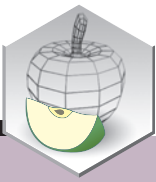
* System upgrade is possible to convert it into a near-field optical microscope or a laser confocal microscope.
** Any additional objectives can be supplied optionally.
*** Can be performed without compromise in optical or AFM performance.

Papers:

• Risveden K., Ponten J.F., Calander N., Willander M., Danielsson B. The region ion sensitive fi eld effect transistor, a novel bioelectronic nanosensor // Biosensors and Bioelectronics. 2007. N 22.



NTEGRA Tomo



Flat 2D data from an intriguing 3D world? Not any more!

Add the real 3rd dimension to your nanoworld!

Have you ever dreamed about looking inside the matter, seeing the distribution of domains or particles within a polymer? Examining the 3D ultrastructure of a cell? Tracing the true context of branching structures such as polyurethane forms or nerves?

NTEGRA Tomo makes your dream come true. This integrated AFM/ultramicrotome slices your sample into nanometer thin layers then renders its 3D image in a dynamic virtual model. See your sample's internal landscape in a whole new context.

Image of Leica EM UC6 Ultramicrotome. Courtesy of Leica Microsystems

Nanotomography: strong traditions and progress unite

The microtomy has a history nearly two centuries long. Although the much-younger, SPM has been known for less than a quarter of a century, it is rapidly becoming the instrument of choice for nanotechnology. In **NTEGRA** Tomo, NT-MDT SI has linked the two technologies, re-defining 3D imaging.

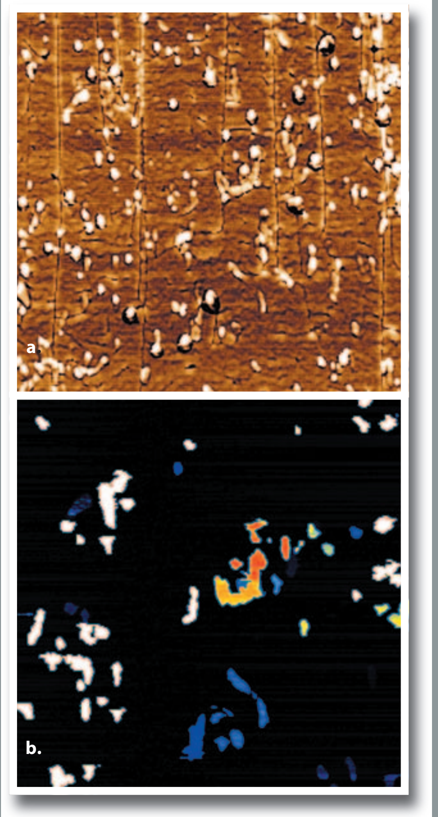
Today's state-of-the-art ultramicrotome produces high quality sections only a few nanometers thick. SPM, using a variety of imaging modes, also elicits scientific data in nanometers. Uniting them two opens the door to true 3D information at the nanoscale. **NTEGRA** Tomo images directly from the block-face, generating stable, well-oriented volumetric data and eliminating typical cutting artifacts such as tearing, stretching, and distortion. All you have to do is turn on the system, prepare your samples, insert and voila! Slice... image… slice… image… **NTEGRA** Tomo puts ultrastructure and internal structure at your fingertips.

Contrast from unexpected sources

Conventionally, ultramicrotomy is used for TEM imaging. To generate contrast in the fine ultrastructure for the TEM requires elaborate staining with heavy metals. SPMs minimize this type of sample preparation by using local physical properties in the surface ranging from elasticity and adhesion forces to dielectric capacitivity. Can't get contrast with one AFM technique? No need to prepare a new sample or restain. Whether you are investigating the 3D distribution of domains in a polymer or the ultrastructure in tissue, just switch to another AFM mode for the maximum in information.

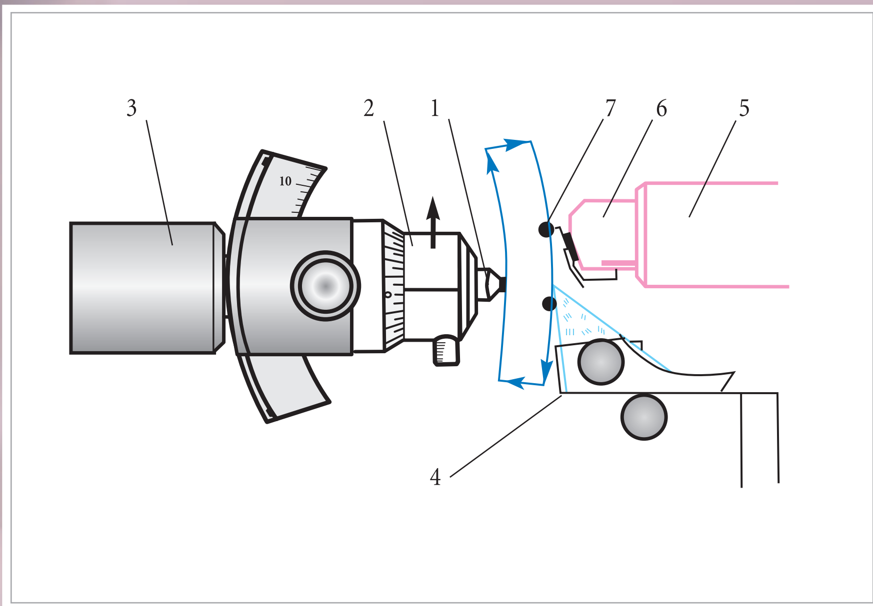
AFM, EM and LM: the perfect complement

NTEGRA Tomo is the perfect fit in your EM suite. Although it images directly from the block face, it still produces traditional sections that can be used for your TEM or light microscopy studies. Since each microscopy uses different mechanisms for imaging, the information is complementary. **NTEGRA** Tomo bridges the gap.

