Enabling Nanoscale Advances

NANOSCALE IMAGE GALLERY

Elevate nanoscale exploration with Atomic Force Microscopy and advanced nanometrology

Volume 07

Epitaxial silicon fin p.07

NANOSCALE IMAGE GALLERY

Explore an extensive collection of nanoscale measurement images obtained using advanced Atomic Force Microscopy (AFM) and nanometrology systems by Park Systems. This gallery showcases high-resolution imaging across diverse applications, from materials science and semiconductor analysis to biological imaging, achieved through various AFM modes, including non-contact, tapping, and conductive AFM. Each image highlights the precision, versatility, and advanced capabilities of Park Systems' technologies in capturing intricate surface details, structural characteristics, and nanoscale properties of a wide array of sample types, from micro-LEDs to biomolecules.

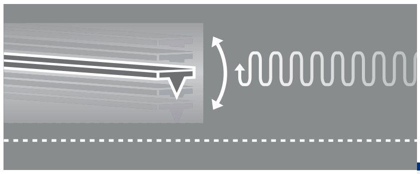
Atomic Force Microscopy

Topography Imaging

Atomic Force Microscopy
Advanced Imaging Modes

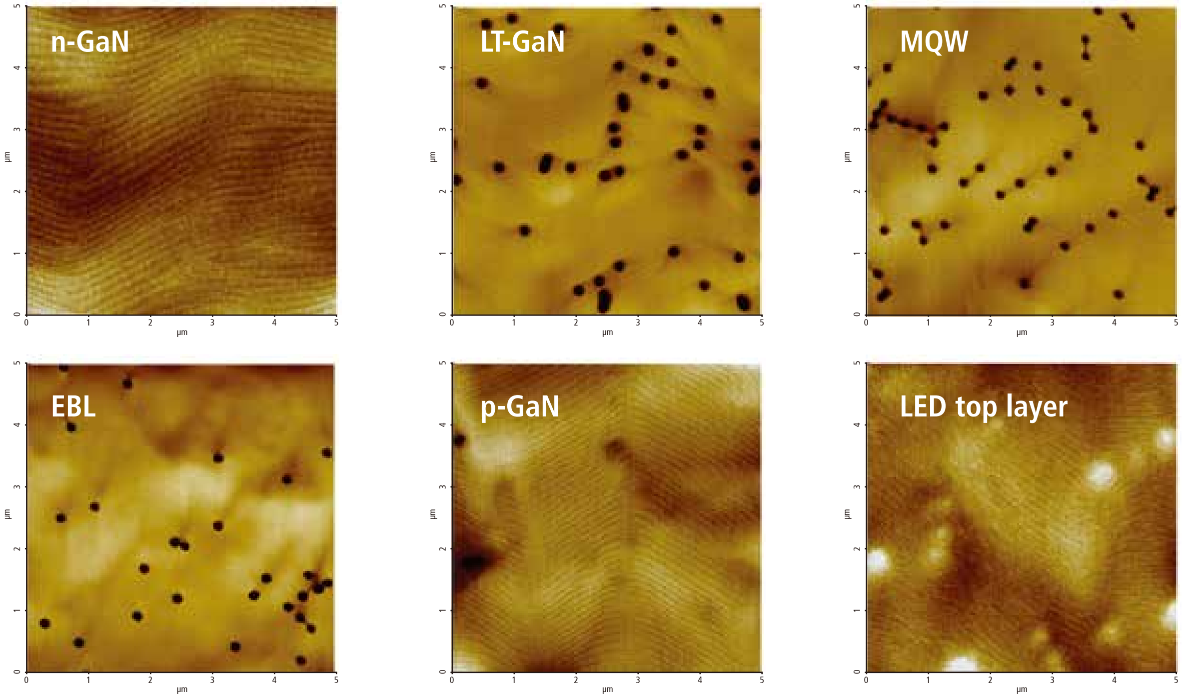
Imaging Spectroscopic Ellipsometry (ISE)
Applications

GaN-based LED



Non-contact

Height images of each layer-by-layer



LED layer structure

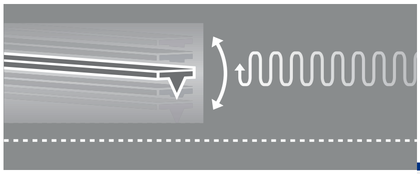
ITO
p-GaN
EBL (Electron Blocking layer)
MQW (Multi Quantum Wells)
LT-GaN (Low Temperature GaN)
n-GaN
Sapphire

- The images on the above show the layer-by-layer surface morphology of GaN-based LED.

