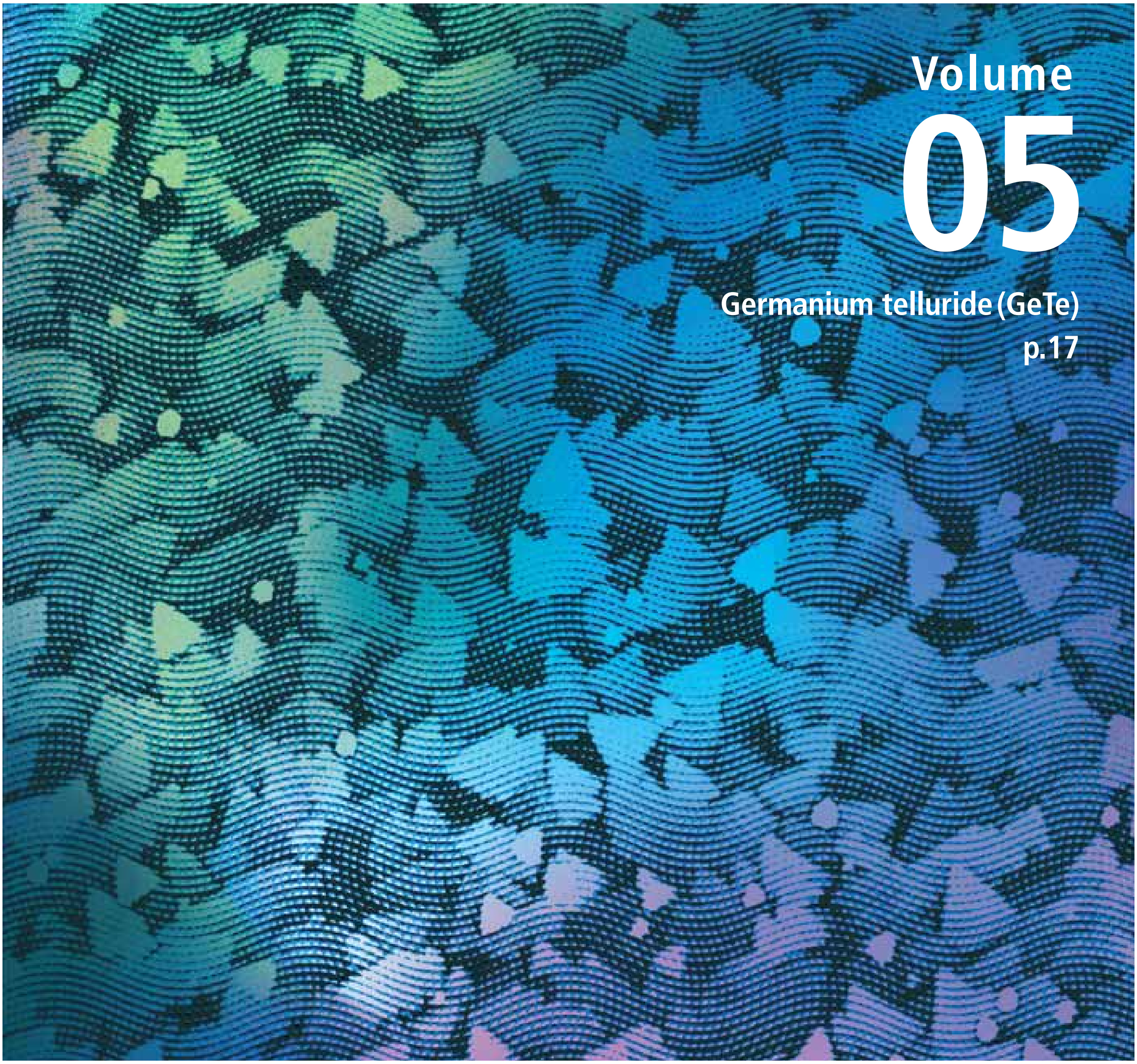
Park Systems Atomic Force Microscopy

IMAGE GALLERY

Here, at Park Systems, we offer a full range of advanced imaging solutions for a wide variety of research applications.
Enjoy the images in the gallery which highlight examples from a wide variety of sample types and imaging modes.



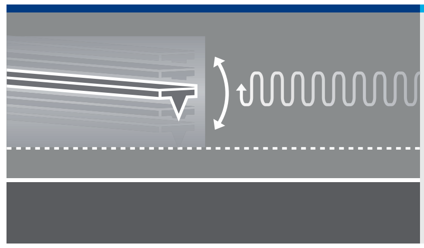
01.

Topography

02.

Advanced mode

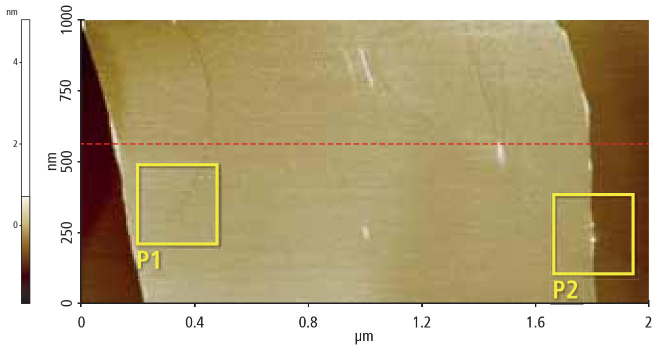
$C_{36}H_{74}$ on HOPG



True Non-contact™ Mode

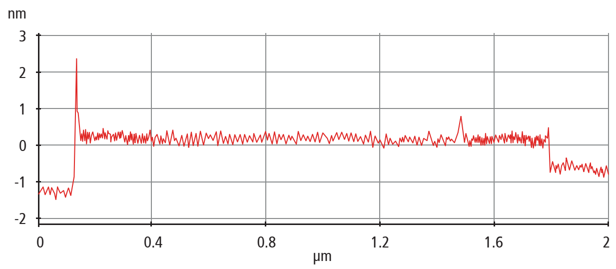
In this technique, the cantilever oscillates just above the surface as it scans. A precise, high-speed feedback loop prevents the cantilever tip from crashing into the surface, keeping the tip sharp and leaving the surface untouched. As the tip approaches the sample surface, the oscillation amplitude of the cantilever decreases. By using the feedback loop to correct for these amplitude deviations, one can generate an image of the surface topography.

■ Height (2 µm × 1 µm scan)



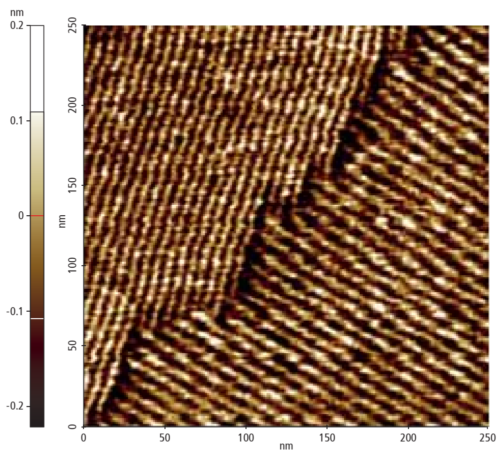
Peak to valley: 6.7 nm
RMS roughness: 0.42 nm

■ Line profile

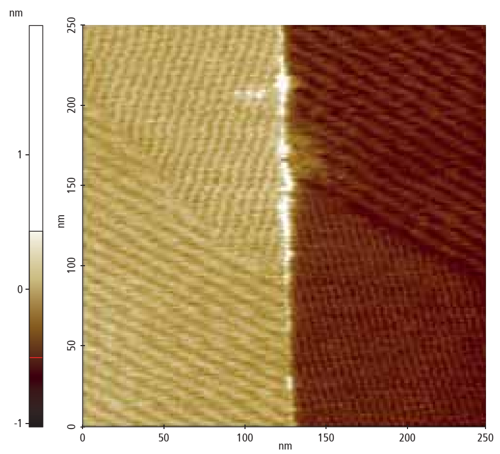


■ Zoom in (250 nm × 250 nm scan)

Position 1

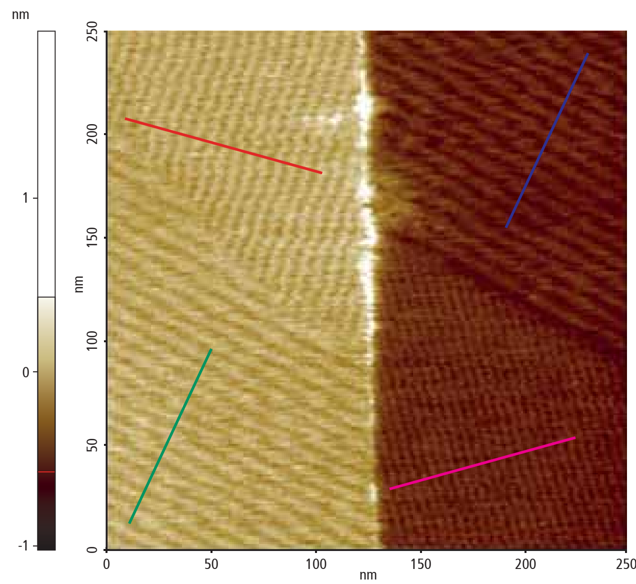


Position 2



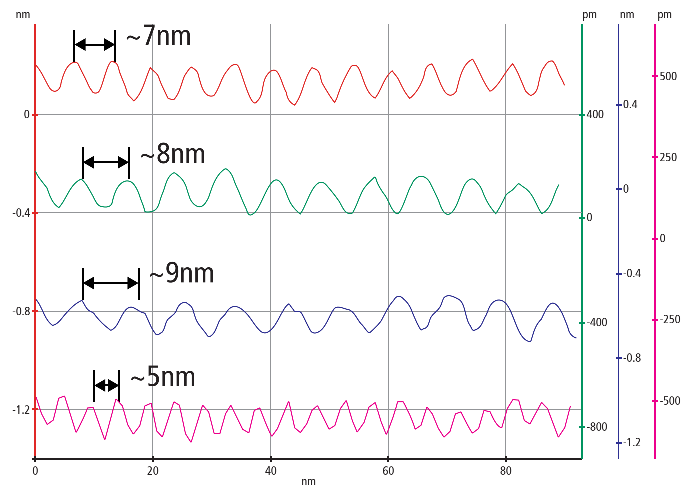
$C_{36}H_{74}$ on HOPG (250 nm scan)

■ Height of position 2



Peak to valley: 3.0 nm
RMS roughness: 0.37 nm

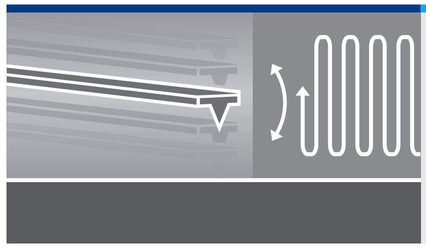
■ Multi-line profiles



Scanning conditions

- System: FX40
- Scan Size: 250 nm × 250 nm
- Scan Mode: Non-contact
- Scan Rate: 0.3 Hz
- Cantilever: PPP-FMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 512 × 512

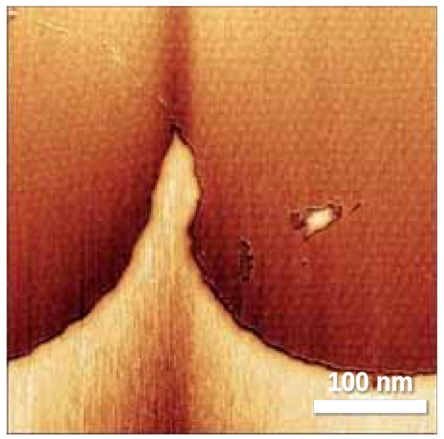
Molecular network on HOPG (400 & 100 & 25 nm scan)



Tapping Mode

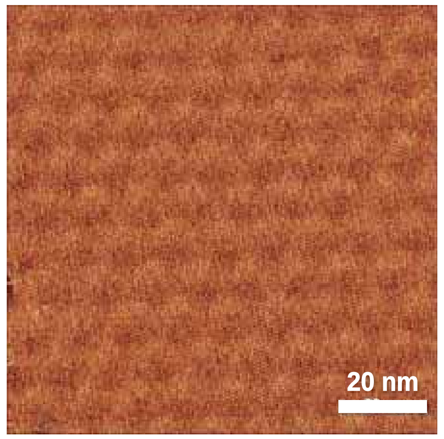
In this alternative technique to non-contact mode, the cantilever again oscillates just above the surface, but at a much higher amplitude of oscillation. The bigger oscillation makes the deflection signal large enough for the control circuit, and hence an easier control for topography feedback. It produces modest AFM results but blunts the tip's sharpness at a higher rate, ultimately speeding up the loss of its imaging resolution.

■ **Phase (400 nm scan)**



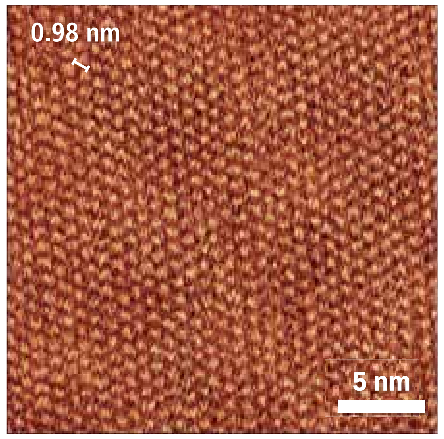
Moiré pattern

■ **Phase (100 nm scan)**



Moiré pattern and molecular lattice structure

■ **Phase (25 nm scan)**



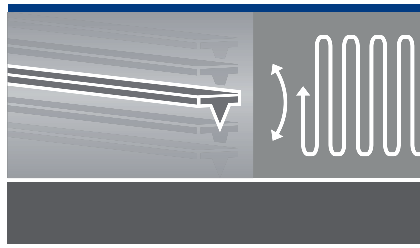
Molecular lattice structure

When co-adsorbed on an atomically flat surface, melamine and cyanuric acid form 2D-molecular network with a period of 0.98 nm. Due to a lattice mismatch between molecular network and underlying HOPG lattice, a Moiré pattern can be observed as well.

Scanning conditions

- System: NX20
- Scan Size: Left 400 nm × 400 nm
  Middle 100 nm × 100 nm
  Right 25 nm × 25 nm
- Scan Mode: Tapping
- Scan Rate: Left 2 Hz
  Middle 3 Hz
  Right 6 Hz
- Cantilever: Multi75Al-G (k=3 N/m, f=75 kHz)
- Pixel Size: All 512×512

Isotactic polypropylene (500 & 100 nm scan)



Tapping Mode

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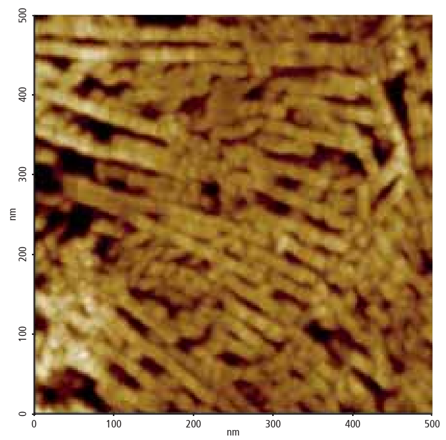
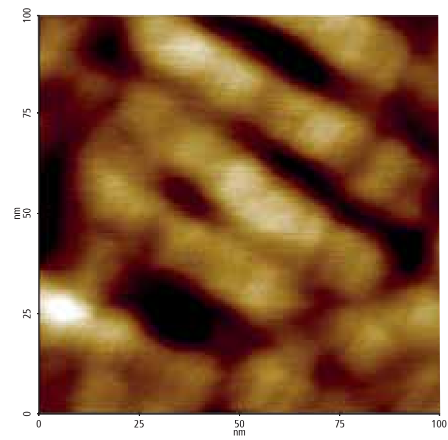
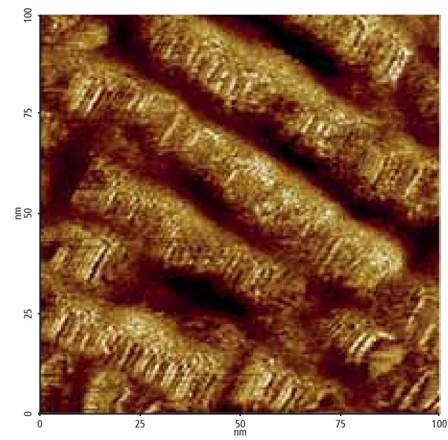
■ **Height (500 nm scan)**



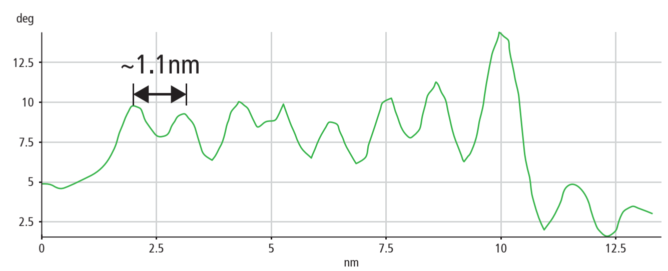
■ **Height (100 nm scan)**



■ **Phase (100 nm scan)**



Peak to valley: 4.1 nm
RMS roughness: 0.55 nm

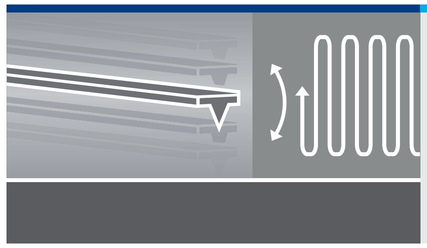


Oriented isotactic polypropylene film displaying lamellar structure. Individual molecules can be seen as well.