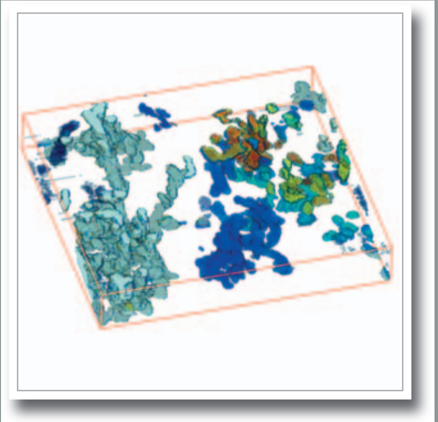


Cross section images of material sample containing carbon nanotubes embedded into polymer matrix. a) Phase image, b) Spreading resistance image. Scan size 2x2 µm

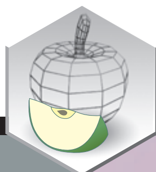
SPM tomography scheme (ultramicrotome combination with the SPM)



1 – sample
2 – sample holder
3 – ultratome movable bar
4 – ultratome cutter
5 – SPM piezoscanner
6 – probe holder
7 – SPM measuring probe



3D model of carbon nanotubes network within polymer matrix. The model was made of series of spreading resistance images (22 individual images). Distance between images (section thickness – 12 nm). Scan size 2x2x0.3 µm



Scanning probe microscopy

in-situ: AFM (contact + semi-contact + non-contact) / Lateral Force Microscopy / Phase Imaging/Force Modulation/ Adhesion Force Imaging/ Magnetic Force Microscopy/ Electrostatic Force Microscopy / Scanning Capacitance Microscopy/ Kelvin Probe Microscopy/ Spreading Resistance Imaging/ Lithography: AFM (Force and Current)

Sample size		10x5x5 mm
Sample weight		Up to 10 g
Scan range		100x100x10 µm
Positioning resolution		5 µm
Non-linearity, XY		<0.15%
Noise level, Z (RMS in bandwidth 1000 Hz)		0.06 nm (typically), ⩽0.07 nm
Noise level, XY (RMS in bandwidth 200 Hz)		0.2 nm (typically), ⩽0.3 nm
Vibration isolation	Dynamic	Frequency range 0.7–1000 Hz
	Passive	For frequencies above 1 kHz