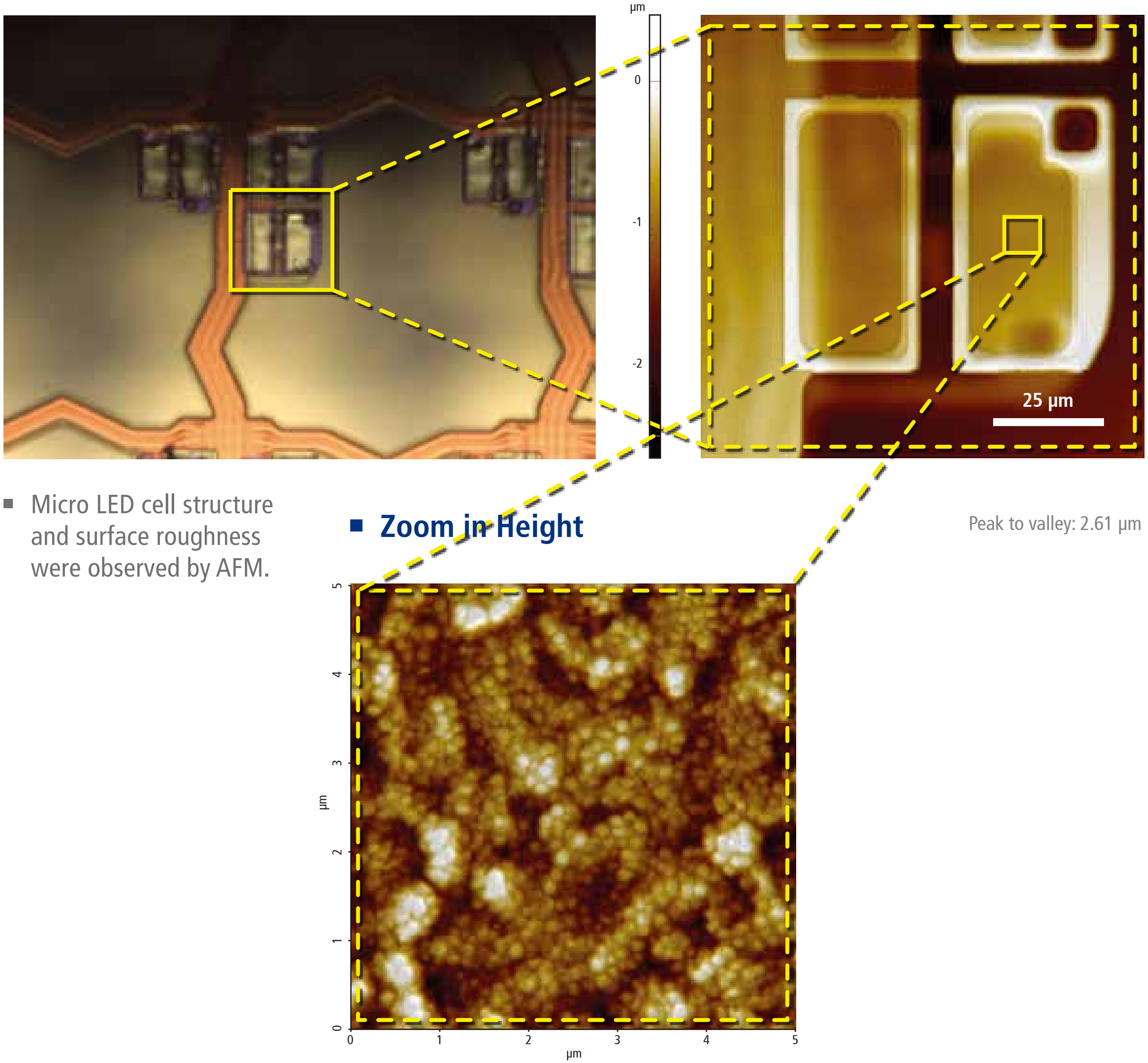
Scanning conditions

- System: FX40
- Scan Size: All 5 µm × 5 µm
- Scan Mode: Non-contact
- Scan Rate: 1.5 Hz, 0.42 Hz, 0.4 Hz
  0.52 Hz, 1.5 Hz, 1.5 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: All 256 × 256

Micro LED



Non-contact



▪ Optic view

▪ Height of 100 µm×100 µm scan

Peak to valley: 2.61 µm

- Micro LED cell structure and surface roughness were observed by AFM.

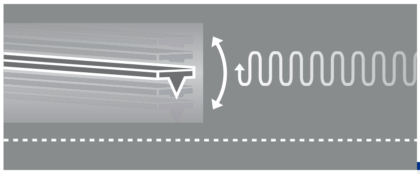
▪ Zoom in Height

Peak to valley: 66.5 nm

Scanning conditions

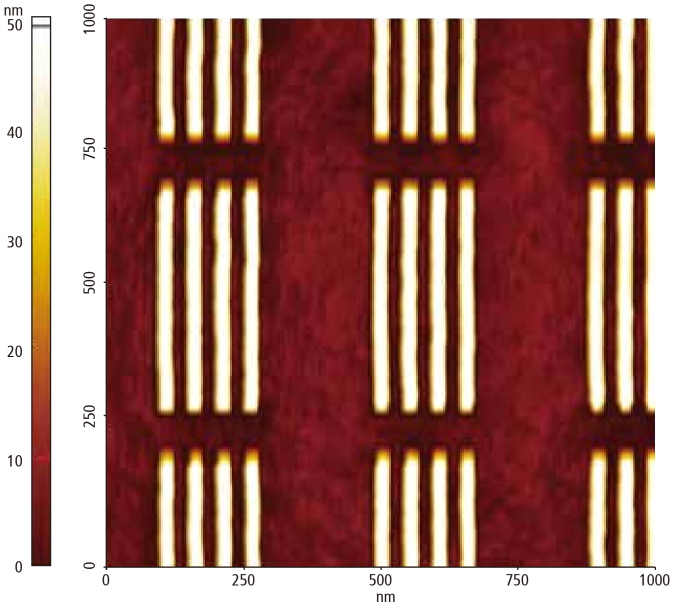
- System: NX-Wafer
- Scan Size: 100 µm × 100 µm, 5 µm × 5 µm
- Scan Mode: Non-contact
- Scan Rate: 0.3 Hz, 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 1024 × 512, 512 × 256

FinFET



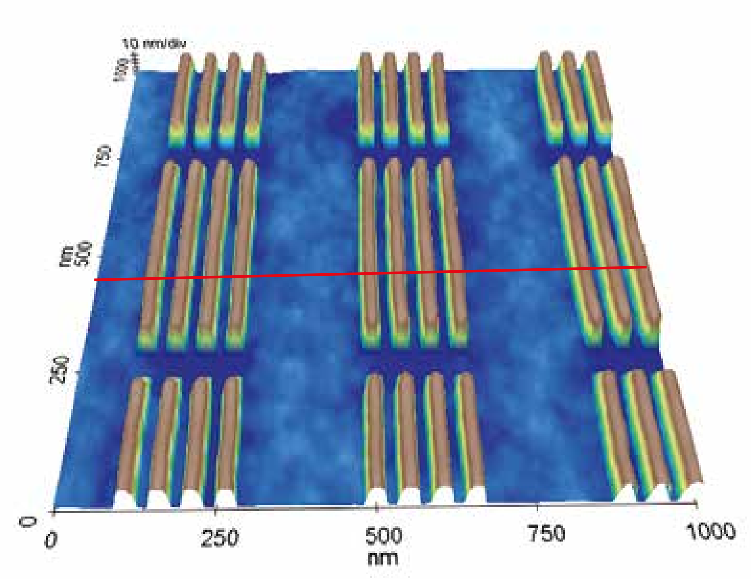
Non-contact

Height



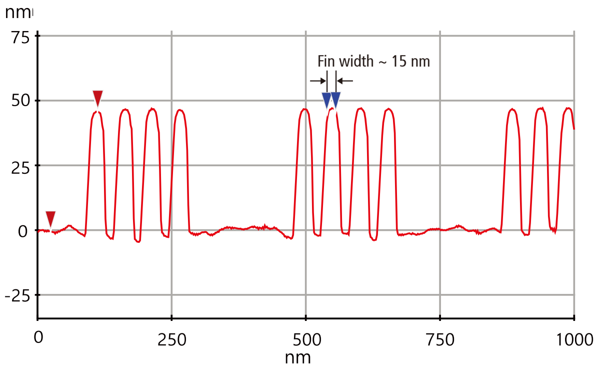
Peak to valley: 57.9 nm

3D of 4-fin structure



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

Line profile

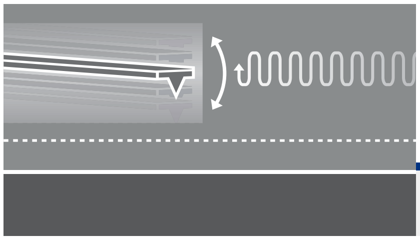


Cursor	ΔX (nm)	ΔY (nm)
Red	87.17	46.22
Blue	15.02	0.07

Scanning conditions

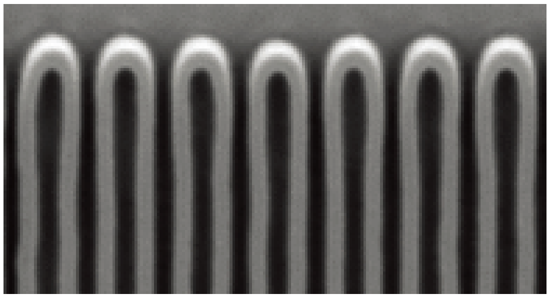
- System: NX-Wafer
- Scan Size: 1 μm × 1 μm
- Scan Mode: Non-contact
- Scan Rate: 0.5 Hz
- Cantilever: MCNT-100 (k=40 N/m, f=320 kHz)
- Pixel Size: 512 × 128

