High Resolution Thermal Imaging and Quantitative Biomechanics

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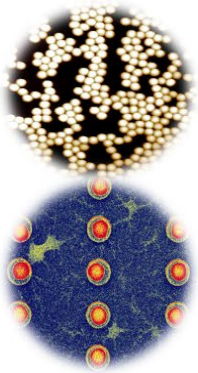
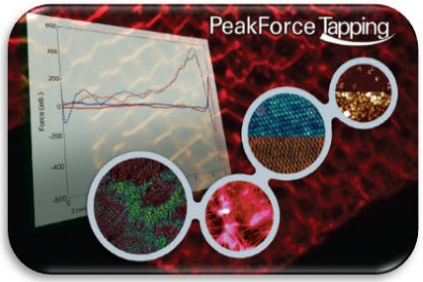
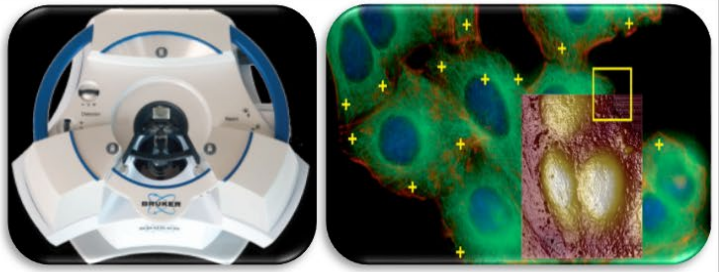
Scanning Probe Imaging and Development Facility (SPID)

Dimension ICON AFM System







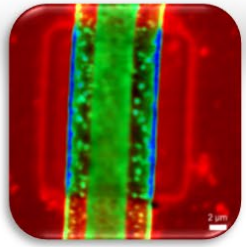
Life Science Imaging System

High Speed AFM System

32 Hz scan rate with peak force tapping and scan Assyst Mode.

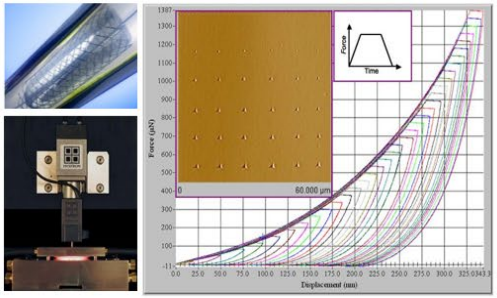
1fr/sec at 256 pixel, automated measurements

Automated laser and detector alignments



cSi, polySi, ncSi

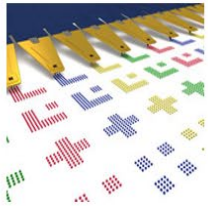
Raman Spectrometer



Nanomechanical Analysis Hard Materials

Biosoft Indenter

Biomaterials nanopatterning capabilities



Quasi Static Indentation
Dynamic Mechanical Analyzer
Feedback Control Displacement
Modulus Mapping
SPM Imaging
Temperature Control
Complete Automation

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Scanning Thermal Microscope

- SThM is a specialized variant of Scanning Probe Microscopy that maps the local thermal properties at nanoscale level.
- Simultaneously maps topography and thermal properties.
- SThM uses AFM cantilever probe with an integrated thermal sensor.
- Provides localized thermal analysis near point of contact and the temperature is measured at each point to create a thermal image.
- Probe acts as a near-field temperature detector and a heat source.

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Scanning Thermal Microscope

Thermal Properties:

- Temperature
- Temperature gradient
- Qualitative thermal conductivity

Applications:

Nanoscale thermal analysis is very important for scientific and industrial interest

- Semiconductor structure/devices.
- Data storage technology.
- Variation in thermal properties in polymers, phase change.
- Heat transport in nanodevices.

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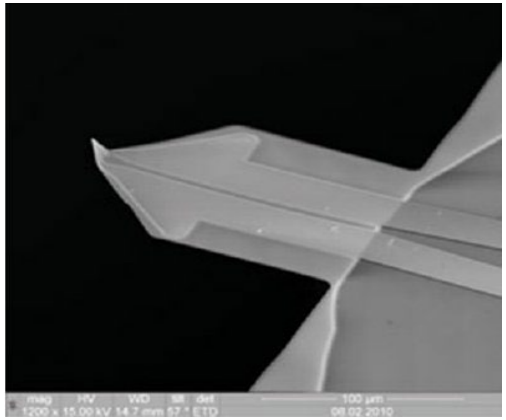
Thermal Probes

Two types thermal sensing elements:

(i) Thermistor - There is a change in resistance when temperature is varie

(ii) Thermocouple - Produces temperature dependent voltage at the juncti



Specifications

Cantilever Material : Silicon Nitride

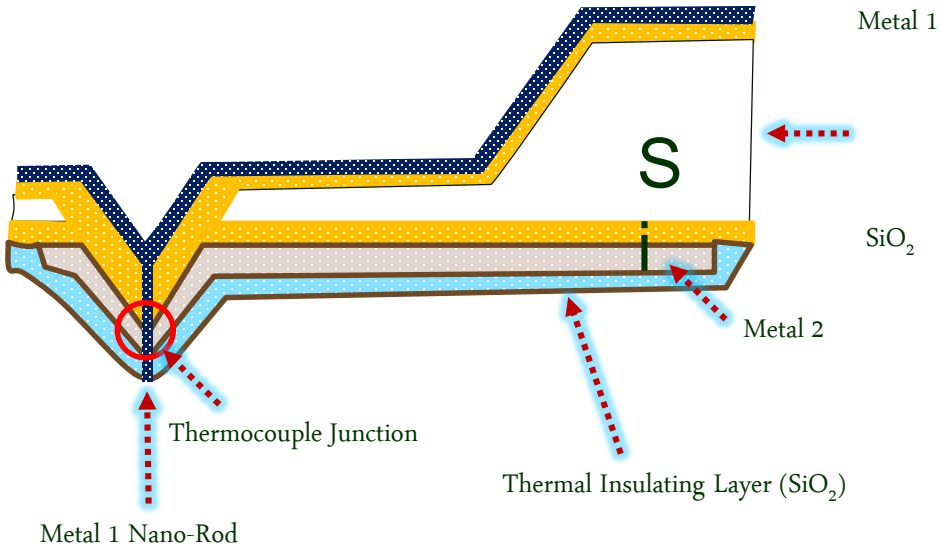
Spatial Resolution : 150-200 nm

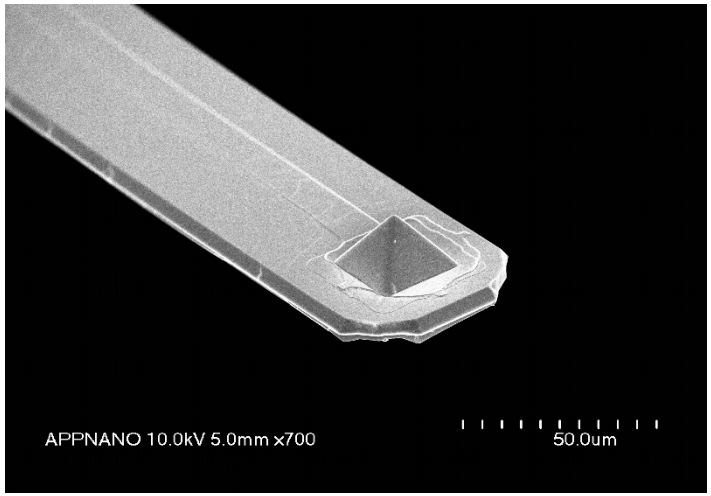
Maximum Temperature : 160^{0}C

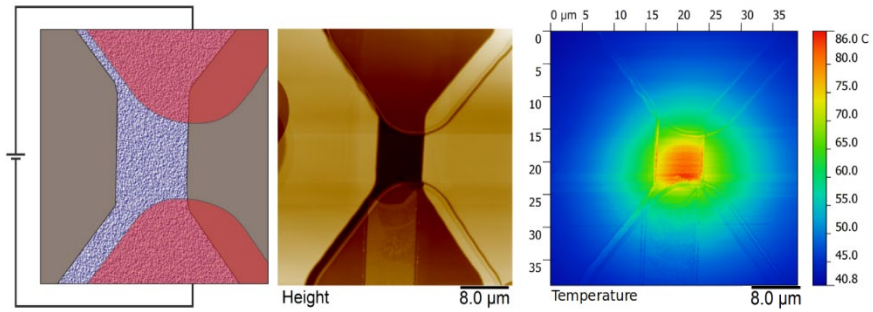
Disadvantages :