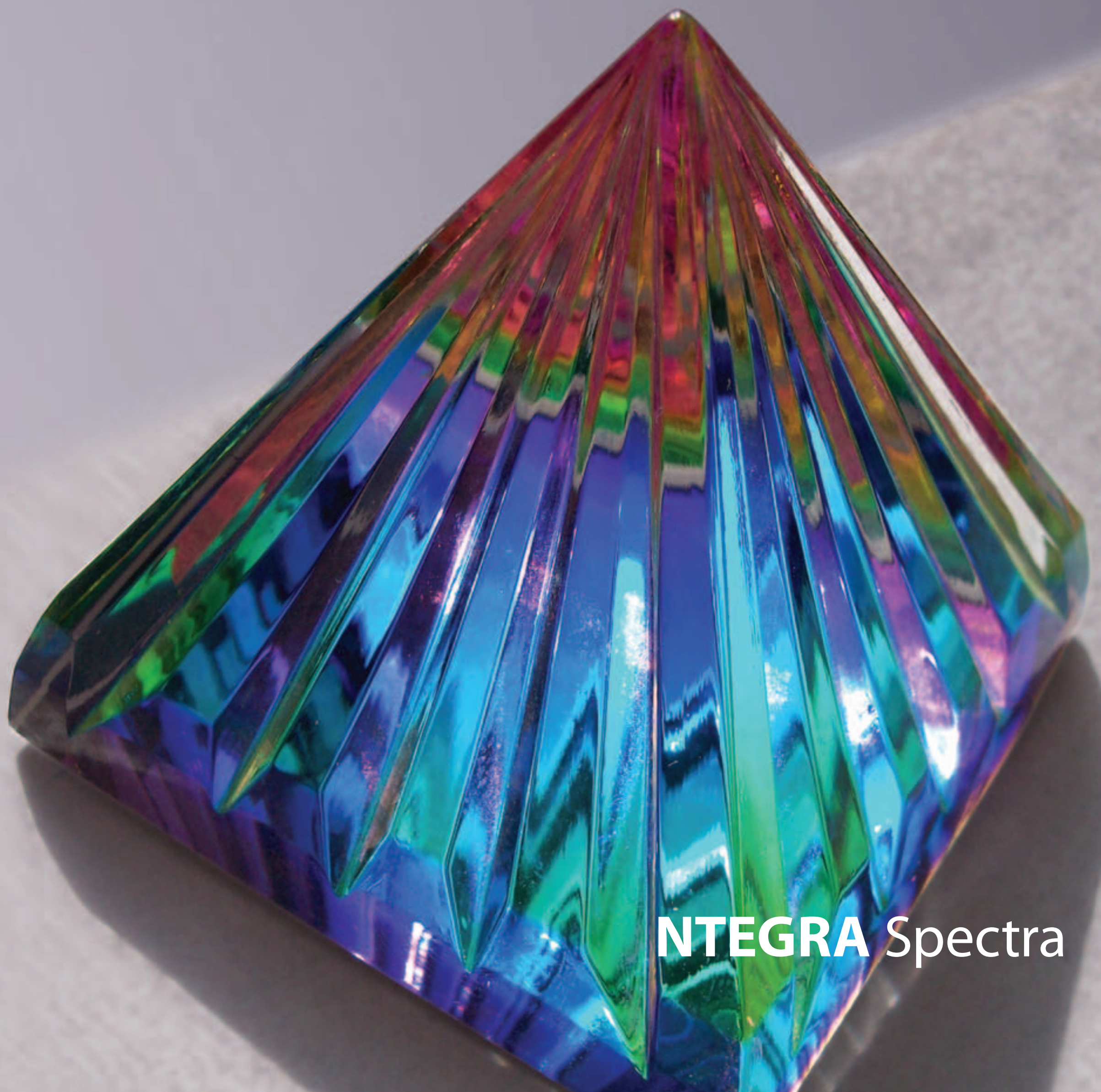
Ultratomy

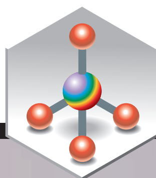
Self locking		Yes
Graduation		±30° graduation
Clearance angle adjustment		-2° to 15° with 1°scale
Knife holder		For 6–12 mm knives
Coarse knife-movements	N-S	10 mm stepping motor
	E-W	25 mm stepping motor
Cutting window		0.2–15 mm adjustable
Cutting speed		0.05–100 mm/s wheel contr.
Section thickness		0–15000 nm wheel contr.
FEED / SPEED storage		5
Return speeds		10, 30, 50 mm/s
Step control		0.1–15 µm steps

Section counter		Yes
Feed totalizer		Yes
Count down		Yes
Rocking mode		Yes
E-W measurement		Yes
Auto trim		Yes
Specimen advance indicator		Yes
Working distance		110 mm
Universal specimen holder		2 pcs.
Flat specimen holder		1p.
Instrument table	Dimensions	0.67 x 1.15 m
	Shock-absorbing elements	Yes

Papers:
• Efimov A.E., Tonevitsky A.G., Dittrich M., Matsko N.B. Atomic force microscope (AFM) combined with the ultramicrotome: a novel device for the serial section tomography and AFM/TEM complementary structural analysis of biological and polymer samples // Journal of Microscopy. 2007. Vol. 226, pp. 207–217.

Color the nanoworld





Chemistry + Structure = New Insights

What mysteries of nature will you uncover?

Award Winner
2006

NTEGRA Spect

A swirl of light, a swoosh of color, the fine point of an SPM scan. NT-MDT SI designers anticipate "what's next" in your analytical thinking, giving new life to SPM instrumentation, filling your lab with new energy and opportunities. Add the power of chemistry to your SPM analyses. Correlate molecular structure and physical parameters. Detect changes and responses with a new vision. **NTEGRA** Spectra. Unlocking the mysteries of chemistry, structure and function.

Integration: The key to the new sciences

Change happens at interfaces and today's most exciting changes in microscopy are happening where multiple technologies interface. **NTEGRA** Spectra is a prime example, uniting the full power of confocal microscopy, scanning probe microscopy, Raman and fluorescence spectroscopy in one platform.

Simultaneous Confocal imaging and chemical mapping

NTEGRA Spectra can map chemical properties of the sample. Show as subtle changes in spectra reflect changes in strain, polarizability, or macromolecular conformation. Measurements can be performed either through upright or inverted viewing modes. The sample can be either in a controlled atmosphere or in an liquid environment. **NTEGRA** Spectra provides two separate detection channels: one for acquiring the laser confocal (Rayleigh) signal and the second for simultaneous but independent collection of the delicate Raman map that reveals the local chemical composition. The second channel can also be used for fluorescence spectroscopy or direct fluorescence imaging. Complete Raman/fluorescence spectrum is recorded in each point of 2D/3D scan. Due to excellent microscopy performance 3D spectral distribution can be studied with the spatial resolution close to the theoretical limit.

Microspectroscopy at the molecular scale

Signal strength is a major challenge in Raman measurements. The Raman signal is often only 1/millionth the strength of a fluorescence signal. The new world of nanotechnology has disclosed a fascinating phenomenon: the electromagnetic field is strongly enhanced near nanometer-scale asperities. The resulting effects are called Surface Enhanced Raman Scattering (SERS) and, when done in conjunction with an SPM tip, Tip-Enhanced Raman Scattering (TERS). By using a specially prepared sharp needle tip, **NTEGRA** Spectra can multiply the Raman signal strength by factors of hundreds, thousands and even millions from a precisely scanned, localized spot on the surface several nanometers in diameter. Even single molecules can be detected and recognized by their spectra. Lateral resolution of TERS mapping is no longer limited by light diffraction.