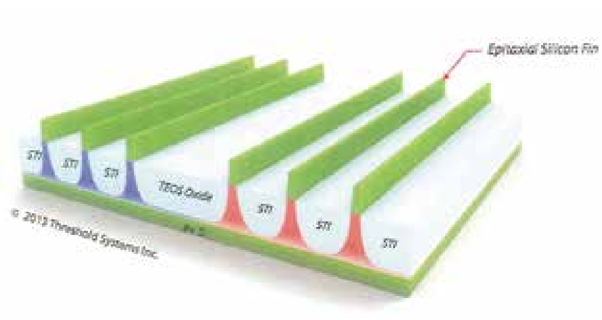
Epitaxial silicon fin



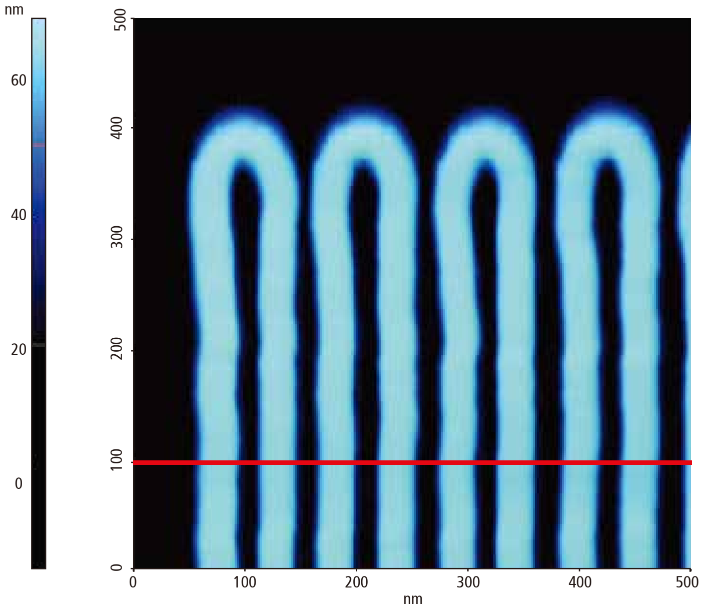
Non-contact

SEM



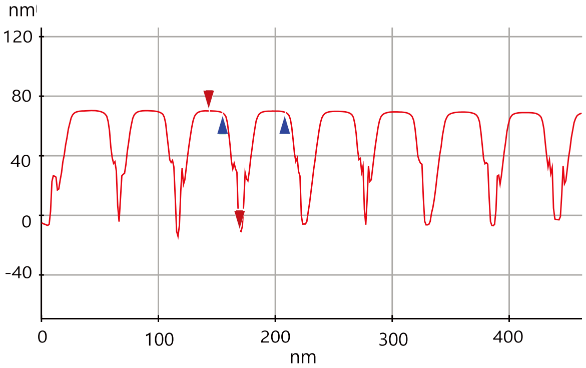


Height



Peak to valley: 88.7 nm

Line profile

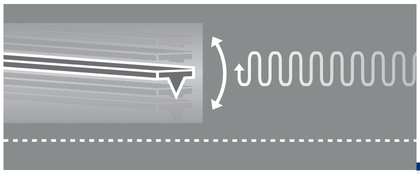


Cursor	ΔX (nm)	ΔY (nm)
🟥 Red	25.82	80.68
🟦 Blue	53.93	0.35

Scanning conditions

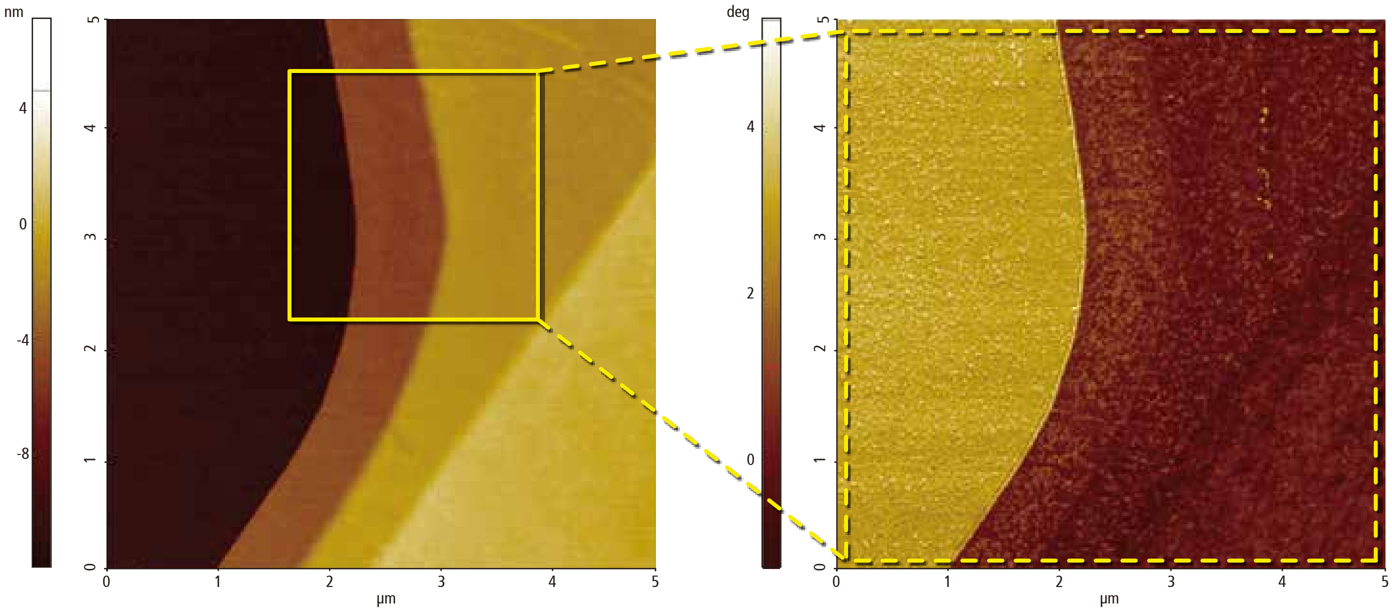
- System: NX-Wafer
- Scan Size: 0.5 µm × 0.5 µm
- Scan Mode: Non-contact
- Scan Rate: 0.2 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 512 × 64