Scanning conditions

- System: NX20
- Scan Size: Left 500 nm × 500 nm
  Middle/Right 100 nm × 100 nm
- Scan Mode: Tapping
- Scan Rate: Left 2 Hz
  Middle/Right 4 Hz
- Cantilever: Multi75Al-G (k=3 N/m, f=75 kHz)
- Pixel Size: All 512 × 512

Graphene/hBN heterostructure



Tapping Mode

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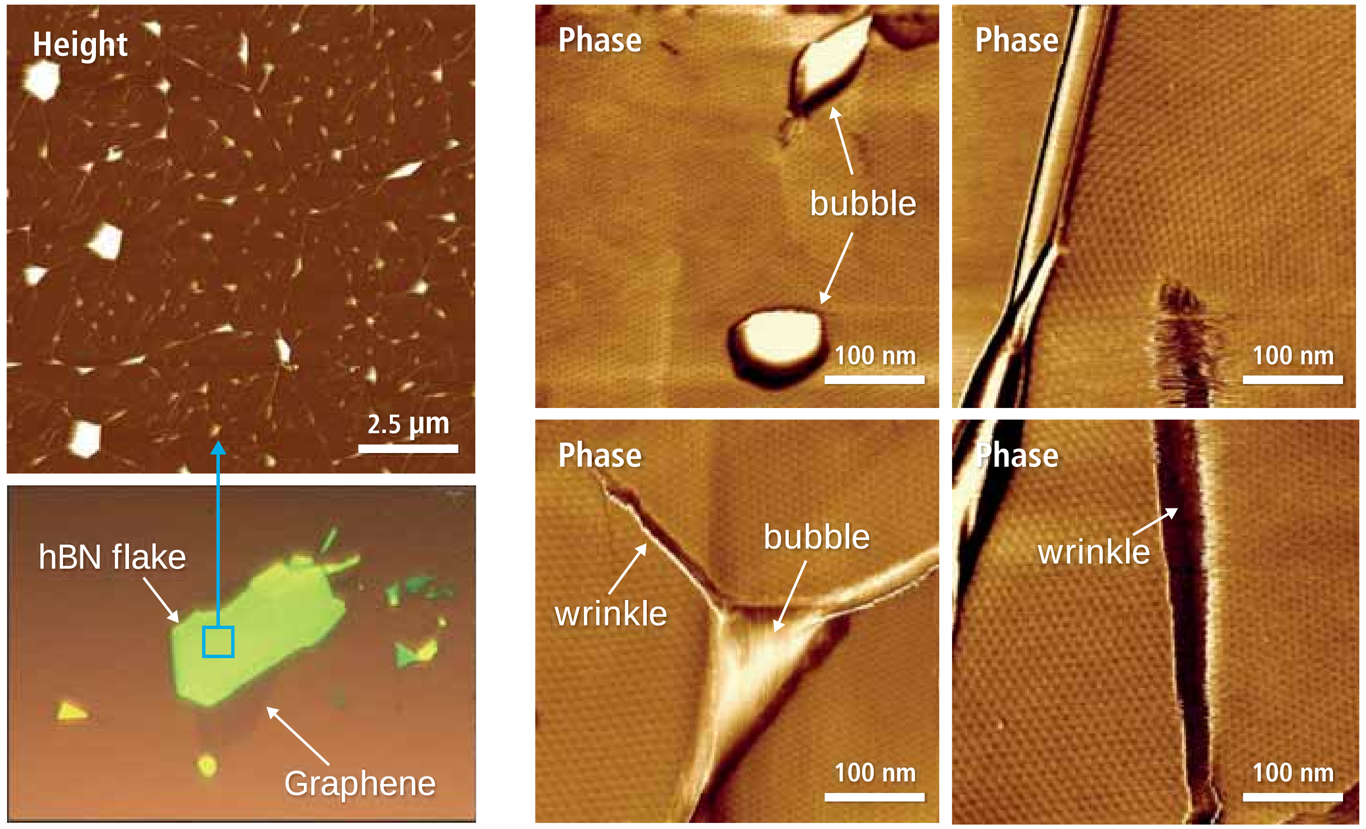
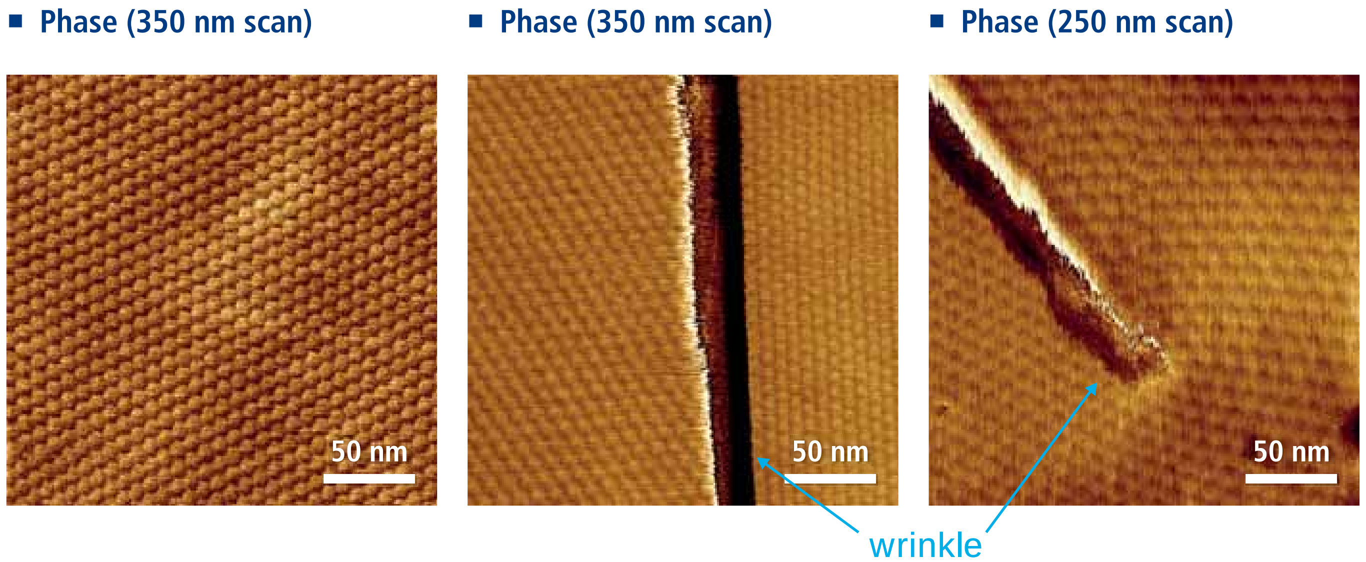
Large scale height image showing typical landscape of microstamped graphene layer with bubbles and wrinkles. A set of high-resolution images shows various Moiré patterns originating from lattice mismatch.



Graphene/hBN heterostructure (350 & 250 nm scan)

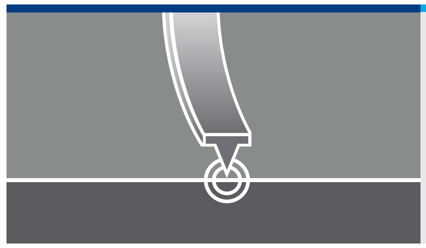


Imaging Moiré pattern on graphene in Tapping modes.

Scanning conditions

- System: NX20
- Scan Size: Left 350 nm × 350 nm
  Middle 350 nm × 350 nm
  Right 250 nm × 250 nm
- Scan Mode: Tapping
- Scan Rate: Left 2 Hz
  Middle 2 Hz
  Right 3 Hz
- Cantilever: Multi75Al-G (k=3 N/m, f=75 kHz)
- Pixel Size: All 512 × 512

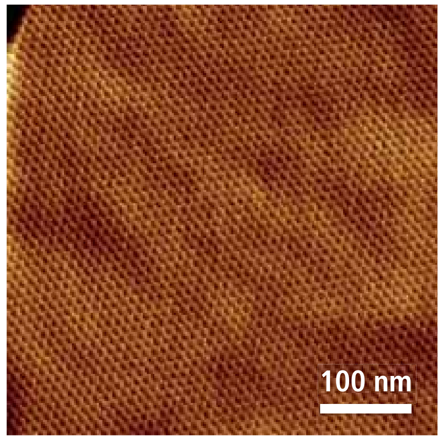
Graphene/hBN heterostructure (500 & 250 & 100 nm scan)



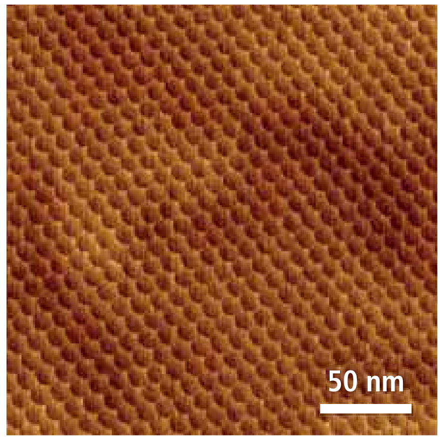
Contact Mode

In this method, the cantilever scans across a sample surface. Because the cantilever is in contact with the surface, strong repulsive force causes the cantilever to deflect as it passes over topographical features.

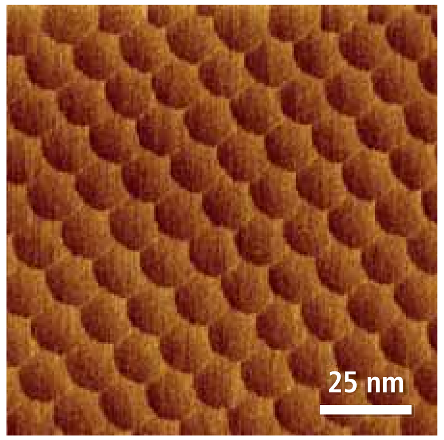
■ Lateral (500 nm scan)



■ Lateral (250 nm scan)



■ Lateral (100 nm scan)

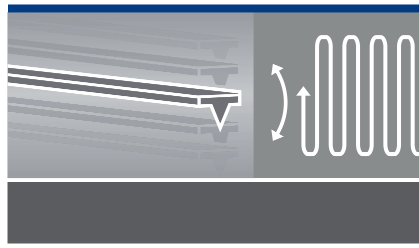


Imaging Moiré pattern on graphene in LFM mode based on Contact mode.
Scan angle of LFM image is set to 45˚.

Scanning conditions

- System: NX20
- Scan Size: Left 500 nm × 500 nm
  Middle 250 nm × 250 nm
  Right 100 nm × 100 nm
- Scan Mode: Contact
- Scan Rate: Left 2 Hz
  Middle 3 Hz
  Right 3 Hz
- Cantilever: Multi75Al-G (k=3 N/m, f=75 kHz)
- Pixel Size: All 1024 × 1024

Boron nitride on monolayer graphene (80 nm scan)



Tapping Mode

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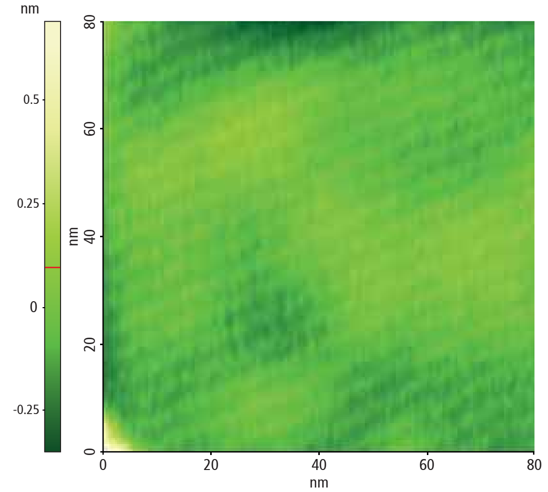
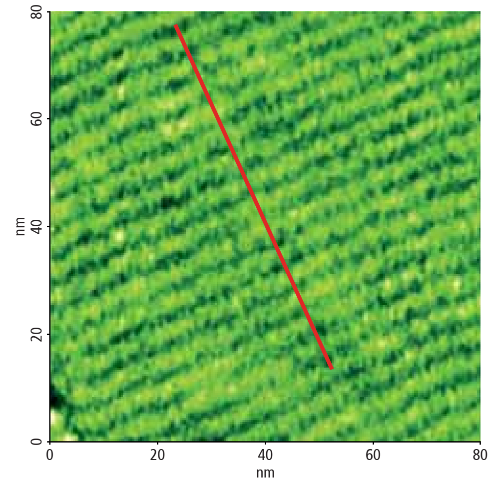
■ Height (80 nm scan)

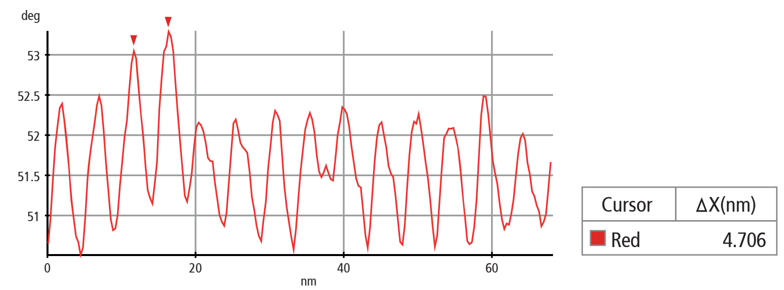


Peak to valley: 1.04 nm
RMS roughness: 0.085 nm

■ Phase (80 nm scan)



■ Line profile



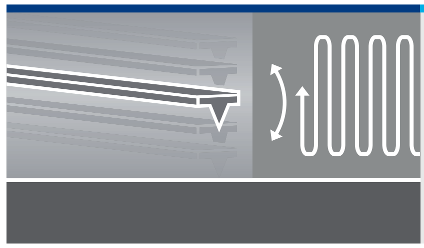
4.7 nm striated superlattice on boron nitride on top of monolayer graphene (tBN+MLG) was visualized in both height and phase signals.

- Sample courtesy: Qiong Ma, Boston College, US

Scanning conditions

- System: NX10
- Scan Size: 80 nm × 80 nm
- Scan Mode: Tapping
  :Drive amplitude 13 nm, Set point 2 nm
- Scan Rate: 4 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f=330 kHz)
- Pixel Size: 256 × 256

Di-Phe-Phe nanotubes (70 & 30 & 25 nm scan)



Tapping Mode

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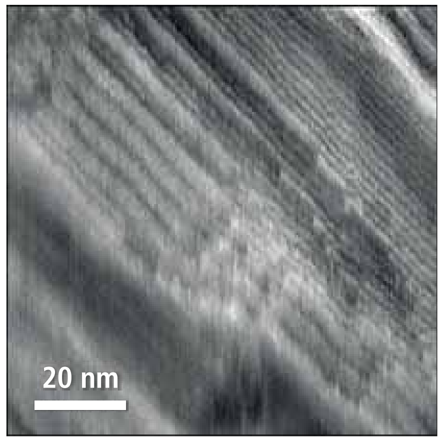
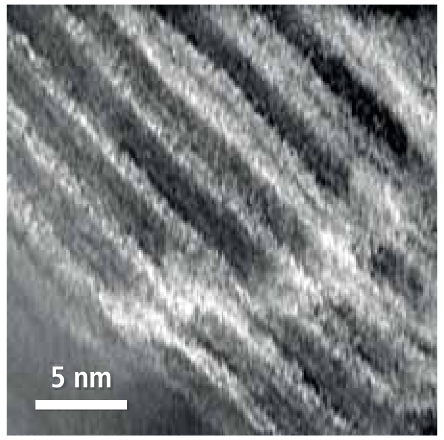
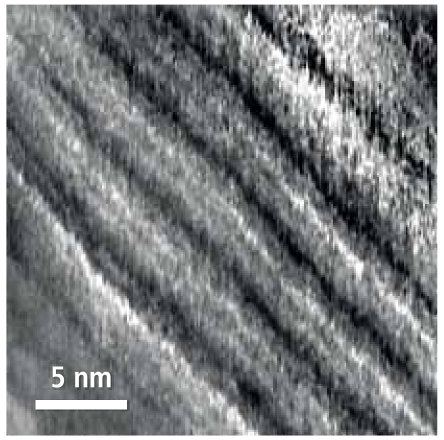
▪ Phase (70 nm scan)

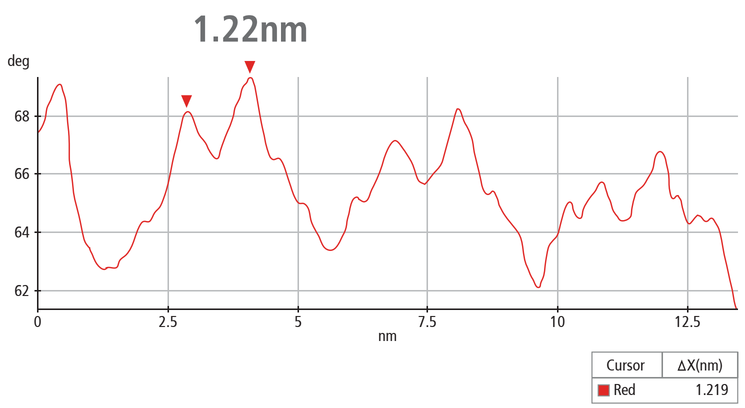


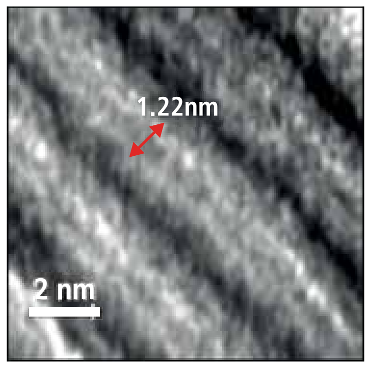
▪ Phase (30 nm scan)



▪ Phase (25 nm scan)



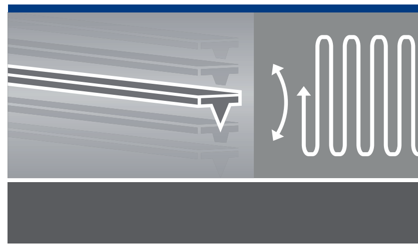




Scanning conditions

- System: NX20
- Scan Size: Left 70 nm × 70 nm
  Middle 30 nm × 30 nm
  Right 25 nm × 25 nm
- Scan Mode: Tapping
- Scan Rate: Left 3 Hz
  Middle 3 Hz
  Right 2 Hz
- Cantilever: Multi75Al-G (k=3 N/m, f=75 kHz)
- Pixel Size: All 512 × 512

Di-Phe-Phe nanotubes (NTs)



Tapping Mode

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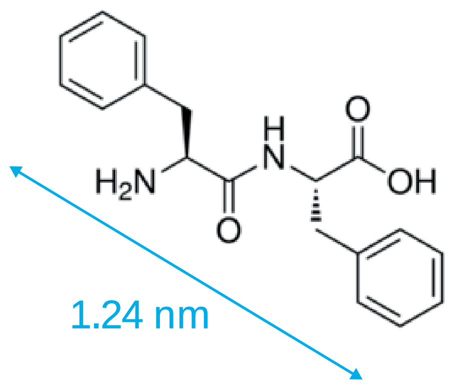
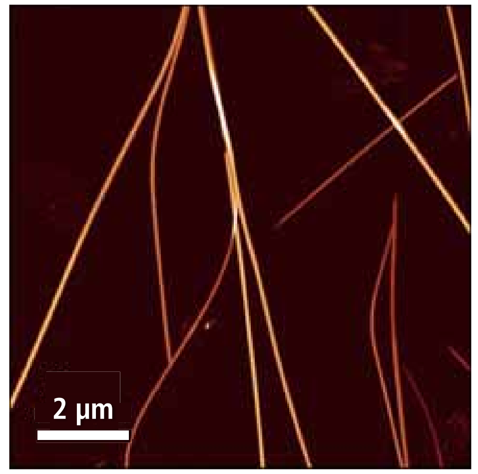
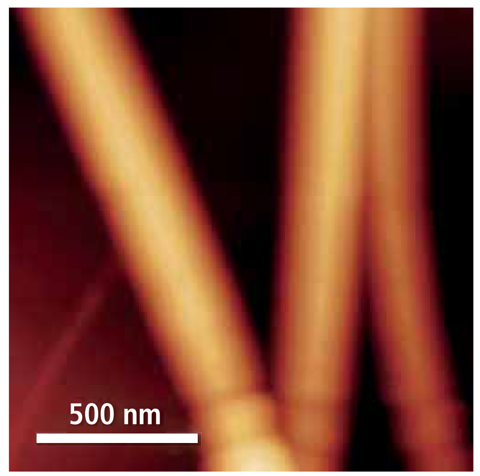
▪ L-Phenylalanyl-L-phenylalanine, Di-L-phenylalanine