A laser for every purpose

NTEGRA Spectra is built to offer you maximum flexibility. As with many microscopy parameters, Raman presents trade-offs. The intensity of Raman scattering is inversely proportional to the fourth order of the excitation wavelength. Therefore, to obtain the maximum signal, the experiment dictates the use of the shortest possible wavelengths. However, longer wavelengths penetrate deeper into the sample and are less harmful to delicate preparations, especially biological samples. **NTEGRA** Spectra can be configured with three different software selectable lasers. Simply choose the one that best fits your needs.

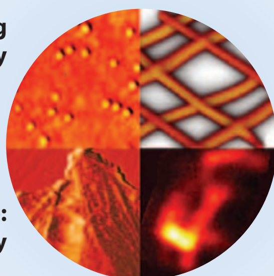
One master Nova™ software program makes the complex simple

Truly great engineering makes complex processes transparent to the user. **NTEGRA** Spectra is a prime example of NT-MDT's brilliant engineering. Taken piece by piece, **NTEGRA** Spectra can be overwhelming: there are multiple lasers, a spectrometer, a confocal laser system, polarizers, pinholes, photomultipliers and other detectors, and of course, the scanning probe microscope. All of these have to be individually controlled and seamlessly integrated. Not to worry. One can manage them easily through the fully integrated system software. Specify the pinhole size on the confocal system, choose the appropriate laser & polarization, adjust the spectrometer all with using a couple clicks with the mouse.

Atomic-force microscopy: mechanical, electrical, magnetic properties and nanomanipulations

Confocal Raman: imaging and spectroscopy

Near-field optical microscopy

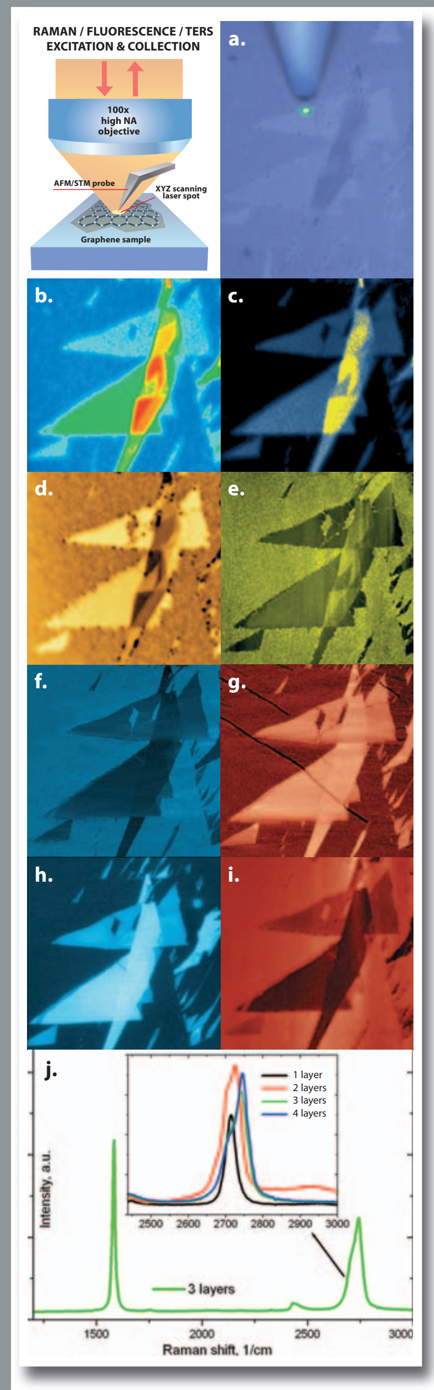


Confocal fluorescence: imaging and spectroscopy

Optical microscopy and laser confocal imaging

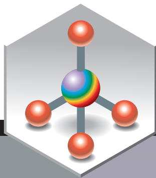
All techniques can be applied to the same object. Measurements in air, liquids, gases with controlled temperature and humidity.

The same graphene flakes imaged by different AFM and spectroscopy techniques in the single experiment



a) White light image of graphene flakes with AFM tip and Raman laser spot
b) Raman map: G-band intensity
c) Raman map: 2D (G') band mass center
d) Rayleigh light intensity
e) AFM: Height (topography)
f) AFM: Lateral force (friction)
g) AFM: Force modulation (elastic properties)
h) AFM: Kelvin probe (surface potential)
i) AFM: Electrostatic force (charge distribution)
j) Raman spectra of flakes with different thickness

Size of images: 30x30 µm



NTEGRA Spectra optical scheme

CCD
APD
Spectrometer
PMT
Grating 1
Grating 2
Grating 3
Echelle grating
Pinhole
Laser
532 nm
405 nm
473 nm
633 nm
785 nm
Pinhole
λ/2
Confocal module
Inverted
Upright
XYZ scanning AFM/STM probe
XYZ scanning stage
Laser spot
100x high NA objective
RAMAN / FLUORESCENCE / TERS EXCITATION & COLLECTION
AFM/STM probe
XYZ scanning laser spot
XYZ scanning stage
TERS EXCITATION/COLLECTION

1 AFM probe and laser beam are perfectly coordinated with each other. The AFM probe can be placed within the laser spot with nanometer precision — as it is necessary for tip-enhanced optical effects. Movement in 6 different axes is controlled by closed-loop sensors.

