



NT-MDT Co. Company introduction and products overview

Your choice is granted

History and background

NT-MDT that is:

- **More than 17 years on the SPM market**
- **More than 900 installations in 52 countries**
- **250+ employees in Zelenograd & Moscow offices**
- **Distribution worldwide**

“Zelenograd” means “The Green Town”. In the 20th century it became the cradle of Russian microelectronics. Outburst of High-Tech activity that had occurred at the edge of 20-21th centuries named Zelenograd as “Russian Silicon Valley”.

NT-MDT brief introduction

**NT-MDT that is:
Leading Nanotechnology
instrumentation supplier in
Russia**

**Personal:
NT-MDT: 250 staff,
2 Professors, 29 PhD,
128 engineers +
Holland – 10
Ireland -18
USA - 3**



Dr. Victor Bykov

**The President and the major
company founder started the
company in 1989**

Sales map



Sales in more than 40 countries worldwide

NT-MDT Concern structure



Branch offices in Europe

Holland, Eindhoven



Ireland, Limerick



Your choice is granted

Sales and Support in Europe

Ireland:

*Assembling
Logistics*

Netherlands:

*Sales
Customer support*



OMNILAB

Switzerland



France

SURFACE

Germany

PRA.MA.

Italy



Your choice is granted

NT-MDT-USA, SANTA CLARA



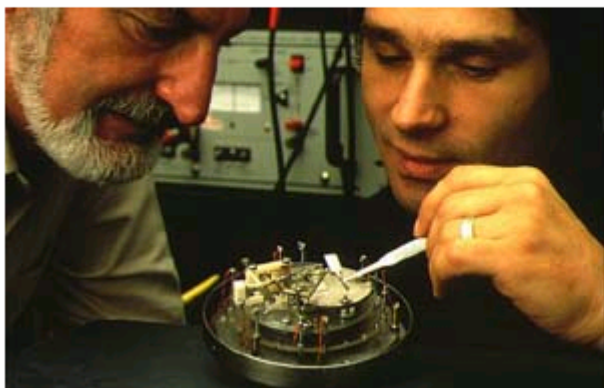
Scanning Probe Microscopy

What is it?

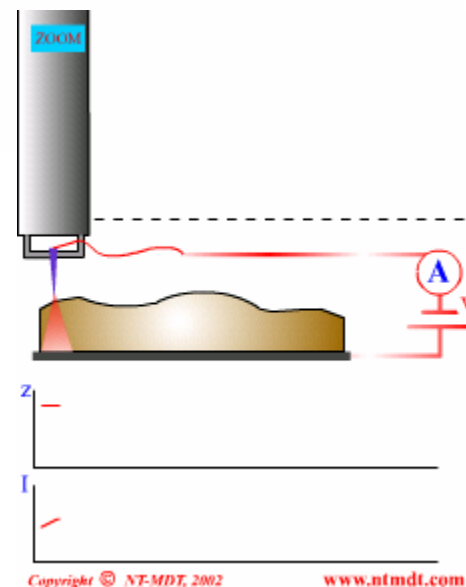
STM invention was awarded by Nobel Price in 1986

Founding Fathers of Scanning Probe Microscopy.

The founders Scanning Probe Microscopy are Binnig and Rohrer. Patent for Scanning Tunneling Microscope was issued Aug. 10, 1982 (Priority Sept. 20, 1979) ([Patent](#), [Figures 1-6](#), [Figures 7-12](#), [Figures 13-14](#)).



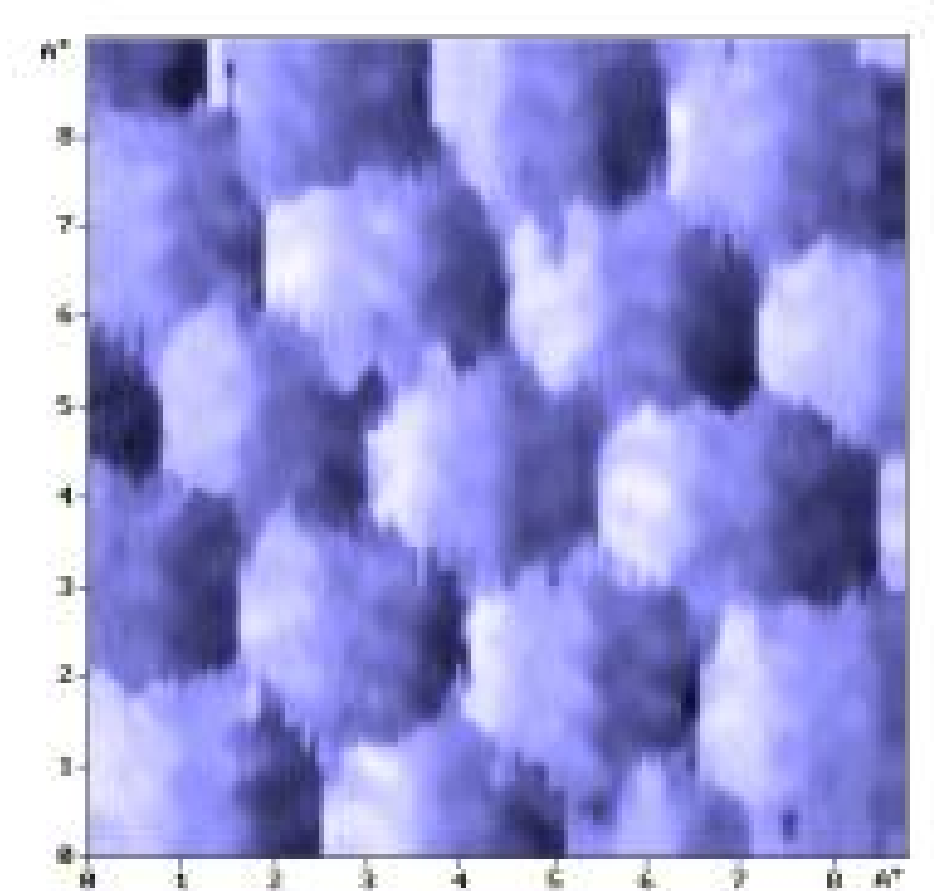
Heinrich Rohrer, left, and Gerd K. Binnig, right, scientists at IBM's Zurich Research Laboratory in Switzerland, are awarded the 1986 Nobel Prize in physics for their work in scanning tunneling microscopy. The researchers are recognized for developing the powerful microscopy technique, which allows scientists to view individual atoms on the surface of a sample. The photo is kindly submitted for a museum by Dr. G. Binnig.



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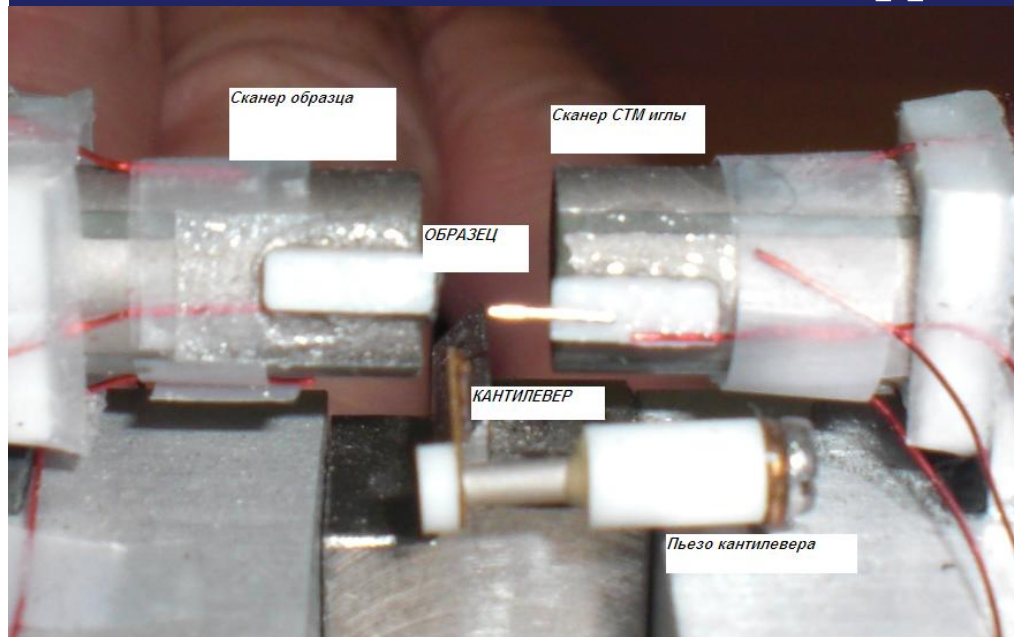
www.ntmdt.com

Scanning Probe Microscopy – the way to see atoms

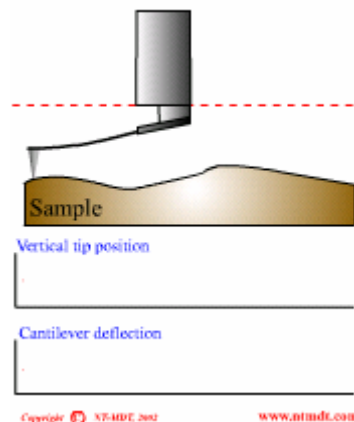


SPM image of graphite surface. Spheres are individual carbon atoms. Image size 8x8 angstrom.

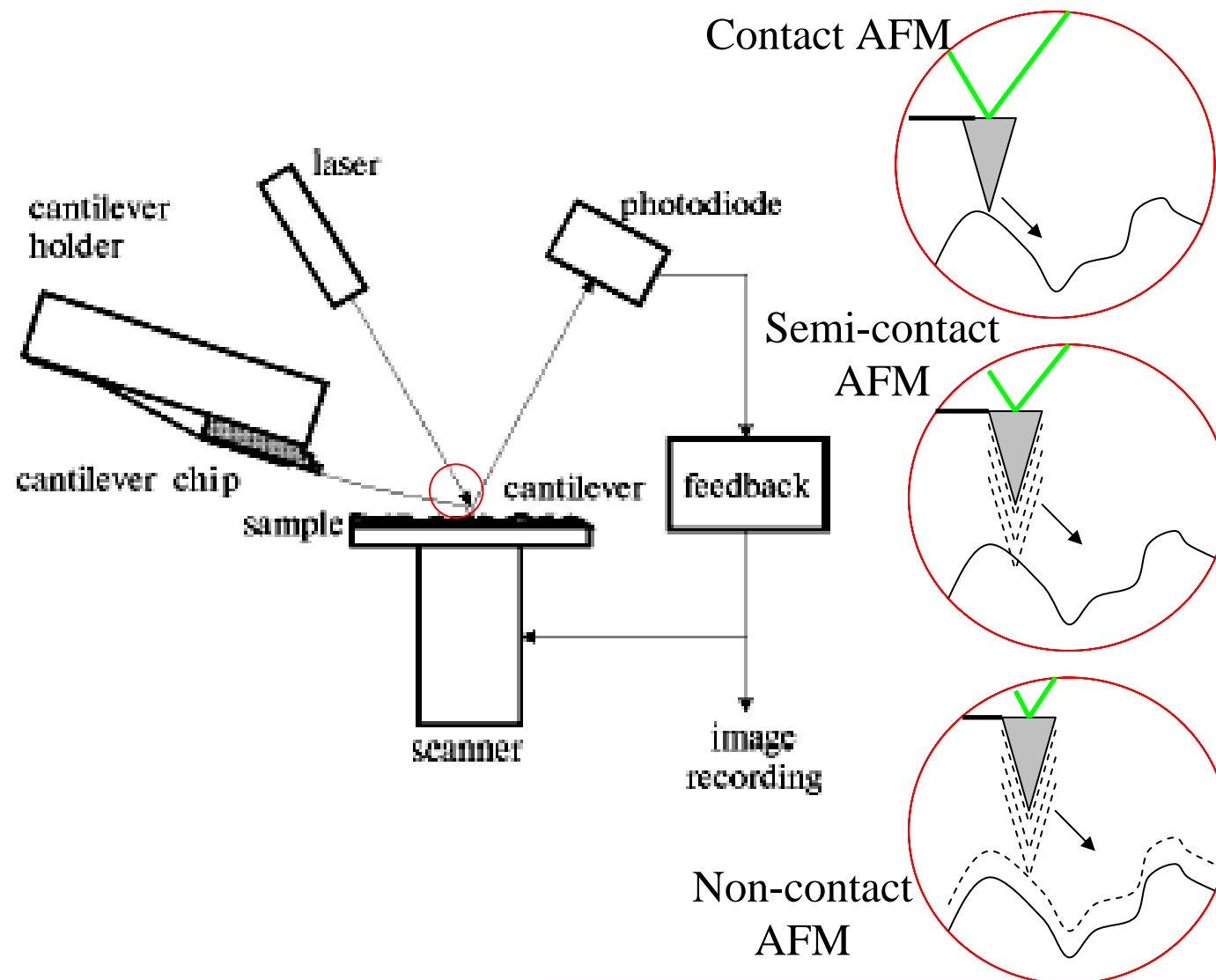
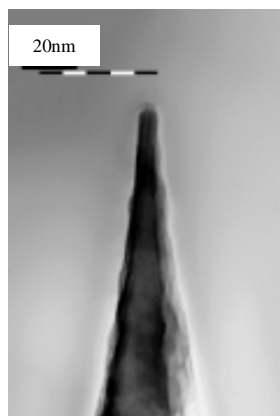
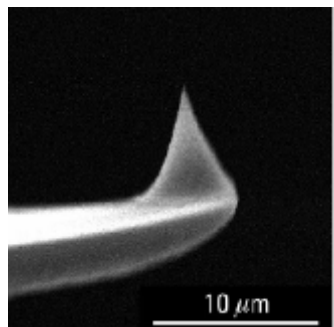
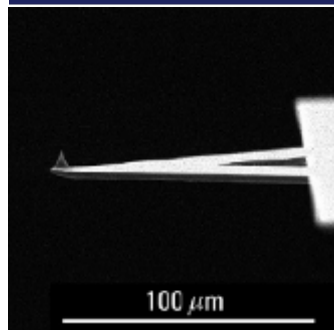
First AFM was built by C. Gerber and expands greatly possible applications