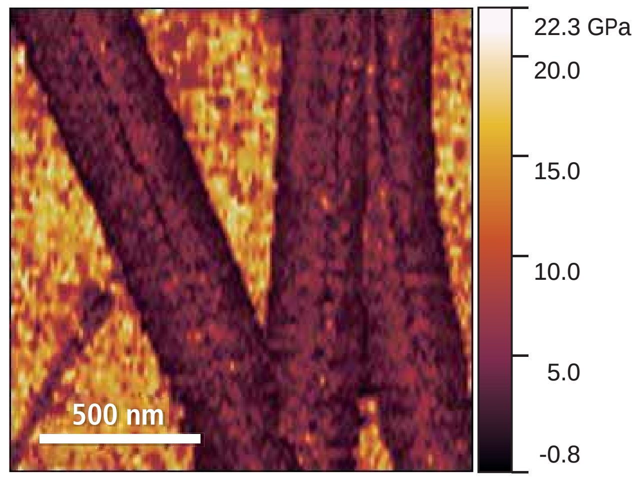
▪ Large scale image of peptide NTs on mica



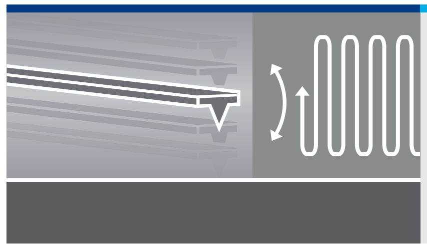
▪ Height



▪ Young's modulus



Block copolymer



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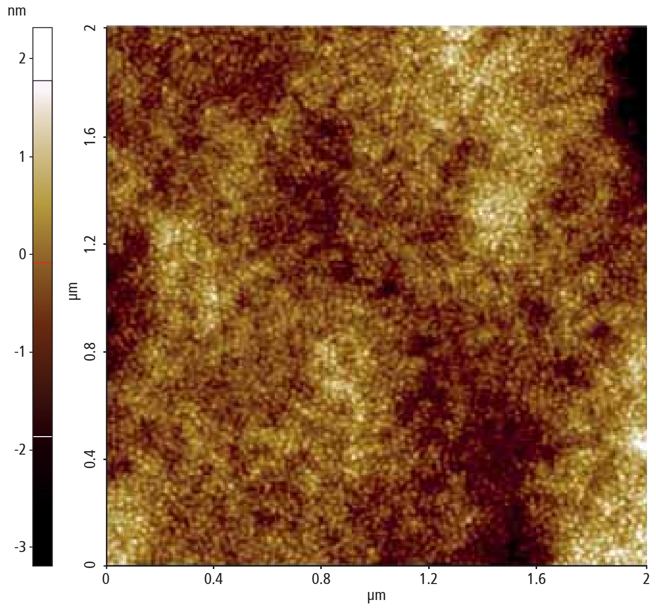
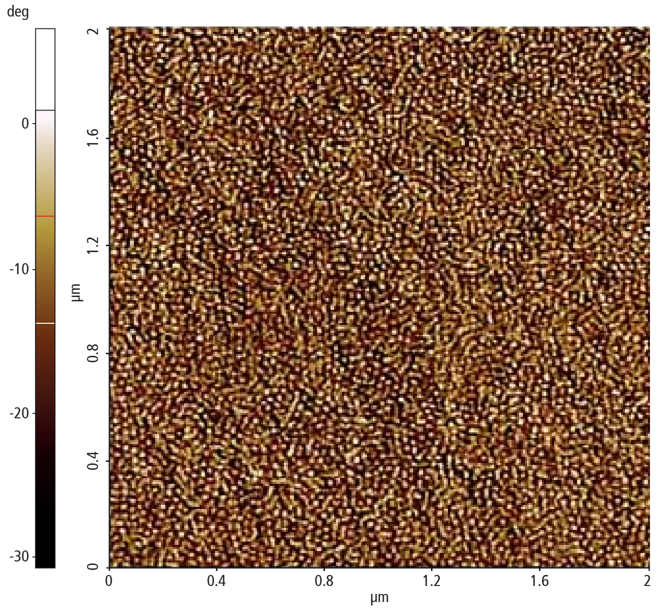
■ Height



Peak to valley: 5.5 nm
RMS roughness: 0.54 nm

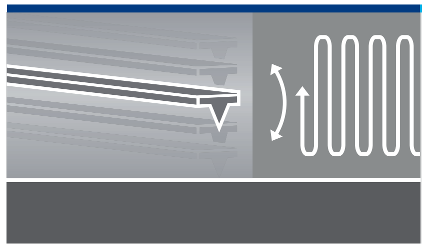
■ Phase



Scanning conditions

- System: NX10
- Scan Size: 2 μm × 2 μm
- Scan Mode: Tapping
- Scan Rate: 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 1024 × 512

Poly(styrene-block-butadiene styrene) (SBS)



Tapping Mode

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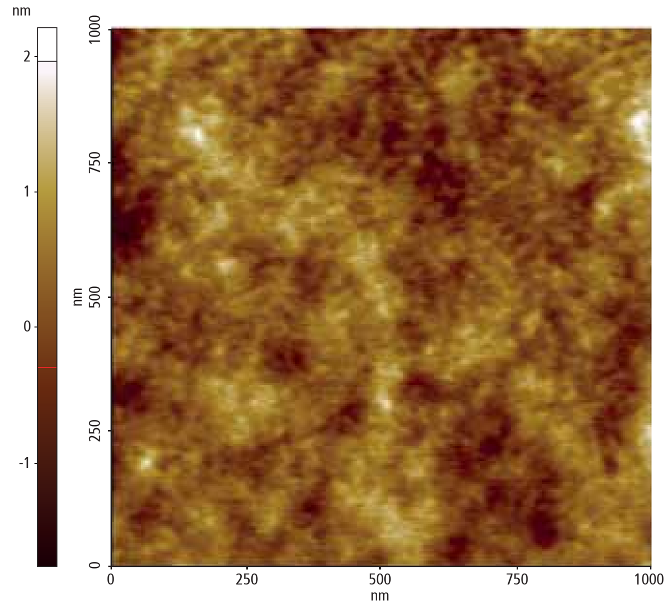
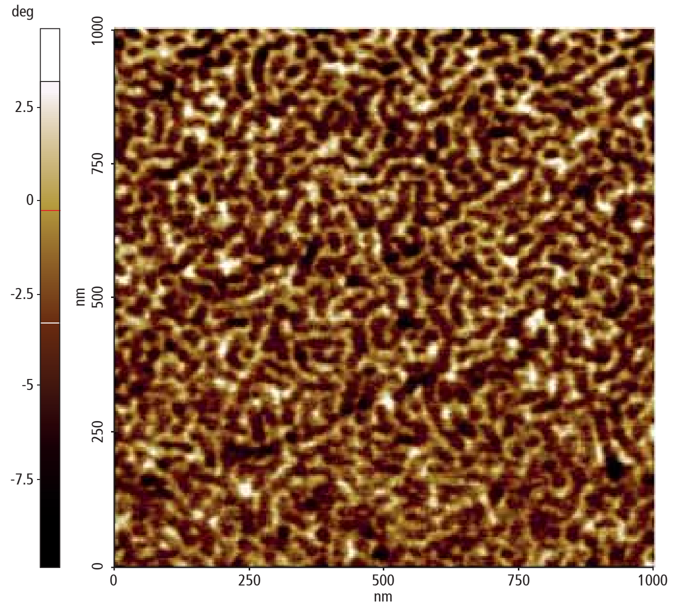
■ Height



Peak to valley: 3.97 nm
RMS roughness: 0.44 nm

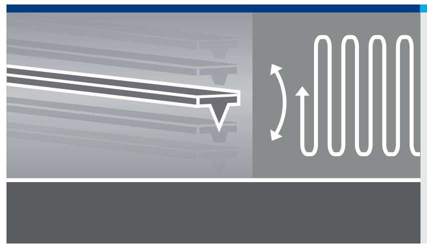
■ Phase



Scanning conditions

- System: FX40
- Scan Size: 1 μm × 1 μm
- Scan Mode: Tapping
- Scan Rate: 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 256 × 256

Polystyrene-polyvinyl acetate (PS-PVAc)



Tapping Mode

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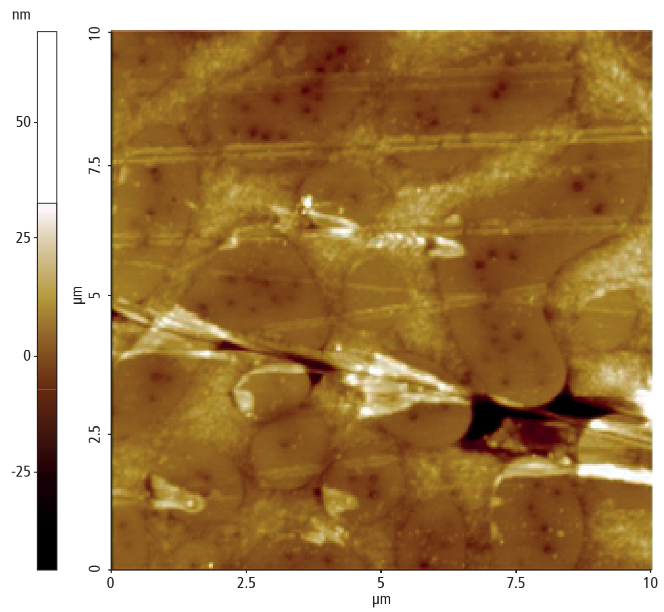
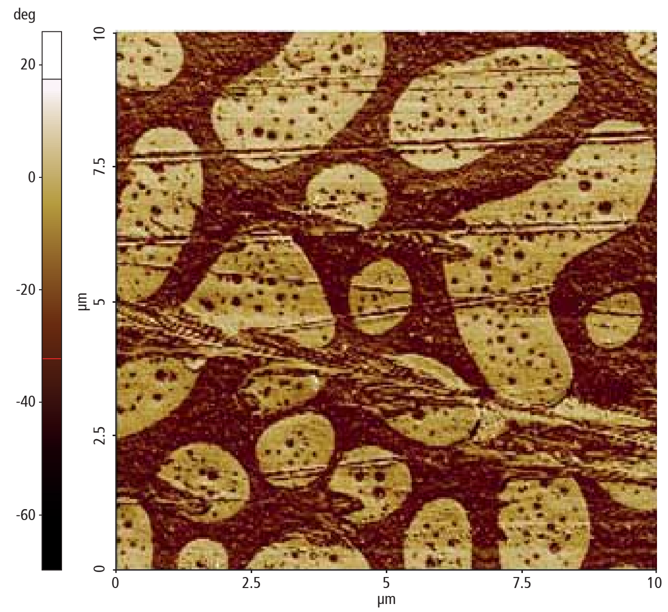
■ Height



Peak to valley: 115.5 nm
RMS roughness: 8.51 nm

■ Phase

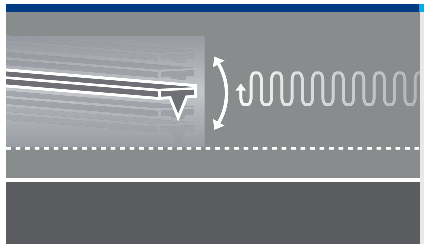


Blended polystyrene and polyvinyl acetate (PS-PVAc) film.

Scanning conditions

- System: FX40
- Scan Size: 10 µm × 10 µm
- Scan Mode: Tapping
- Scan Rate: 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 512 × 256

Germanium telluride (GeTe)



True Non-contact™ Mode

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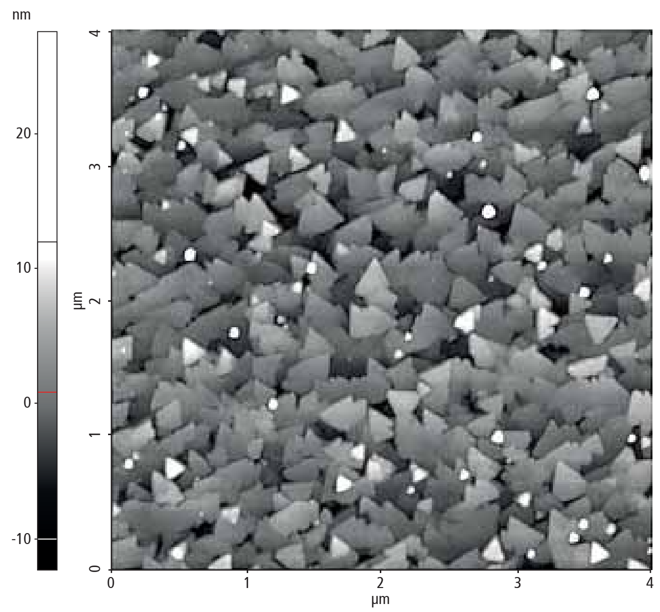
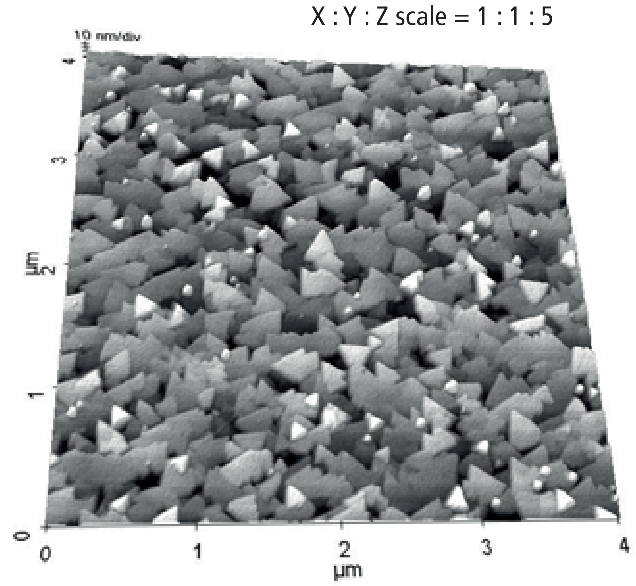
■ Height



Peak to valley: 39.9 nm
RMS roughness: 3.4 nm

■ 3D



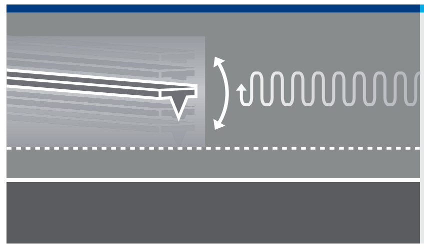
Triangular domains formed by germanium telluride when grown on silicon 7x7 by molecular beam epitaxy.

▪ Sample courtesy: Raffaella Calarco, Paul-Drude-Institut für Festkörperelektronik (PDI), Berlin

Scanning conditions

- System: NX10
- Scan Size: 4 µm × 4 µm
- Scan Mode: Non-contact
- Scan Rate: 0.5 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 1024 × 1024

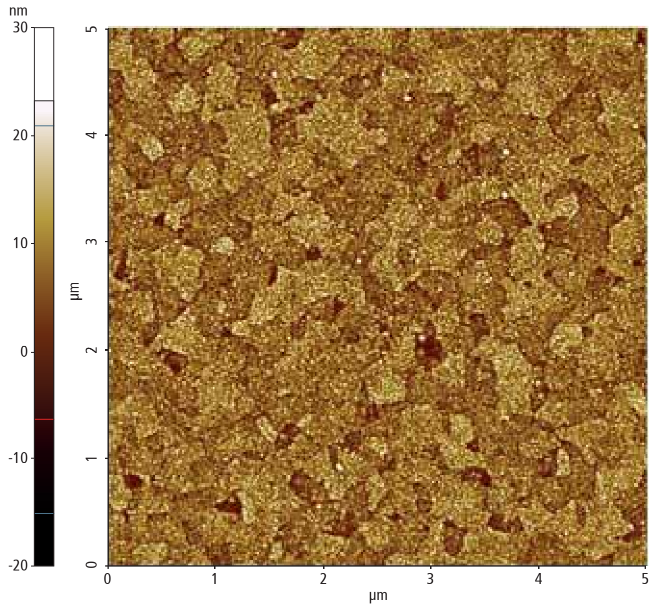
Nickel oxide (NiO) on indium tin oxide (ITO) glass



True Non-contact™ Mode

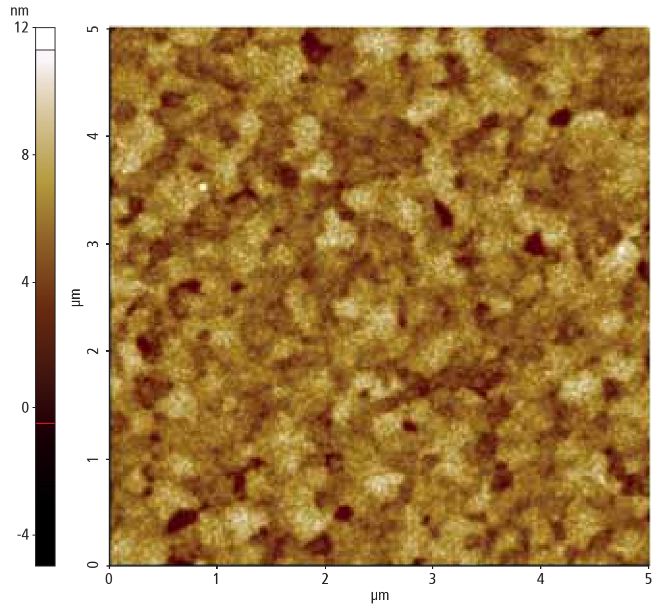
In this technique, the cantilever oscillates just above the surface as it scans. A precise, high-speed feedback loop prevents the cantilever tip from crashing into the surface, keeping the tip sharp and leaving the surface untouched. As the tip approaches the sample surface, the oscillation amplitude of the cantilever decreases. By using the feedback loop to correct for these amplitude deviations, one can generate an image of the surface topography.

▪ Height prepared by sputtering



Peak to valley: 36.0 nm
RMS roughness: 7.51 nm

▪ Height prepared by spin coating



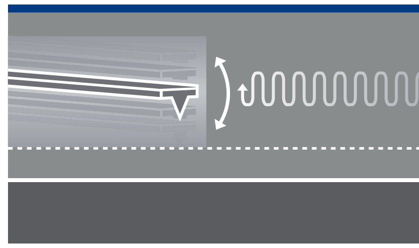
Peak to valley: 17.0 nm
RMS roughness: 2.38 nm

Surface morphology comparison of NiO coated on ITO glass by two different preparations.

