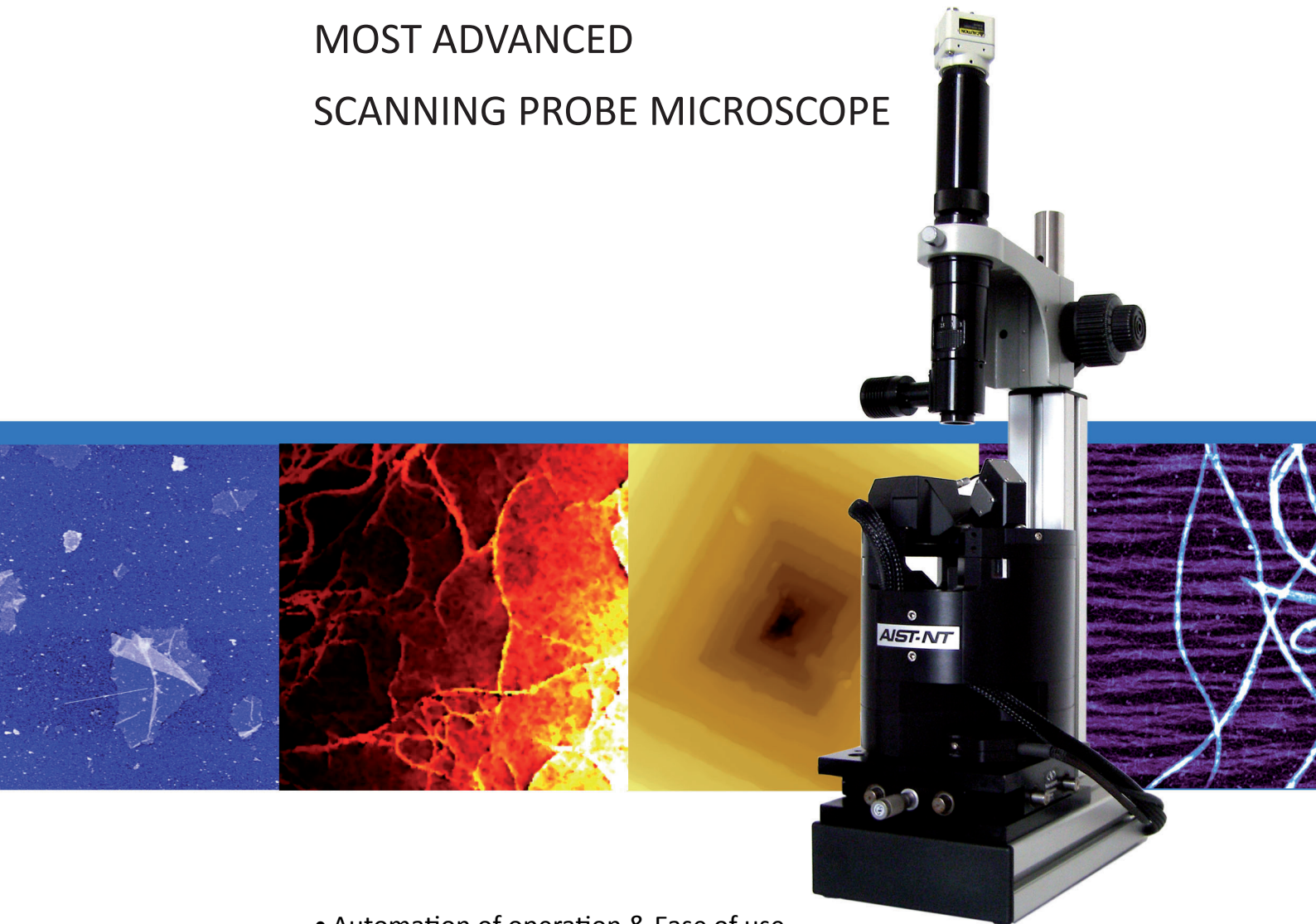


# SmartSPM™

THE WORLD'S FASTEST AND  
MOST ADVANCED  
SCANNING PROBE MICROSCOPE



- Automation of operation & Ease of use
- High resolution, stability and accuracy
- Fastest scanning
- All SPM modes included plus Nanolithography and Dynamic AFM with no extra units and costs
- Flexibility to upgrade to AFM-Raman