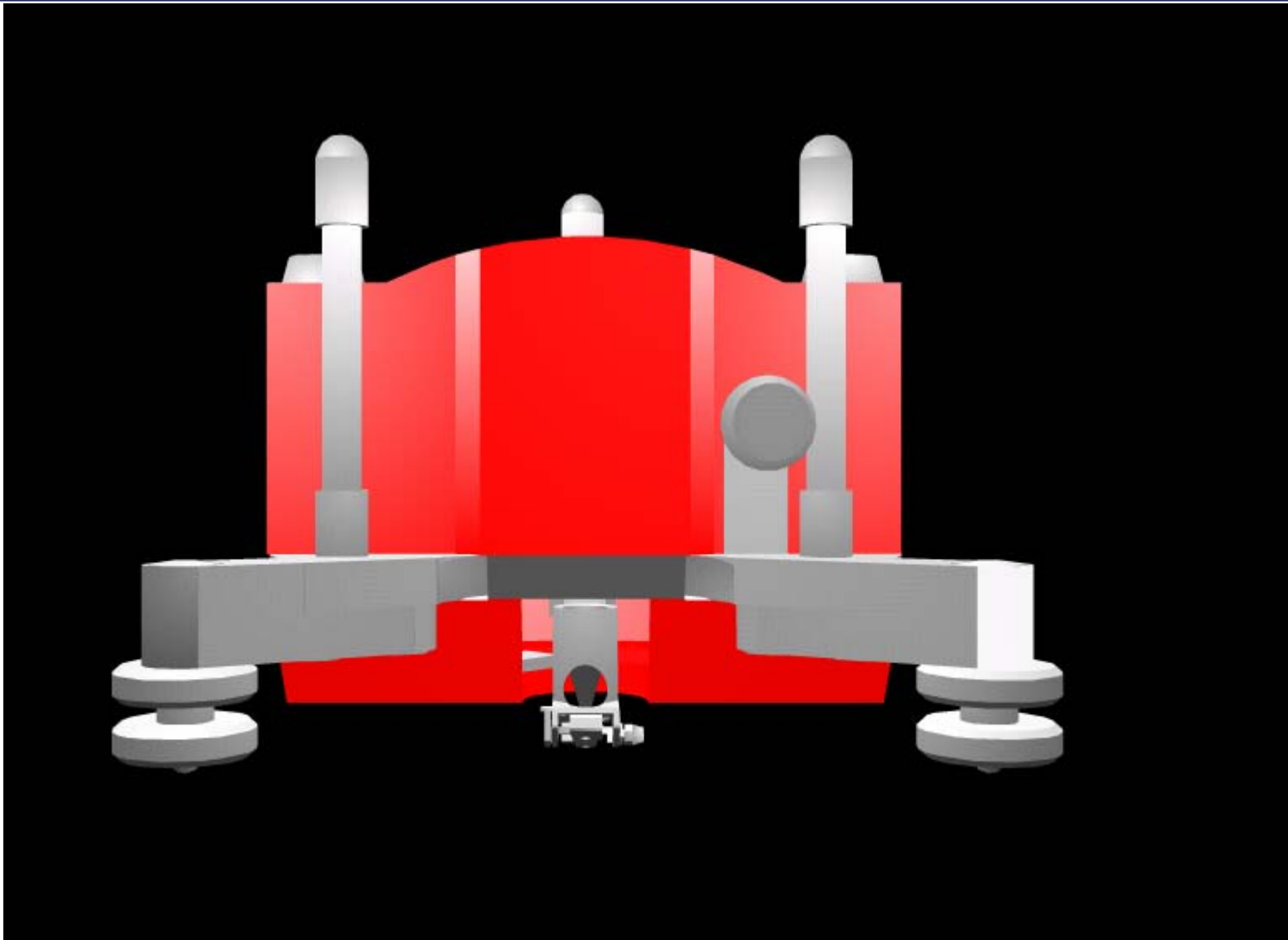
AFM renews the old gramophone concept and boost nanotechnology!






AFM - principles



AFM – how it works



There are 3 different SPM technologies: STM, AFM, SNOM

	 Atomic Force Microscope (AFM)	 Scanning Tunneling Microscope (STM)	 Scanning Near-Field Optical Microscope (SNOM)
Principle	Micro-scale cantilever with a sharp tip (probe) at its end that is used to scan the specimen surface; laser reflection of probe tip measures changes	Electrons hop or “tunnel” from the probe tip to sample; the rate of tunnelling is measured to calculate the distance between the tip and the sample	A tip scans the surface like an AFM while light scatters through an aperture in the end of the tip; light is detected from above or below
Information provided	Surface topography, physical properties	Surface topography, surface electronic structure	Surface topography and optical properties
Possible resolution	2 to 10nm; mainly affected by the curve radius of the tip (7-12nm) and roughness of the surface	Lateral: 0.01nm to 1 nm; vertical: 0.1 nm	30 to 100 nm, depending on mode, probe and sample preparation
Scan area	max. 100 μm x 100 μm	100 μm x 100 μm	80 μm x 80 μm
Scan speed	1 to 20 minutes (0.5 to 10 lines per second)	Several minutes; speed of scanning is restricted by the response time of feedback system	20 to 70 μm per second

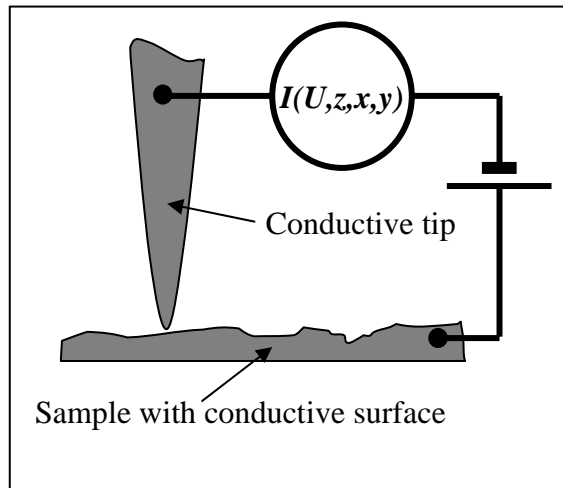
92%

of total SPM market

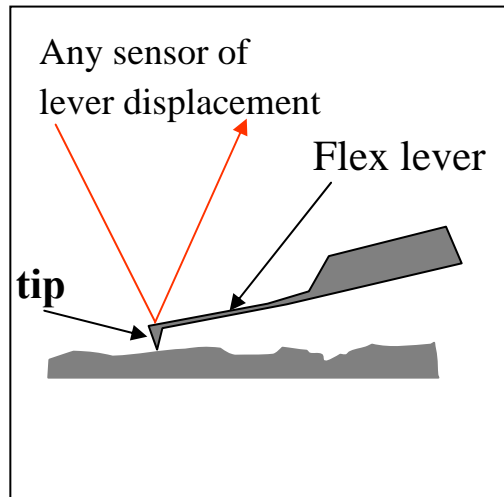
8%

SPM=Scanning Probe Microscopy

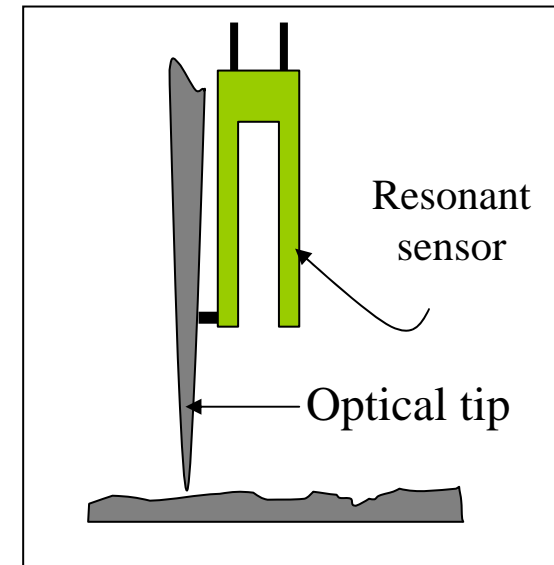
*Probe tip obtain the information from every point of an object surface.
Different methods get different information.*