2 High NA objective is rigidly integrated into the SPM base. It provides unprecedented optical system stability — designed for long-term and weak-signal experiments.

3 Reflected laser light is used to obtain fast confocal laser (Rayleigh) image.

4 TE-cooled (down to -100°C) CCD or EMCCD serves as a sensitive spectroscopy detector. Alternatively avalanche photodiode or photon multiplier (PMT) can be used for single photon counting.

5 Flexible polarization optics in both excitation and detection channels. User defined optical filters. All motorized, software controlled.

6 Excellent software integration has been realized. All system modules (AFM, optics and mechanics) are driven by the same software package. Lasers, gratings, polarizers, pinholes etc, can be chosen and adjusted from the program.

7 AFM and confocal Raman maps are acquired simultaneously and analyzed in the same software package

8 Solutions for all possible TERS geometries. Dual scan option: scan by sample *plus* scan by tip / by laser beam

Inverted setup:

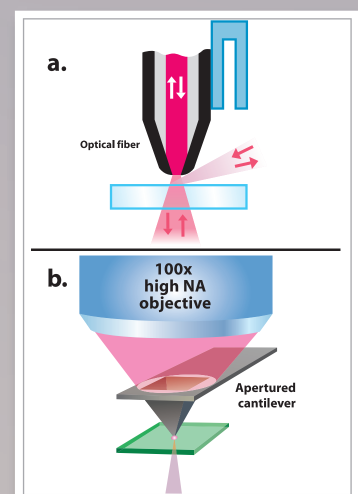
- Optimized for transparent samples
- Highest optical resolution achievable (<200 nm) *simultaneously* with AFM
- Highest efficiency of Raman/fluorescence Photon collection (with immersion optics) *simultaneously* with AFM
- Probe scanning in addition to sample scanning (important for TERS)
- Equipped with heating stage, temperature controlled liquid cell and environmental chamber
- Fits most commercial inverted microscopes, supporting advanced imaging modes

Upright setup:

- Optimized for opaque samples
- Highest optical resolution (400 nm) *simultaneously* with AFM
- Highest efficiency of Raman/Fluorescence photon collection *simultaneously* with AFM
- Beam scanning in addition to sample scanning (necessary for TERS)
- Equipped with heating stage, environmental chamber

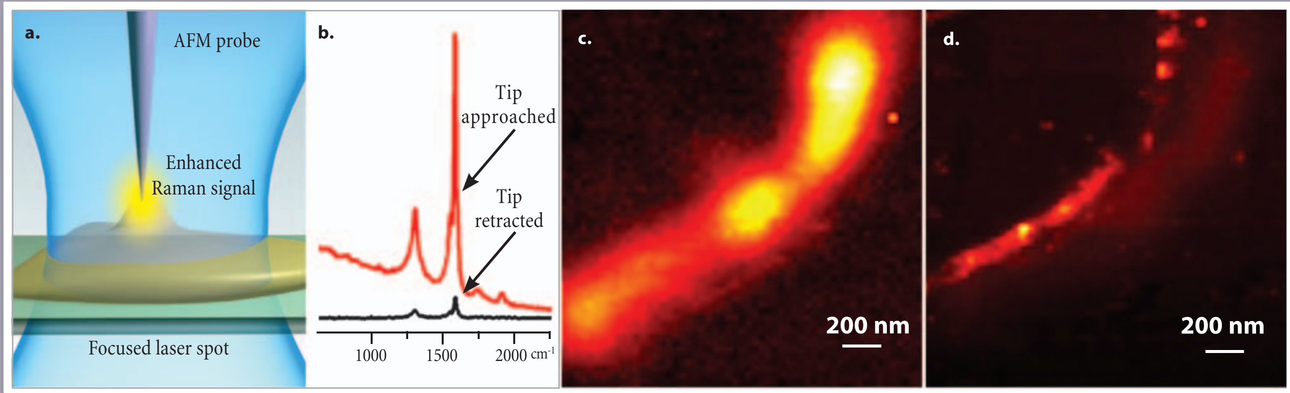
Work both with cantilevers (contact, intermittent contact and other modes: more than 30) and with metal tips (STM mode, shear force mode, normal force mode)