Scanning conditions

- System: NX10
- Scan Size: 5 μm × 5 μm
- Scan Mode: Non-contact
- Scan Rate: 0.5 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 512 × 512

Organosilane self-assembled monolayer (SAM)



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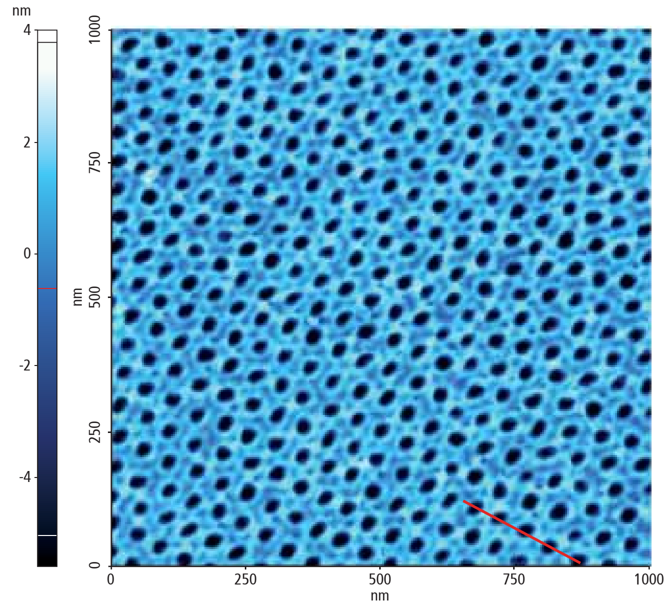
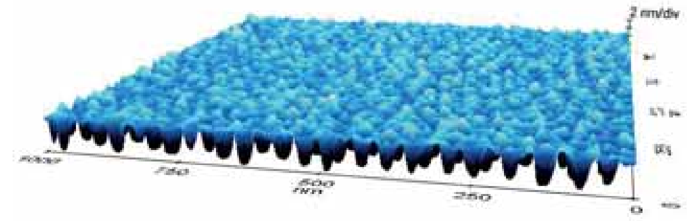
▪ Height

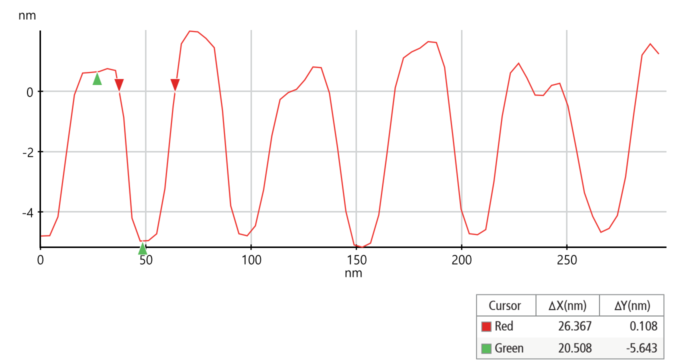


Peak to valley: 9.6 nm
RMS roughness: 1.76 nm

▪ 3D



▪ Line profile

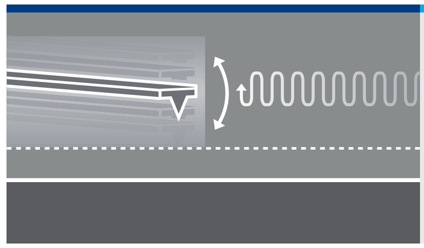


Nanopattern of organosilanes SAM used in functional films for surface sensors, molecular electronic devices and surface coating.

Scanning conditions

- System: NX10
- Scan Size: 1 μm × 1 μm
- Scan Mode: Non-contact
- Scan Rate: 0.3 Hz
- Cantilever: SSS-NCHR (k=42 N/m, f=330 kHz)
- Pixel Size: 512 × 256

Barium titanate ($BaTiO_3$, BTO) thin film



True Non-contact™ Mode

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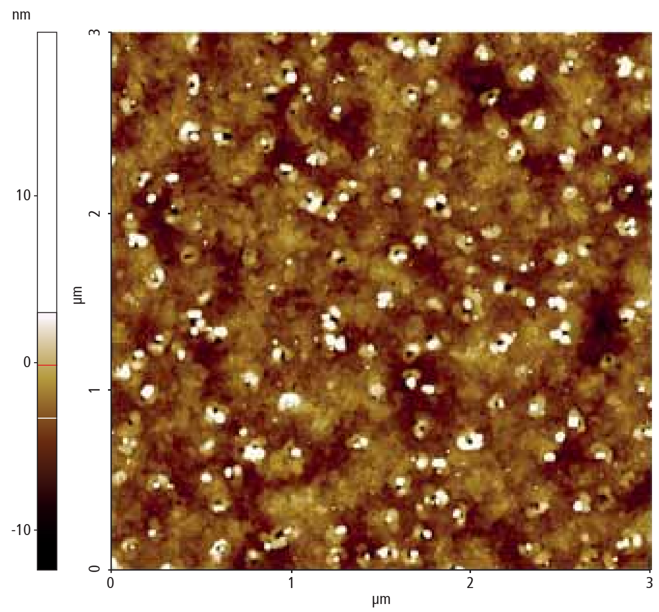
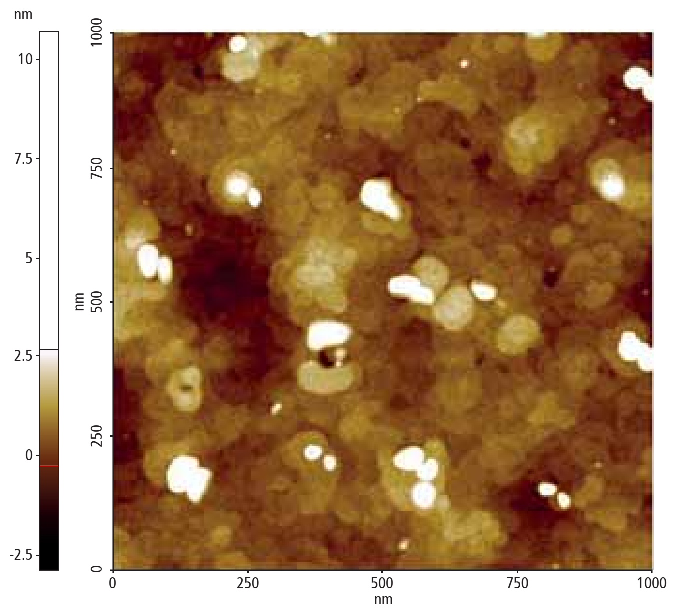
- **Height (3 µm scan)**



Peak to valley: 32.17 nm
RMS roughness: 1.27 nm

- **Height (1 µm scan)**

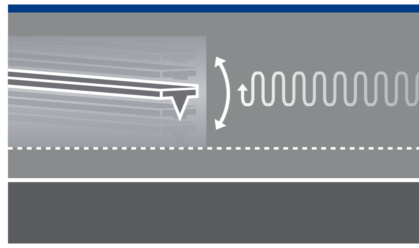


Peak to valley: 13.56 nm
RMS roughness: 1.00 nm

Scanning conditions

- System: NX-Wafer
- Scan Size: Left 3 µm × 3 µm
  Right 1 µm × 1 µm
- Scan Mode: Non-contact
- Scan Rate: Left 0.5 Hz
  Right 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: Left 2048 × 256
  Right 512 × 512

Defects on Si wafer



True Non-contact™ Mode

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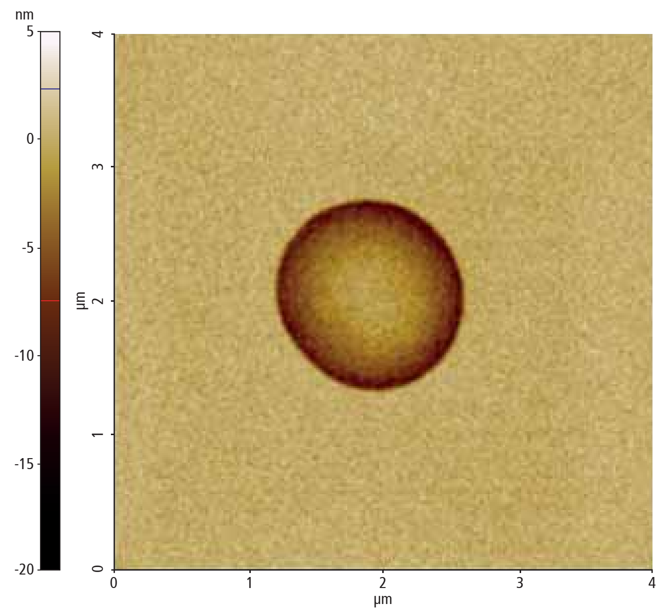
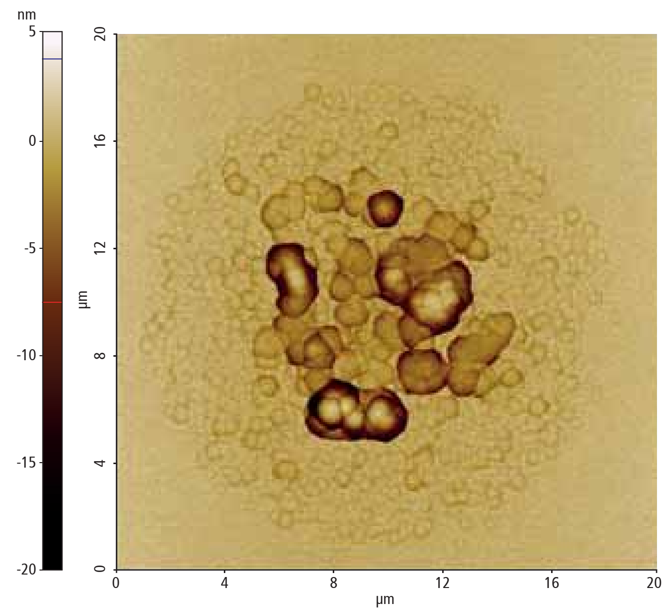
- **Defect 1 (4 µm scan)**



Peak to valley: 15.34 nm
RMS roughness: 1.99 nm

- **Defect 2 (20 µm scan)**

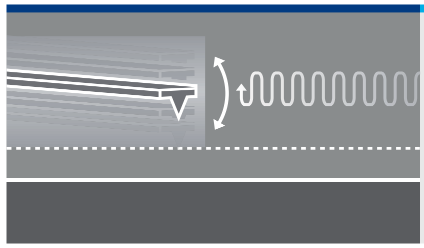


Peak to valley: 33.56 nm
RMS roughness: 2.47 nm

Scanning conditions

- System: NX-Wafer
- Scan Size: Left 4 µm × 4 µm
  Right 20 µm × 20 µm
- Scan Mode: Non-contact
- Scan Rate: Left 1 Hz
  Right 0.2 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: Left 512 × 256
  Right 4096 × 512

Gallium nitride (GaN) LED wire



True Non-contact™ Mode

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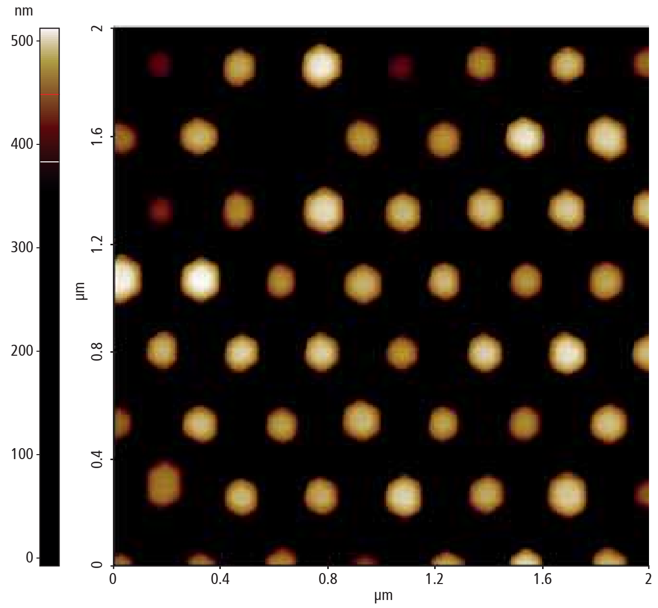
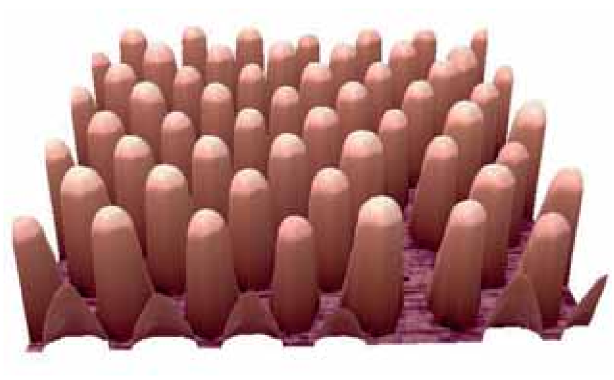
■ **Height**



Peak to valley: 517.4 nm
RMS roughness: 184.7 nm

■ **3D**

X : Y : Z scale = 1 : 1 : 1



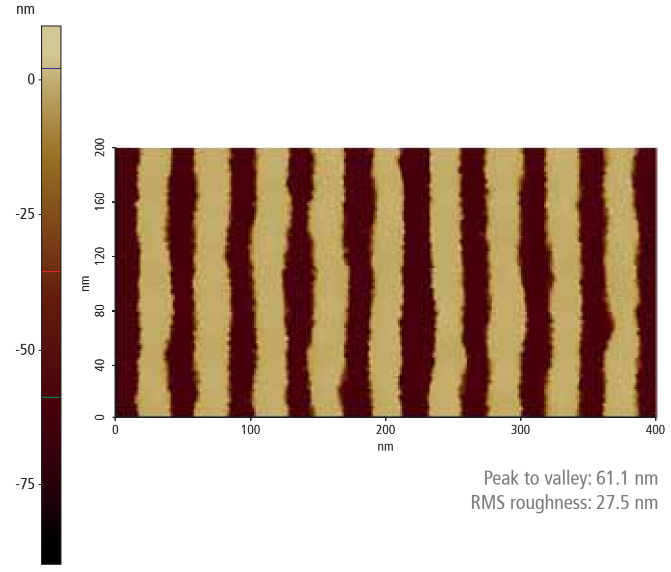
Scanning conditions

- System: NX-HDM
- Scan Size: 2 μm × 2 μm
- Scan Mode: Non-contact
- Scan Rate: 1 Hz
- Cantilever: OMCL-AC55TS (k=85 N/m, f=1.6 MHz)
- Pixel Size: 2048 × 512

Line/Space patterns

Narrow Trench Mode

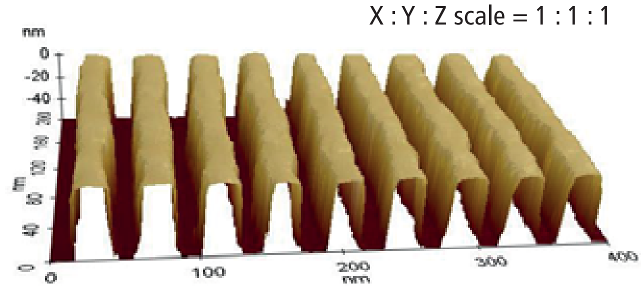
■ **Height**

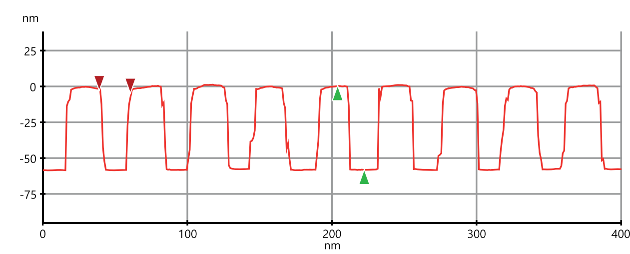


Peak to valley: 61.1 nm
RMS roughness: 27.5 nm

■ **3D**

X : Y : Z scale = 1 : 1 : 1





Cursor	ΔX(nm)	ΔY(nm)
Red	19.000	1.112
Green	22.000	-58.497

Line/Space patterns measured in Narrow trench mode (NTM).

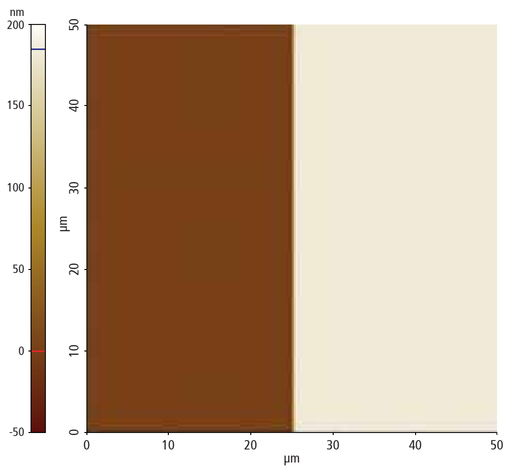
Scanning conditions

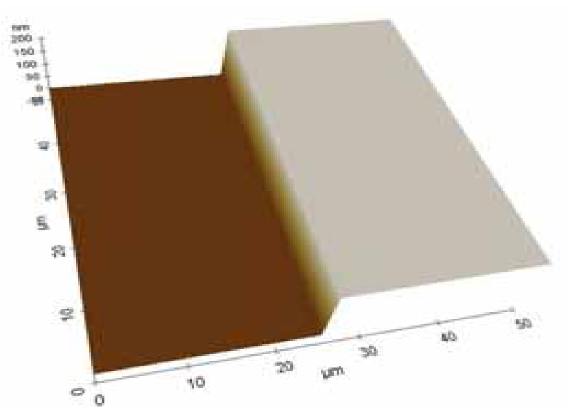
- System: NX-Wafer
- Scan Size: 400 nm × 200 nm
- Scan Mode: NTM
- Scan Rate: 1 Hz
- Cantilever: MSS-Soft 13deg (k=2.8 N/m, f=75 kHz)
- Pixel Size: 400 × 100

Auto stitched WLI image

■ AFM image

- Z Height
- Scan size: 50 µm × 50 µm

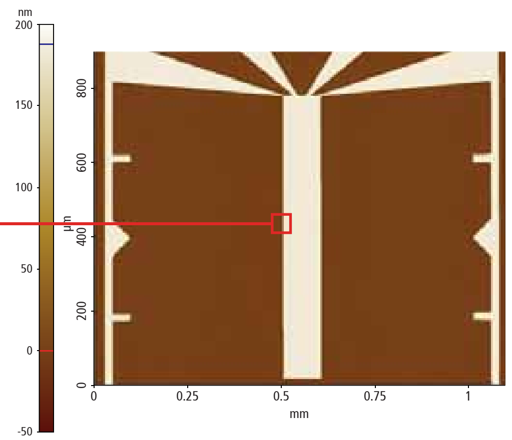


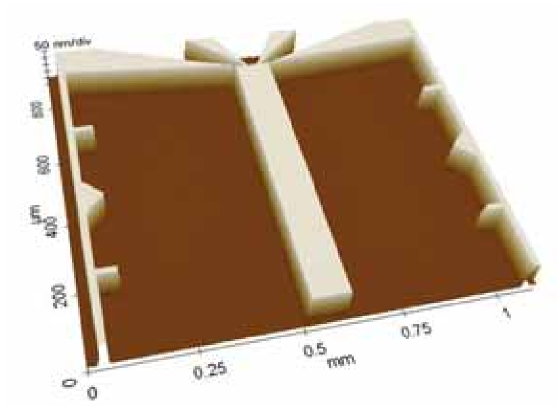


X : Y : Z scale = 1 : 1 : 50

■ WLI image

- Single shot
- Lens magnification: ×10
- Field of view: 1,120 µm × 930 µm

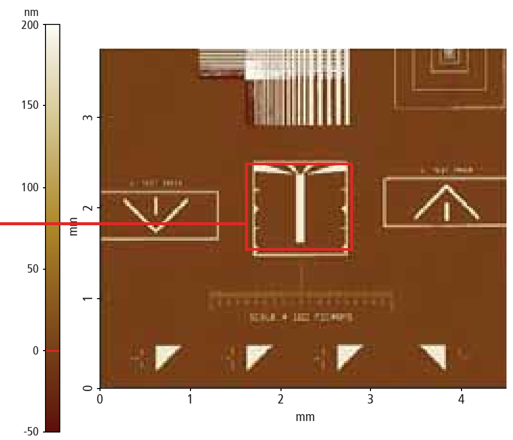


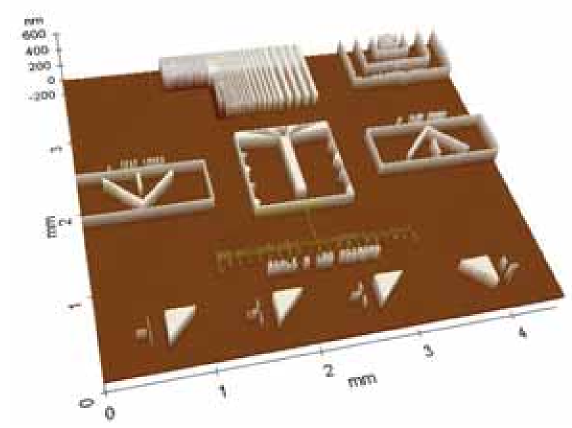


X : Y : Z scale = 1 : 1 : 500

■ WLI image

- Single shot
- Lens magnification: ×2.5
- Field of view: 4,500 µm × 3,755 µm

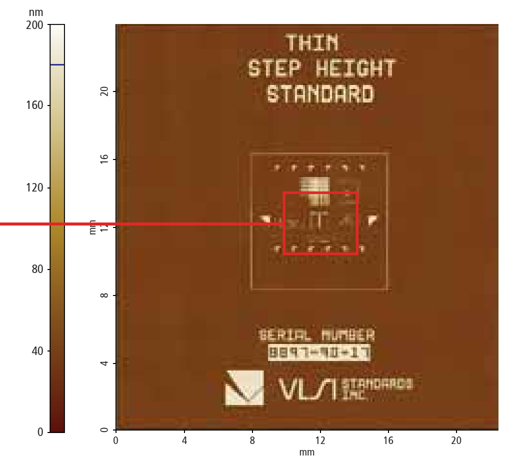


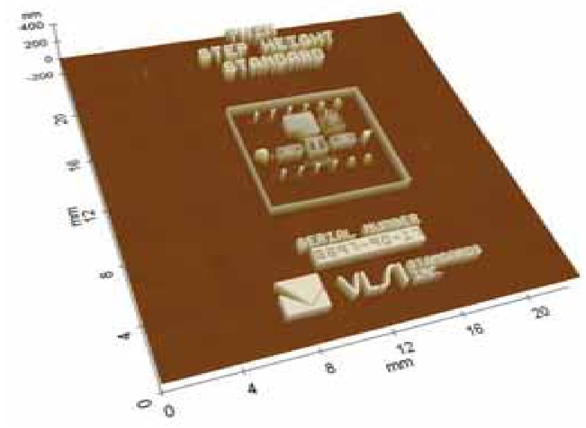


X : Y : Z scale = 1 : 1 : 1100

■ WLI image

- Auto stitched
- Lens magnification: ×2.5
- Field of view: 22,510 µm × 23,930 µm