Few layers MoS_2 on SiO_2/Si



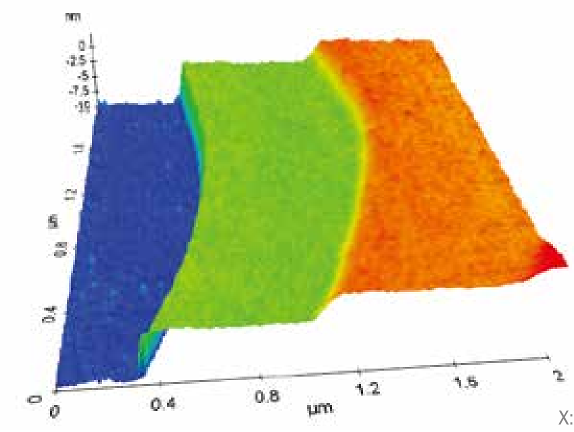
Non-contact

■ Height ■ NCM Phase



Peak to valley: 14.1 nm

■ Zoom-in 3D

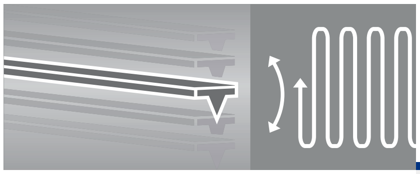


X:Y:Z scale = 1:1:200

Scanning conditions

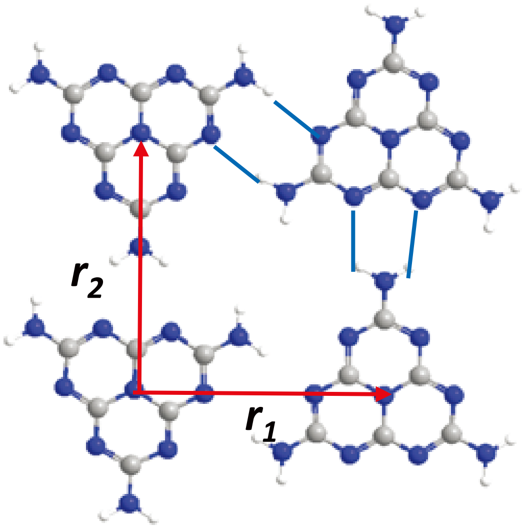
- System: FX40
- Scan Size: 5 µm × 5 µm, 2 µm × 2 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.5 Hz
- Cantilever: : AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 256 × 256

Melem molecules on HOPG



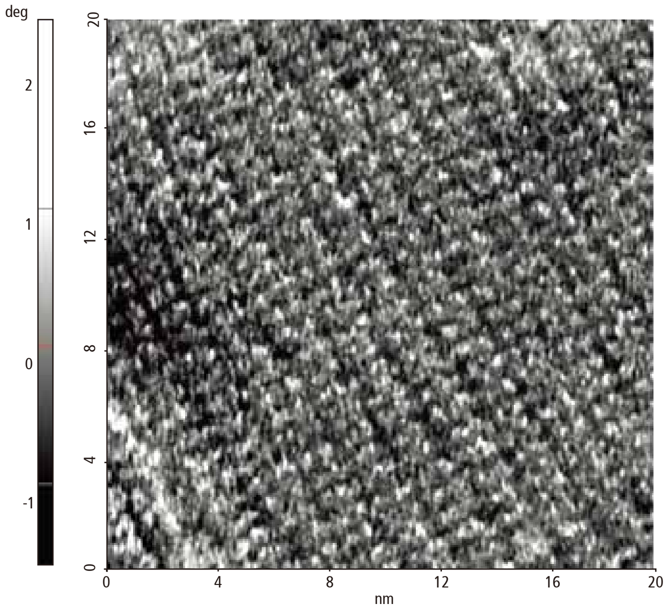
Tapping

▪ Theoretical model



Method	r_1, nm	r_2, nm
B3LYP/6-31G1D1P	0.832	0.882
experiment	0.84	0.89

▪ NCM Phase of 20 nm scan

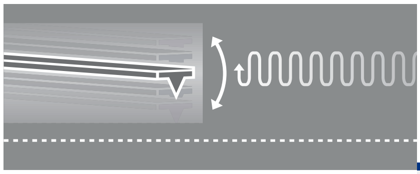


- Single molecules can be clearly seen on the phase image. A sketch on the left shows a theoretical model for this molecular assembly. And the table shows both experimental and theoretical values for a cell unit that are in an excellent agreement.

Scanning conditions

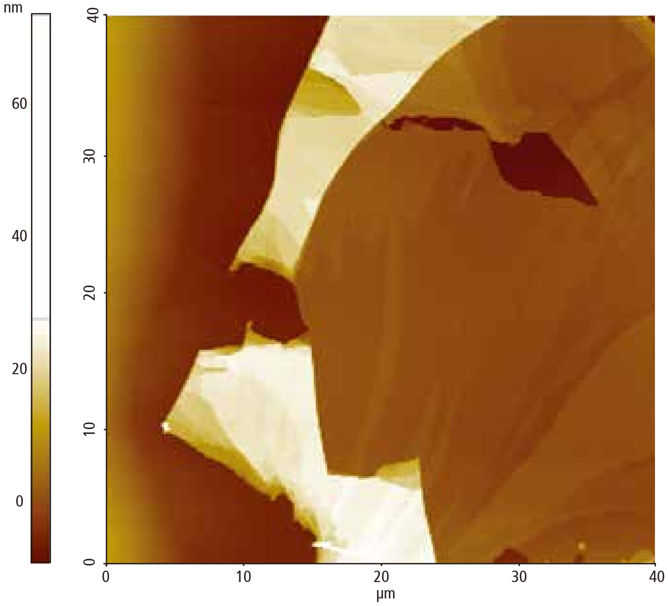
- System: NX20
- Scan Size: 20 nm × 20 nm
- Scan Mode: Tapping
- Scan Rate: 6 Hz
- Cantilever: : Multi75Al-G (k=3 N/m, f=75 kHz)
- Pixel Size: 512 × 512

Few layers of $MnBi_2Te_4$ (MBT)



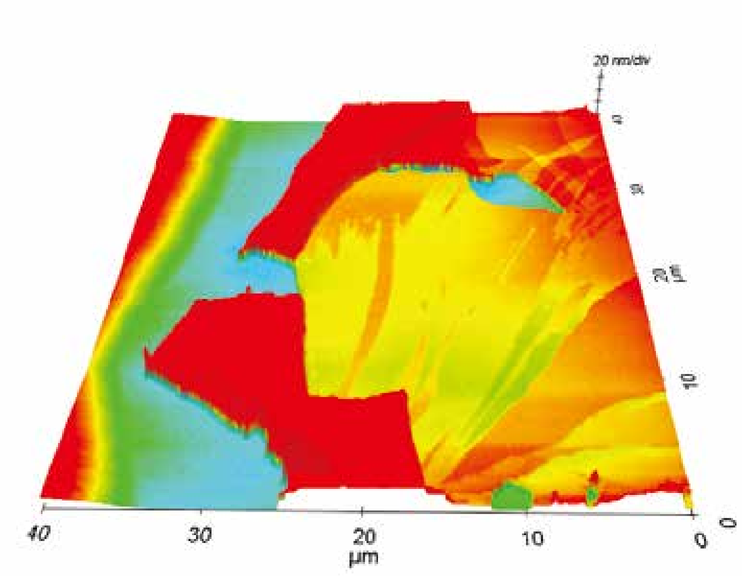
Non-contact

Height



Peak to valley: 85.9 nm

3D



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

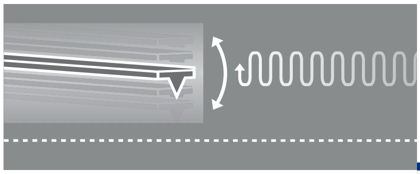
- The image on the left shows a few-layer of the compound $MnBi_2Te_4$ (MBT), consisting of a small number of atomic layers. Typically, these few-layer structures are of particular interest in the field of two-dimensional (2D) materials and topological insulators. The properties of these thin layers are highly tunable, and they exhibit quantum confinement effects and enhanced surface-to-volume ratios.