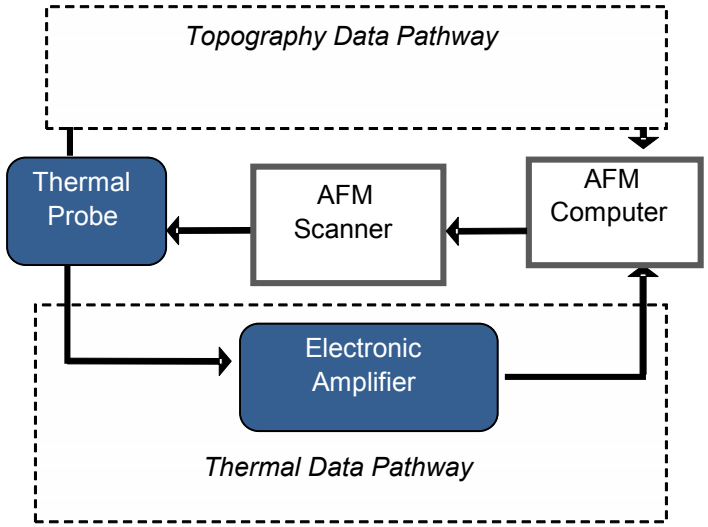
- The sensing element is situated away from the tip apex
- Does not measure direct temperature
- Poor Thermal and Spatial Resolution
- Cantilever starts bending for temperatures above 160^{o}C

Micromachined Scanning Thermal Imaging System (Joint Development with AppNANO)









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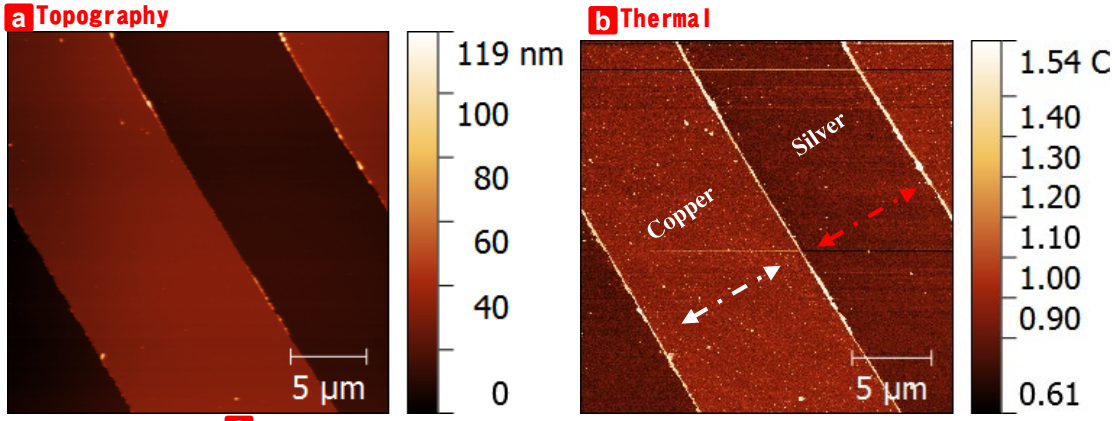
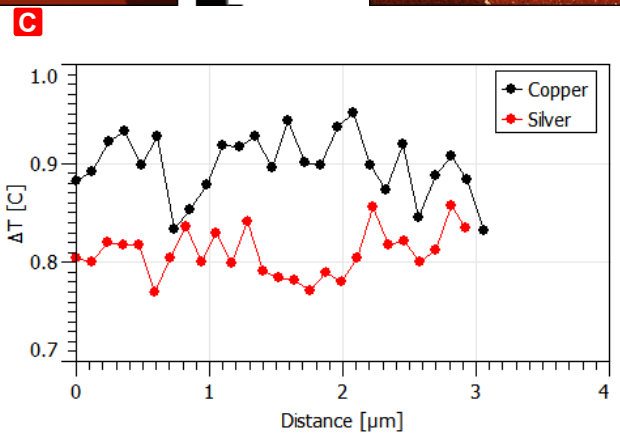
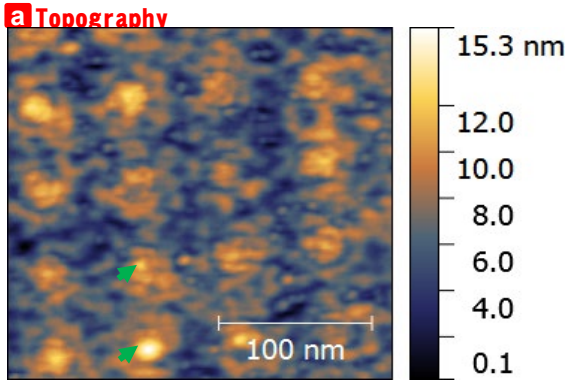
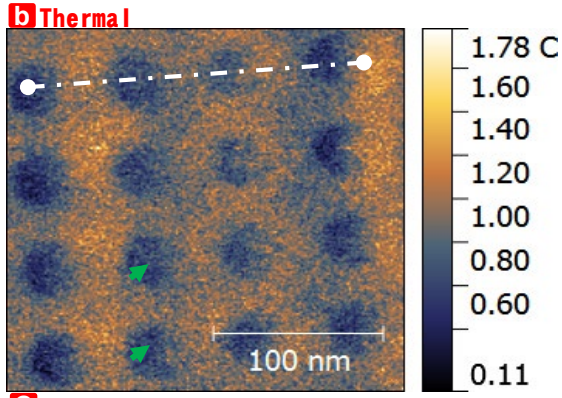
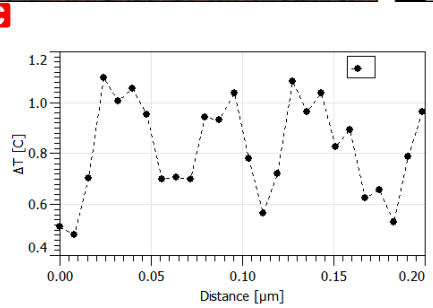
STHm-Applications