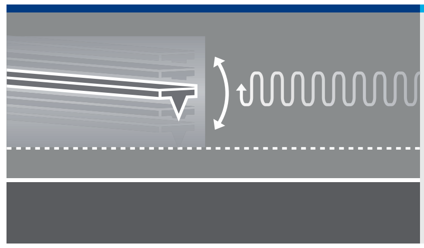




X : Y : Z scale = 1 : 1 : 8000

AFM and WLI measurements on VLSI standard,
SHS-1800 QC (Chrome-coated) sample with certified step height 183.9 ± 2.0 nm.

Silicon on insulator (SOI) wafer



True Non-contact™ Mode

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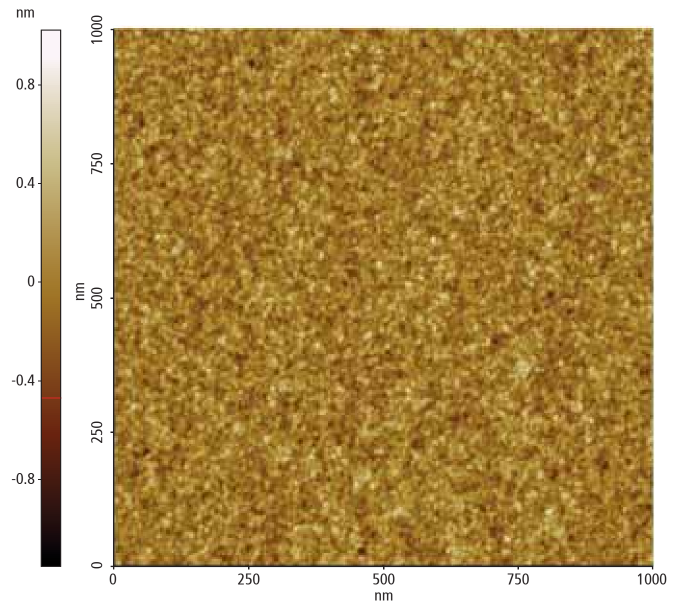
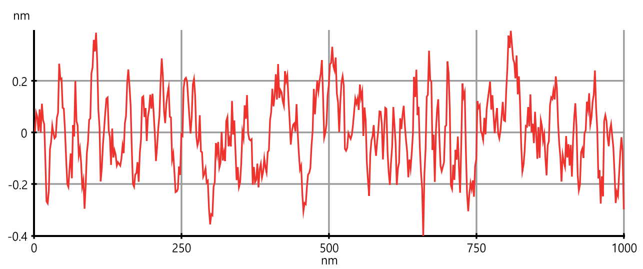
■ Height



■ Line profile



■ Statistics

Rpv(nm)	Rq(nm)	Ra(nm)
2.180	0.232	0.185

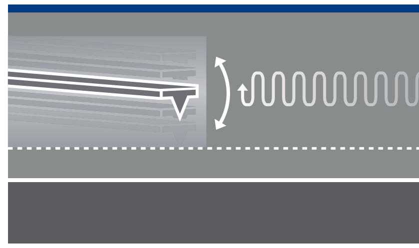
Rpv: Peak to valley
Rq: RMS roughness
Ra: Average roughness

Extremely flat surface roughness of silicon on insulator (SOI) wafer.

Scanning conditions

- System: NX-Wafer
- Scan Size: 1 µm × 1 µm
- Scan Mode: Non-contact
- Scan Rate: 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 1024 × 256

Epitaxial gallium nitride (epi-GaN) film



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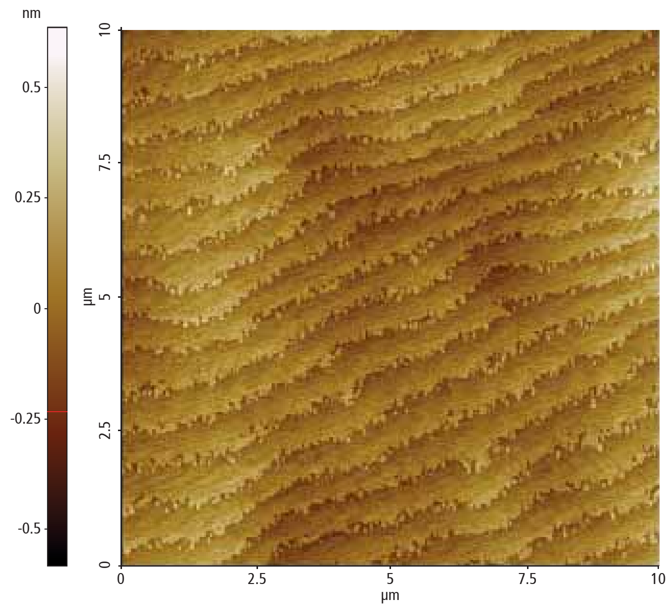
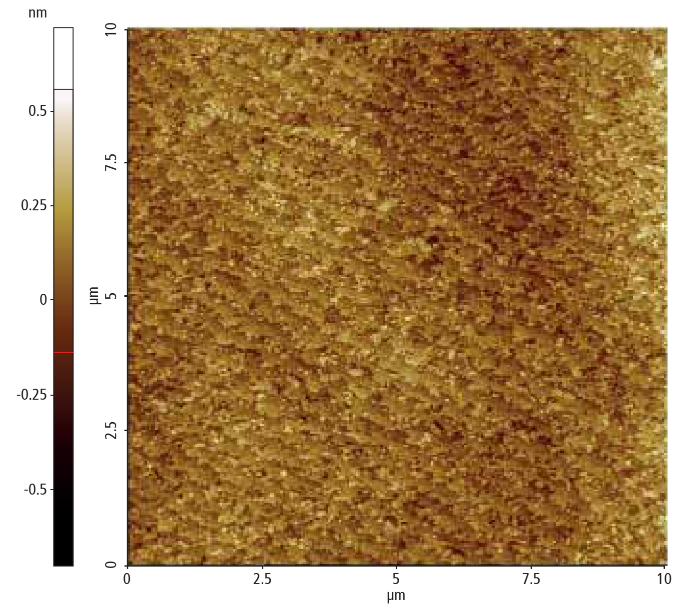
■ Height of position 1



Peak to valley: 1.2 nm
RMS roughness: 0.14 nm

■ Height of position 2

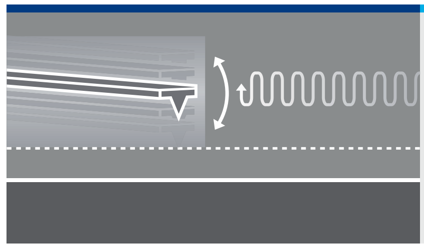


Peak to valley: 1.4 nm
RMS roughness: 0.15 nm

Scanning conditions

- System: NX20
- Scan Size: Left 10 µm × 10 µm
  Right 10 µm × 10 µm
- Scan Mode: Non-contact
- Scan Rate: Left 2 Hz
  Right 2 Hz
- Cantilever: OMCL-AC55TS (k=85 N/m, f=1.6 MHz)
- Pixel Size: Left 512 × 512
  Right 512 × 512

Dendrimer



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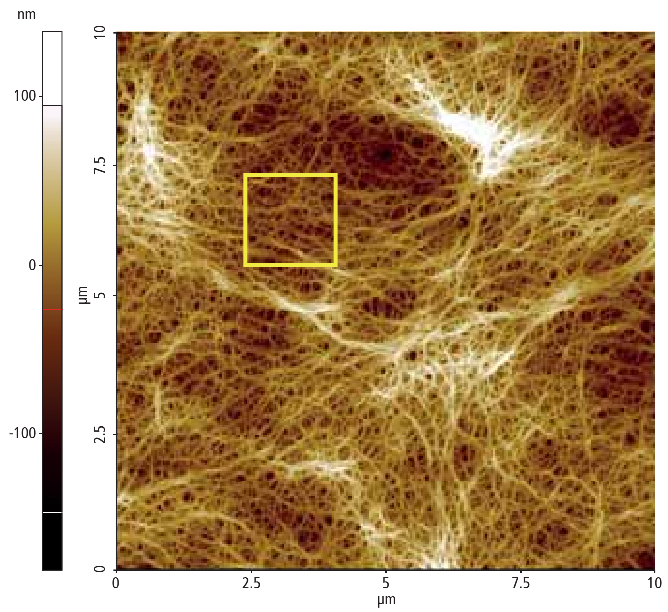
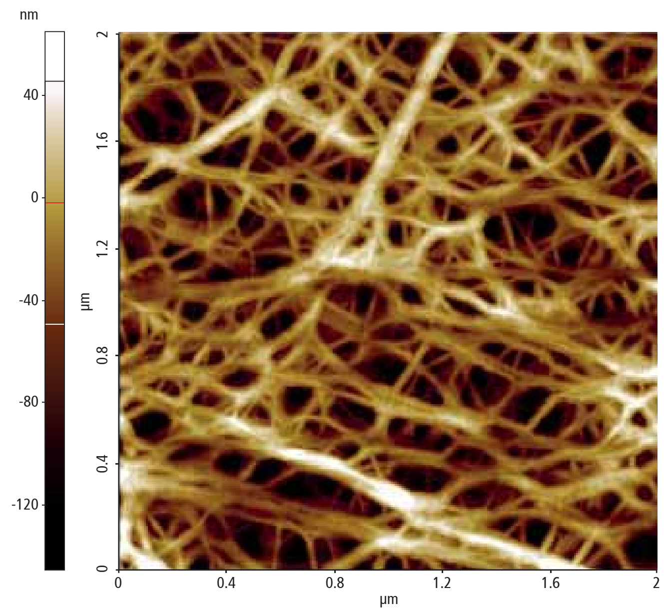
■ Height (10 µm scan)



Peak to valley: 318.4 nm
RMS roughness: 33.6 nm

■ Height (2 µm scan)

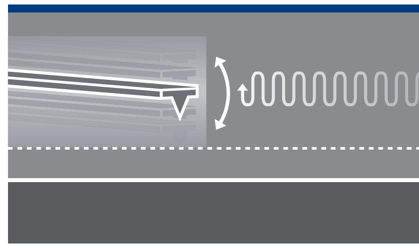


Peak to valley: 209.6 nm
RMS roughness: 22.6 nm

Scanning conditions

- System: NX10
- Scan Size: Left 10 µm × 10 µm
  Right 2 µm × 2 µm
- Scan Mode: Non-contact
- Scan Rate: Left 0.5 Hz
  Right 0.5 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: Left 1024 × 1024
  Right 1024 × 256

Blood cell



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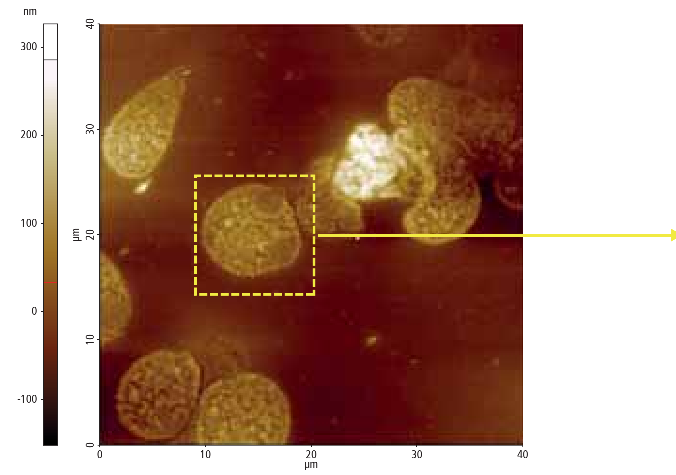
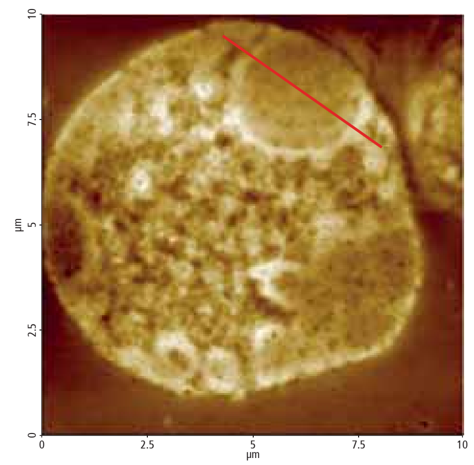
■ Height (40 µm scan)



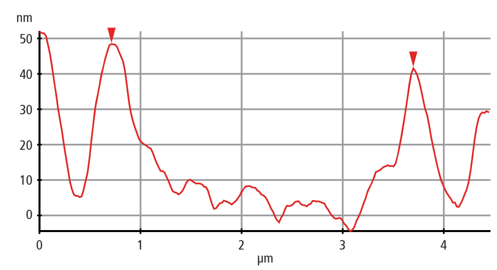
Peak to valley: 477.7 nm
RMS roughness: 60.12 nm

■ Height (10 µm scan)



Peak to valley: 211.6 nm
RMS roughness: 39.11 nm

■ Line profile



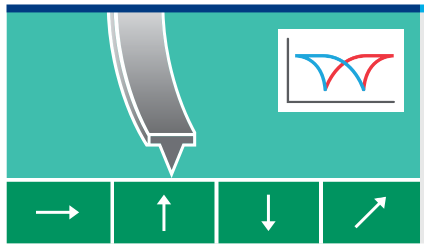
Cursor	ΔX(µm)
Red	3.000

A late-stage erythroblast sample just above to expel its nucleus. The status of the erythroblast was confirmed by measuring the size of the nucleus, which has a width of 3 µm and peak to valley distance of 56.5 nm inside the nucleus. The Rq roughness inside the nucleus is 9 nm, which is flatter compared to the rest of the cell with a Rq of 25.8 nm.

Scanning conditions

- System: NX10
- Scan Size: Left 40 µm × 40 µm
  Right 10 µm × 10 µm
- Scan Mode: Non-contact
- Scan Rate: Left 0.4 Hz
  Right 0.21 Hz
- Cantilever: PPP-FMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: Left 256 × 256
  Right 512 × 512

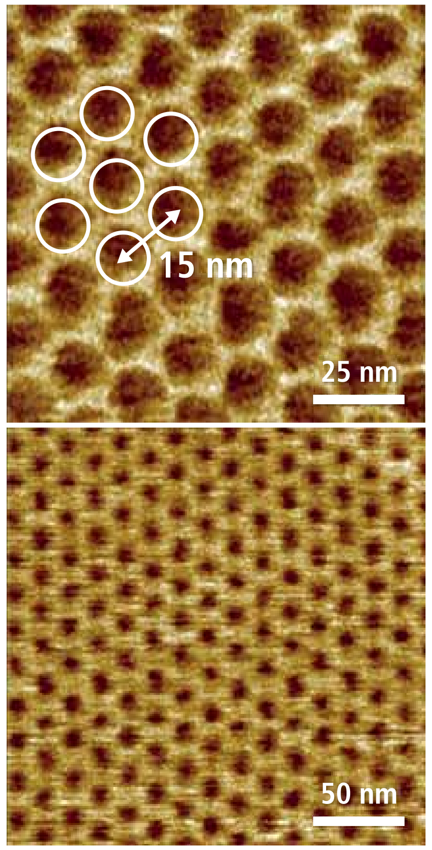
MLG-hBN , tBG+bBN (100 & 200 nm scan)



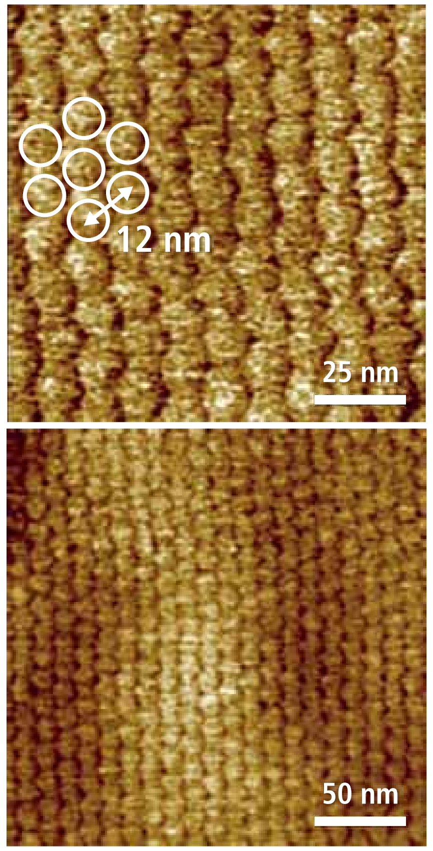
CR-PFM

PFM utilizes a lock-in amplifier to study the electrical properties and topography of a piezo sample surface in one single scan. Here, the AC voltage biased cantilever will introduce sample surface oscillation with same frequency. PFM signal can be enhanced by using the contact resonance frequency generated by the contact between the sample and the cantilever.