SNOM



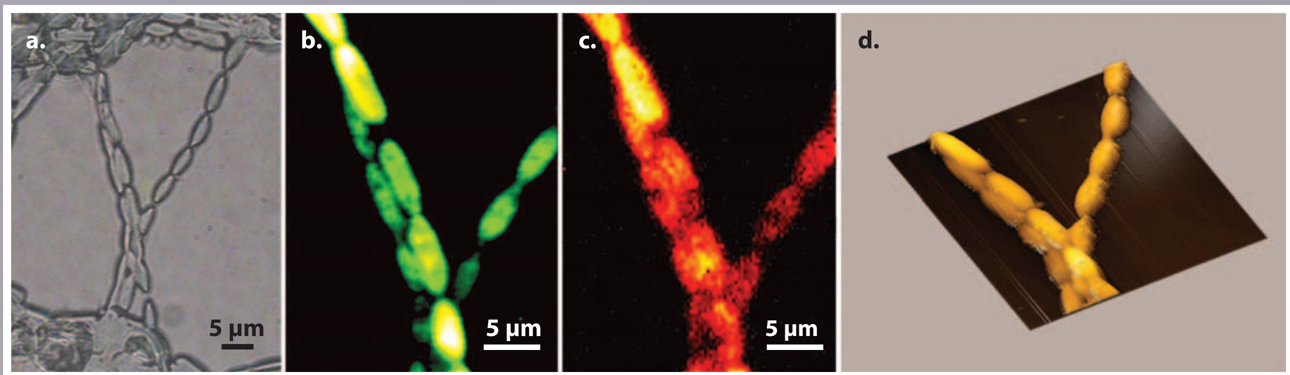
a) Based on quartz SNOM fiber, shear-force feedback.
b) Based on silicon cantilevers with nanofabricated aperture

Raman microscopy with ultra-high spatial resolution



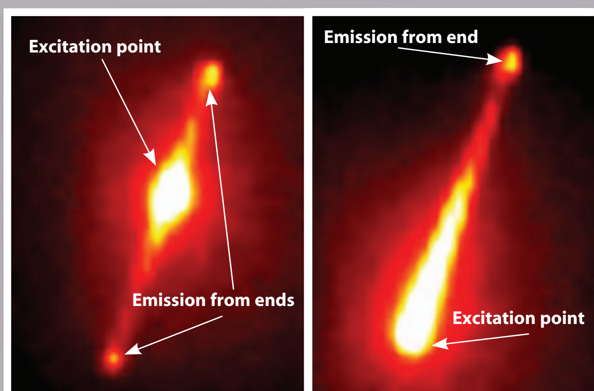
a) A specially prepared AFM probe (metal coated cantilever or etched metal wire) is precisely positioned inside a tightly focused laser spot. b) Intensity of carbon nanotube G- and D- Raman bands increases by several orders of magnitude when the special AFM probe is landed and positioned over a small (5 nm height) nanotube bundle — the effect of Tip Enhanced Raman Scattering (TERS). c) "Conventional" confocal Raman image of the nanotube bundle, the observed width of the bundle is ~250 nm (diffraction limit of confocal microscopy, laser wavelength — 633 nm). d) TERS image of the same bundle – now the observed width is 50–70 nm.
Note, in this example, TERS provides more than 4-times better spatial resolution as compared to confocal microscopy. Resolution down to 10 nm and less is theoretically possible. Measurements are done with NTEGRA Spectra in Inverted configuration.
Data courtesy of Dr. S. Kharintsev, Dr. J. Loos, Dr. G. Hoffmann, Prof. G. de With, TUE, the Netherlands and Dr. P. Dorozhkin, NT-MDT SI

Comprehensive analysis of biological structures



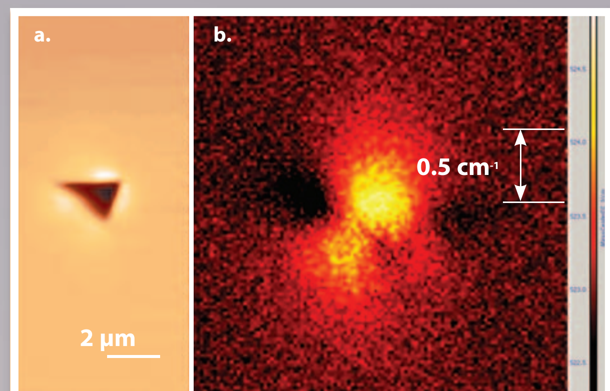
Algal cells visualization by different techniques. a) Bright field overview. b) Confocal Raman map at 1524 cm^{-1} (beta-carotene line).
c) Confocal image of autofluorescence at 492–513 nm. d) AFM image.
Sample courtesy of Don McNaughton, Monash University, Victoria, Australia

Light transport in nanostructures



Fluorescent nanowire is excited by 488 nm light at the body (left image) and at the left bottom end (right image). Excitation light is completely cut off from the image by two edge filters (with 10^{-6} transmission). Part of the fluorescence light emitted from nanowire (>10%) is transmitted through it and is emitted from nanowire ends

Stress mapping in silicon structures



a) AFM topography of indentation in silicon substrate. b) Center of mass position shift of 520 cm^{-1} silicon line — proportional to stress distribution around the indentation.
Spectral resolution better then 0.1 cm^{-1}

Confocal Raman/Fluorescence microscopy

Confocal Raman/Fluorescence/Rayleigh imaging runs simultaneously with AFM (during one sample scan)

Diffraction limited spatial resolution: <200 nm in XY, <500 nm in Z (with immersion objective)

True confocality; motorized confocal pinhole for optimal signal and confocality

Motorized variable beam expander/collimator: adjusts diameter and collimation of the laser beam individually for each laser and each objective used