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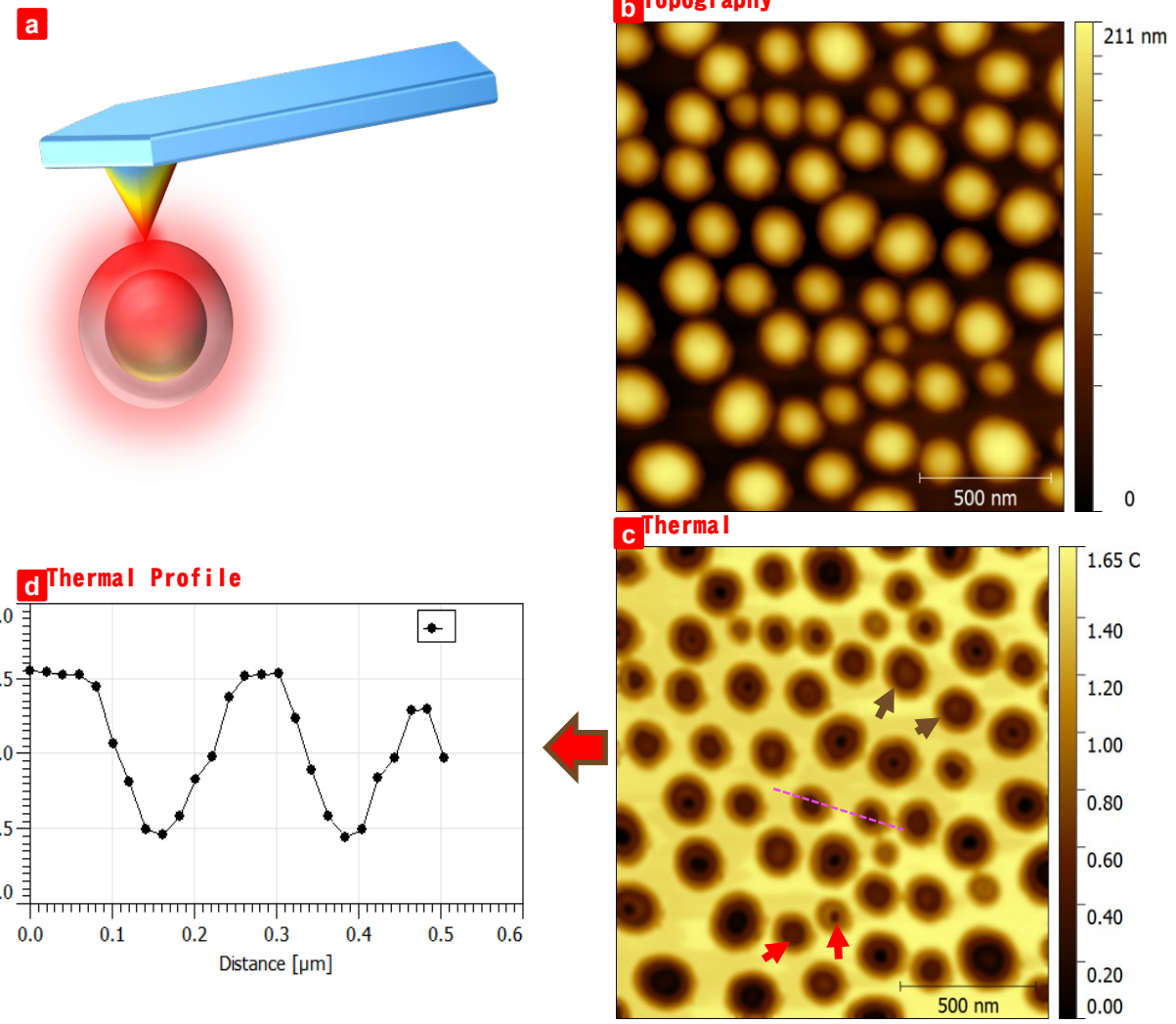
STHm-Applications



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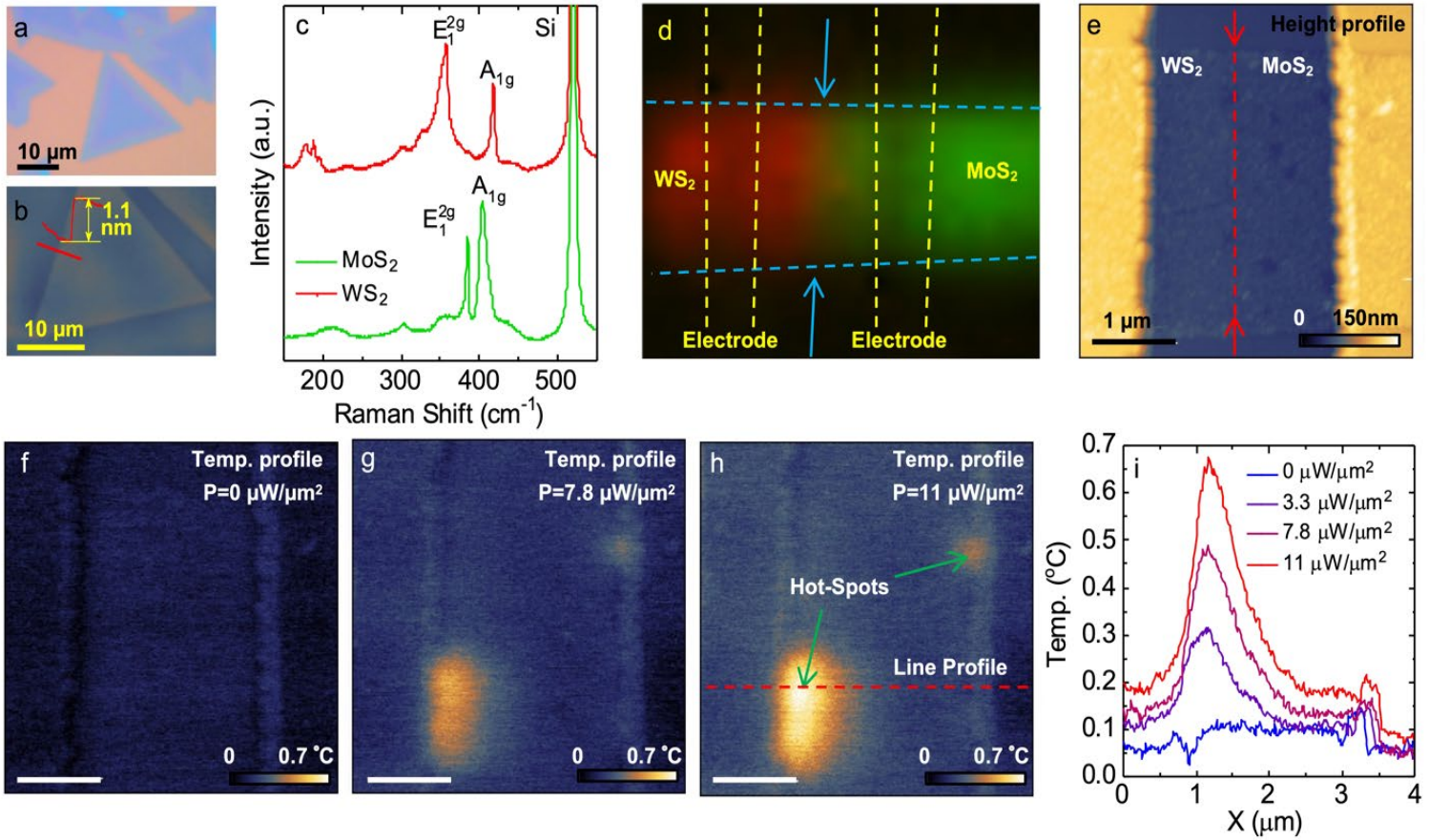
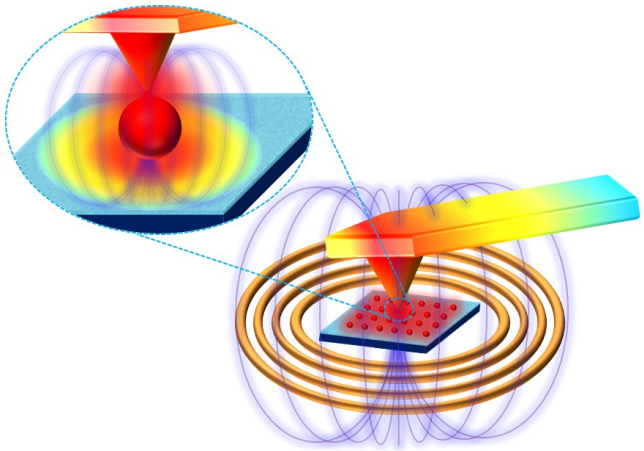
Mapping Hot Spots in Layered Materials



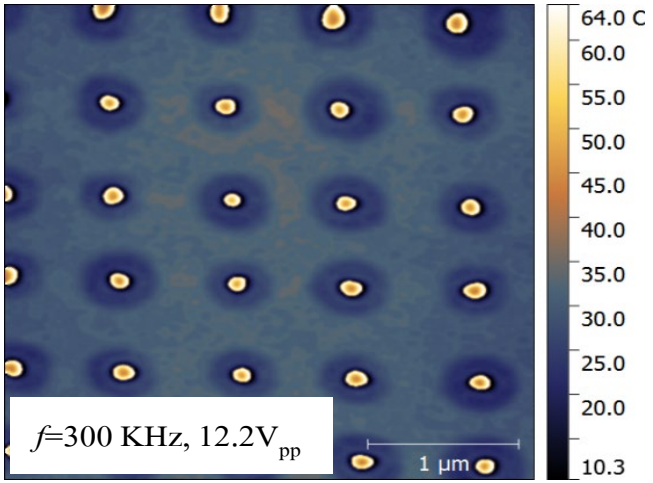
(a) Optical and **(b)** AFM images obtained from a MoS_2-WS_2 heterostructure. **(c)** Raman spectra obtained from MoS_2 and WS_2 regions. **(d)** Raman map of the MoS_2-WS_2 heterostructure device. **(e)** AFM topography image of the same device. **(f-h)** Temperature rise profiles of the device at different dissipated electrical power at V_G = +60V. The heating predominantly takes place on the WS_2-metal vertical junction and the lateral interface does not contribute to localization of the heat. The green arrows in (h) shows the position of the formed hot-spots. **(i)** Temperature line profiles on the dashed red line in (h) at different applied powers.