PFM Amplitude on MLG-hBN



PFM Amplitude on tBG-bBN



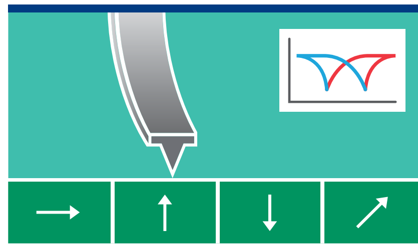
- 2D Moiré superlattice were measured using contact resonance PFM (CR-PFM).
- MLG-hBN (Monolayer graphene on hexagonal boron nitride): 15 nm pitch honeycomb Moiré superlattice visible on the surface (Left)
- tBG+bBN (Twisted bilayer graphene on boron nitride): 12 nm pitch honeycomb Moiré superlattice visible on the surface (Right)

- Sample courtesy:
- Qiong Ma, Boston College, US for tBG-bBN / David Goldhaber Gordon, Stanford University, US for MLG-hBN

Scanning conditions

- System: NX10
- Scan Size: Top 100 nm × 100 nm
  Bottom 200 nm × 200 nm
- Scan Mode: CR-PFM
- Scan Rate: Top left 1.5 Hz, right 3 Hz
  Bottom left 1 Hz, right 2 Hz
- Cantilever: PPP-EFM (k=2.8 N/m, f=75 kHz)
- Pixel Size: Top left 512 × 256, right 256 × 256
  Bottom left 256 × 256, right 256 × 512

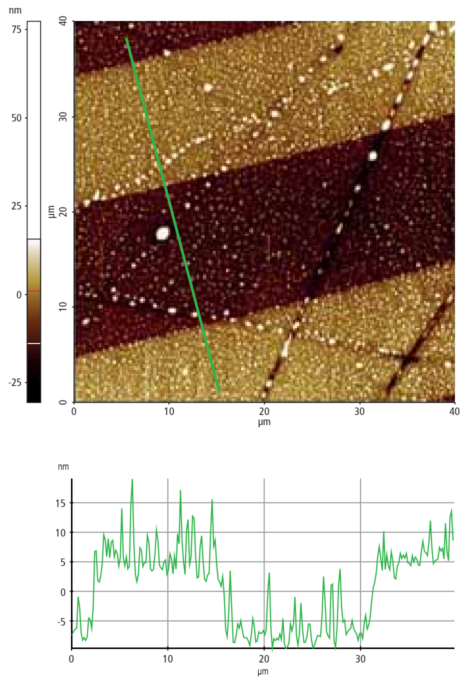
Lithium niobate ($LiNbO_3$, LN)



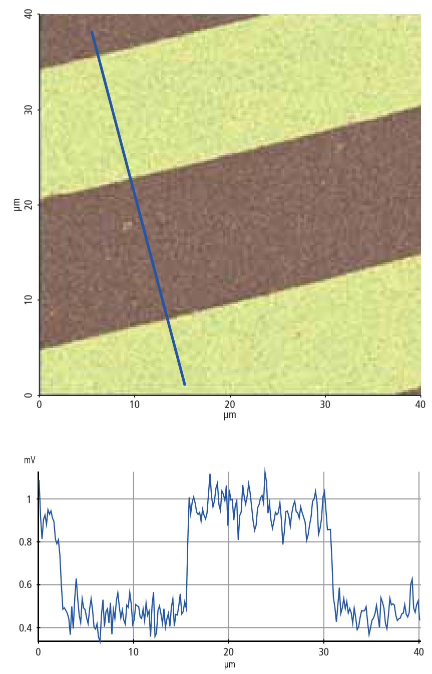
Piezoelectric Force Microscopy

PFM utilizes a lock-in amplifier to study the electrical properties and topography of a piezo sample surface in one single scan. Here, the AC voltage biased cantilever will introduce sample surface oscillation with same frequency. The oscillation component of the PSPD signal is extracted by the lock-in amplifier, resulting in the PFM signal.

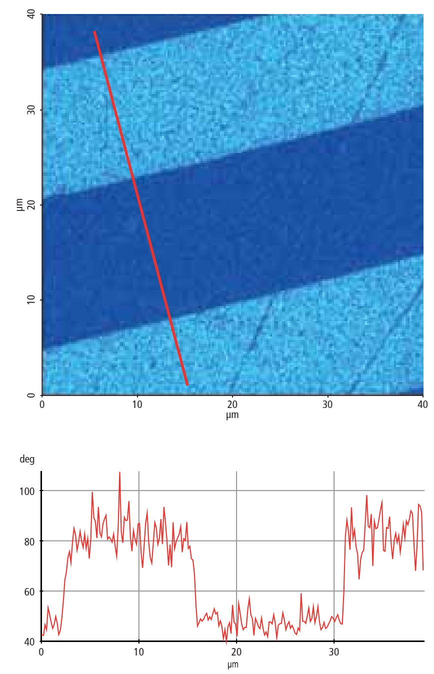
■ Height



■ PFM Amplitude



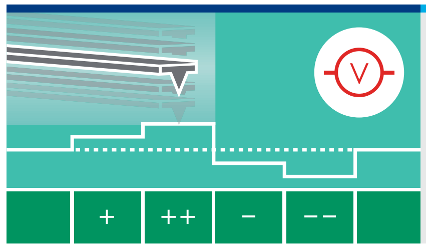
■ PFM Phase



Scanning conditions

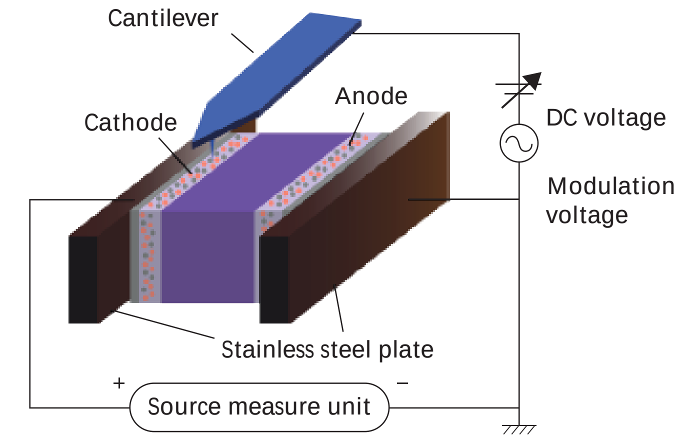
- System: FX40
- Scan Size: 40 μm×40 μm
- Scan Mode: PFM
- Scan Rate: 0.4 Hz
- Cantilever: PPP-NCSTAu (k=7.4 N/m, f=160 kHz)
- Pixel Size: 256 × 256

All-solid-state Li ion battery (ASS-LIB)

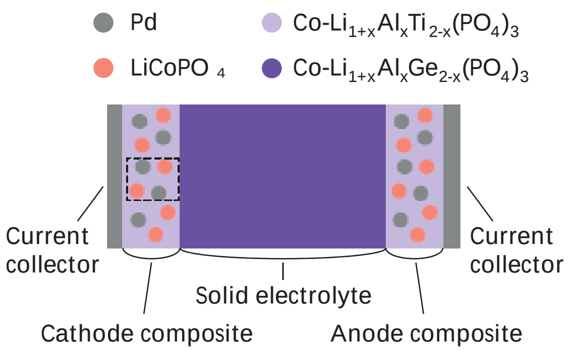


Kelvin Probe Force Microscopy

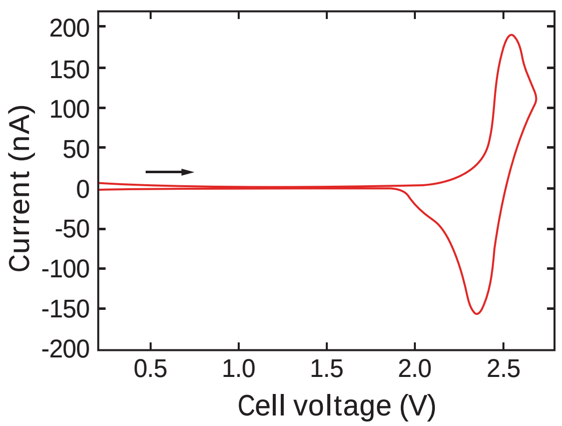
In Kelvin Probe Force Microscopy (KPFM), the AFM operates in non-contact mode while a conductive cantilever, oscillated at its fundamental resonant frequency, laterally scans over the sample surface.
The resulting electrostatic signal provides information related to surface potential and the capacitance gradient.
The topographic data is taken by controlling the force between the tip and the sample.



Schematic illustration of cross-sectional KPFM setup equipped with a source measure unit for (Cyclic voltammogram) CV operation of the ASS-LIB.



Schematic structure of the ASS-LIB. The region measured by KPFM is enclosed by a dashed square.



CV of the ASS-LIB during the KPFM measurement. The scan rate was 0.1 mV/s, and the voltage range was 0.2~2.7 V.

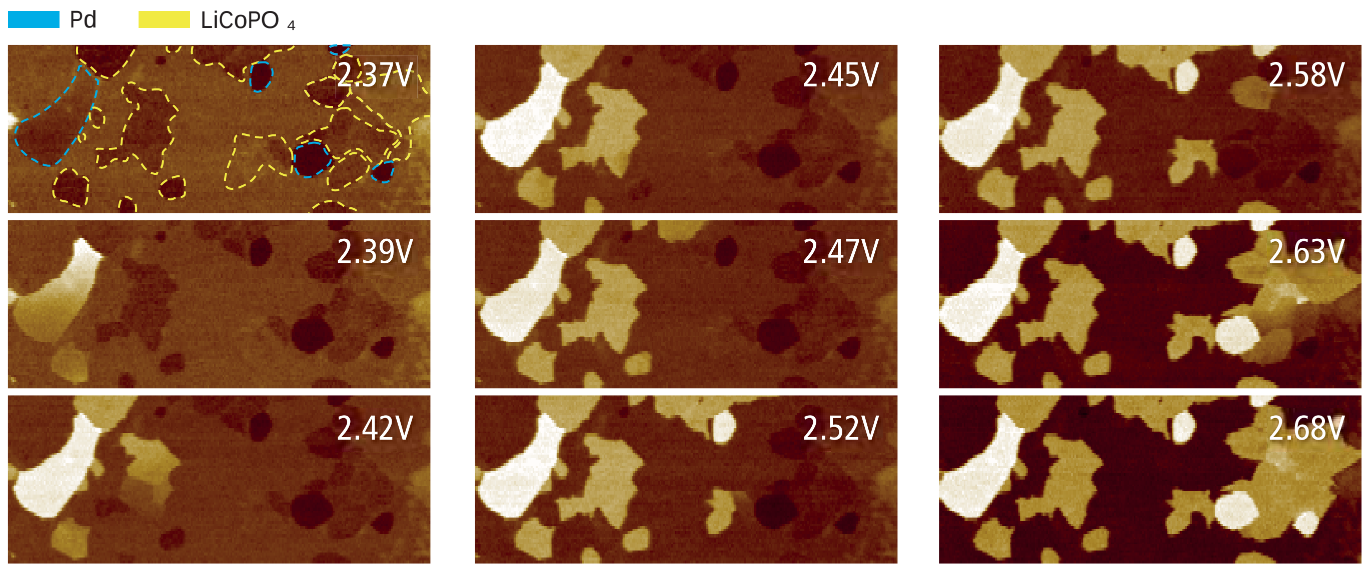
COMMUNICATIONS CHEMISTRY | (2019) 2:140 | https://doi.org/10.1038/s42004-019-0245-x
Dynamically visualizing battery reactions by operando Kelvin probe force microscopy
Hideki Masuda, Kyosuke Matsushita, Daigo Ito, Daisuke Fujita & Nobuyuki Ishida

All-solid-state Li ion battery (ASS-LIB)

■ Height

KPFM measurement on cathode composite region of ASS-LIB during CV operation. Surface potential images below are measured while the cell voltages were swept from 2.37 to 2.68 V.

■ Surface potential during cyclic voltammetry operation



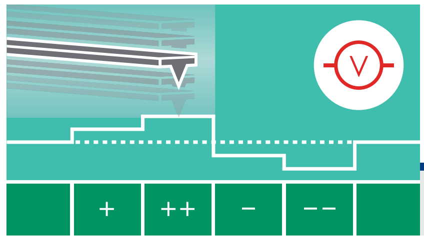
• Image courtesy: Dr. Nobuyuki Ishida, NIMS, Japan

• COMMUNICATIONS CHEMISTRY | (2019) 2:140

Scanning conditions

- System: XE-100
- Scan Size: 10 µm × 4 µm
- Scan Mode: KPFM
- Scan Rate: 0.25 Hz
- Cantilever: Multi75E-G (k=3 N/m, f=75 kHz)
- Pixel Size: 1024 × 64

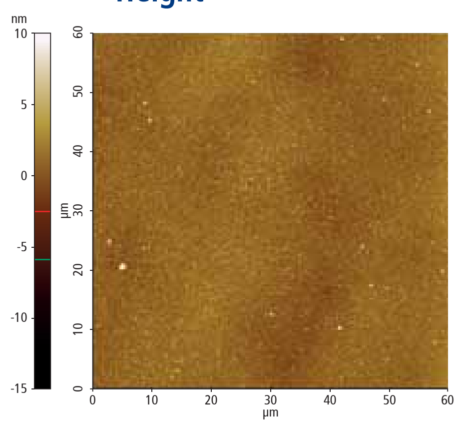
PZT thin film



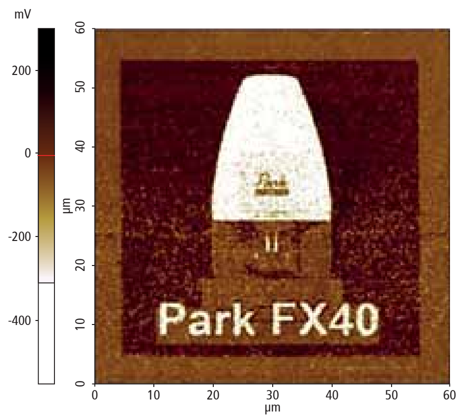
Sideband KPFM + CR-PFM after lithography

■ Design for lithography

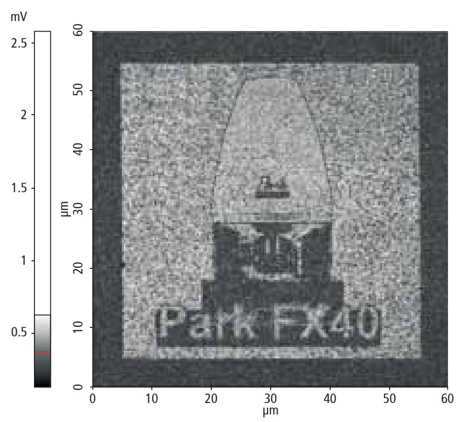
■ Height



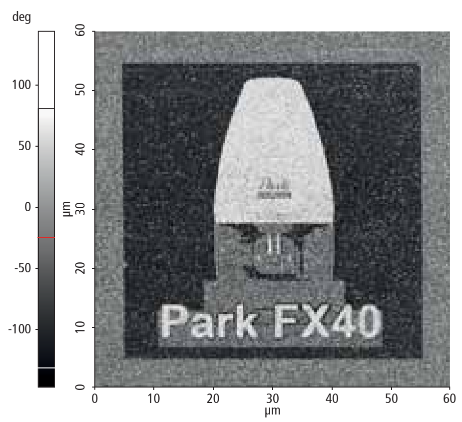
■ Surface Potential



■ PFM Amplitude



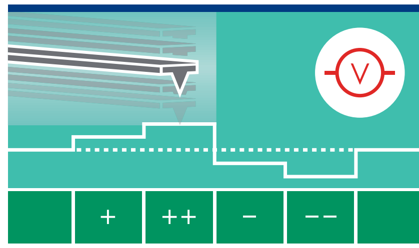
■ PFM Phase



Scanning conditions

- System: FX40
- Scan Size: 60 μm × 60 μm
- Scan Mode: Sideband KPFM & CR-PFM after lithography
  - Lithography mode: Bias mode White/Black area → +10 V/ -10 V bias
- Scan Rate: Top 0.3 Hz
  Bottom 0.2 Hz
- Cantilever: PPP-NCSTAu (k=7.4 N/m, f=160kHz)
- Pixel Size: All 1024 × 1024

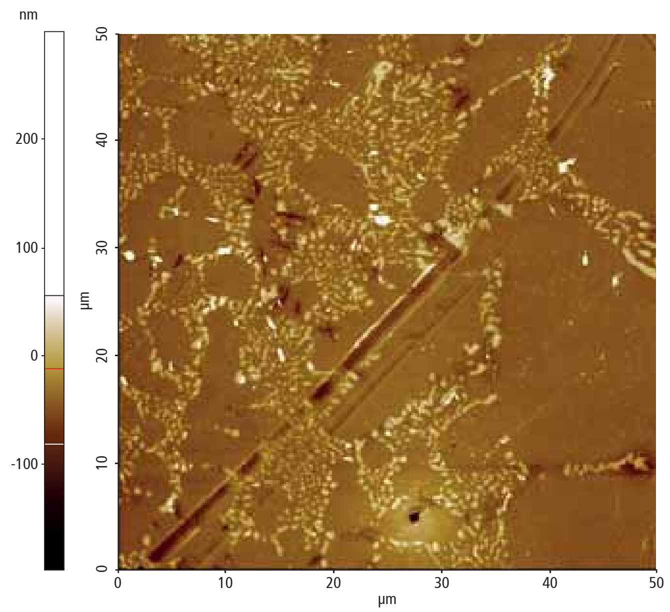
Aluminium TX630 alloy



Sideband KPFM

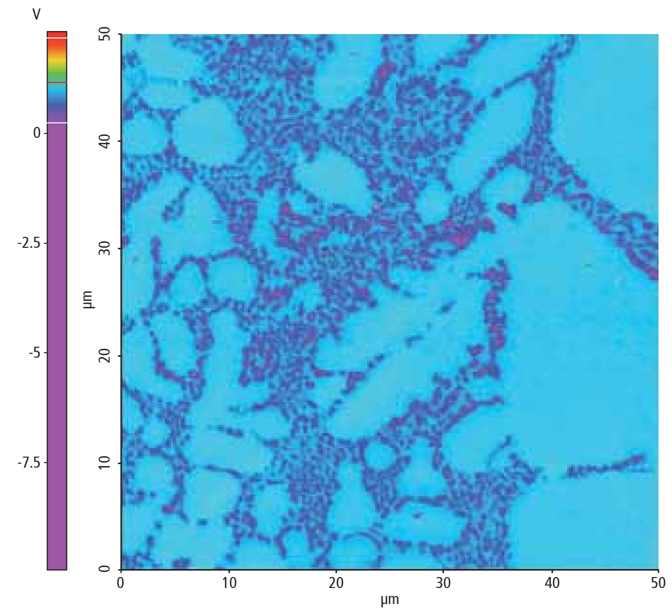
In Kelvin Probe Force Microscopy (KPFM), the AFM operates in non-contact mode while a conductive cantilever, oscillated at its fundamental resonant frequency, laterally scans over the sample surface. Sideband KPFM measures the surface potential of the sample using the signal that appears in the sideband of the resonant frequency. By using the force gradient, it measures the local interaction at the tip apex, not the average value acting on the entire lever.

■ Height



Peak to valley: 487.5 nm
RMS roughness: 12.95 nm

■ Surface Potential



Peak to valley: 1201 mV
Mean: 685 mV

Surface potential on Aluminium TX630 alloy prepared by semi-solid process.