• Image courtesy: School of physical and mathematical sciences, Nanyang Technological University, Singapore

Scanning conditions

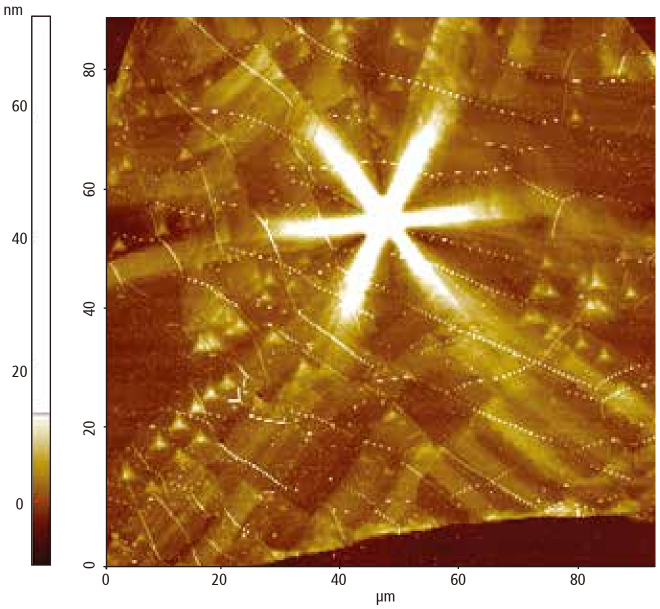
- System: NX10
- Scan Size: 40 µm × 40 µm
- Scan Mode: Non-contact
- Scan Rate: 1 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f=320 kHz)
- Pixel Size: 256 × 256

Tungsten disulfide (WS_2)



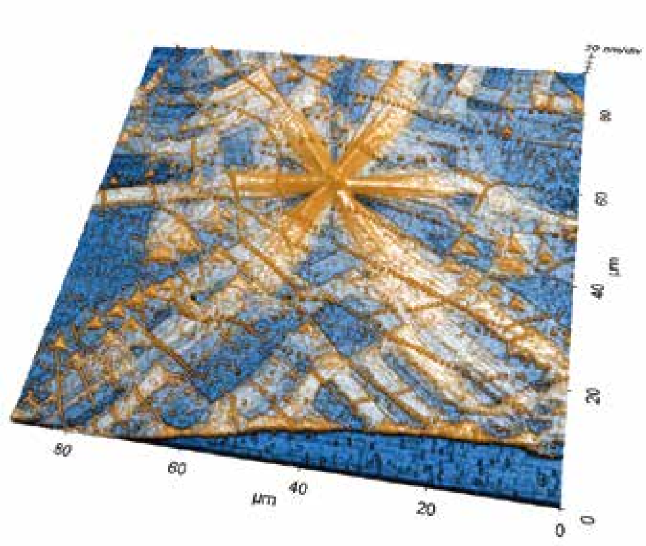
Non-contact

■ Height



Peak to valley: 87.2 nm

■ 3D (Edge enhanced color)



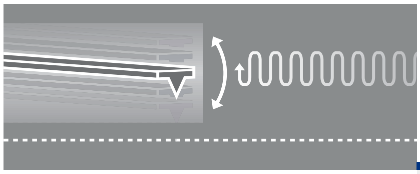
X:Y:Z scale = 1:1:100

- Tungsten disulfide (WS_2) is a 2D material with a layered structure, composed of tungsten atoms sandwiched between sulfur atom layers, and has unique surface properties. The surface of WS_2 is often modified or functionalized to enhance its performance in various applications, such as solid lubricants, catalysts, and electronic devices.

Scanning conditions

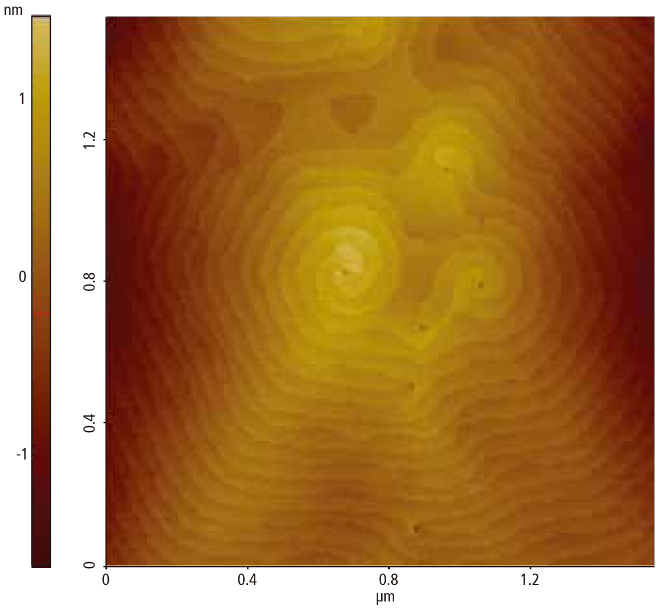
- System: NX20 Lite
- Scan Size: 90 µm × 90 µm
- Scan Mode: Non-contact
- Scan Rate: 0.4 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: 512 × 256