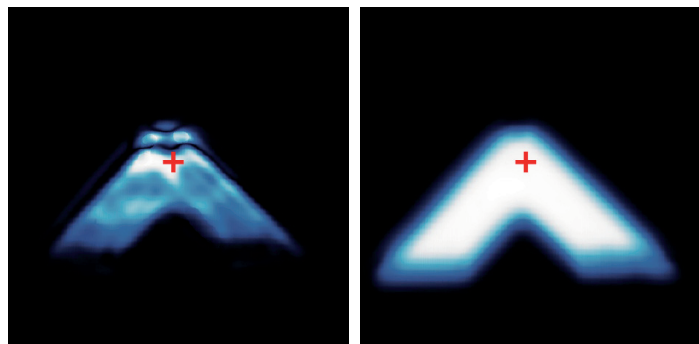
# Simplifying surface characterization at the nano scale

The 100% automated system that offers its cutting-edge technology of ultra-fast, metrological and high resolution measurements for the most advanced materials research at the nano scale in all AFM and STM modes.

## AUTOMATION? JUST PREPARE YOUR SAMPLE, OUR MICROSCOPE DOES THE REST FOR YOU!

With the SmartSPM the automated click-on-a-button laser-to-tip alignment sets researchers free from this routine operation. This feature also provides a high level of the system adjustment reproducibility that doesn't depend on operator's experience. But this is just the beginning of all the automation built-in into the SmartSPM!

In the automatic mode the operator should only specify the main probe parameters and required scan area to let the SmartSPM perform the full system adjustment, engage the probe with the sample surface and start scanning. The minimal learning period as well as the very quick start of measurements (less than 5 minutes!) makes the SmartSPM a perfect solution for any multi-user facilities.



Distribution maps of cantilever's oscillation amplitude (left) and photodiode signal (right) across the cantilever backside. Cantilever: fpN20S (triangular), resonance frequency 519 kHz.

## TEST YOUR CANTILEVER BEFORE RUNNING MEASUREMENTS

Only with the SmartSPM it's become possible to test cantilever's reflective backside coating before starting any measurements by mapping the distribution of cantilever's oscillation amplitude. In addition, after the mapping is done, the operator can manually choose the most appropriate position of the laser spot on the cantilever based on his specific measurement requirements.

## QUICKLY FIND THE RIGHT PLACE ON YOUR SAMPLE

The combination of the motorized sample positioning in the horizontal plane and the high resolution top-view optics allows researchers to easily find the surface area where the further scanning is to be done. This combination is also powered by the calibrated software

video grabbing, so the user can identify the interesting location on the sample surface and move the cantilever where by clicking on the video image on his computer screen. During this process there is no any irritating light blinking. The optical image remains absolutely clear, because the AFM laser is 1300 nm IR.



Signal access module

## BREAK THE SOFTWARE LIMITS

For advanced users both the embedded scripting language (Lua) and DSP programming macro language are available. They allow them to easily personalize and automate his SPM experience by extending the SmartSPM software with his custom program extensions in such categories as scanning, force curves, nanolithography, high-throughput screening (HTS) and more.

## RESOLUTION. STABILITY. ACCURACY

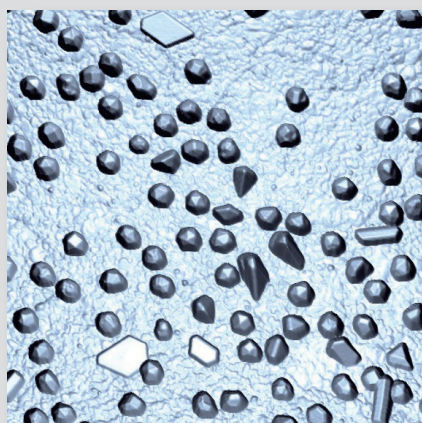
Due to the combination of the low-noise registration system, unique scanner, advanced electronics and smart scanning procedures that incorporated over 100 years of combined SPM research experience, with AIST-NT's SmartSPM one can perform the unique measurements which are extremely difficult, if possible at all, for other SPM instruments.