Advaned Materials 31 (2019), 1808244

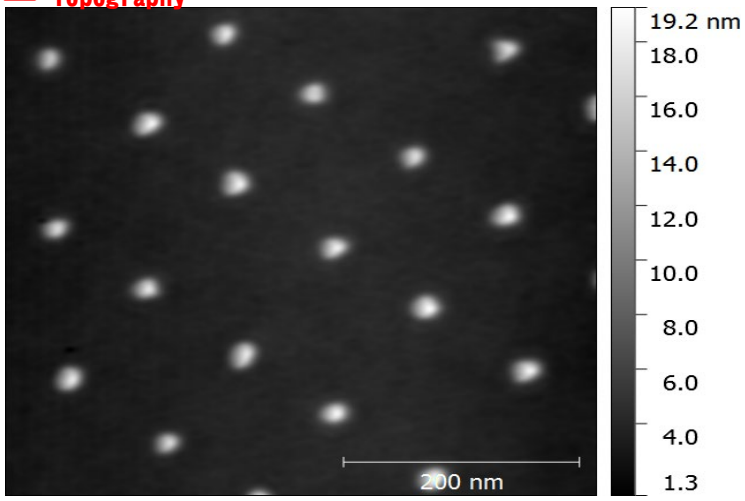
Single Magnetic Nanostructure Temperature Mapping for Theronostics



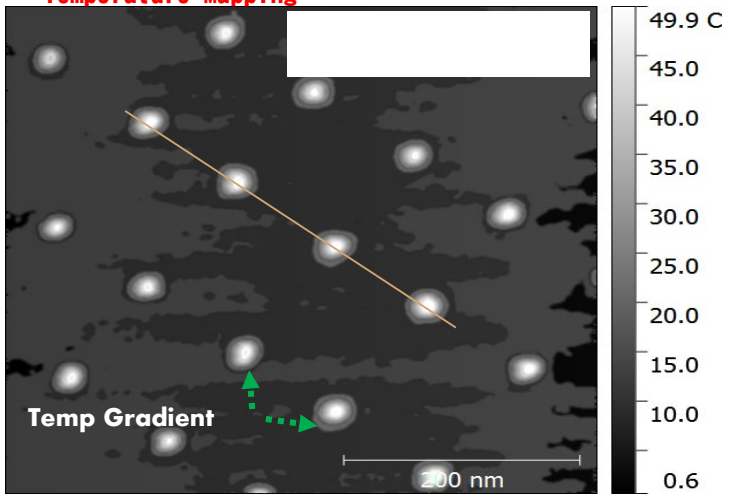
Temperature Mapping



a Topography



c Temperature Mapping



Quantitative Biomechanics and Imaging Capabilities in SPID

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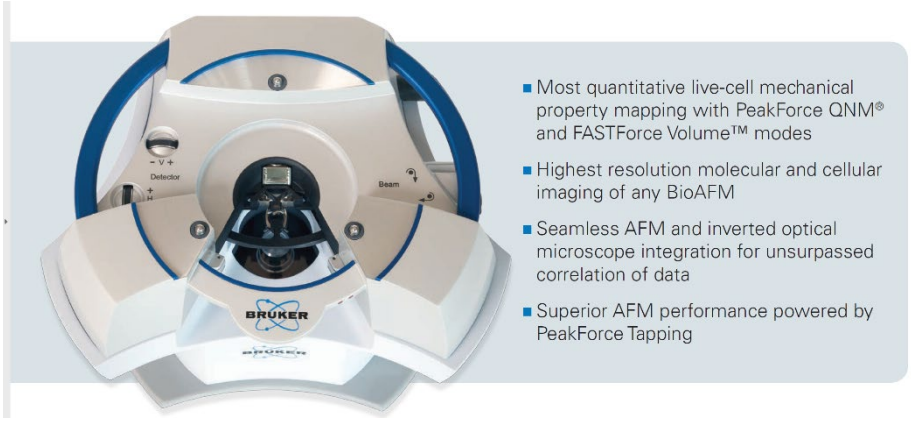
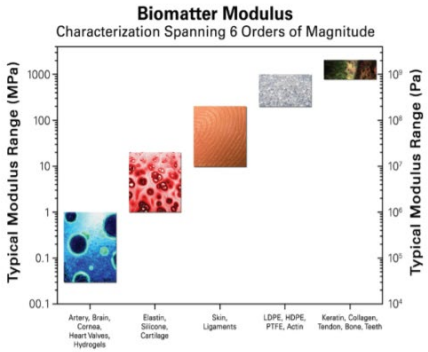
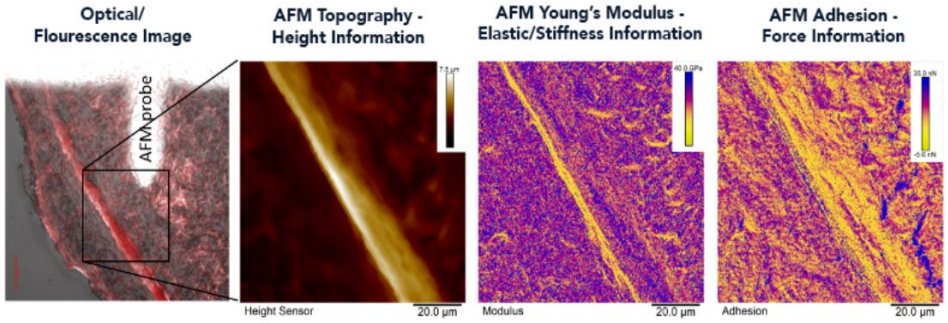


- Most quantitative live-cell mechanical property mapping with PeakForce QNM® and FASTForce Volume™ modes
- Highest resolution molecular and cellular imaging of any BioAFM
- Seamless AFM and inverted optical microscope integration for unsurpassed correlation of data
- Superior AFM performance powered by PeakForce Tapping

Stiffness • Modulus • Hardness •
Creep • Stress • Relaxation • Adhesion



- Comprehensive Package for live cell and tissue imaging and nano-mechanical mapping
- Small volume capabilities (~60µl) with sample perfusion for molecular biology and single molecule applications
- Software controlled heating stage from ambient temperatures to ~60°C



Transform Your Optical Microscope into a Powerful Biomaterials Test System

- Access to physiological pressures from pa-Kpa.
- In-situ observation during mechanical testing
- Maximum force: 10mN
- Maximum displacement: 150 micron
- Normal bit force resolution: 1nN

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Life Science Imaging System

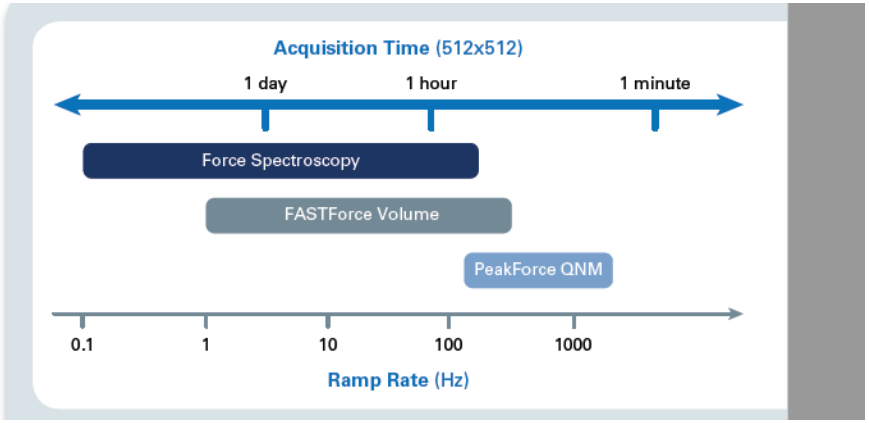
Expand Measurement Possibilities with MIROView