Full 3D (XYZ) confocal imaging with powerful image analysis

Hyperspectral imaging (recording complete Raman spectrum in every point of 1D, 2D or 3D confocal scan) with further software analysis

Optical lithography (vector, raster)

AFM/STM: Integration with spectroscopy

Upright and Inverted optical AFM configurations (optimized for opaque and transparent samples correspondingly);
side illumination option

Highest possible resolution (numerical aperture) optics is used simultaneously with AFM: 0.7 NA for Upright, 1.3–1.4 NA for Inverted

AFM/STM and confocal Raman/Fluorescence images are obtained simultaneously (during one scan)

All standard SPM imaging modes are supported (>30 modes) — combined with confocal Raman/Fluorescence

Low noise AFM/STM (atomic resolution)

Vibrations and thermal drifts originating from optical microscope body are minimized due to special design of optical AFM heads

Focus track feature: sample always stays in focus due to AFM Z-feedback; high quality confocal images of very rough or inclined samples can be obtained

Software

Seamless integration of AFM and Raman; all AFM/Raman/SNOM experiment and further data analysis is performed in one and the same software

Powerful analysis of 1D, 2D and 3D hyperspectral images

Powerful export to other software (Excel, MatLab, Cytospec etc.)

Spectroscopy*

Extremely high efficiency 520 mm length spectrometer with 4 motorized gratings

Visible, UV and IR spectral ranges available

Echelle grating with ultrahigh dispersion; spectral resolution: 0.007 nm (< 0.1 1/cm)**

Up to 3 different detectors can be installed
- TE cooled (down to -100 ºC) CCD camera. EMCCD camera is optional — *for ultrafast imaging*
- Photon multiplier (PMT) or avalanche photodiode in photon counting mode
- Photon multiplier for fast confocal laser (Rayleigh) imaging

Flexible motorized polarization optics in excitation and detection channels, cross-polarized Raman measurements

Fully automated switch between different lasers — with a few mouse clicks

Scanning Near Field Optical Microscopy (SNOM)

Two major SNOM techniques supported: (i) based on quartz fiber probes, (ii) based on silicon cantilever probes

All modes supported: Transmission, Collection, Reflection

All SNOM signals detected: laser intensity, fluorescence intensity, spectroscopy

SNOM lithography (vector, raster)

Optimized for Tip Enhanced Raman Scattering (TERS) and other tip-related optical techniques (S-SNOM, TEFS, STM-LE etc.)

All existing TERS geometries are available: illumination/collection from bottom, from top or from side

Different SPM techniques and TERS probes can be used: STM, AFM cantilever, quartz tuning fork in tapping and shear force modes

Dual scan (for Hot Point Mapping in TERS): scan by sample AND scan by tip / by laser spot

Motorized polarization optics to produce optimal polarization for TERS

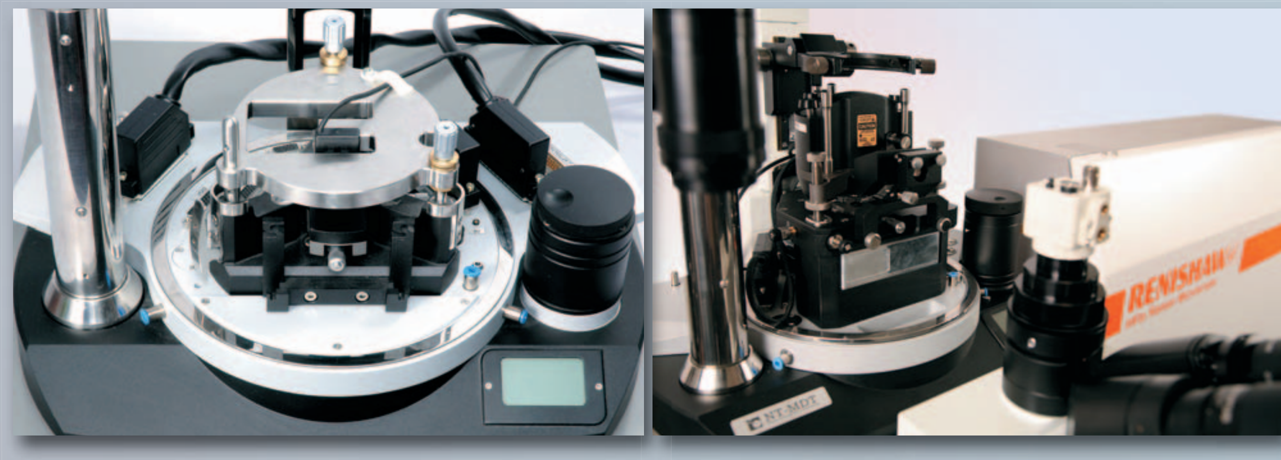
AFM-Raman measurements can run in air, in controlled atmosphere or in liquid — all with variable temperature

Some features listed are *optional* — not included into basic system configuration

* NT-MDT SI AFM can be integrated with Renishaw inVia or with NT-MDT SI spectrometer. Specifications are given for the latter. Renishaw specifications can be found at www.renishaw.com/AFM-Raman

** Exact value of spectral resolution highly depends on how “resolution” is defined

The policy of NT-MDT SI is to provide the complete instrumentation compatibility with the world-famous manufacturers of SPM-associated devices



Nanoindentation

Any **NTEGRA** based system can be supplied with the TriboScope® nanomechanical test instrument. The TriboScope® utilizes an in-situ imaging capability to realize the benefits of SPM imaging and nanoindentation in a single system.