The extra-safe and at the same time fast tip-sample engagement procedure makes it possible to protect even very sharp fragile tips from any possible damage. Due to the availability of the true non-contact scanning mode one can measure even the most delicate and mechanically sensitive samples. The unique smart scanning procedures allow the user to obtain high quality images on very challenging objects like 120 nm Ag nanoparticles, DNA or polymer lamellar structures.

Due to the very well designed and calculated construction of the AFM and the scanner, only AIST-NT's instrument features the outstanding mechanical stability, which allows the user to get atomic resolution images with the same 100 micron scanner and at the same time to

### APPLICATIONS:

- Polymers
- Piezoelectric materials
- Biology
- Fast scanning
- Nanolithography
- Seamless integration with SNOM /Raman /TERS techniques





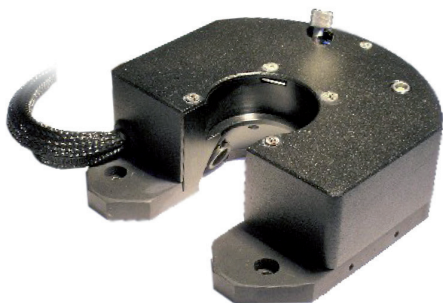
produce high quality images without any vibration isolation tables. This is of extreme importance for the integration of the AFM with the optical facilities on top of an optical table.



Liquid cell with heating up to 60°C and cooling down to 5°C below room temperature.

## HIGH SPEED AND HIGH QUALITY SCANNING HAS BECOME A REALITY!

One of the unique features of the SmartSPM is its scanner. Due to our innovative design and flexure guide technology, this scanner with the built-in capacitive sensors shows the unmatched performance characteristics (significant scanner natural frequencies come up to 7 kHz in XY and up to 15 kHz in Z) allowing a significant increase in the scanning speed without sacrificing the image quality while using the standard cantilevers. The scanner allows the high scan rate imaging of samples with coarse topography features.



AFM head (#HE002) with capability to use simultaneously top and side planapochromat objectives (100x, NA=0.7 and 10x, NA=0.28 respectively)

The advanced digital controller equipped with the optimized scanning control algorithms (MagicScan Technology) allows to decrease the phase lag, overshooting and ringing during the scanning process, making sure that the quality of the image remains the same even at higher speeds and during the online speed changes.

The novel proprietary MFM imaging mode allows the user to obtain the magnetic profile of the sample at outstanding speeds.

## OPEN DESIGN FOR MULTIPLE OPTICAL ACCESS

The SmartSPM AFM has been designed to be easily integrated with optical instruments such as Raman spectrometers. The open design of the AFM head makes it possible to have the high quality top (100X, 0.70 NA) and off-axis (20X, 0.42 NA) optical access using commercially available plan apo objectives.



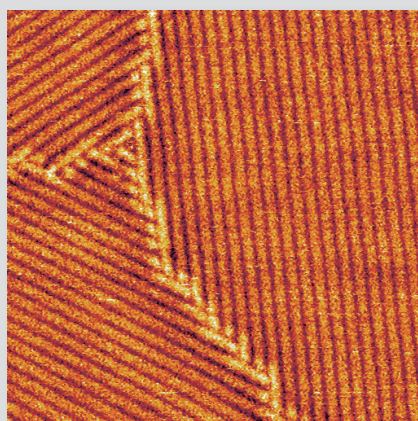
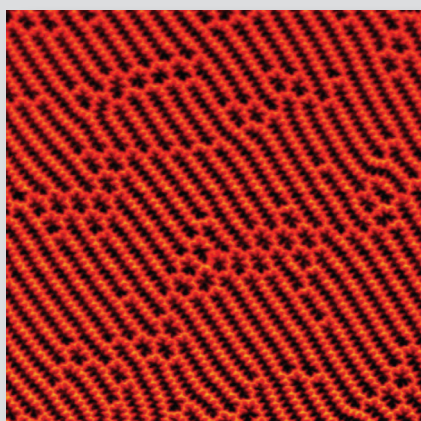
Seamless upgrade of SmartSPM to the OmegaScope SL AFM-Raman system

Having the off-axis illumination becomes very important in case of TERS (Tip Enhanced Raman Scattering) and scattering SNOM experiments as with the off-axis illumination it is easy to get a significant Z component of the optical field. It also may be very valuable for investigation of SERS (Surface Enhanced Raman Scattering) structures. Precise alignment of the off-axis and top objectives allows performing experiments that involve investigation of the influence of illumination conditions on TERS and SERS efficiency.