Scanning Tunneling
Microscopy
Conductive sample

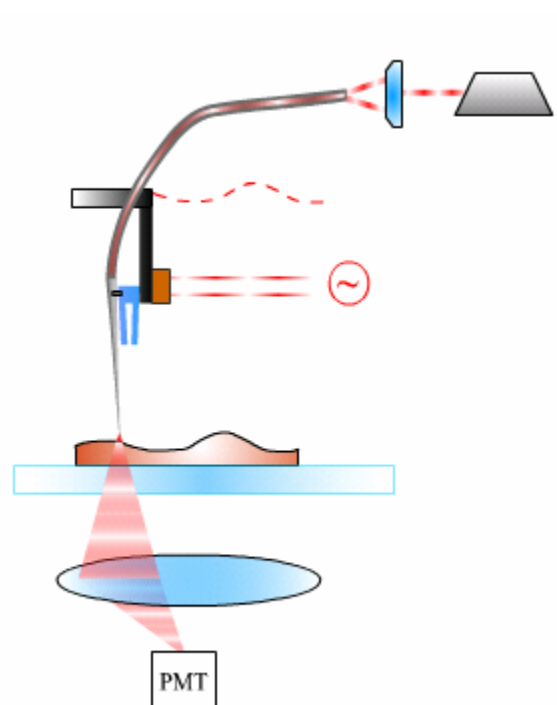


Atomic Force
Microscopy
Any solid surfaces



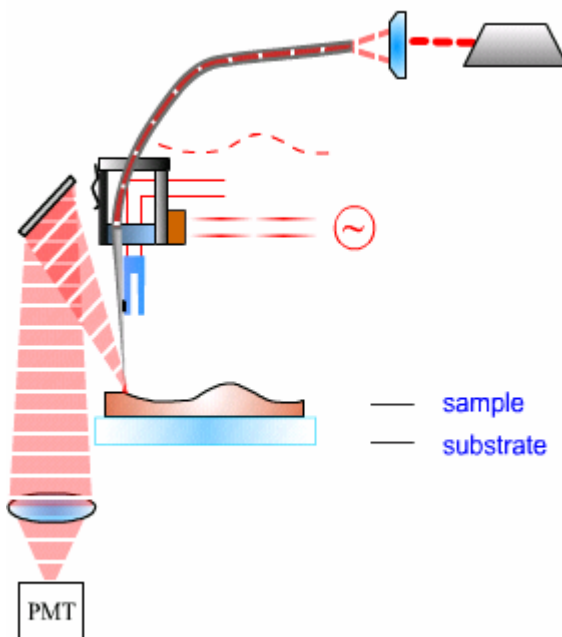
Scanning Near-Field
Microscopy
Optical properties

SNOM modes



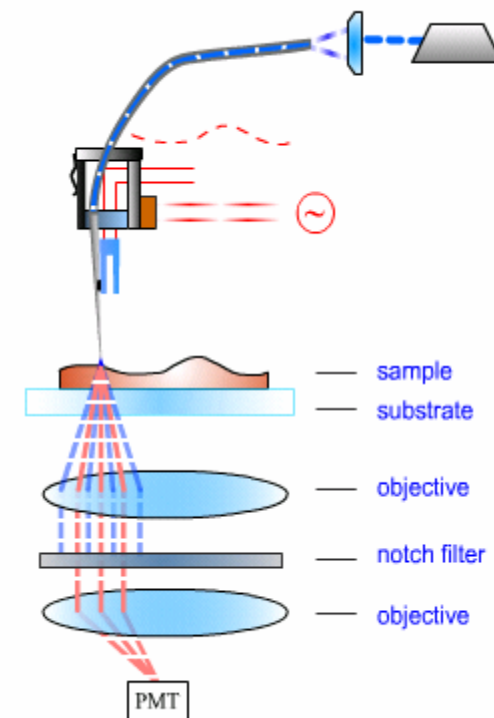
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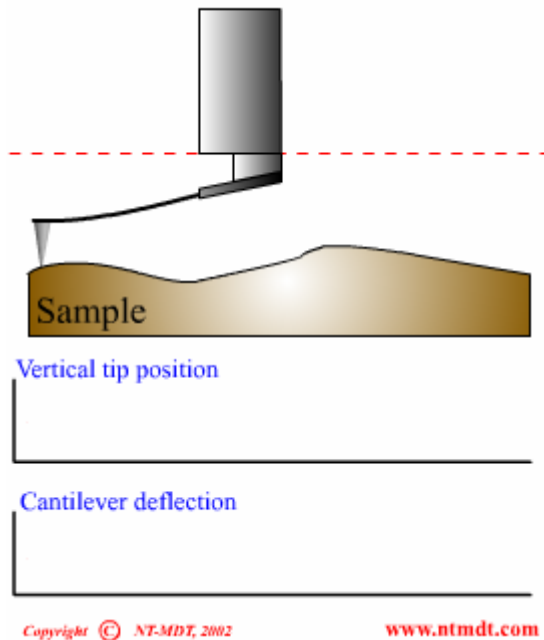
www.ntmdt.com

Transmission

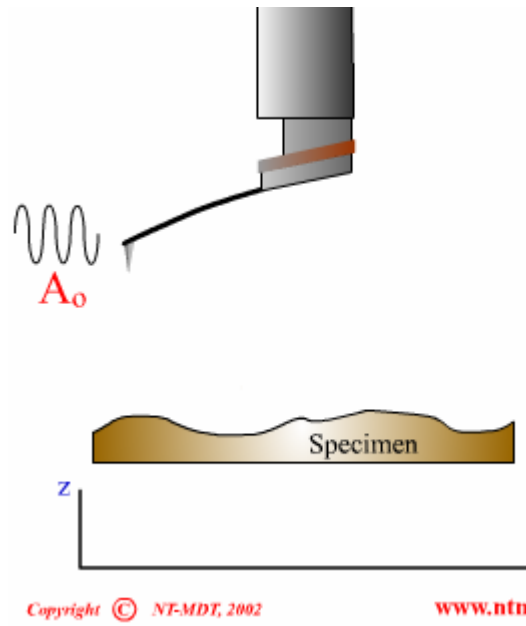
Reflection

Fluorescence

AFM techniques

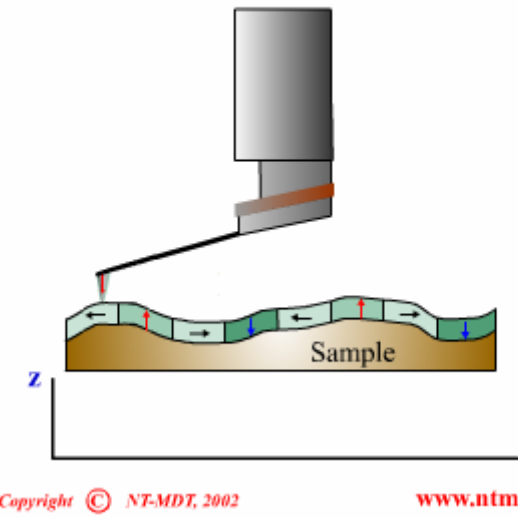


Contact AFM



Semi-Contact
AFM

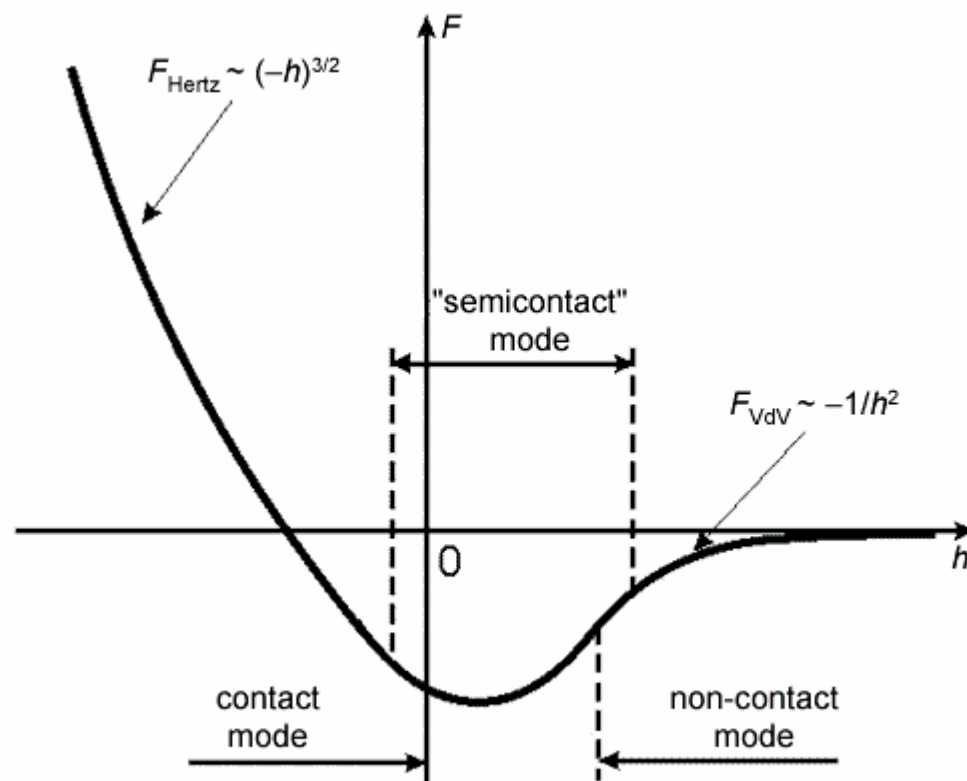
1-st pass. Sample profile acquisition.



Many-Pass
AFM

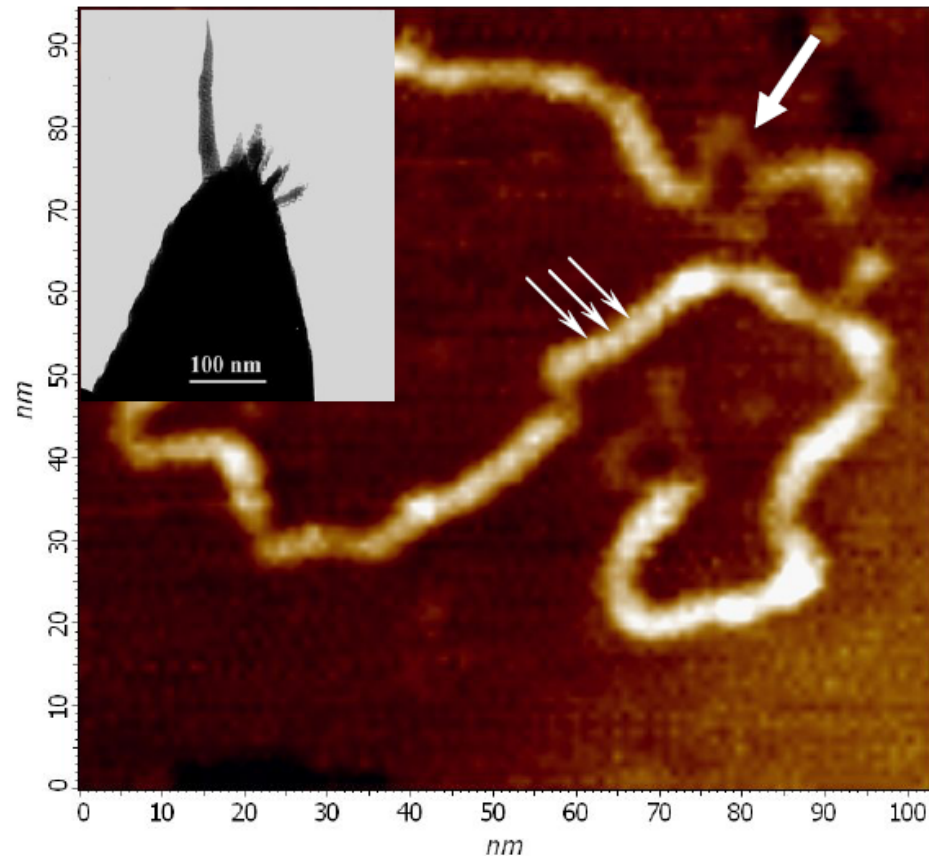
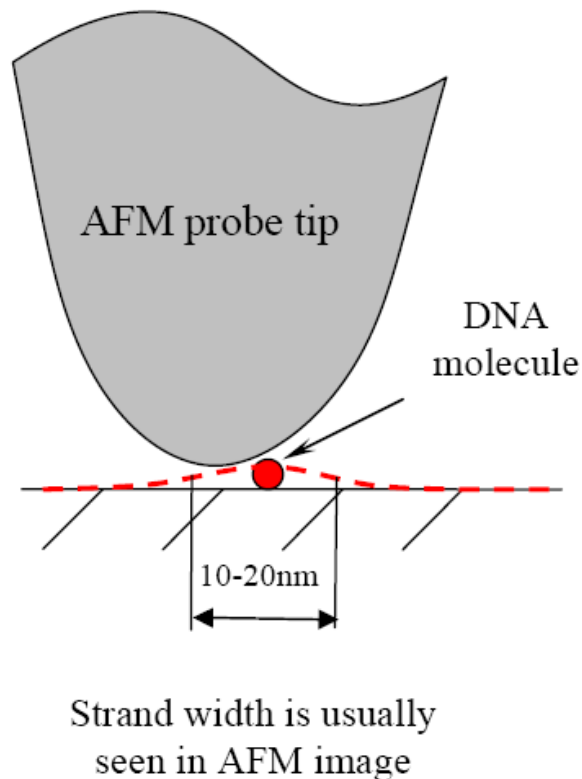
There are more than 40 different methods to form an image by AFM

Forces behind AFM



Probe-sample interaction potential.