GaAs on PSS



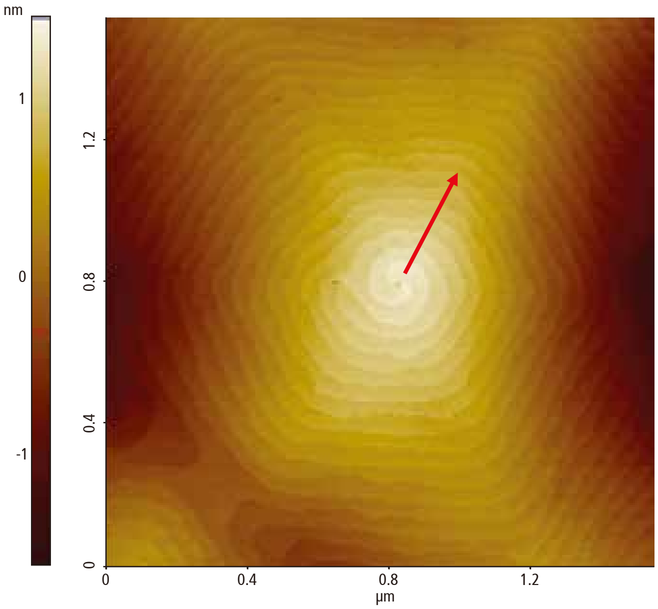
Non-contact

Height on position 1



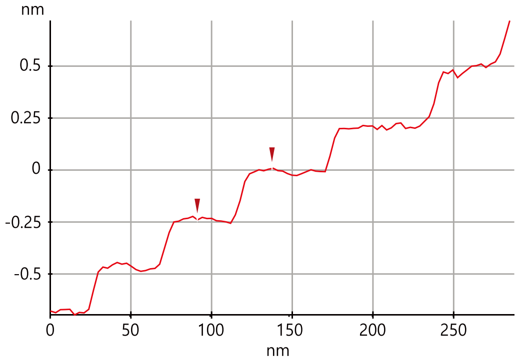
Peak to valley: 3.1 nm

Height on position 2



Peak to valley: 4.8 nm

Line profile

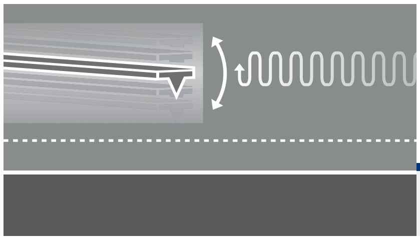


Cursor	ΔY (nm)
🟥 Red	0.249

Scanning conditions

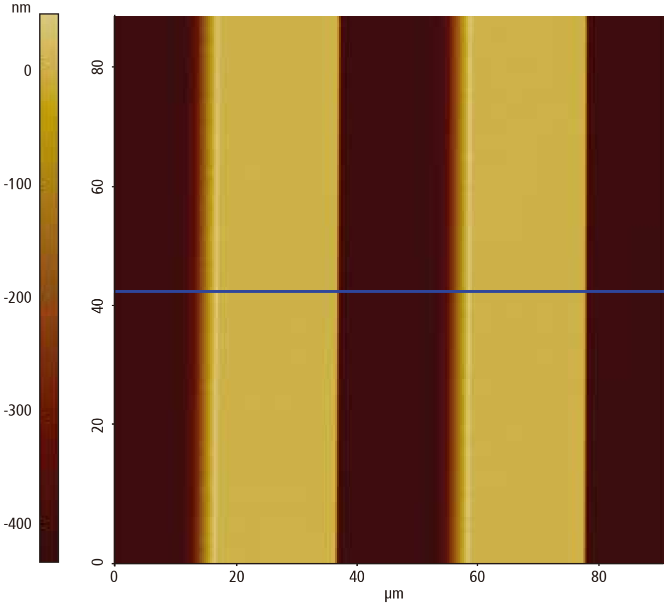
- System: NX20
- Scan Size: All 1.5 µm × 1.5 µm
- Scan Mode: Non-contact
- Scan Rate: All 1.2 Hz
- Cantilever: AC55TS (k=85 N/m, f=1600 kHz)
- Pixel Size: All 512 × 512

Ion beam etched MgO trench



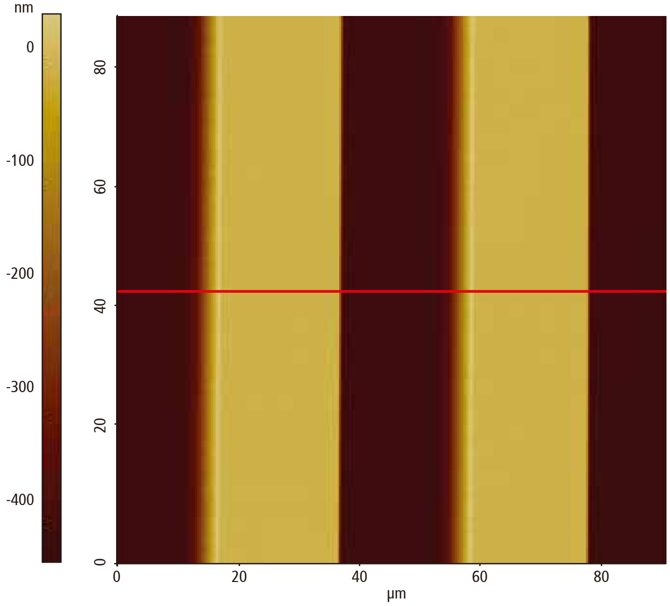
Non-contact

Height of trench 1



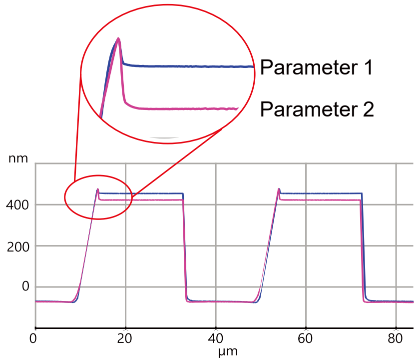
Peak to valley: 518.4 nm

Height of trench 2



Peak to valley: 490.2 nm

Multi-line profile

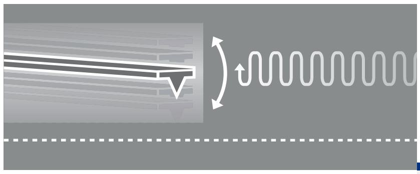


- AFM can observe changes in MgO trench height and edges depending on ion beam etching parameters.

Scanning conditions

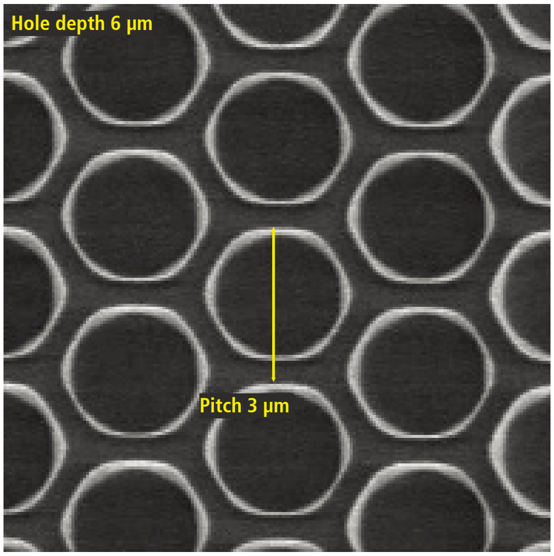
- System: FX40
- Scan Size: All 90 µm × 90 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.12 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 4096 × 256