AIST-NT's AFM head includes 1300 nm registration laser, which allows to eliminate any cross-talk artifacts with the most popular Raman lasers up to 1064 nm. The IR registration laser also allows to work with the visible light-sensitive semiconductor and biological samples.

## ABOUT AIST-NT

AIST-NT's R&D team is a solid team of 20 experts with over 300 years combined experience in SPM design. They are extremely specialized and possess unprecedented know-how. No group in the world is more knowledgeable in the SPM market. They have created virtually compromise-free SPM performance. This is the key to AIST Nano Technologies' success in the marketplace.



## SUPERIOR RESULTS (FROM LEFT TO RIGHT):

- 130 nm Ag decahedra. Courtesy of Matthew McEachran, Brendan Pietrobon and Prof. Vladimir Kitaev, Wilfrid Laurier University.
- Local anodic oxidation nanolithography on GaAs. 2.9 x 2.9 μm scan.
- MFM image of ferrite garnet film. Scan size 100x100 μm. 2048x2048 points. Scan speed 10 Hz.
- 100x100 nm topography scan of C<sub>28</sub>H<sub>58</sub> lamellae on HOPG. Z range is 1.3 Å.

# Technical Specifications

## MEASURING MODES

### STANDARD:

- Contact AFM (in air&liquid)
- Semicontact AFM (in air&liquid)
- Non-contact AFM
- Phase Imaging
- Lateral Force Microscopy (LFM)
- Force Modulation
- Magnetic Force Microscopy (MFM)
- Kelvin Probe (Surface Potential Microscopy)
- Capacitance and Electric Force Microscopy (EFM)
- Force curve measurements
- Piezo Response Force Microscopy
- Dynamic AFM
- Nanolithography & Nanomanipulation

### OPTIONAL:

- Conductive AFM
- STM
- Photocurrent Mapping
- Volt-ampere characteristic measurements.

## SCANNER AND BASE

**Scanning range:** 100  $\mu\text{m}$  x 100  $\mu\text{m}$  x 15  $\mu\text{m}$  (+/-10%);

**Scanning type:** by sample;

**XY non-linearity:** 0.05%;

**Z non-linearity:** 0.05%;

### Noise level:

- 0.1 nm RMS in XY dimension in 200 Hz bandwidth with capacitance sensors on;
- 0.02 nm RMS in XY dimension in 100 Hz bandwidth with capacitance sensors off;
- <0.04 nm RMS Z capacitance sensor in 1000 Hz bandwidth;

**XY resonance frequency:** 7 kHz (unloaded);

**Z resonance frequency:** 15 kHz (unloaded);

Digital closed loop control for X, Y, Z axes;

**Motorized approach range:** 18 mm;

**Maximum sample size:** 40x50 mm, 15 mm thickness;

**Motorized sample positioning range:** 5x5mm;

**Positioning resolution:** 1  $\mu\text{m}$ .

## AFM HEAD

**Laser wavelength:** 1300 nm;

**Registration system noise:** <0.03 nm.

**Fully motorized:** 4 stepper motors for cantilever and photodiode automated alignment

## LIQUID CELL (OPTIONAL)

**Sample size:** 2 mm thickness, 25 mm diameter;

**Sample positioning range:** 5x5 mm;

**Positioning resolution:** 1  $\mu\text{m}$ ;

**Cell size:** 40x40x12 mm;

**Volume of liquid:** 3 ml;

Capability of liquid exchange;

Autoclave and ultrasonic cleaning of cell parts.