Resolution is often limited by the probe



Small unwound single-strand fragments can be seen (bold arrow on the scan) and even helical pitch of the DNA molecule can be resolved (thin arrows) with a sharp enough tip (like DLC probe tip shown on the inset). See comprehensive discussion on sub-molecular imaging in “High resolution atomic force microscopy of duplex and triplex DNA molecules” Klinov D. et al. Nanotechnology (2007), V18, N22, p.225102.

Closed-loop control is essential for nanolithography and metrology applications



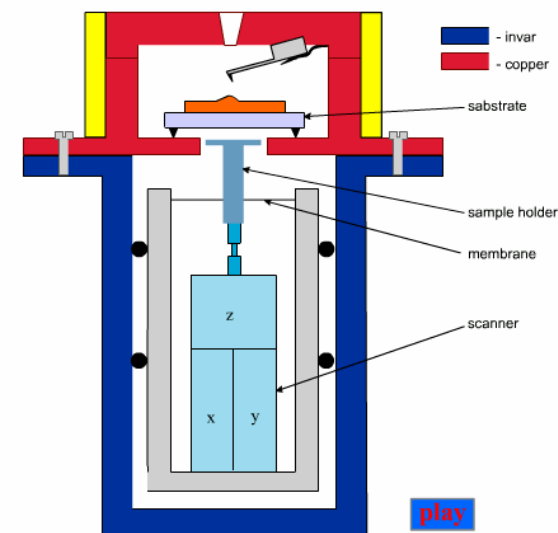
Closed-loop correction off



Closed-loop correction on

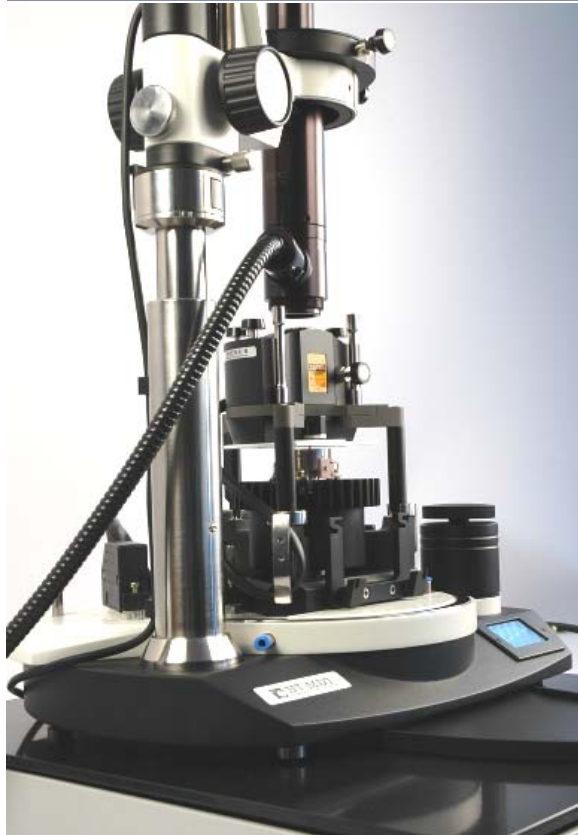
AFM nanolithography image obtained by electrical local probe oxidation technique on ultrathin titanium film. Scan size $1.9 \times 1.9 \mu\text{m}$. Image courtesy of S. Lemesko, NT-MDT.

Resolution is often limited by the drift

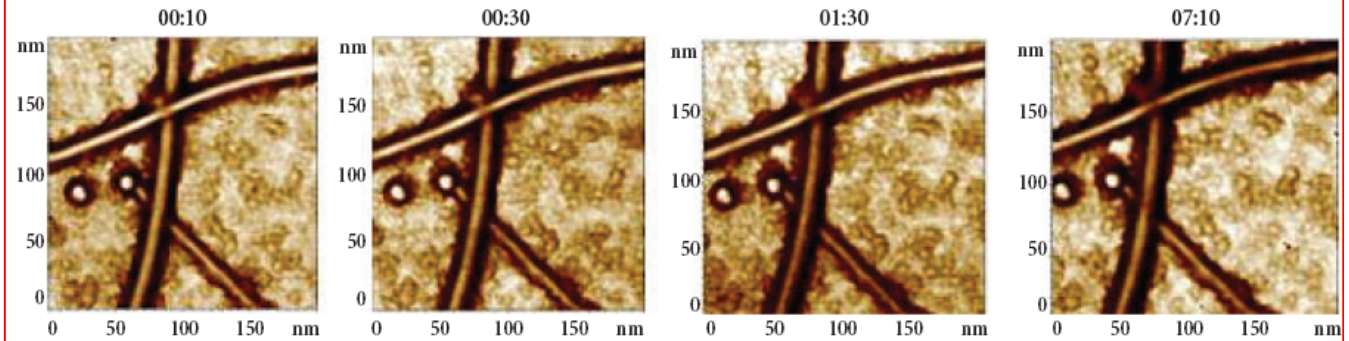


Parameter	Value
Drift XY, less than	3 nm/hour
Drift Z, less than	1 nm/hour
Thermal drift XY, less than	20 nm/°C (with special adjustment about 10 nm/°C)
Thermal drift Z, less than	10 nm/°C

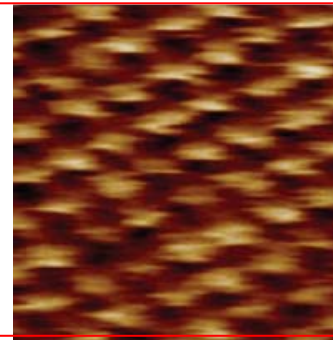
NTEGRA Thermo: the same atoms for hours



Long-term stability (nanotubes at room T)



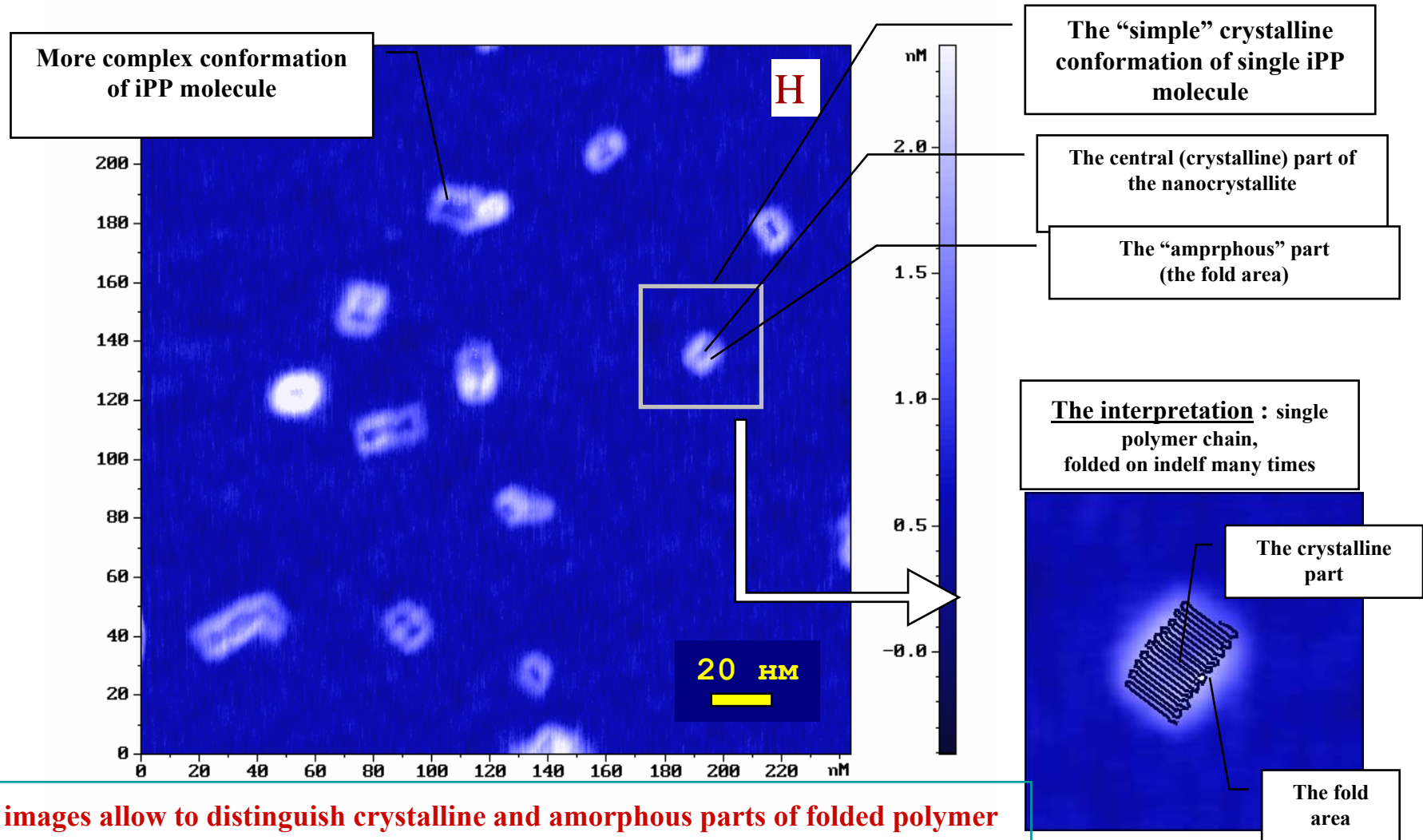
Closed-loop
correction on very
small fields
(mica atomic lattice)



- ❑ Drifts at constant T° : < 3 nm per hour
- ❑ Drifts at changing T° : < 10 nm/K
- ❑ Closed-loop sensors available down to 10 nm

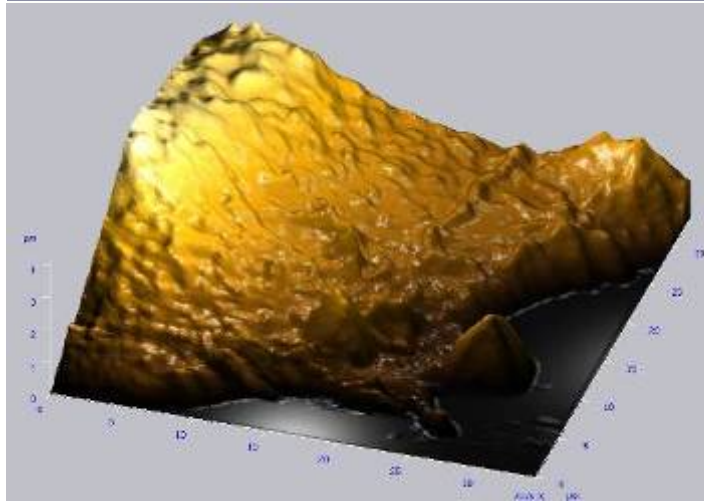
Extremely low drifts
at heating or cooling
(for the ranges $-30\dots+80^\circ\text{C}$
and $\text{RT}\dots+200^\circ\text{C}$)

AFM image of world highest resolution – single-molecule crystallites of isotactic polypropylene on mica