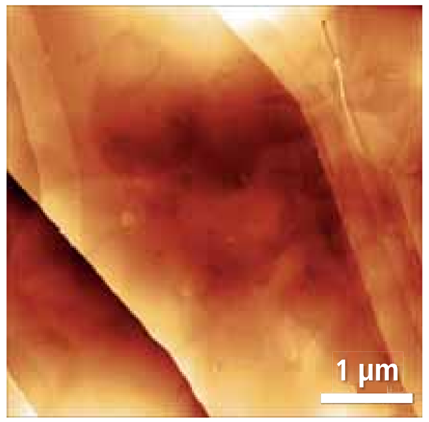
Scanning conditions

- System: NX20
- Scan Size: 50 μm × 50 μm
- Scan Mode: Sideband KPFM
- Scan Rate: 0.2 Hz
- Cantilever: NSC36 Cr-Au C (k=0.6 N/m, f=65 kHz)
- Pixel Size: 1024 × 512

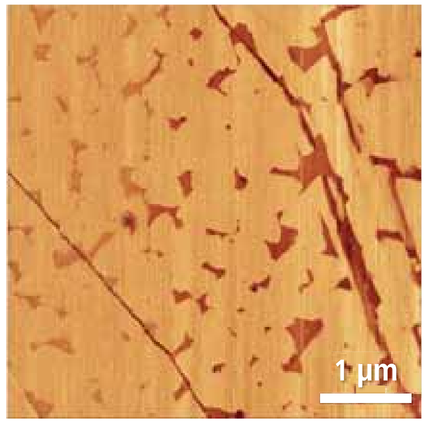
Cyanuric acid and melamine (CAM) on HOPG

Sideband KPFM + Tapping

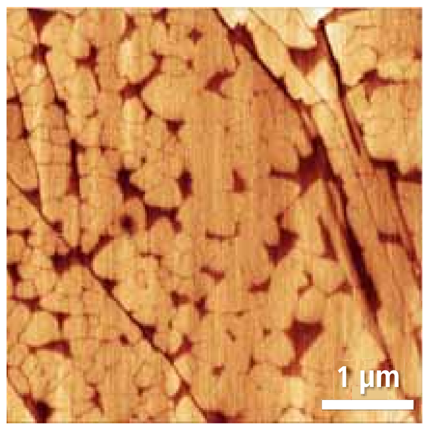
■ Height



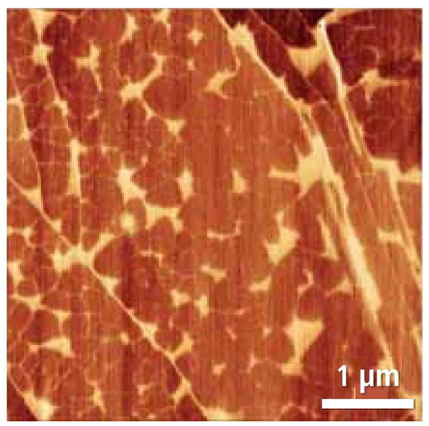
■ Phase



■ Surface Potential



■ Work Function

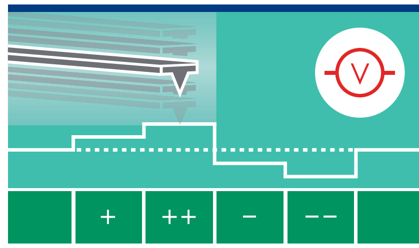


A melamine cyanuric network that forms a single layer on HOPG.
* CAM: cyanuric acid (CA) and melamine (M)

Scanning conditions

- System: NX20
- Scan Mode: Top Tapping
  Bottom Sideband KPFM
- Cantilever: Multi75E-G (k=3 N/m, f=75 kHz)
- Scan Size: 5 µm × 5 µm
- Scan Rate: All 0.25 Hz
- Pixel Size: All 2048 × 2048

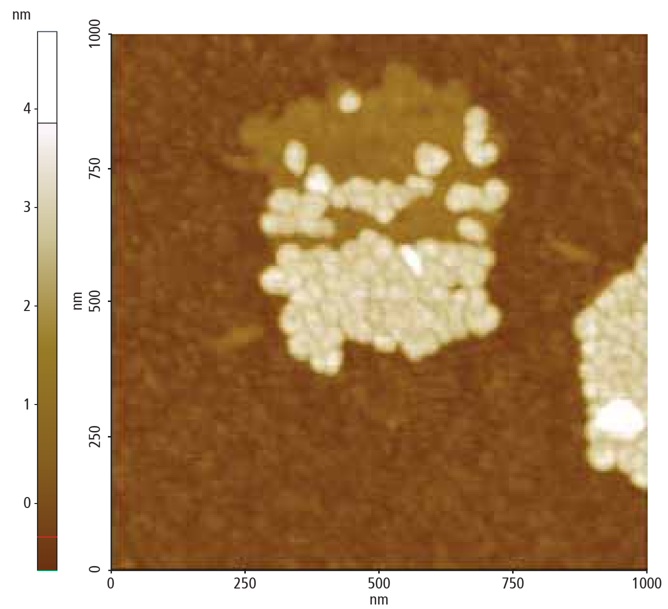
$F_{14}H_{20}$



Sideband KPFM

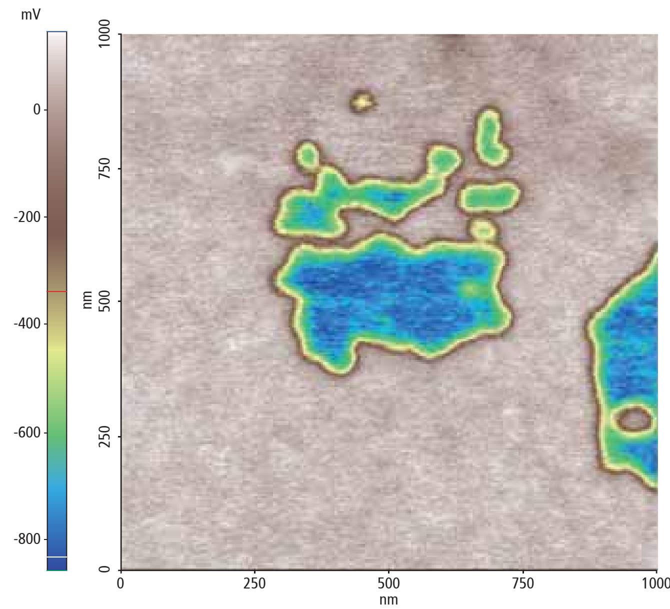
In Kelvin Probe Force Microscopy (KPFM), the AFM operates in non-contact mode while a conductive cantilever, oscillated at its fundamental resonant frequency, laterally scans over the sample surface. Sideband KPFM measures the surface potential of the sample using the signal that appears in the sideband of the resonant frequency. By using the force gradient, it measures the local interaction at the tip apex, not the average value acting on the entire lever.

■ Height



Peak to valley: 5.45 nm
RMS roughness: 1.12 nm

■ Surface Potential

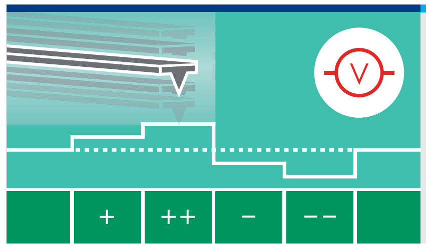


Peak to valley: 998.2 mV
Mean: -108.6 mV

Scanning conditions

- System: FX40
- Scan Size: 1 µm × 1 µm
- Scan Mode: Sideband KPFM
- Scan Rate: 0.5 Hz
- Cantilever: PPP-NCSTAu (k=7.4 N/m, f=160 kHz)
- Pixel Size: 512 × 256

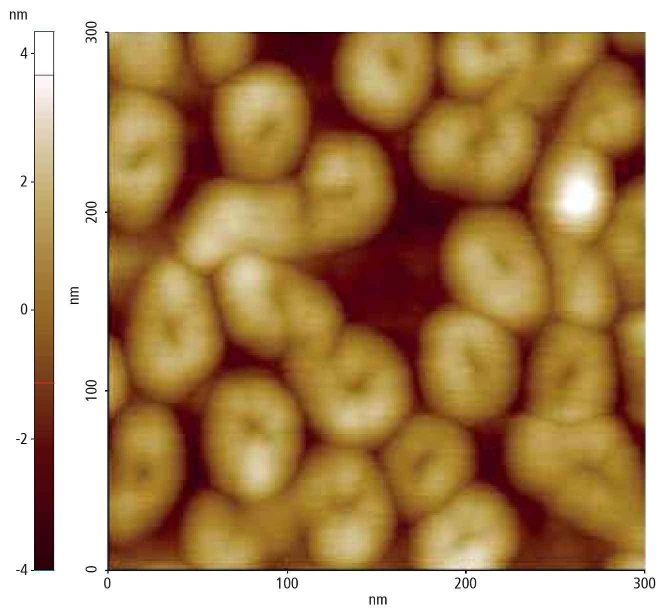
$F_{14}H_{20}$ (300 nm scan)



Sideband KPFM

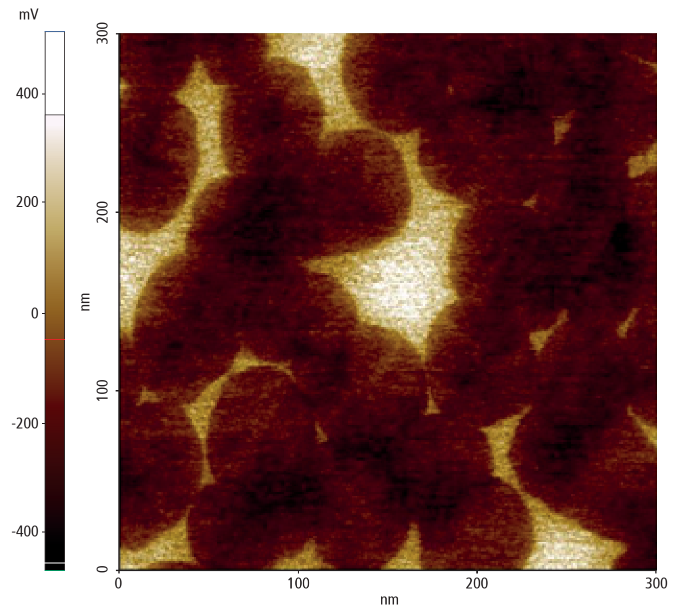
In Kelvin Probe Force Microscopy (KPFM), the AFM operates in non-contact mode while a conductive cantilever, oscillated at its fundamental resonant frequency, laterally scans over the sample surface. Sideband KPFM measures the surface potential of the sample using the signal that appears in the sideband of the resonant frequency. By using the force gradient, it measures the local interaction at the tip apex, not the average value acting on the entire lever.

▪ Height



Peak to valley: 8.38 nm
RMS roughness: 1.39 nm

▪ Surface Potential



Peak to valley: 978.4 mV
Mean: -155.5 mV

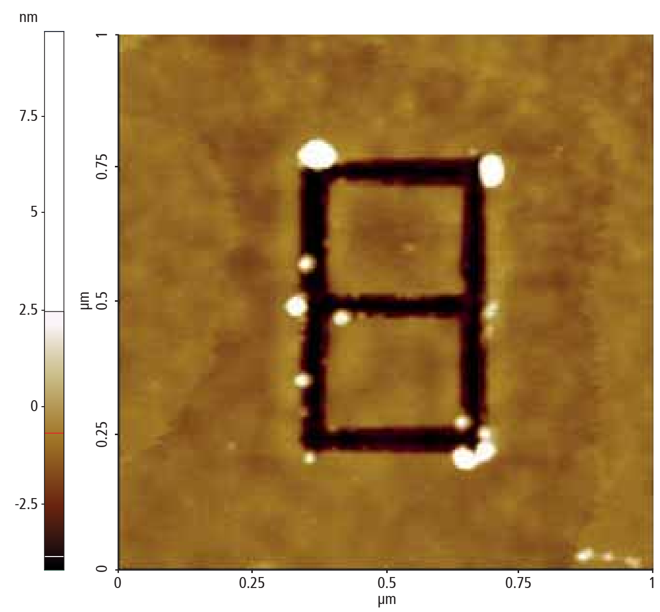
Scanning conditions

- System: FX40
- Scan Size: 300 nm × 300 nm
- Scan Mode: Sideband KPFM
- Scan Rate: 0.5 Hz
- Cantilever: NSC36 Cr-Au C (k=0.6 N/m, f=65 kHz)
- Pixel Size: 512 × 256

Boron nitride on monolayer graphene

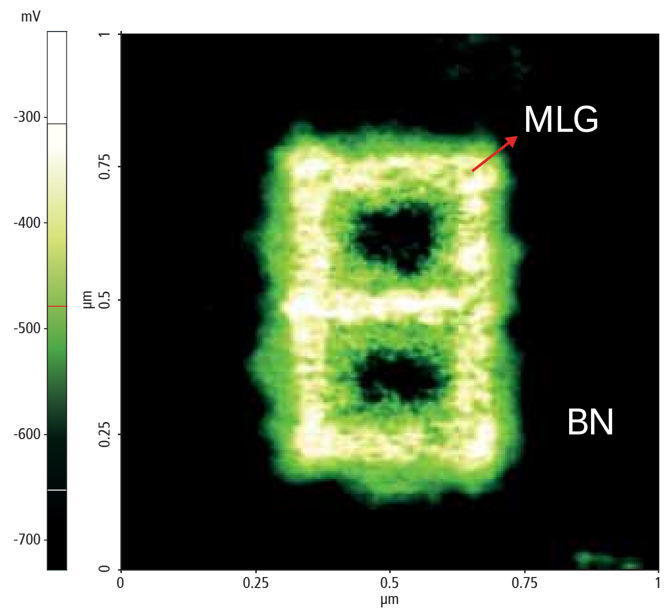
Sideband KPFM after Lithography

▪ Height



Peak to valley: 13.8 nm
RMS roughness: 0.89 nm

▪ Surface Potential



Peak to valley: 613.9 mV
Mean: -591.9 mV

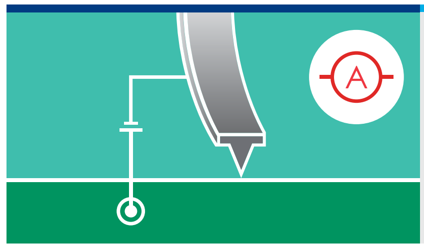
Isolated square blocks were cut using voltage-biased contact mode (6 V_{AC}@17 kHz) and then imaged in sideband-KPFM.

▪ Sample courtesy: Qiong Ma, Boston College, US

Scanning conditions

- System: NX10
- Scan Size: 1 μm × 1 μm
- Scan Mode: Sideband KPFM after Lithography
- Scan Rate: 1 Hz
- Cantilever: PPP-EFM (k=2.8 N/m, f=75 kHz)
- Pixel Size: 256 × 256

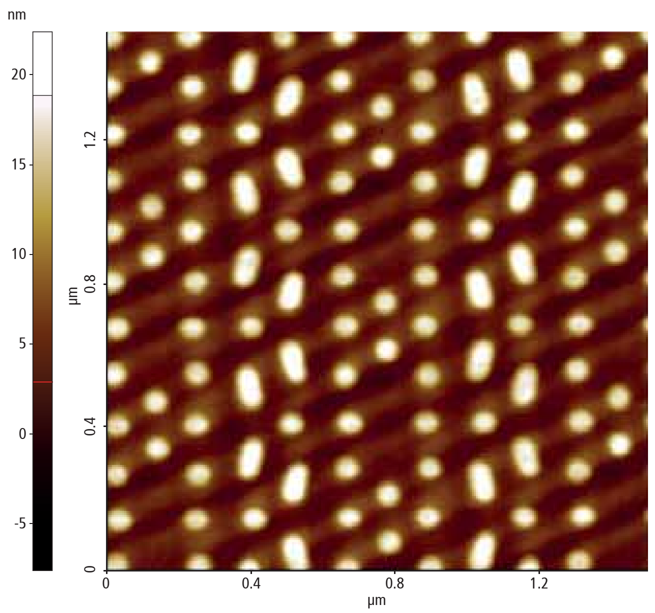
SRAM



Conductive AFM

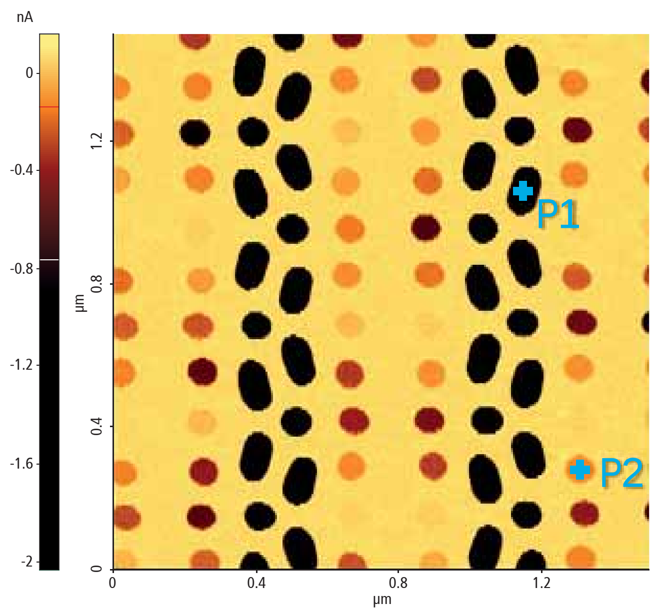
The conductivity of the sample can be measured by performing a contact AFM scan with a conducting, biased tip. Regions of high conductivity on the sample surface alalow current to pass through easily, while regions of low conductivity will have a higher resistance. CP-AFM yields both the topography and the electrical properties of a sample surface.

■ Height



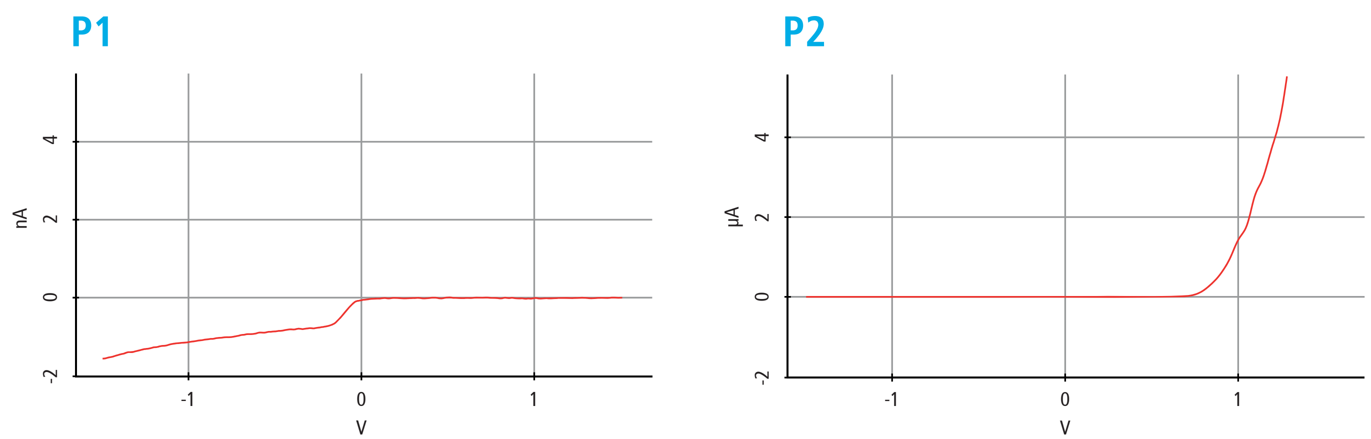
Peak to valley: 30 nm
RMS roughness: 6.21 nm

■ Current



Peak to valley: 2.2 nA
Mean: -0.124 nA

■ IV spectroscopy

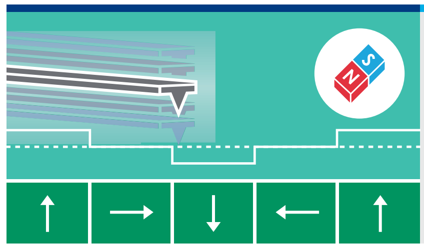


Current measurement on SRAM with -1.5 V sample bias.
P and N type of contact dot are well distinguished by IV spectroscopy measurements.