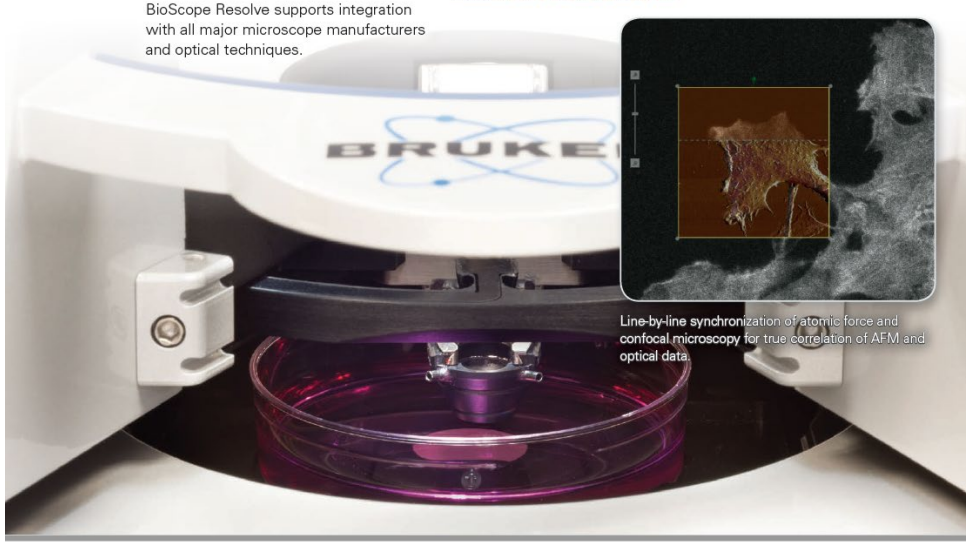
MIROView™ is a new graphical user interface (GUI) that supports seamless integration between the AFM and the light microscope. MIROView and ScanAsyst-Cell ensure expert data generation, regardless of the user's experience level.

- Single, integrated view for AFM or optical microscope for ease of use and enhanced productivity
- Fully synchronized AFM images, force maps, and single-force curves with optical images and data
- Point-and-click setup for automated force and imaging measurements
- Video creation of experiment sessions using MovieMaker™

BioScope Resolve supports integration with all major microscope manufacturers and optical techniques.

MIROView GUI enables seamless mode switching and automated measurements of multiple data types.





Line-by-line synchronization of atomic force and confocal microscopy for true correlation of AFM and optical data.

Unmatched Live-Cell Property Mapping

PeakForce QNM uniquely enables quantitative cell mechanics and imaging of whole, live cells with no artifacts and the fastest cell imaging times.

- High-speed mapping of entire live cells with an unrivalled level of resolution
- Repeatable, robust mechanical property measurements
- Highest resolution image and force curve acquisition with PeakForce Capture™

Quantitative FASTForce Volume

Bruker's new FASTForce Volume mode complements PeakForce QNM to provide the widest range of ramp frequencies.

- FASTForce Volume data acquisition, from 1 Hz to 300 Hz
- pN level trigger forces for the most sensitive, highest resolution force distance curves for force spectroscopy
- Widest ramp frequency range, when combined with PeakForce QNM, from 0.1 Hz to 1 kHz in liquid or 2 kHz in air

Superior Force Spectroscopy and Ramp Scripting

BioScope Resolve provides automated scripting and data-collection recipes, making it easy to design extended-time, biological-dynamics studies.

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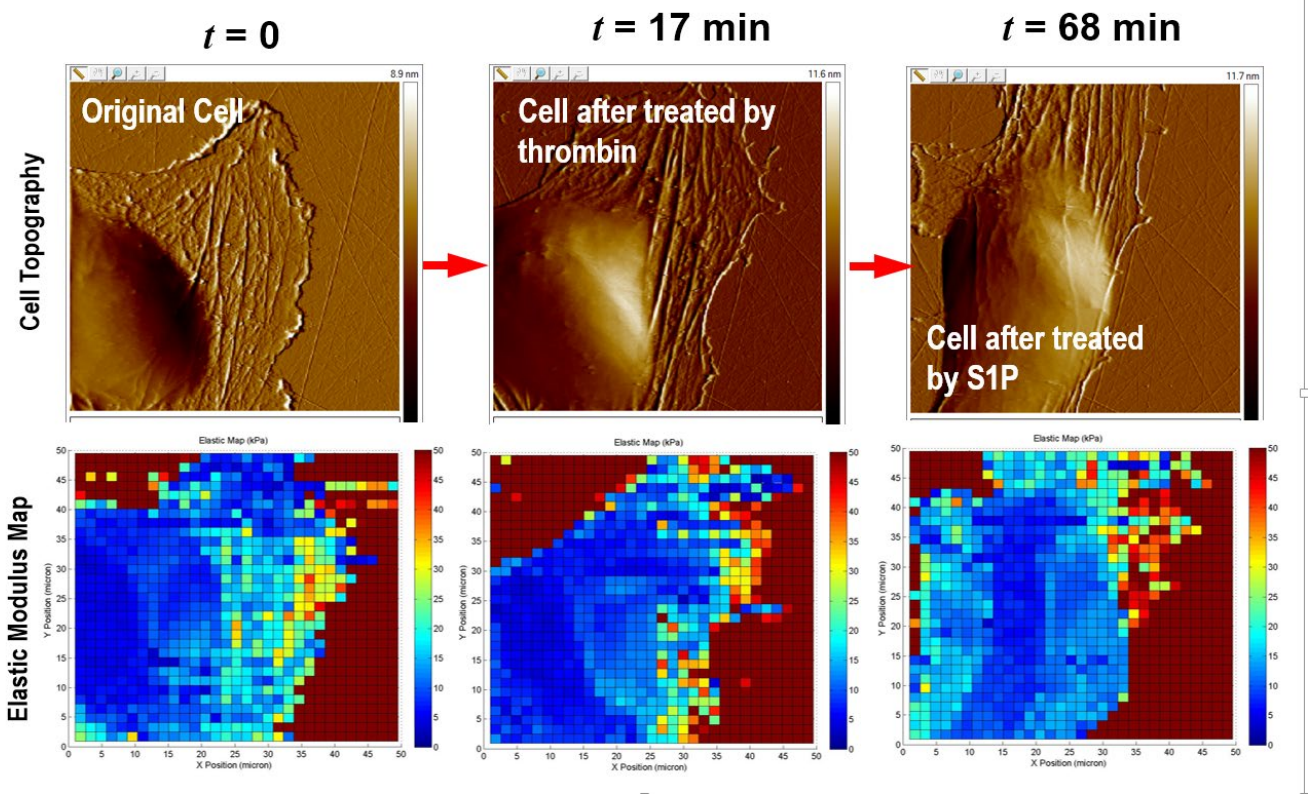
Quantitative Nano-Biomechanics in Fluid

Time series of elastic modulus maps of the same live cell in response to added thrombin and S1P agonists show how the cell elastic properties change over its different regions with time.