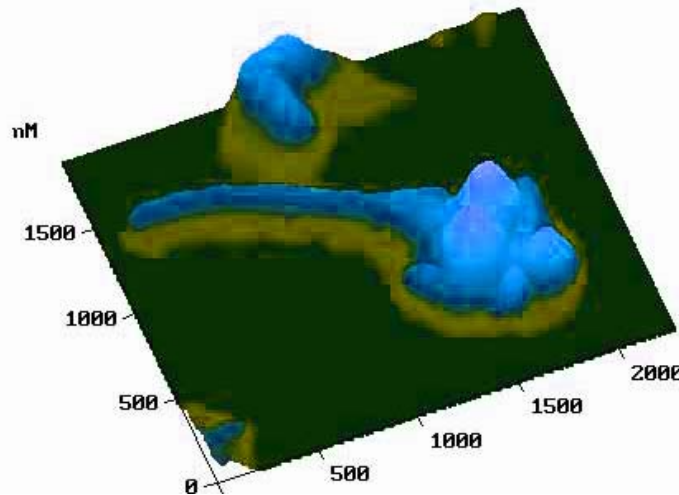


AFM images allow to distinguish crystalline and amorphous parts of folded polymer chain even within single polymer molecule

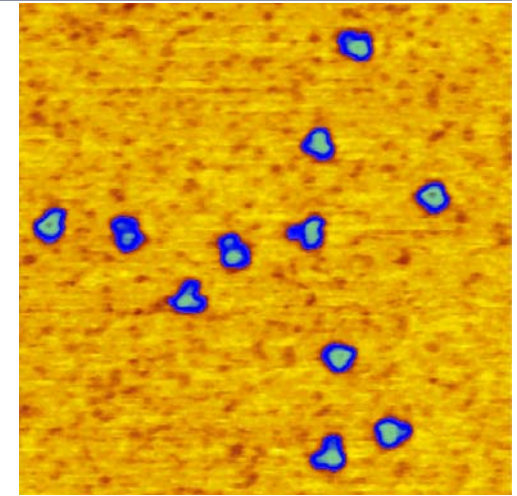
From cells to molecules



Fragment of the canine kidney
epithelial cell represented as a
3D model



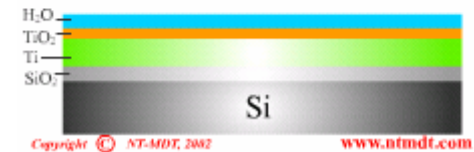
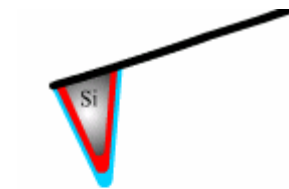
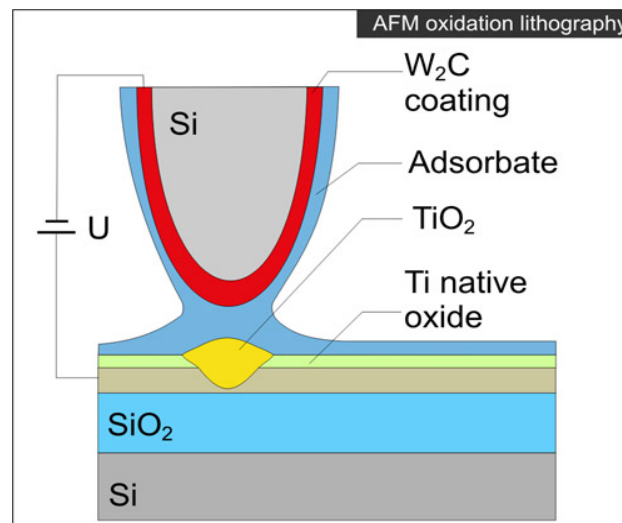
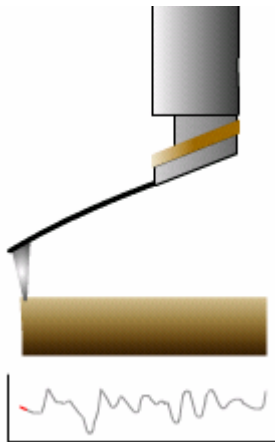
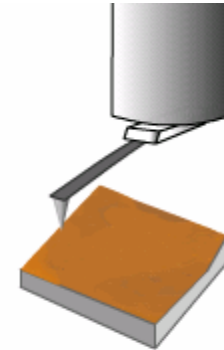
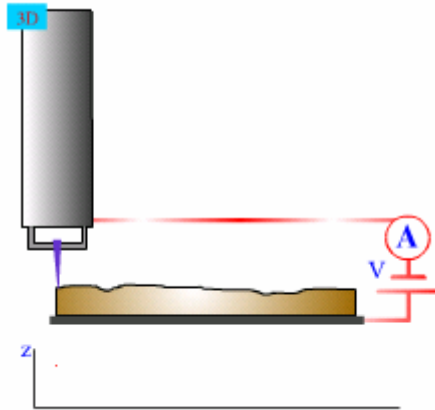
Ebola virus



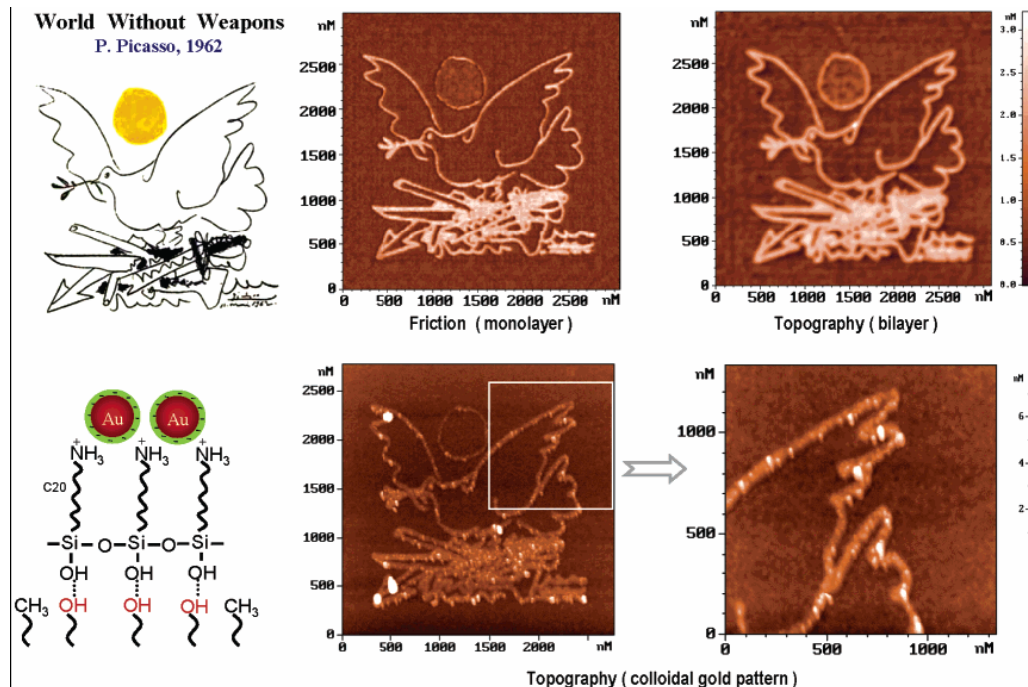
IgG single molecules

Atomic Force Microscopy (AFM) becomes a powerful tool for studying biological objects at different levels – from whole cells down to single molecules. The object size range is from 10^{-5} to 10^{-10} m!

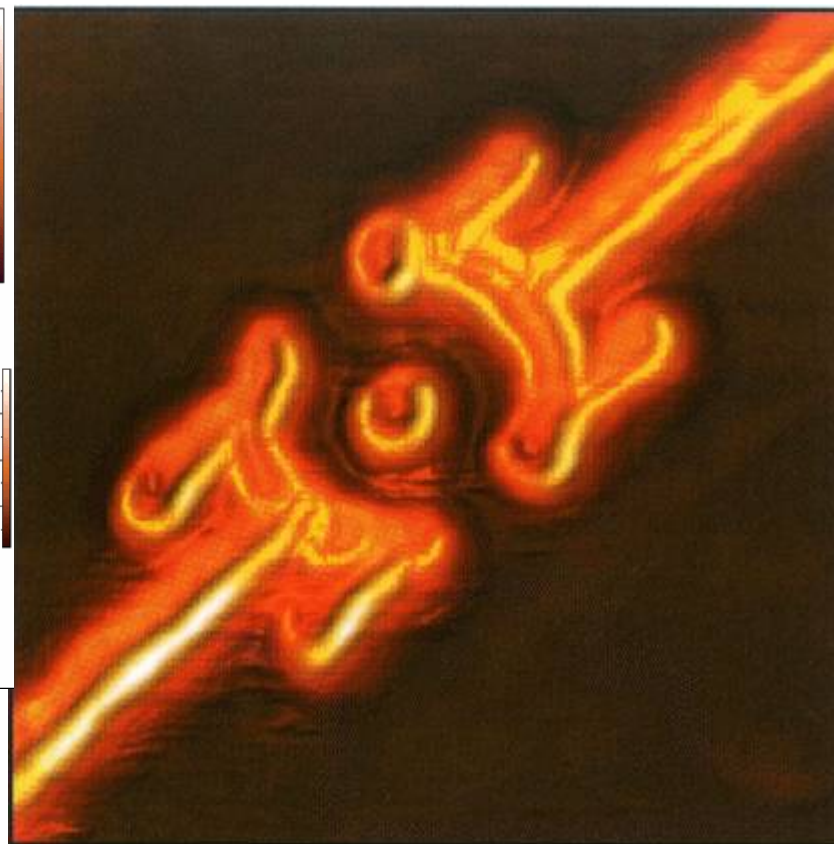
SPM lithography methods



SPM lithography – local`oxidation



Maoz, R., Frydman, E., Cohen, S., Sagiv, J. - J. Adv. Mater. 2000, 12, 725 – 731.