The TriboScope® combines nanoNewton force sensitivity and picometer displacement resolution with SPM imaging for a powerful tool to aid in material studies from basic research to product development to quality control.

TriboScope® is a registered trademark of the Hysitron Inc. company.

NTEGRA Spectra + Renishaw Raman microscope = Real integration

NT-MDT SI, a world-known manufacturer of scanning probe microscopes, and Renishaw, a world-known manufacturer of Raman microscopes, joined their efforts in creation of the fascinating scientific instrument for comprehensive surface analysis.

Only **NTEGRA** Spectra provides fully technical integrated with Renishaw spectrometer solution in terms of software, hardware, and concept for interdisciplinary science at the molecular level. As a result of such union, researcher can obtain optimum efficiency and more time for investigations which allow to focus on data collection and analysis. Real integration is better than just a combination.

Renishaw spectrometer is a product of the Renishaw plc.

NT-MDT SI customer focus means ease of use and strong support

Cutting-edge information

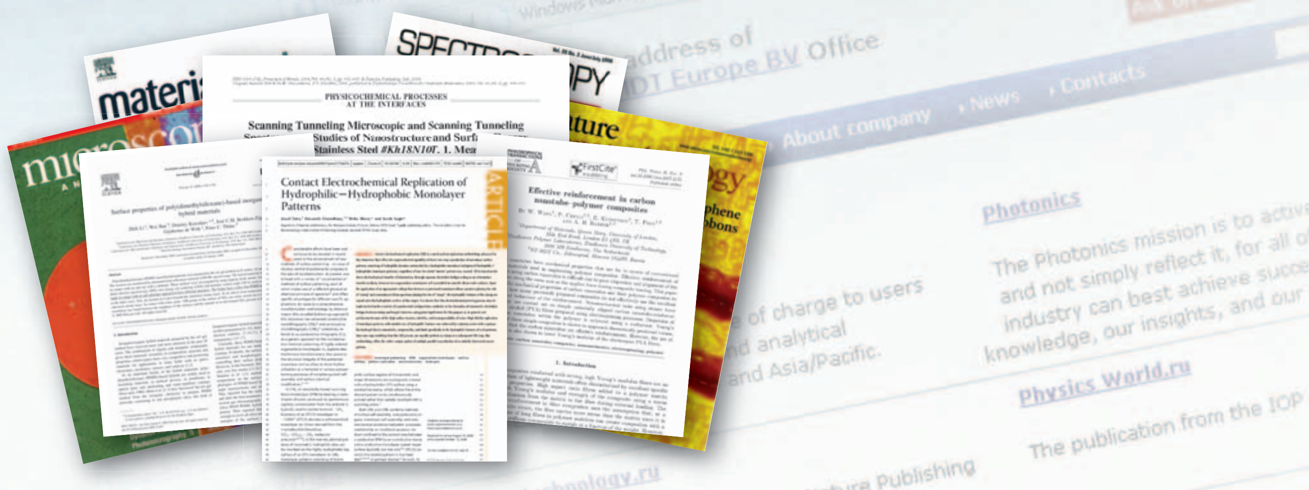
At NTMDT.com you have access to updated selections of relevant web-links, high technology materials, including world-wide nanotechnology news portals, research centers, laboratories sites, famous scientists' home-pages, etc.

Workshops

NT-MDT SI strives to keep our customers at the leading edge of innovation through workshops, lectures and advanced user courses, on the latest SPM methods, enabling scientist and engineers in all aspects of nanotechnology.

Equipment and software updates

NT-MDT SI values our customers' time and endeavors. We want to provide you with the quickest path to success. Our customers are the first to get insight of NT-MDT's latest product developments. This early opportunity provides our customers with technical advantages enabling their scientific research.



Service and support

World-wide service support

NT-MDT SI is a global company with a full service and support staff that allows us to care for our customer regardless of their location. Wherever you are, you're not far from help, please don't hesitate to call on us for assistance.

Installation & periodical equipment diagnostics

Every NT-MDT SI customer is a customer forever. Your equipment will be installed and you will receive training from an NT-MDT SI expert. We will ensure that you understand all the basics to operate your new SPM properly.

Moreover, all NT-MDT SI SPM systems have integrated diagnostic tools. In case of an unexpected system failure it also eases the conversation with our technical assistance team. Upon your request a service engineer can easily examine your system remotely and carry out all necessary steps in order to ensure it is operating correctly.

Ask-online service

Nothing can be compared with personal conversation and sincere concern from professionals in solving your problems. Ask-online system – expert consultation via Internet.

For any problems and questions, urgent or not, we have a group of specialists standing by to assist you via our unique Ask-online! It's easy to get in touch with our experts.

Accessories on-line

NT-MDT SI manufactures a complete line of SPM accessories including wide range of probes, test samples, and test gratings, all available on-line at www.ntmdt-si.com.

I T ' S T I M E F O R I N T E G R A T I O N !

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