Nature Scientific Report 5, 11097 (2015)
Nature Scientific Report 8 (1) 1002 (2018),
Nature Scientific Report 7, 14152 (2017)
Nature Materials 15(4), 469 (2016)

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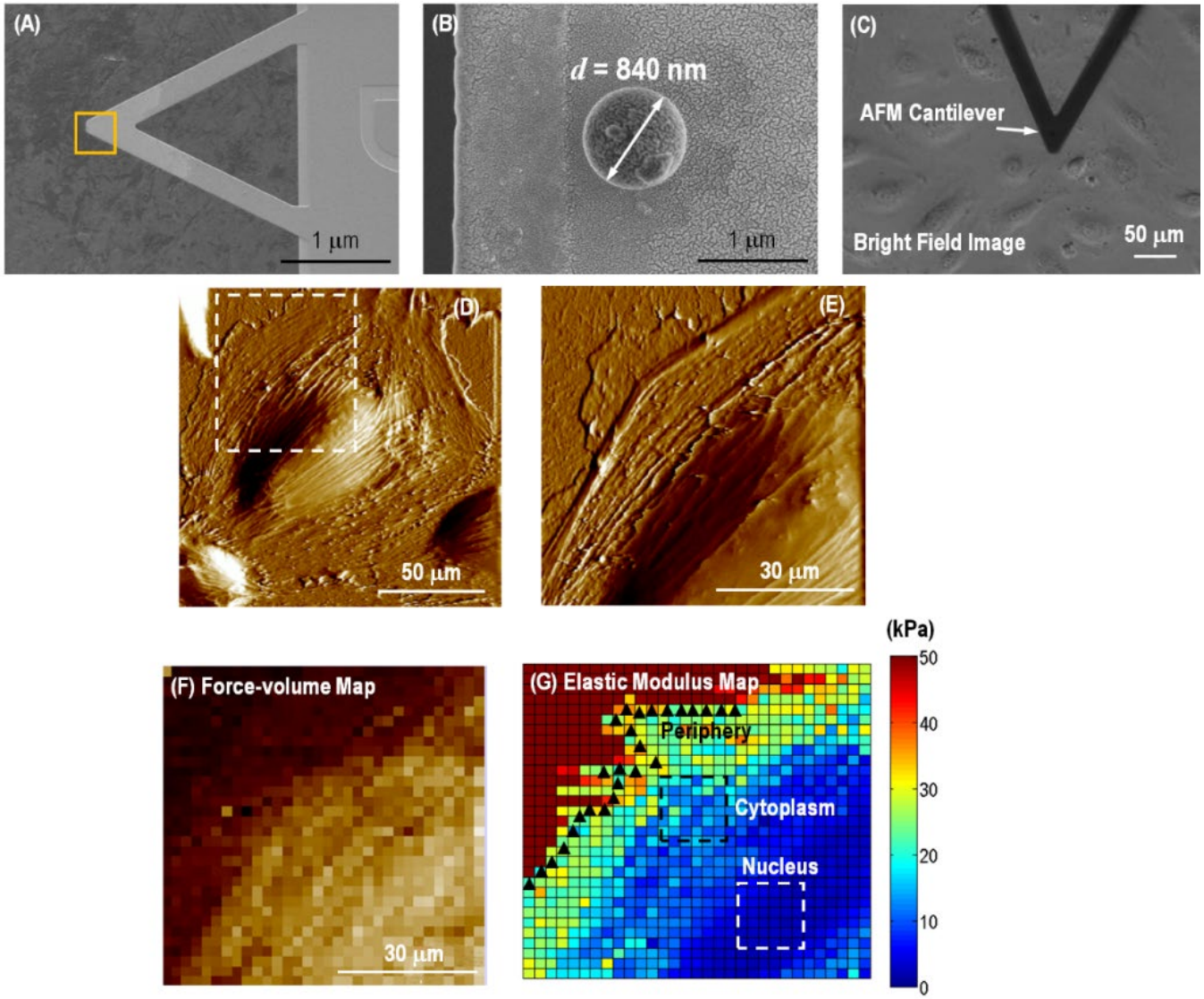
Force-Volume Mapping



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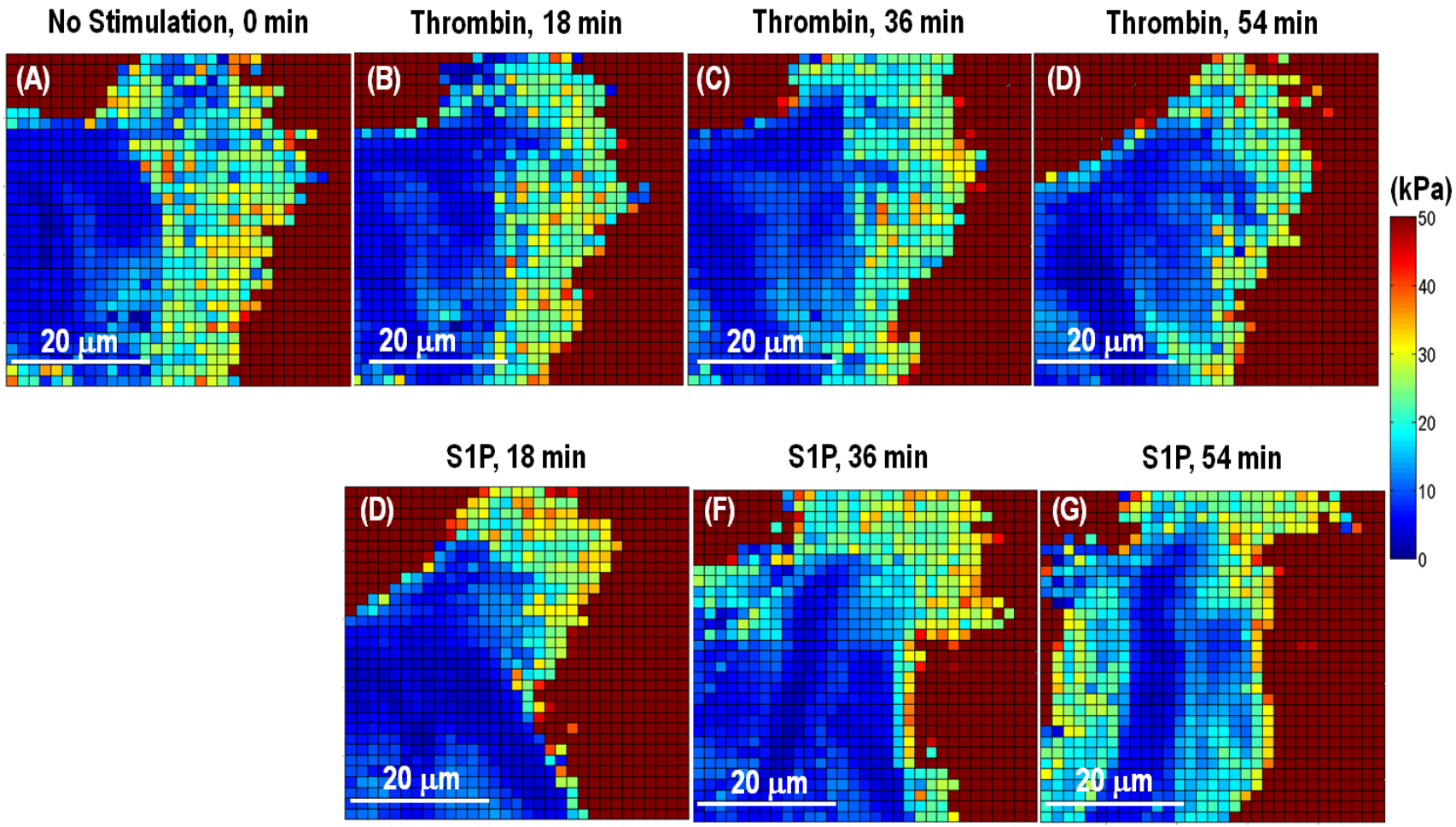
Time-Lapse Elastic Modulus Map of Live EC Cells