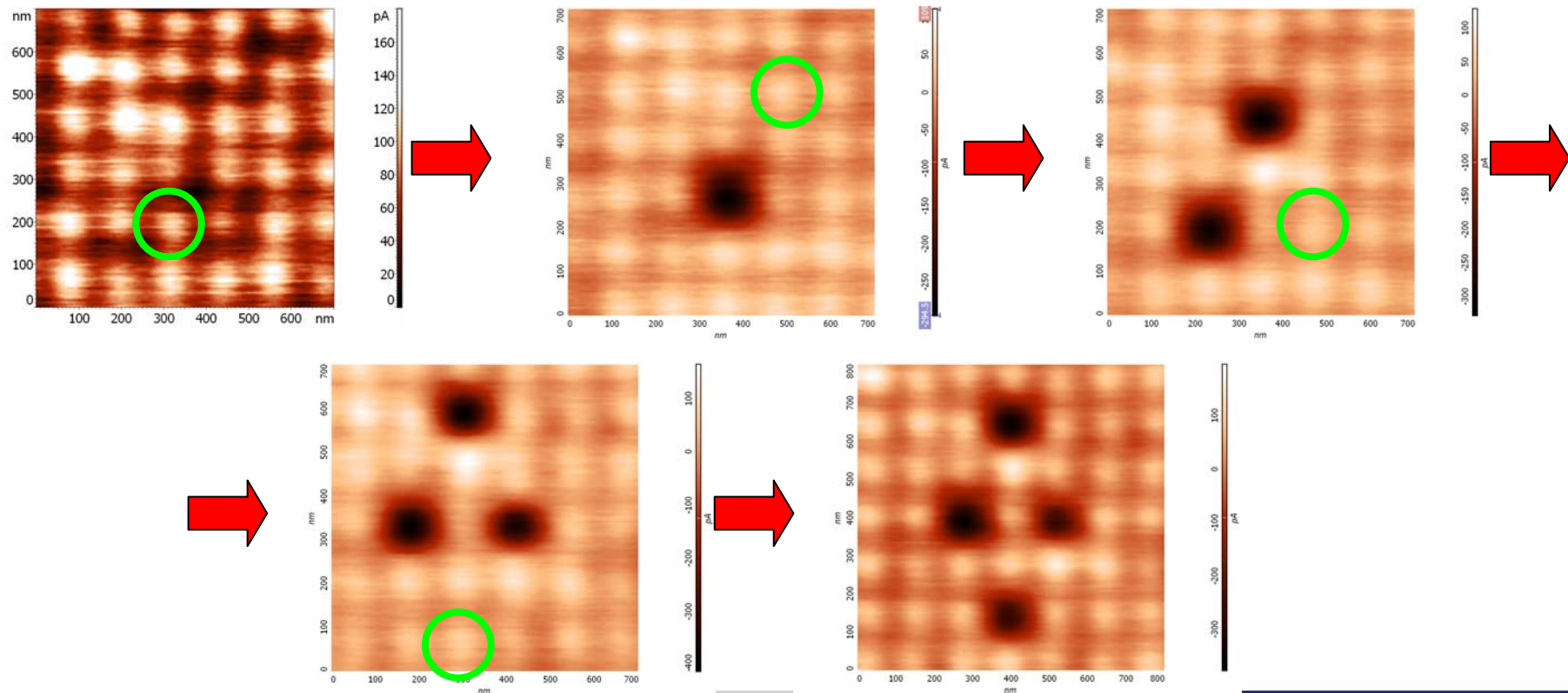


Scan size 800×800 nm, A. Latushev, Z. Kvon, A. Tropov, D. Scheglov, IPS SA RAS

High magnetic density R/W process

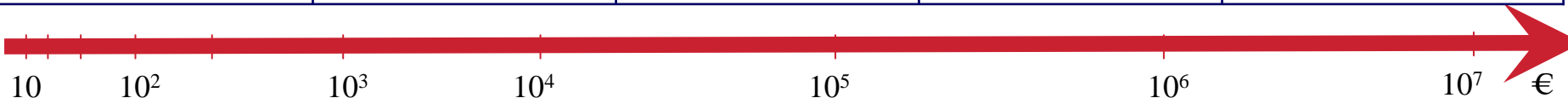
Controllable switching by tip

sample was uniformly magnetized before experiment



NT-MDT Complete product line=one stop buy concept

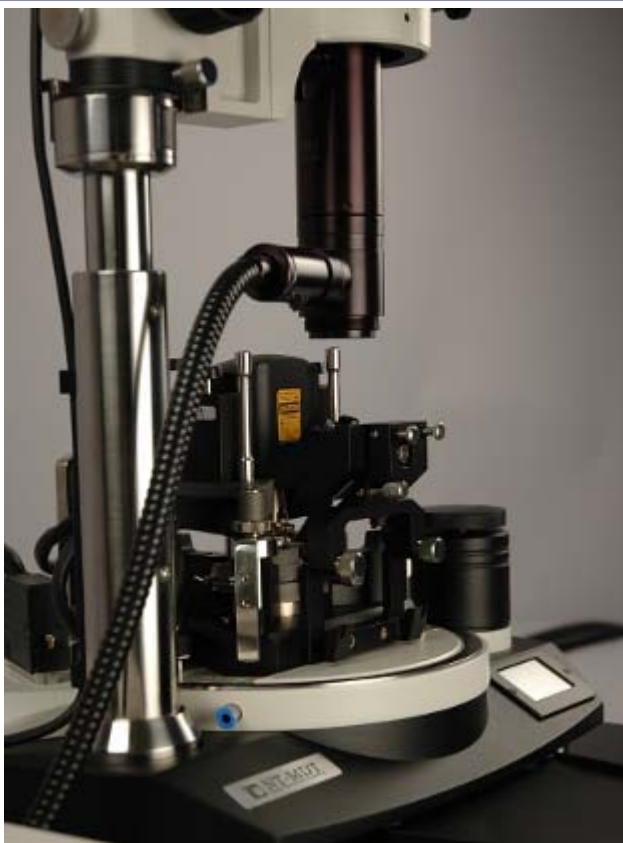
Accessories, Parts, Software	NanoEducator	Solver PRO Solver Next	NTEGRA	NanoFab100
 	 	 	 	 



Nanoeducator – all you need to introduce nanotechnology to students



VERSATILITY or EASY OF USE? – BOTH!



NTEGRA: The platform of choice when range of cross-disciplinary SPM-related methods is quite broad in your lab and if there is a possibility that another SPM specialization is necessary in the future.



Solver: Fully automated=ease of use SPM enables to get SPM data for non experienced users

Integrated AFM with Ultramicrotome

The system is dedicated to reveal internal non-homogeneities within the polymer sample

Material sciences

Life sciences



Critical parameters:

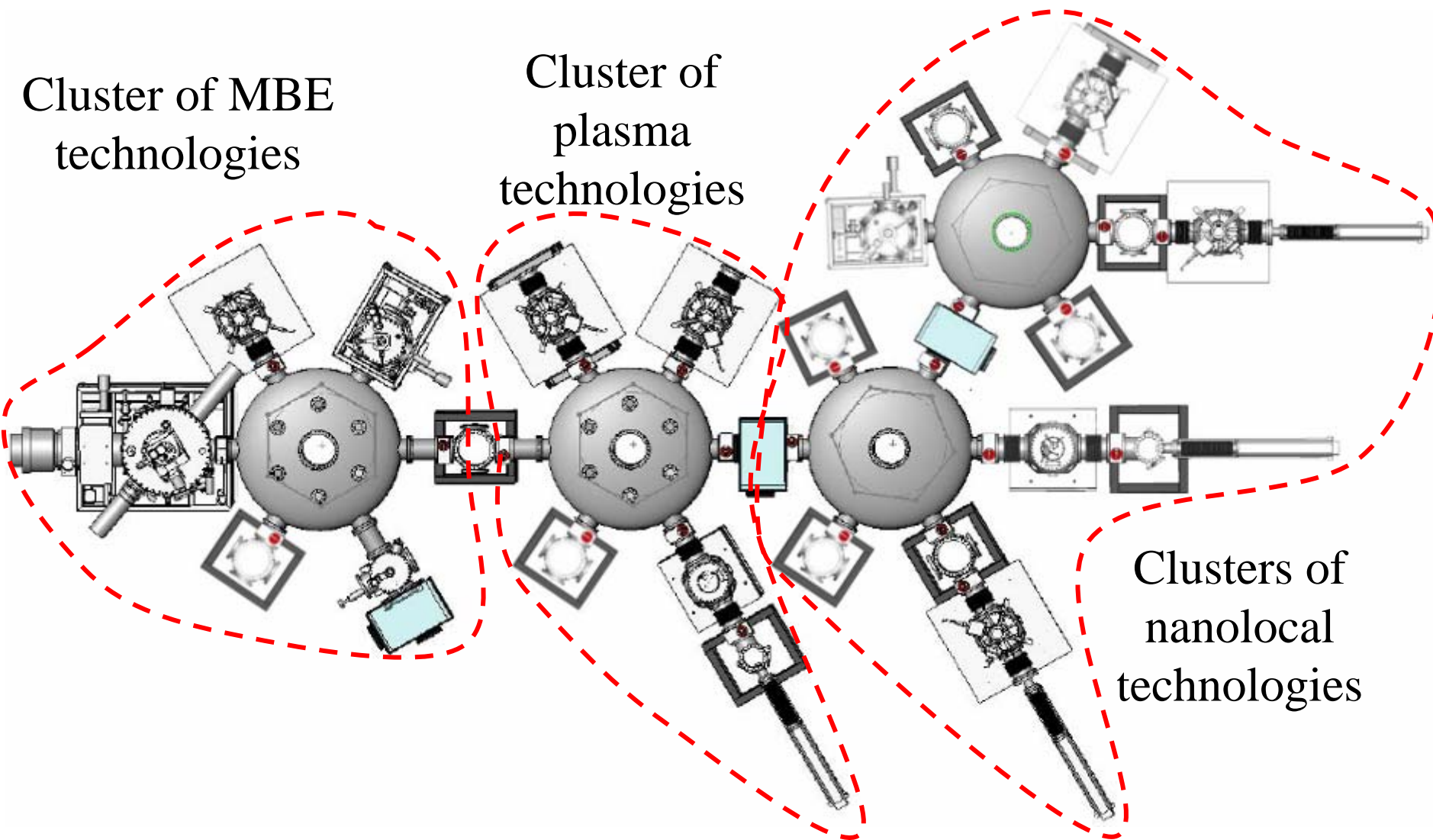
XY resolution	10-20 nm
Z resolution	20-25 nm
Time required to get the stack	5-10 hr

NANOFAB platform

Cluster of MBE
technologies

Cluster of
plasma
technologies

Clusters of
nanolocal
technologies



NanoFab suppose to be one of the major tools for Russian nanoelectronics



NanoFab100 platform has been designed for development, testing and small-series production of nanoelectronics elements.

100 mm wafers can be treated by group technologies (like MBE, PE CVD, MO CVD etc) and by nanolocal techniques (like FIB, SEM, SPM etc)