Molds for Nanoimprint; Hole structure

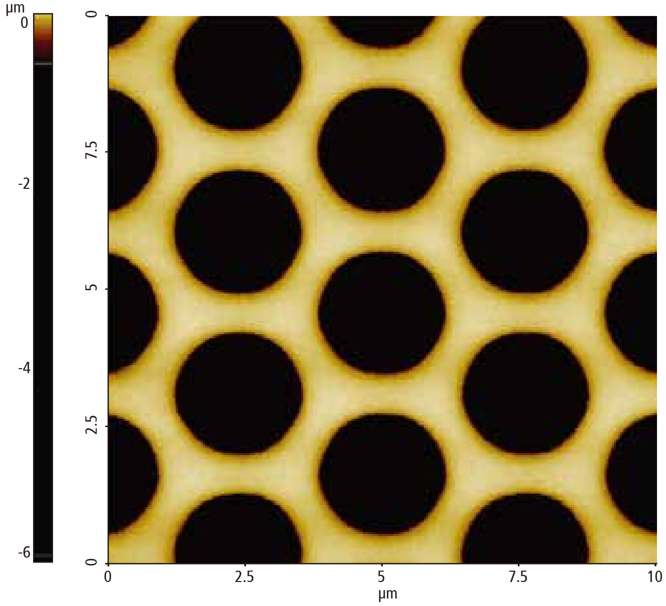


Non-contact

▪ SEM

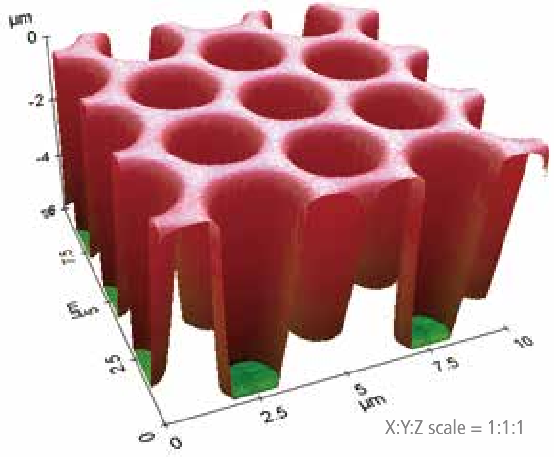


▪ Height



Peak to valley: 5.84 µm

▪ 3D

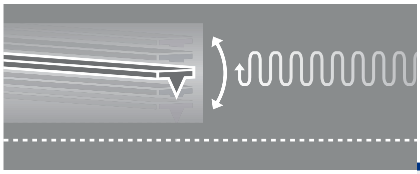


X:Y:Z scale = 1:1:1

Scanning conditions

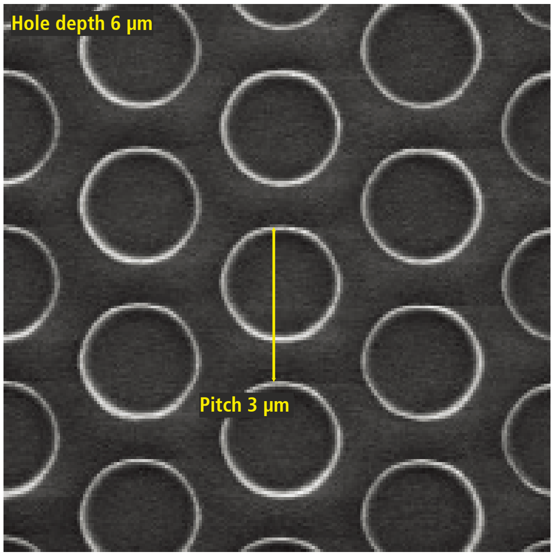
- System: NX-Wafer
- Scan Size: 10 µm × 10 µm
- Scan Mode: Non-contact
- Scan Rate: Adaptive 0.1 - 0.5 Hz
- Cantilever: EBD8-600A (k=40 N/m, f=320 kHz)
- Pixel Size: 2048 × 512

Molds for Nanoimprint; Pillar structure

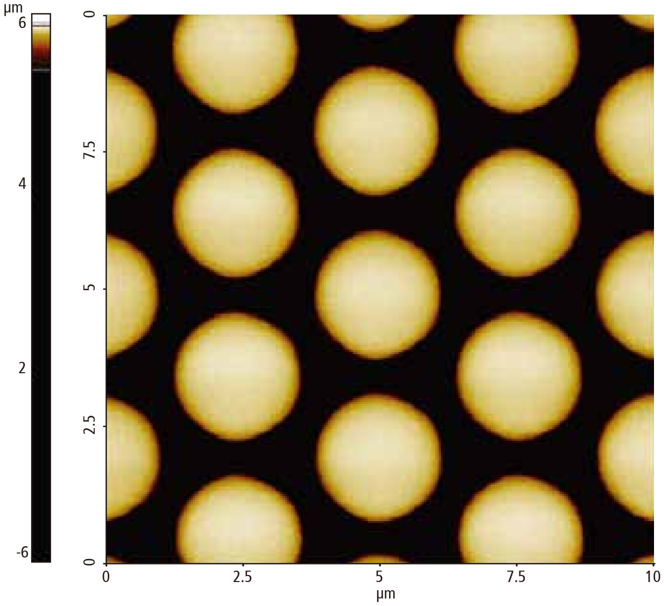


Non-contact

SEM

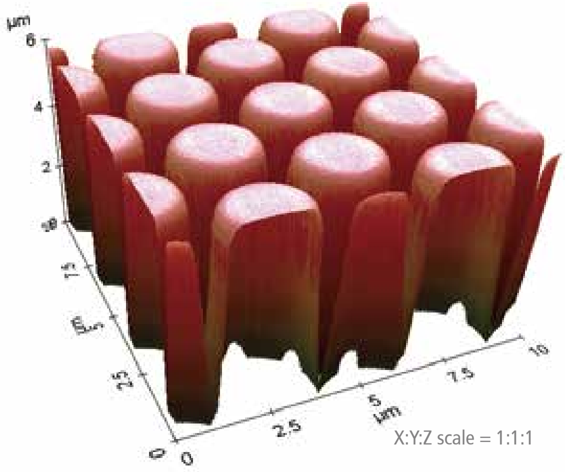


Height



Peak to valley: 5.89 µm

3D

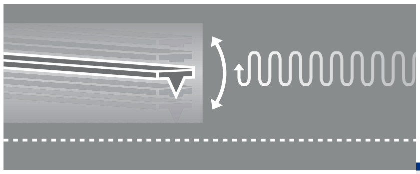


X:Y:Z scale = 1:1:1

Scanning conditions

- System: NX-Wafer
- Scan Size: 10 µm × 10 µm
- Scan Mode: Non-contact
- Scan Rate: Adaptive 0.1 - 0.5 Hz
- Cantilever: EBD8-600A (k=40 N/m, f=320 kHz)
- Pixel Size: 2048 × 512