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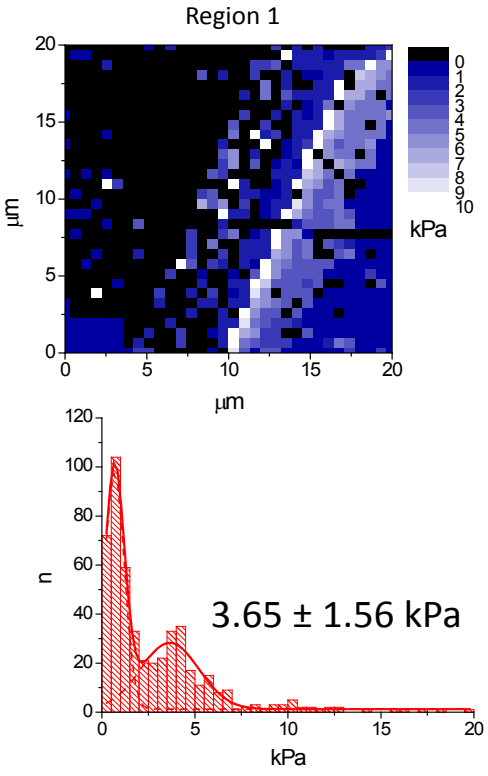
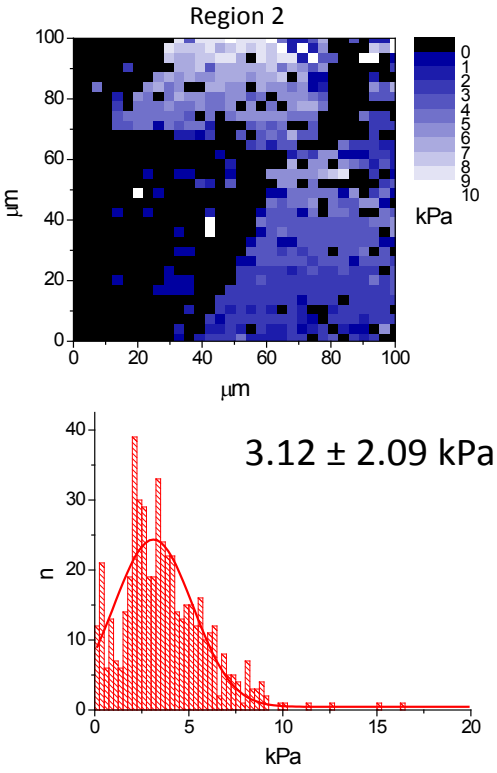
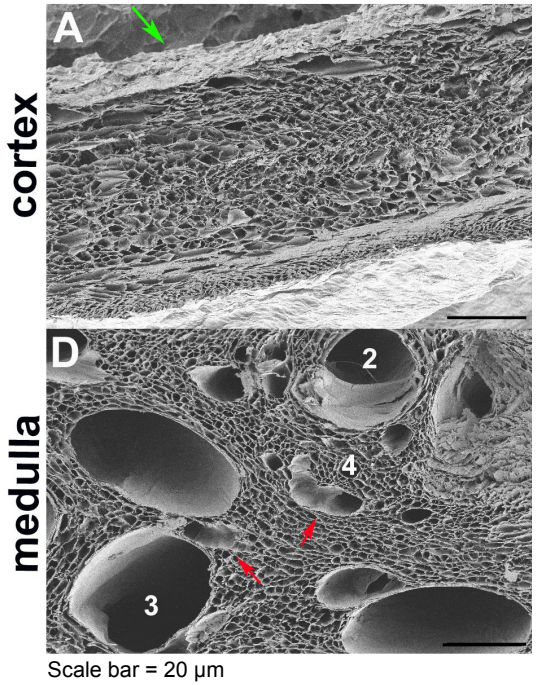
Ovarian Tissue Nanomechanics







Scanning Near Field Ultrasound Holography (SNFUH): *Seeing the Invisible!*

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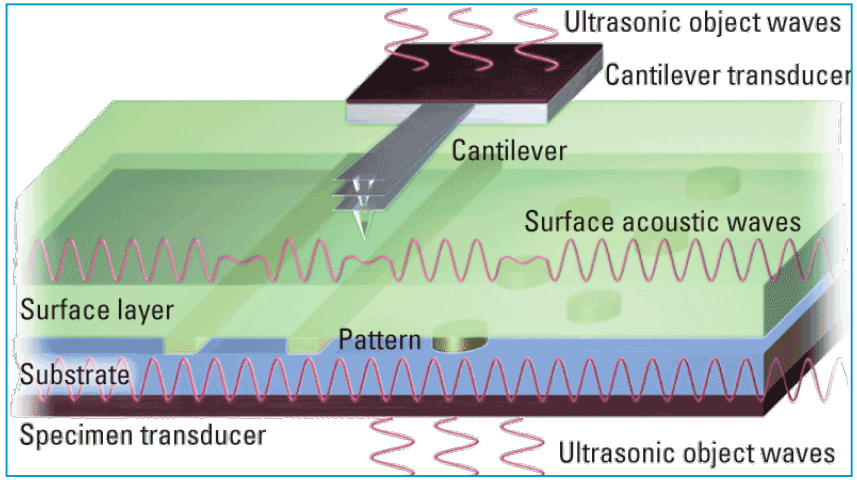
Science 310, 89 (2005), Nature Nanotechnology 3,501 (2008)



Near-Field SPM Platform:

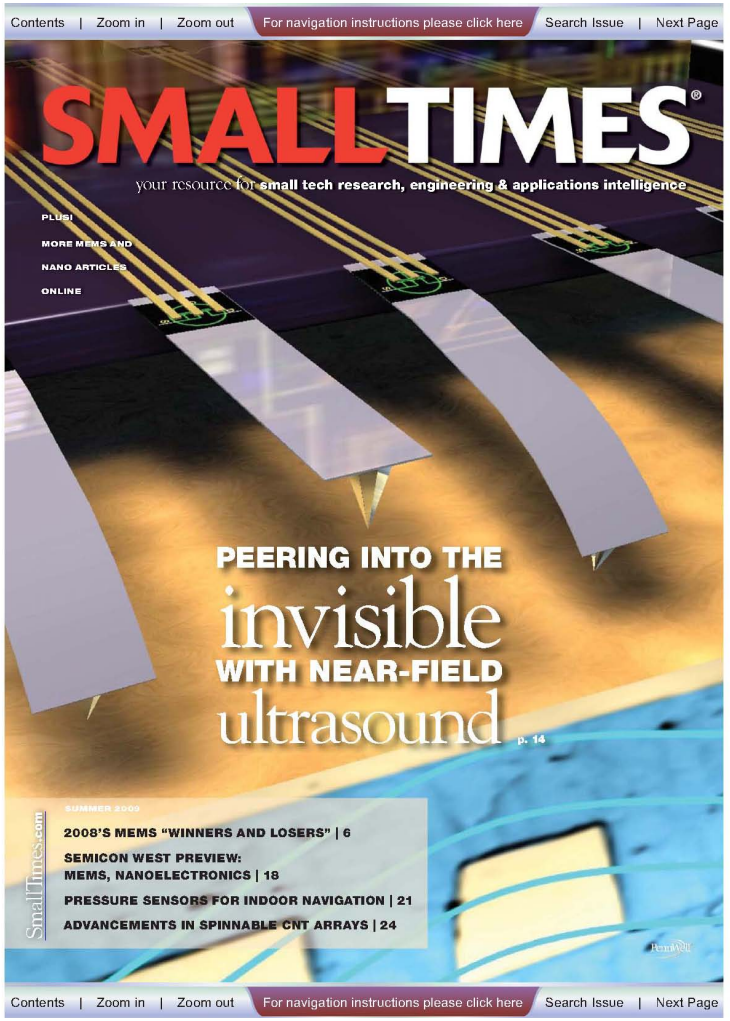
➔ **Excellent Lateral Resolution**

Ultrasound source:

➔ **Non-destructive and Depth-Sensitive**

Holography Paradigm:

➔ **Sensitive to "*Phase*" Perturbations**



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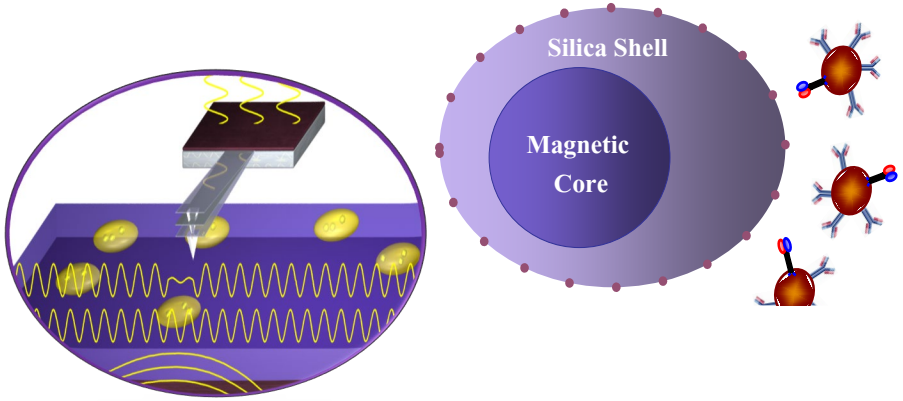
Ultrasound Bioprobe for Nanomechanical Analysis