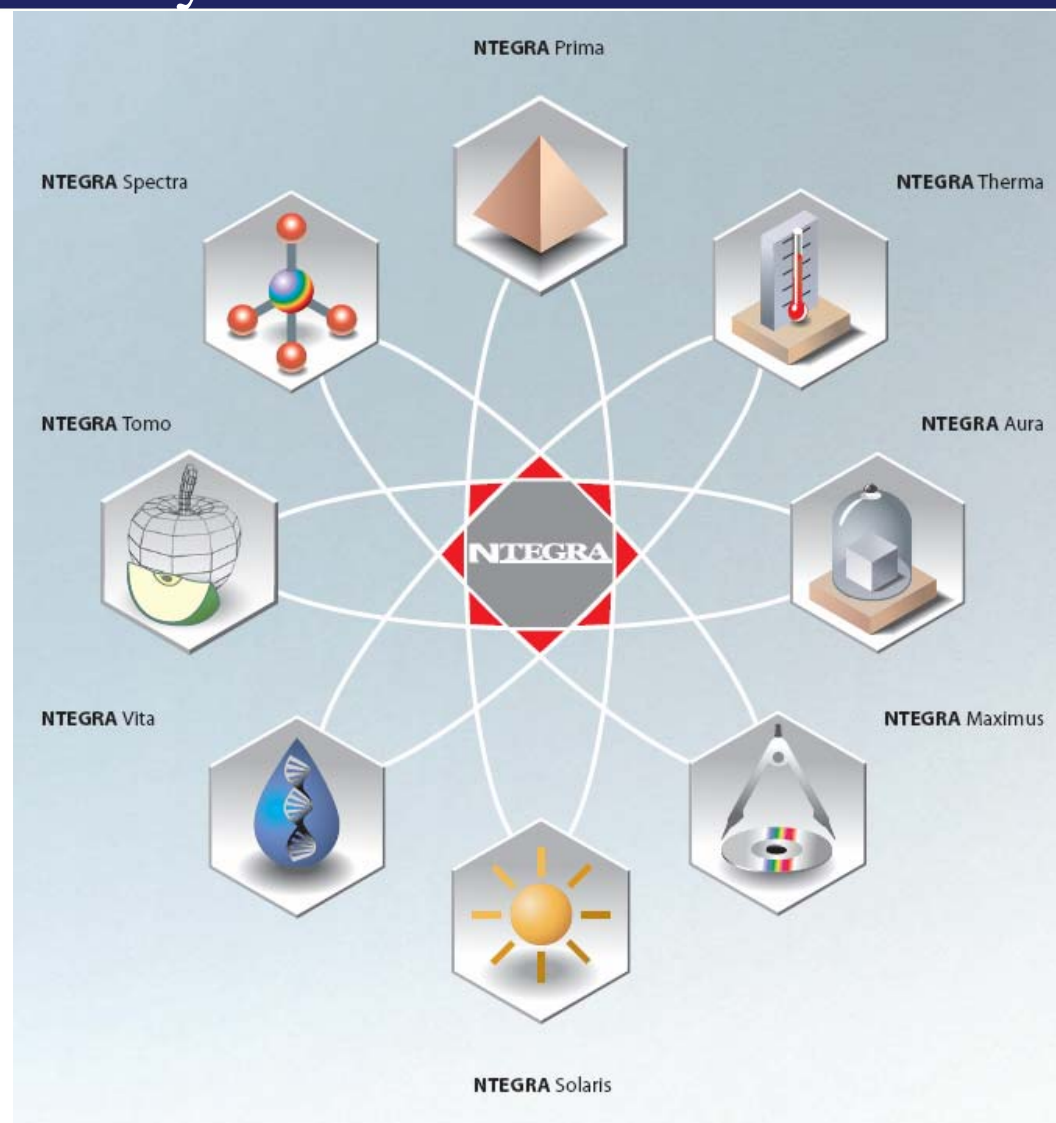


Synchrotron-based SuperFab complex



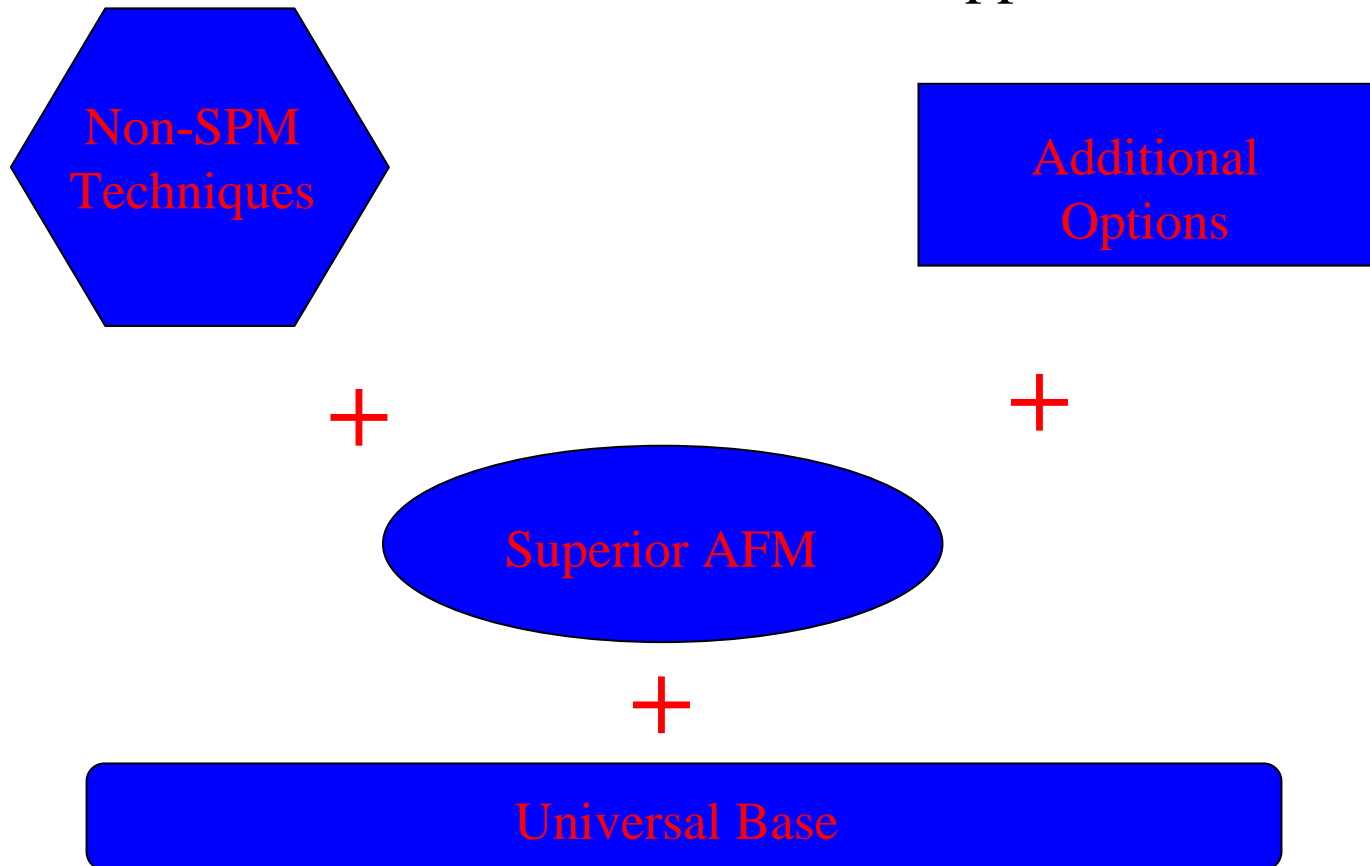
Project for 2008-2010

Ntegra platform - the basis for AFM integration with another analytical instruments



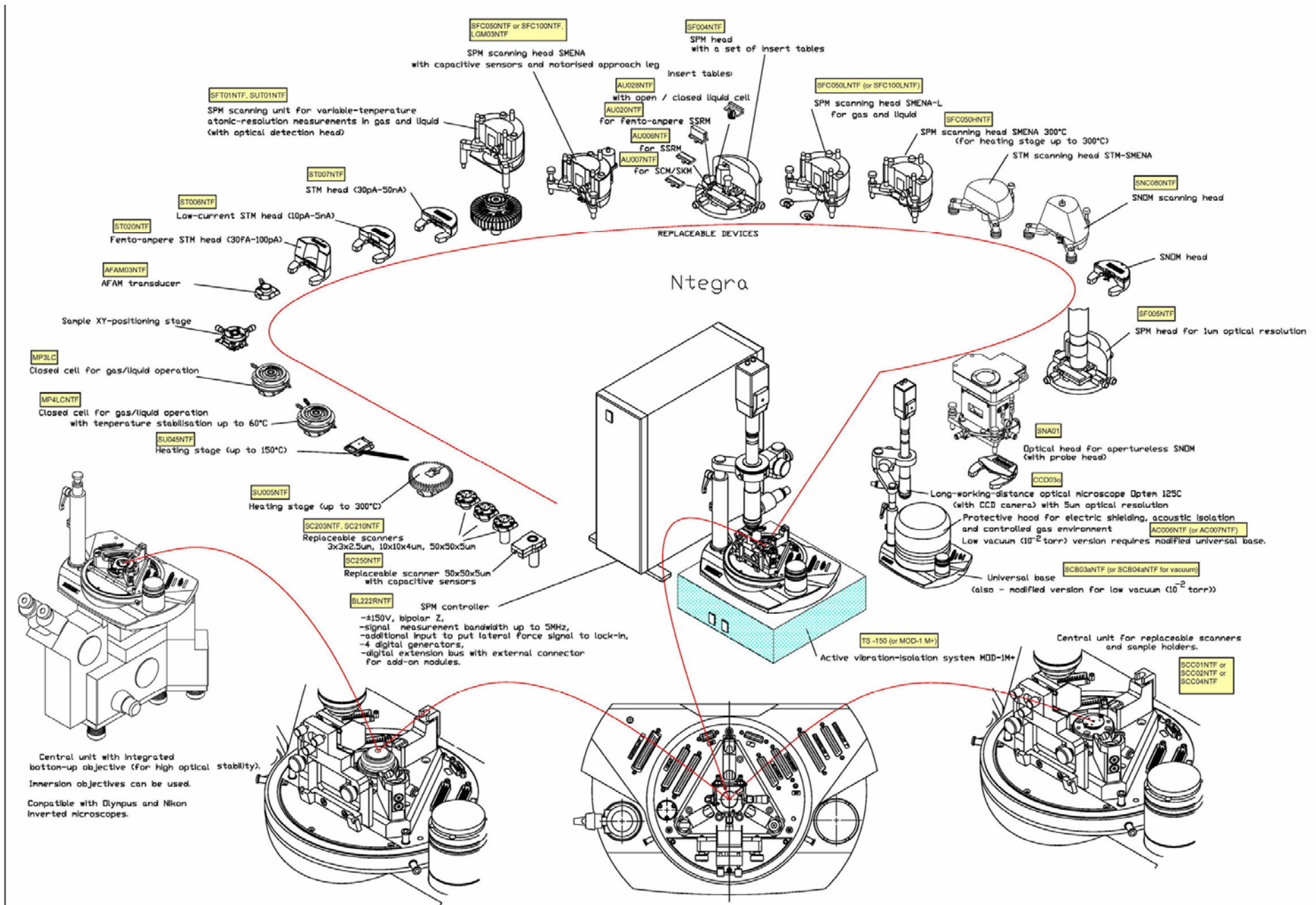
NanoLab or “SPM +” concept

Conception of SPM+ - NOT UNIVERSAL BUT SPECIALIZED
SPM with switchable application

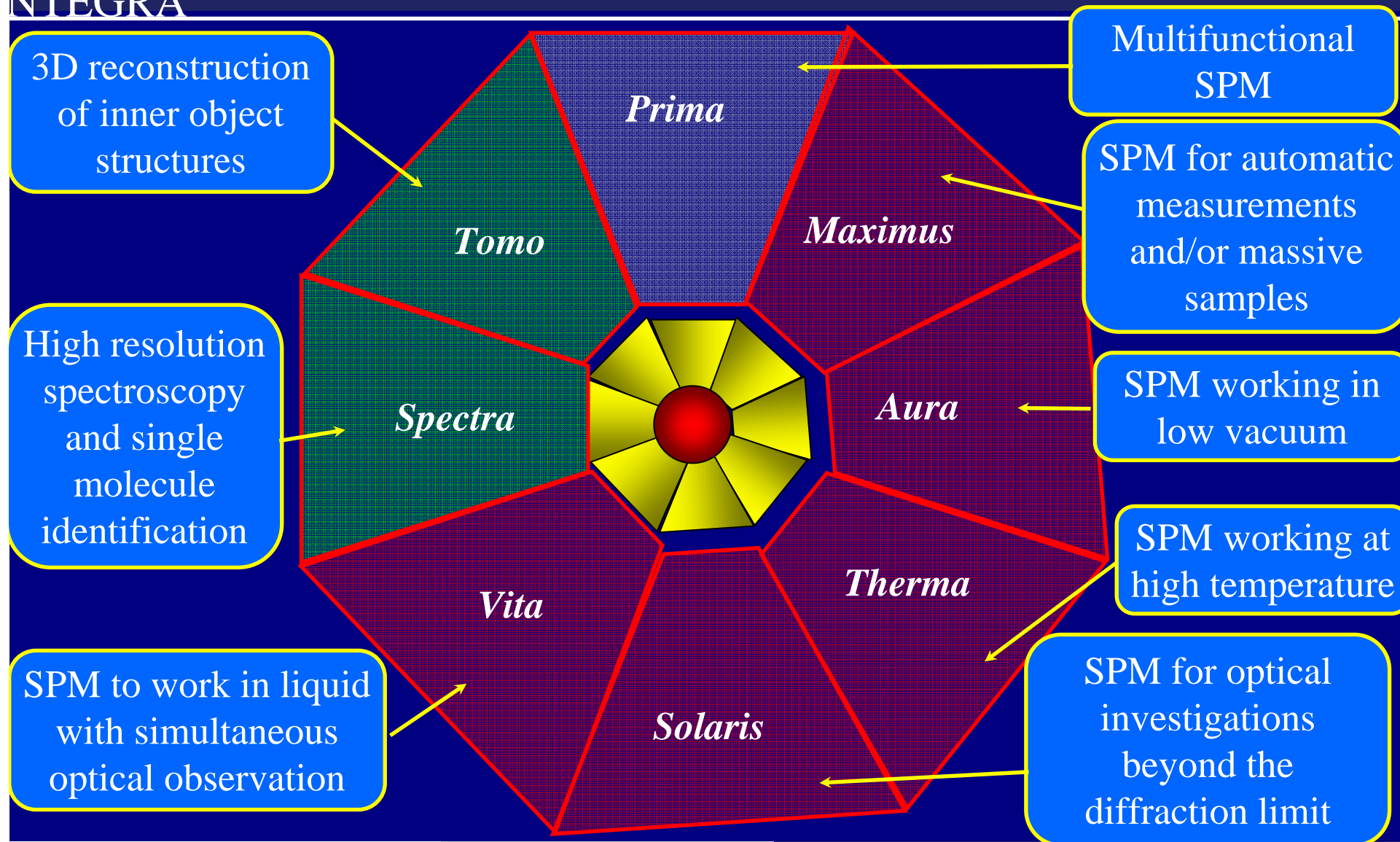


Main concept advantages

- ▣ Each system is highly specialized and has the best performance in chosen area (material science, biology, polymers, semiconductors)
- ▣ Each model can be transformed into another application oriented model within NTEGRA's universal base with modern price of upgrade.