Scanning conditions

- System: NX20
- Scan Size: 1.5 μm×1.5 μm
- Scan Mode: C-AFM
- Scan Rate: 1 Hz
- Cantilever: AD 2.8 AS (k=2.8 N/m, f=65 kHz)
- Pixel Size: 512 × 256

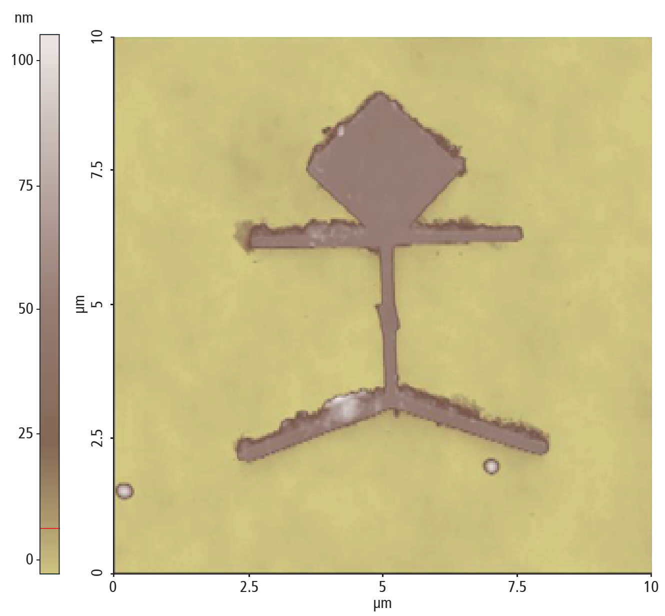
Ta/ NiFe /Ta microman



Magnetic Force Microscopy

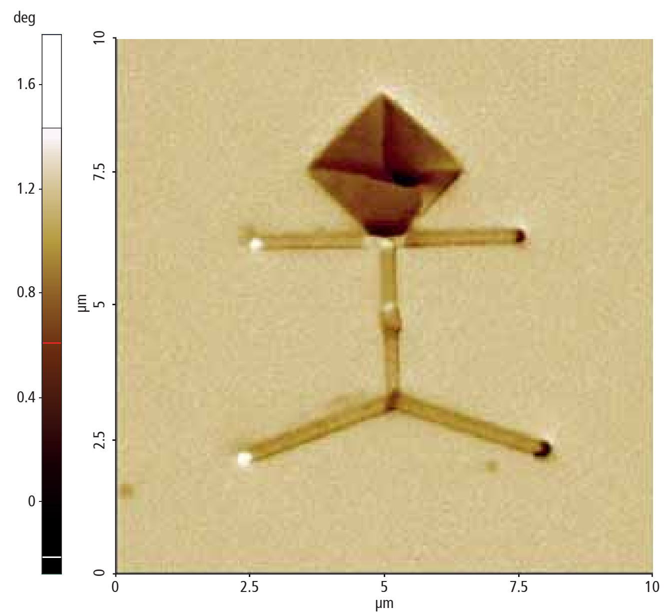
As much as EFM couples a topography scan with a simultaneous scan for electrical properties, Magnetic Force Microscopy (MFM) combines a topography scan with a concurrent scan for magnetic properties. MFM features a non-contact AFM scan to obtain the topography, and a scan farther from the surface to probe long-range magnetic force. In this magnetic force domain, deflections of the magnetized cantilever correspond.

■ Height



Peak to valley: 107.6 nm
RMS roughness: 14.6 nm

■ MFM Phase

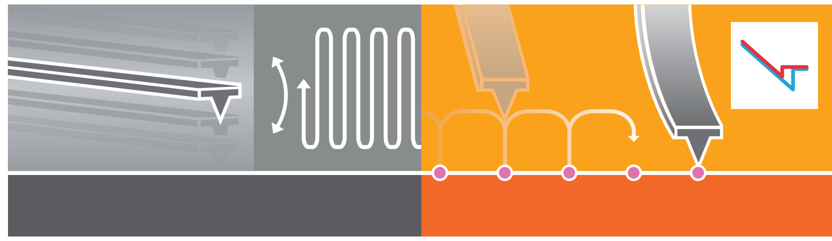


• Sample courtesy: Prof. Lew Wen Siang, NTU SPMS, Singapore

Scanning conditions

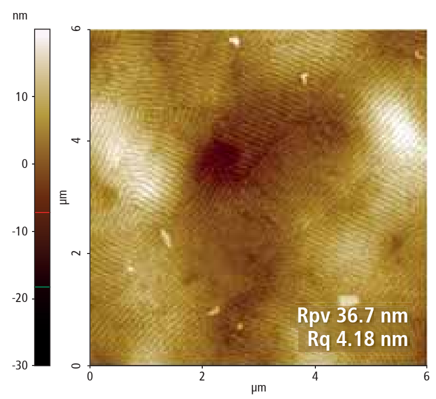
- System: FX40
- Scan Size: 10 µm × 10 µm
- Scan Mode: MFM
- Scan Rate: 0.5 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 512 × 256
- Lift height: 50 nm

PS-PMMA block copolymer

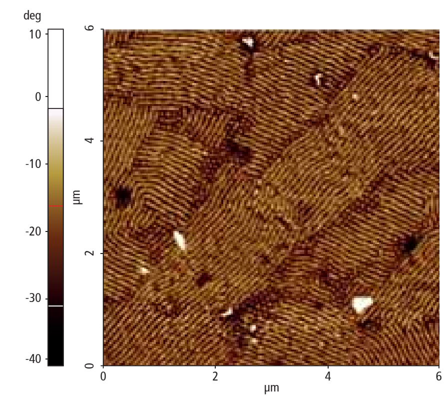


Tapping +
PinPoint™ Nanomechanical Mode

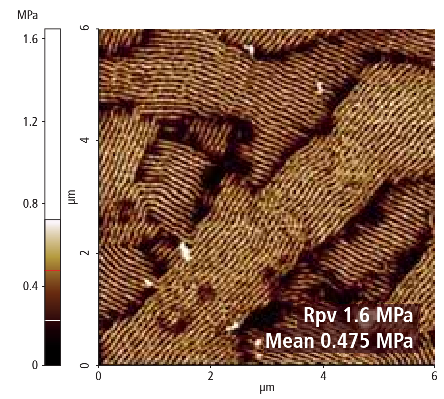
■ Height



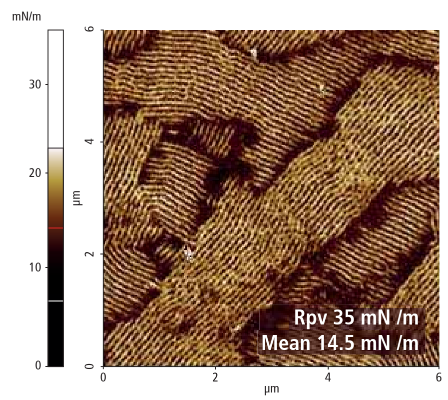
■ Phase



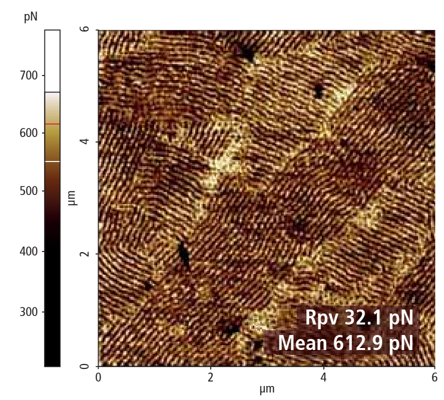
■ Modulus



■ Stiffness



■ Adhesion Force

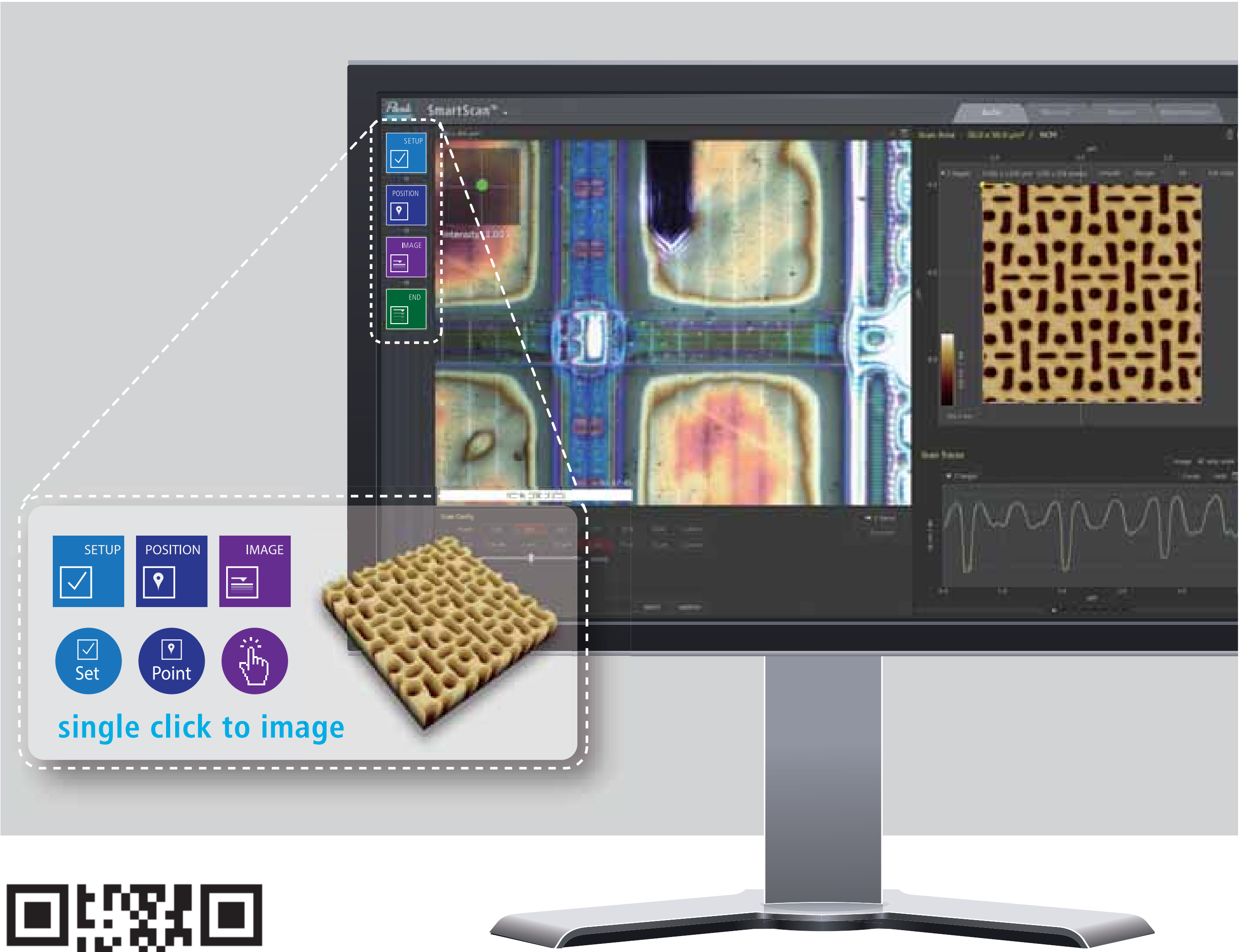


Scanning conditions

- System: FX40
- Scan Size: 6 µm × 6 µm
- Scan Mode: Tapping, PinPoint nanomechanical mode
- Scan Rate: Top Left/Middle 0.5 Hz
  Top Right/Bottom 0.05 Hz
- Cantilever: Top Left/Middle PPP-NCSTAu (k=7.4 N/m, f=160 kHz)
  Top Right/Bottom BL-AC40 (k=0.09 N/m, f=110 kHz)
- Pixel Size: Top Left/Middle 1024 × 512
  Top Right/Bottom 512 × 256

Park SmartScan™

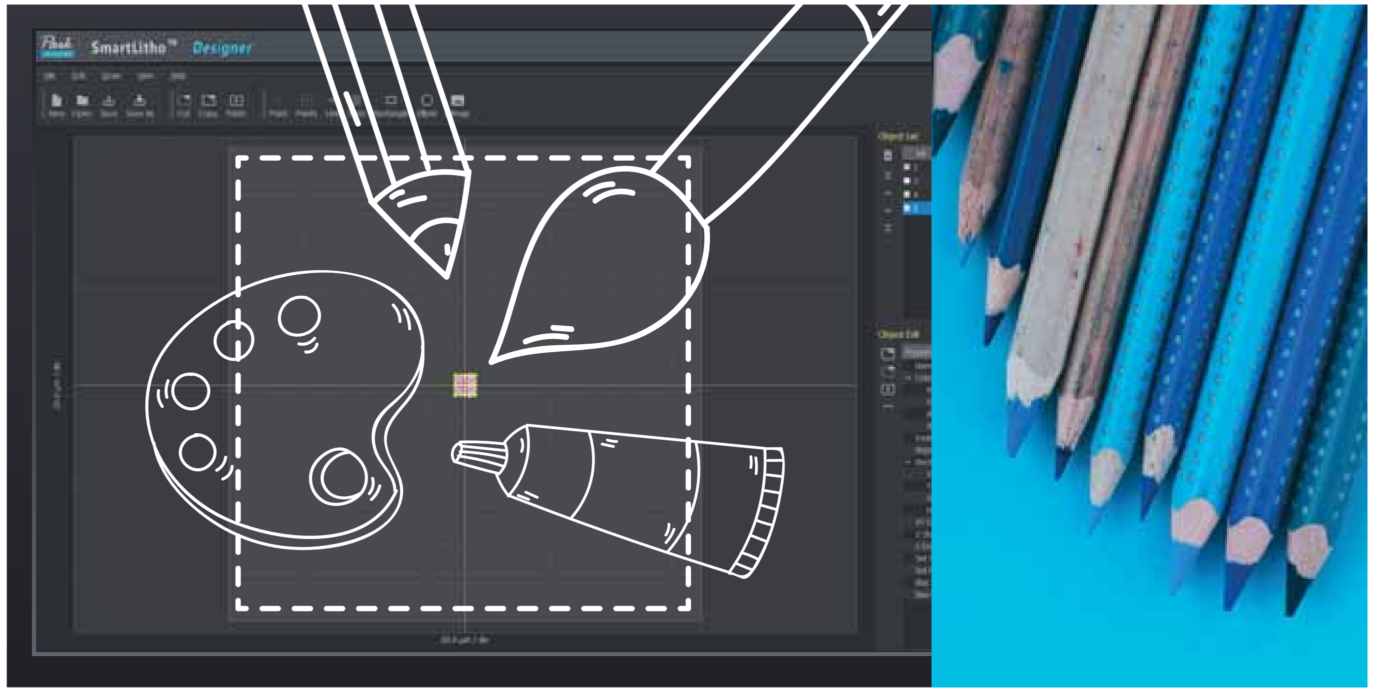
Bringing the power and versatility of AFM technology to everyone



Park SmartScan™ is a revolutionary operating software for Park AFMs that lets even inexperienced, untrained users produce high quality nanoscale imaging through three **simple clicks of a mouse in auto mode**, which rivals that made by experts using conventional techniques. SmartScan manual mode also provides all of the functions and tools necessary for more seasoned users to feel at home. This combination of extreme versatility, ease-of-use, and quality makes SmartScan the best AFM operating software available.

Park SmartLitho™

The next generation nanolithography and nanomanipulation software combining powerful tools with an easy user interface



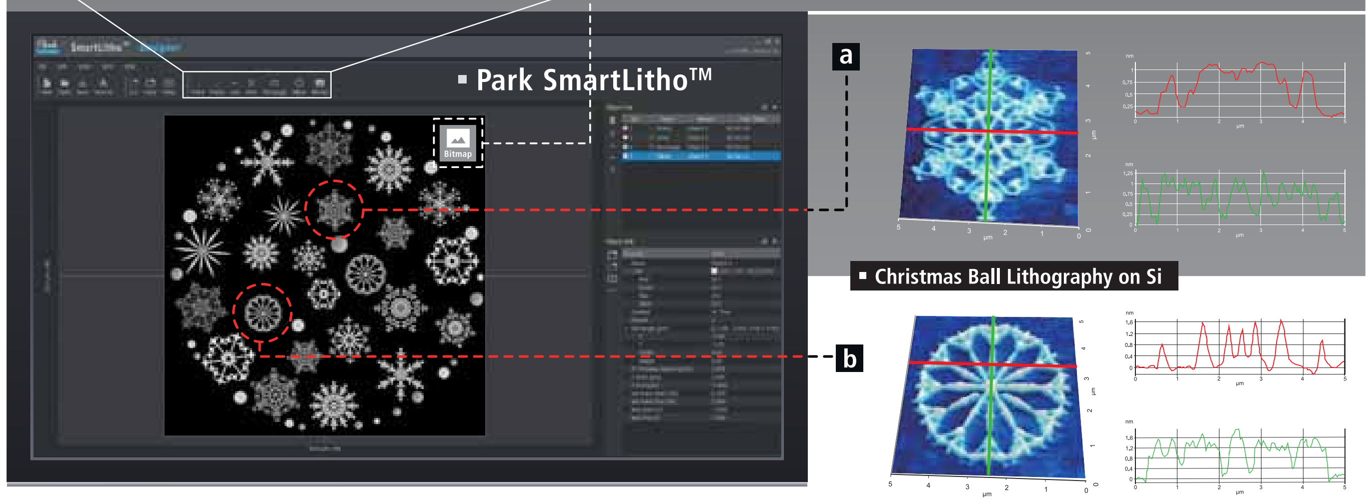
Nanolithography   Nanomanipulation

Park SmartLitho provides a stand-alone convenient drawing editor.

The easiest operating software available for nanolithography and nanomanipulation

Park SmartLitho, enabled by SmartScan is an AFM based platform that performs nanolithography and nanomanipulation on materials, electrical and electronics devices, nanotechnology and other areas of research.

Park SmartLitho software has a variety of lithography modes, supports both Vector mode and Raster mode and operates on the SmartScan platform, which has an easy user



Christmas Ball Lithography on Si

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Park Systems provides a range of popular AFMs for general research and industrial applications. Designed to be extremely versatile while still providing the accuracy and functionality necessary to do high quality work, our line of general AFMs offer researchers and engineers alike the ability to get extremely accurate results quickly and easily.

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- Failure Analysis
- Semiconductor Analysis
- Hard Disk Media Analysis

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A Groundbreaking New Class of Atomic Force Microscope for Nanoscientific Research: The AutonomousAFM

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The premiere choice for nanotechnology research

Park XE7

The most affordable research grade AFM with flexible sample handling

Park XE15

Power and versatility, brilliantly combined

Park NX20

The premiere choice for failure analysis

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Park NX-Hivac

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Park NX12

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- Hard Disk Media Analysis

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Park NX-Wafer

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