## LIQUID CELL WITH TEMPERATURE CONTROL (OPTIONAL)

**Heating:** up to 60°C;

**Cooling:** Down to 5°C below room temperature;

## CONDUCTIVE AFM UNIT (OPTIONAL)

**Current range:** 100 fA  $\div$  10  $\mu\text{A}$ ;

3 current ranges (1 nA, 100 nA and 10  $\mu\text{A}$ ) switchable from the program.

## OPTICAL ACCESS

### With AFM head HE001:

Capability to use simultaneously top and side planapochromat objectives (10x, NA=0.28 and 20x, NA=0.42 respectively);

**Field of view:** from 900  $\mu\text{m}$  to 140  $\mu\text{m}$ ;

**Optical resolution:** 1  $\mu\text{m}$ ;

### With AFM head HE002:

Capability to use simultaneously top and side planapochromat objectives (100x, NA=0.7 and 10x, NA=0.28 respectively);

**Field of view:** from 100  $\mu\text{m}$  to 50  $\mu\text{m}$ ;

**Optical resolution:** 0.4  $\mu\text{m}$ ;

Maximum side planapochromat objectives 20x, NA=0.42.

## COMPATIBILITY WITH

### OPTICAL SYSTEMS

- No interference with optical imaging due to infrared laser;
- Upgradeability to OmegaScope for spectroscopic and TERS operation;
- Optional XYZ positioning system SPS002 for probe tip alignment in objective focus:
  - Manual positioning range: 2x2x2 mm;
  - Piezo positioning range: 10x10x10  $\mu\text{m}$  (capacitive sensors).

## OPTICAL MICROSCOPE (OPTIONAL)

**Numerical aperture:** up to 0.1;

**Magnification:** from 85x to 1050x (on

19" monitor with 1/3" CCD);

**Horizontal field of view:** from 4.5 to 0.37 mm;

**Manual detent zoom:** 12.5x

(motorized zoom optional);

Stand and coarse/fine focusing unit;

Capability to use planapochromat objectives

10x, NA=0.28 and 20x, NA=0.42 and 100x,

NA=0.7 (depends on AFM head).

## ADDITIONAL OPTICAL OPTION

Capability to use M Plan Apo

objective 10x, NA = 0.28;

**Magnification:** 400x to 5300x (on

19" monitor with 1/3" CCD);

**Horizontal field of view:** from 0.96 to 0.07 mm;

**Resolution:** up to 1  $\mu\text{m}$ .

## VIBROISOLATION (OPTIONAL)

**Isolation:** dynamic 0.7 Hz to 1 kHz,

purely passive beyond 1 kHz;

**Maximum load:** 150 kg;

**Size:** 400x450x75 mm (WxDxH).

## CONTROLLER ELECTRONICS

- Modular fully digital expandable controller;
- High speed DSP 300 MHz;
- USB 2.0 interface;
- High speed 500 kHz 18-bit ADC, 20 channels;
- 5 MHz frequency range registration system;
- 2 lock-in amplifiers with 5 MHz frequency range;
- 6 digital 32-bit generators 5 MHz frequency range, 0.01 Hz resolution;
- Software controlled modulation possibilities for probe, X, Y and Z scanners, Bias voltage and two external outputs;
- HV amplifiers -5 ... +120V, 0.4 ppm HV noise;
- AC, DC Bias Voltage -10 ... +10V, 2 MHz frequency range;
- 7 stepper motors control;
- Digital inputs/outputs for integration with external equipment;
- Analog input/outputs for integration with external equipment;
- Integrated Phase Locked Loop (PLL) up to 5 MHz.

## SOFTWARE

- Automatic alignment of AFM registration system;
- Automatic configuration and presetting for standard measuring techniques;
- Automatic cantilever resonance frequency adjustment;
- Capability to work with force curves;
- Macro language Lua for programming user functions, scripts and widgets;
- Capability to program controller with DSP macro language in real time without reloading control software;
- Capability to process images in coordinate space including making cross-sections, fitting and polynomial smoothing up to 8 degree;
- FFT processing with capability to treat images in frequency space including filtration and analysis;
- Nanolithography and nanomanipulation;
- Processing up to 5000x5000 pixel images.

*Specifications are subject to change without notice.*

**AIST-NT**  
Integration, Automation and Performance at the Nano scale

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