Imaging magnetic core nanostructure embedded in refractory silica core shell based molecular

a



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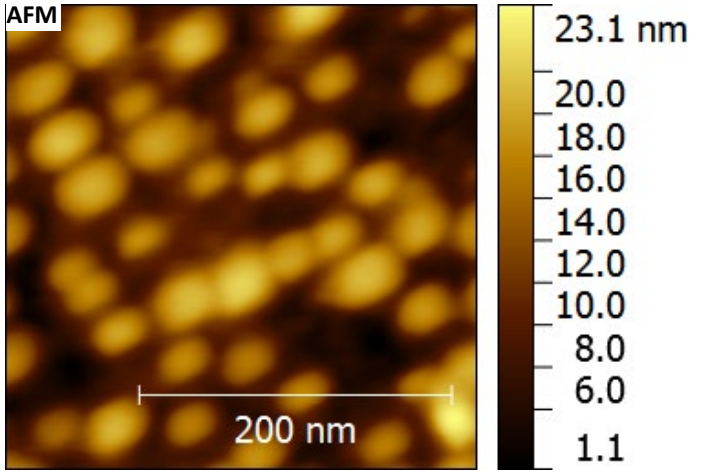

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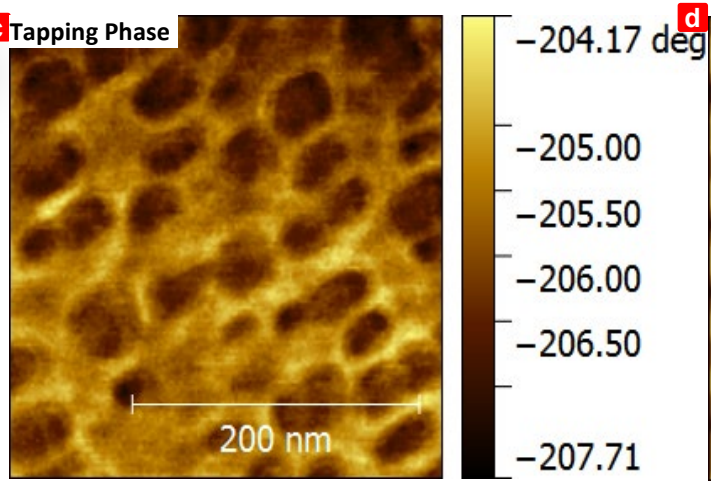
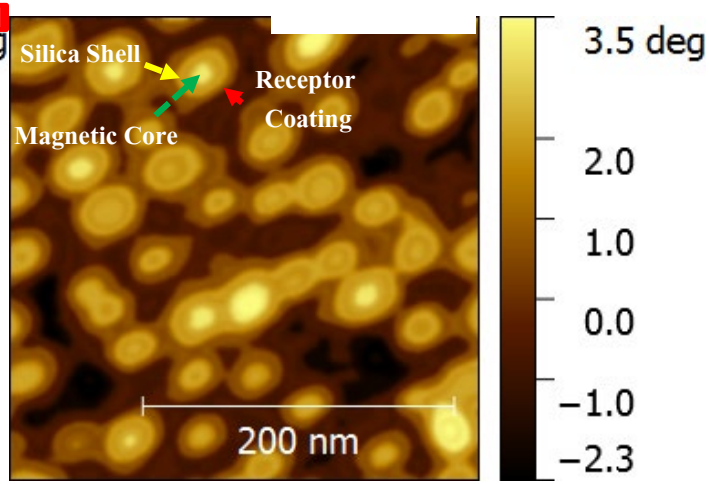


d



Science Advances 2017: 3;e1701176, Nature Scientific Report 8 (1) 1002 (2018), Nature Scientific Report 7, 14152 (2017)

Ultrasound Bioprobe for Nanomechanical Analysis

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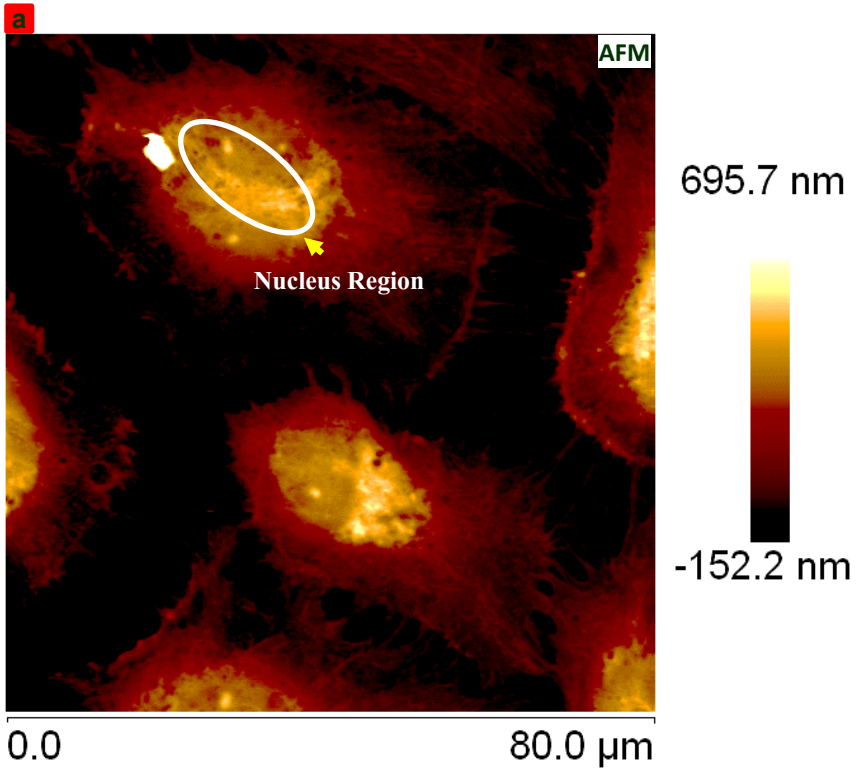
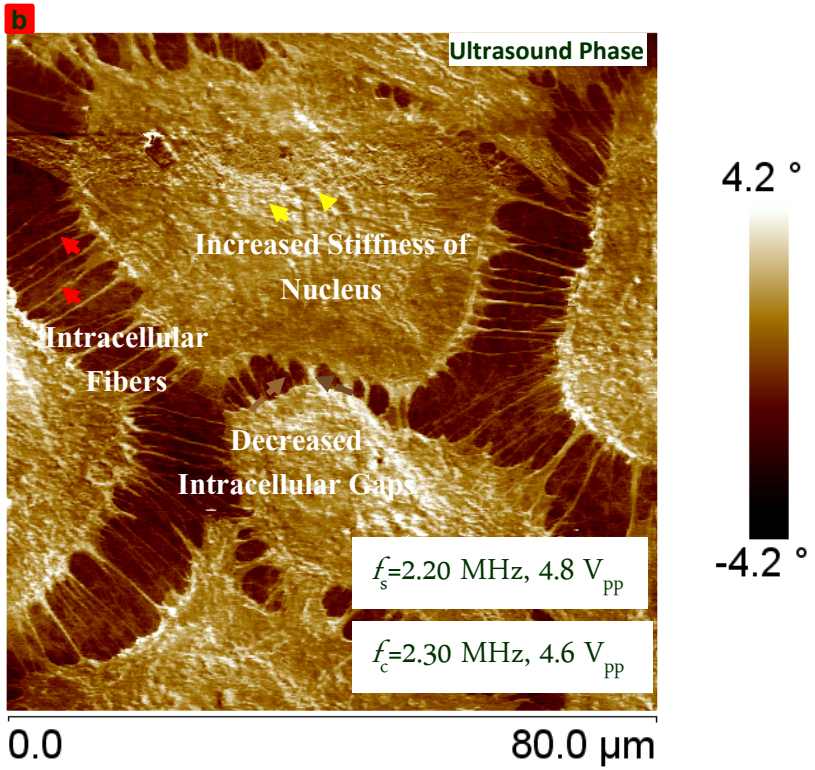
AFM topographical image EC cells altered by addition of thrombin and ultrasound bioprobe phase image demonstrates remarkable contrast from intra-cellular fibers. Intracellular fibers are predominantly seen in the ultrasound phase image along with stretched gaps and sub-cellular phase contrast on the nuclei region of the cells.





Science Advances 2017: 3;e1701176

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Stenotrophomonas maltophilia (Bacteria found in gold mines)