8 application oriented models within Ntegra platform



NT-MDT has developed first commercial Raman confocal system in 1998 and first SPM in 1992



Nanofinder



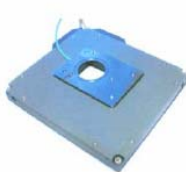
Nanofinder 30



Ntegra Spectra



Z axis lens piezo scanner



X-Y piezo stage



NTEGRA platform



Integrated solution
with Renishaw

1998

2002

2003

2004

2006

NT-MDT CRM: ASK ON LINE – ON LINE customer support system

SPM - Scanning Probe Microscopy - NT-MDT - Windows Internet Explorer

http://www.ntmdt.com/

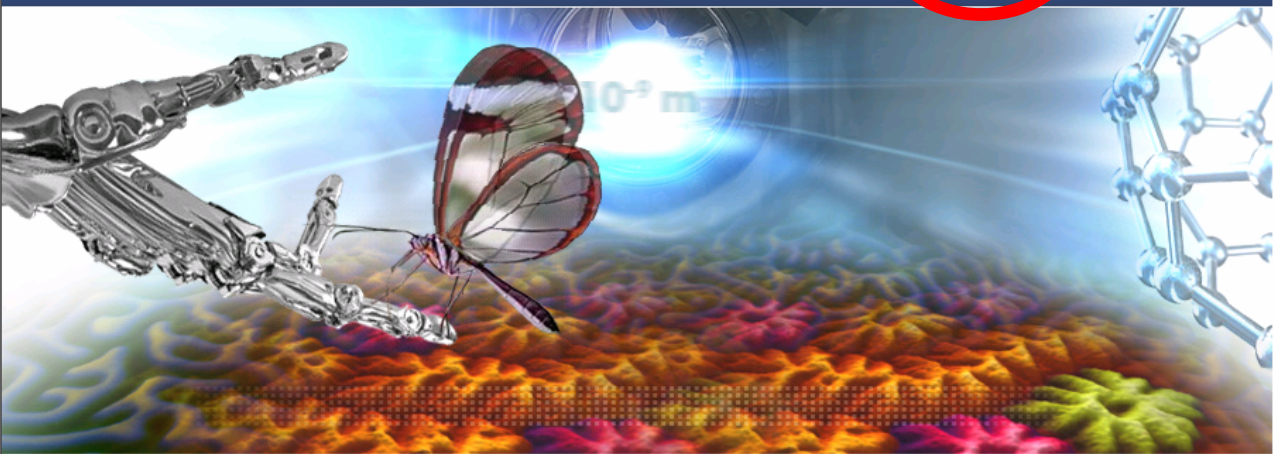
File Edit View Favorites Tools Help

SPM - Scanning Probe Microscopy - NT-MDT

Change language

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Products

- ▶ [NANOFAB 100 platform](#)
- ▶ [NTEGRA platform](#)
- ▶ [SOLVER platform](#)
- ▶ [NANOEDUCATOR platform](#)
- ▶ [SPM accessories](#)

Applications

- ▶ [Special applications](#)
- ▶ [Application notes](#)
- ▶ [Scan-Gallery](#)
- ▶ [Publications](#)

Learning center


- ▶ [Amazing nanotech & SPM links](#)
- ▶ [SPM Principles](#)
- ▶ [SPM Basics](#)
- ▶ [SPM Glossary](#)

Customer support

- ▶ [FAQs](#)
- ▶ [Manuals](#)
- ▶ [Software](#)
- ▶ [SPM Methodology](#)

NT-MDT News


30.09.2008



Upcoming exhibitions

MRS Fall Meeting
USA, Boston
December 1-5, 2008

NanoFab 100 in the nanocenter of SFU, Taganrog!



A unique clustered nanotechnological facility of the new generation, NanoFab100, has been started in the scientific educational centre "Nanotechnology" in SFU,

NT-MDT CRM: ASK ON LINE – ON LINE customer support system

Loyalty
management
team in sales
department
controls speed
and quality of
service support

NT-MDT: Online Support System - Microsoft Internet Explorer

Address: <http://ntmdt.ru/online.pl>

NT-MDT: Online Support System

Navigation: [Your settings](#) | [Users](#) | [Sessions history](#) | [Messages](#) | [Logout](#)

Sessions history

Filter by session user: ---

Date	Duration	Session initiator	Session users	Status	Censorship
09.07.2007 18:35:55	12 min 29 sec	Andrew Shubin	Andrew Shubin, Ekaterina Velskaya	Finished	Technical
09.07.2007 18:39:22	1 h 21 min 23 sec	Свиридов Дмитрий Евгеньевич	Yuri Mordovin, Свиридов Дмитрий Евгеньевич	Finished	Good
04.07.2007 13:52:07	4 h 13 min 50 sec	Поляков дмитрий Сергеевич	Evgeniy Lisov, Поляков дмитрий Сергеевич	Finished	Good
03.07.2007 13:39:21	9 min 14 sec	Xinju Yang	Stanislav Leesment, Xinju Yang	Finished	Good
			Xoxia Wang	Finished	Broken connection
			man Grigorovich	Finished	Technical
			y Leesment	Finished	Good
			t test	Finished	Technical
			Wang, Stanislav Leesment	Finished	Good
			y Leesment	Finished	Good
			t test	Finished	Technical
			y Leesment	Finished	Good
			xoxia Wang, Stanislav Leesment	Finished	Good
			t test	Finished	Technical

Online staff:

- Ekaterina Velskaya (Customer support manager)
- Evgeniy Lisov (Service engineer)
- Julia Morzhova (Regulation engineer)
- Yulya Ryabkova (Regulation engineer)

Offline staff:

- Alexander Bykov (Director of sales)

Service group: Tue Jul 10 10:54:50 2007

Development of multimedia training materials for customer education and training

The image displays three screenshots of the NT-MDT website, illustrating the development of multimedia training materials for customer education and training.

Left Screenshot: SPM techniques / Principles. STM techniques. Constant Current mode

This page provides an overview of SPM techniques, specifically focusing on STM (Scanning Tunneling Microscopy) in Constant Current mode (CCM). It includes a diagram of a tunneling junction and a detailed explanation of the CCM operation, highlighting its advantages and disadvantages. The text states: "In STM bias voltage is applied between a sharp conductive tip and a conductive sample, so when the sample is approached to a few angstroms from the tip, tunneling current occurs, that indicates proximity of the tip to the sample with very high accuracy. In Constant Current mode (CCM) of operation when scanning sample surface the scanner keeps the current constant by feedback circuit. So vertical displacement of the scanner (feedback signal) reflects surface topography. STM gives true atomic resolution on some samples even at ambient conditions. Scanning tunneling microscopy can be applied to study conductive surfaces or thin nonconductive films and small objects deposited on conductive substrates. The speed of scanning in CCM is restricted by usage of feedback system. Larger scanning speeds can be obtained by usage of Constant Height mode (CHM), but CCM allows to investigate the samples with developed relief." It also mentions: "The tunnel currents registered in the course of the measurement are sufficiently small - up to 6.03 nA (with a special STM head - up to 6.01 nA), so it is possible to investigate also low conductivity surfaces, in particular biological objects." and "Among the STM disadvantages one can mention the complexity of the results interpretation for some surfaces since the surface image received in the STM investigation mode is determined not only by the surface relief but also by the density of states, bias voltage sign and value, current value etc. For example on the highly oriented pyrolytic graphite surface one can see only each second atom. It is concerned with special arrangement of wave functions density of states." References: Rep. Prog. Phys. 55, 1165-1249 (1992).

Middle Screenshot: SPM techniques / Lateral Forces. 2.6.4 Qualitative interpretation of results

This page discusses the qualitative interpretation of results for lateral forces in SPM. It includes a list of topics: "2.6 Probe-Sample Interaction: Lateral Forces", "2.6.1 The nature of frictional forces", "2.6.2 Cantilever deformations under the influence of lateral forces", "2.6.3 Calibration of the optical detection system", "2.6.4 Qualitative interpretation of results", and "2.6.5 Appendices". The text states: "The relation between detected signal and the lateral force acting in the x-direction is given by:" followed by the equation
$$F_x = \frac{cI^2}{4I_0 LB} LAT, \quad (1)$$
 where calibration constant B is determined in accordance with procedure presented in the chapter Calibration of the optical detection system:
$$B = \frac{\Delta LAT_{\text{calib}}}{\Delta x_{\text{calib}} \cos(\zeta, \delta)} \quad (2)$$
 Before interpreting LFM measurements we must learn to differentiate the frictional force effect from the topography effect. Let us examine the measured lateral forces and their relation with the frictional force. Both in the first (lateral scanning) and in the second (scanning along the beam length) scan modes it is impossible to measure the frictional force in a single pass. The reason is that lateral forces are influenced by both friction and surface topography. As is shown in Fig. 1, the normal load has a horizontal component at inclined surface features.

Right Screenshot: SPM techniques / SPM-Methodology. Lateral Force Microscopy (LFM)

This page details the SPM-Methodology, specifically Lateral Force Microscopy (LFM). It includes a diagram of a cantilever tip scanning a sample surface, showing the direction of scanning, the tip, and the friction force. The text states: "During scanning in contact mode the cantilever bends not only along normally to the surface but also the cantilever torsional (lateral) deformation occurs. LFM measures the torsional deformation of the cantilever during scanning in contact mode (Fig. 1). The LFM image and topography can be obtained simultaneously. The lateral deformation depends on a frictional (lateral) force acting on tip [1]." It also includes a diagram of a cantilever tip scanning a sample surface, showing the direction of scanning, the tip, and the friction force. The text states: "The cantilever deflections are registered by optical system of microscope. The measurements of cantilever torsion are carried out with constant force condition, i.e. with constant vertical deflection of a cantilever. Therefore, it is possible to distinguish the areas with different friction (Fig. 2), in other words the LFM is sensitive to chemical composition or structure of the surface [1-3]." It also includes a diagram of a cantilever tip scanning a sample surface, showing the direction of scanning, the tip, and the friction force. The text states: "If the sample surface is rough then such interpretation of the LFM image is difficult because lateral deflection is caused also by topography. The direction of scanning in LFM mode should be perpendicular to cantilever axis. This direction is X-axis for NT-MDT microscopes (Fig. 1)."

SPM Principles

<http://www.ntmdt.ru/SPM-Techniques/Principles/>

SPM Basics

<http://www.ntmdt.ru/SPM-Techniques/Basics/>

SPM Methodology

<http://www.ntmdt.ru/SPM-Techniques/SPM-Methodology/>

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