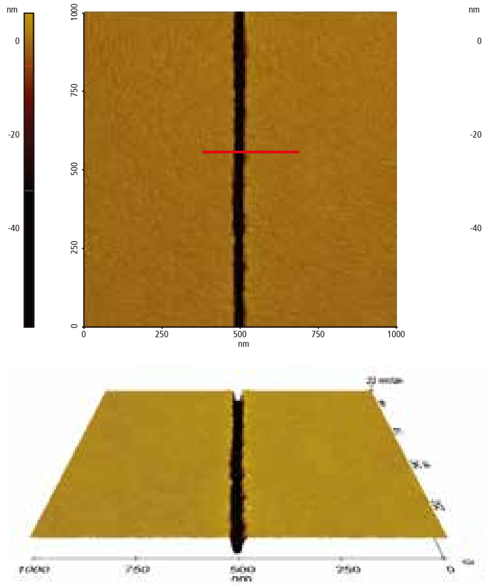
PR trench patterns



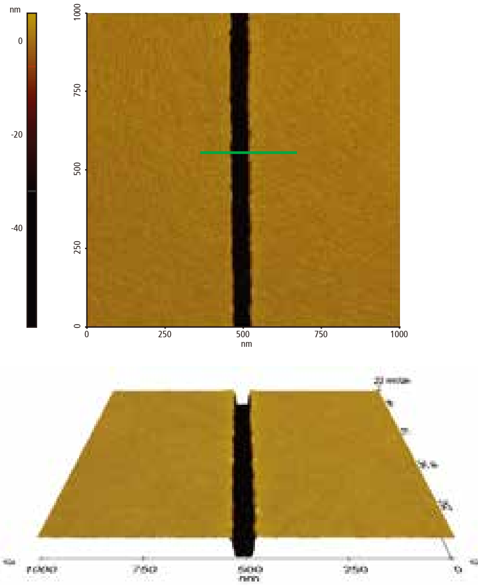
Non-contact

Height and 3D of trench with designed width (after tip deconvolution)

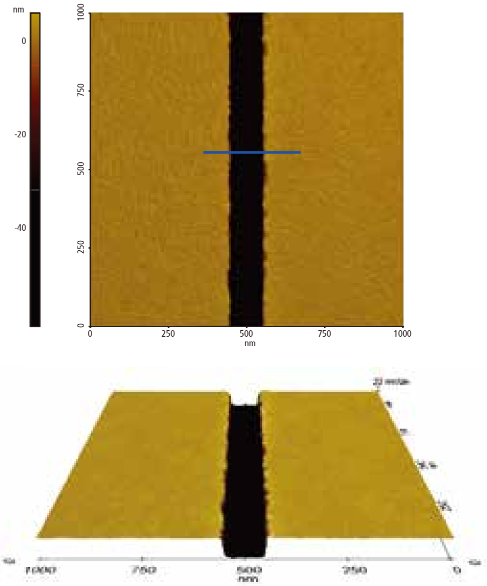
- **Height of 29 nm width**



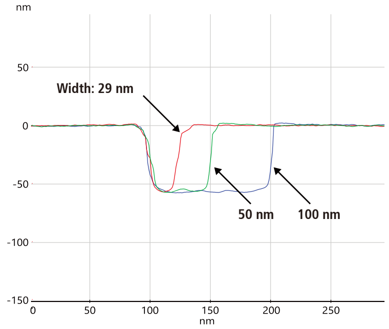
- **Height of 50 nm width**



- **Height of 100 nm width**



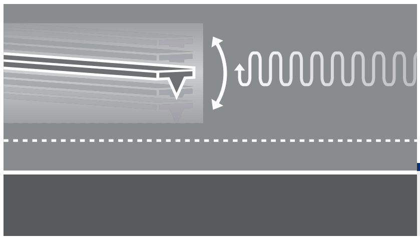
- **Multi-line profile**



Scanning conditions

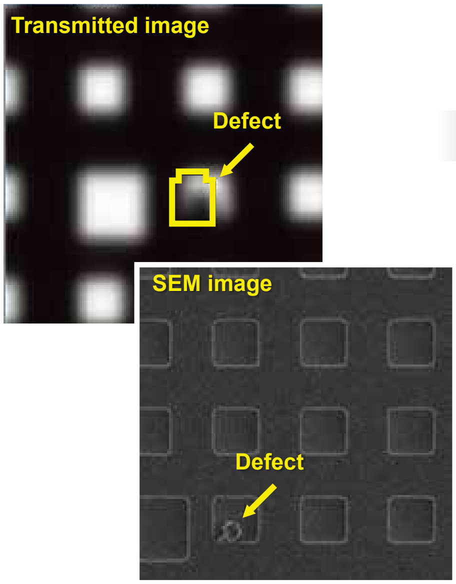
- System: NX-Wafer
- Scan Size: All 1 μm × 1 μm
- Scan Mode: Non-contact
- Scan Rate: All 0.5 Hz
- Cantilever: MCNT-100 (k=40 N/m, f=320 kHz)
- Pixel Size: All 1024 × 256

Mask repair

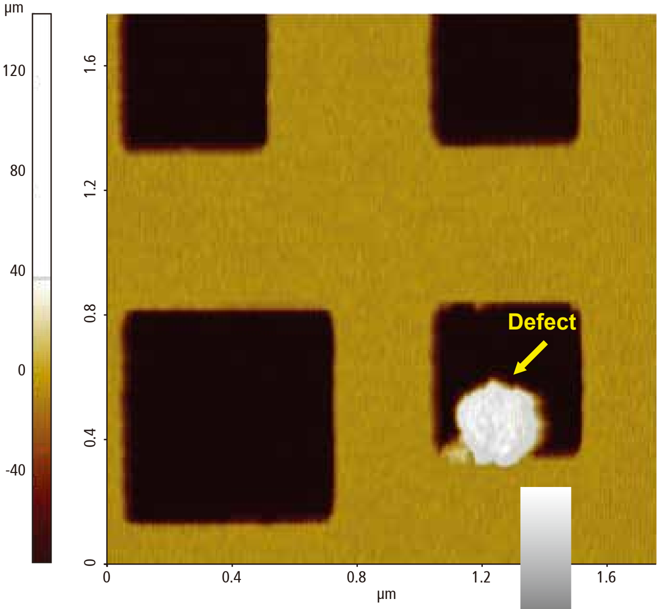


Non-contact

Defect inspection

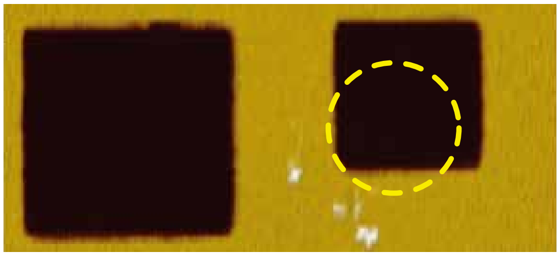


Height before mask repair



Peak to valley: 225.4 nm

Height after mask repair

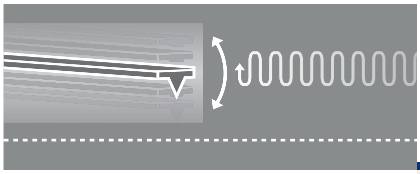


Peak to valley: 122.2 nm

Scanning conditions

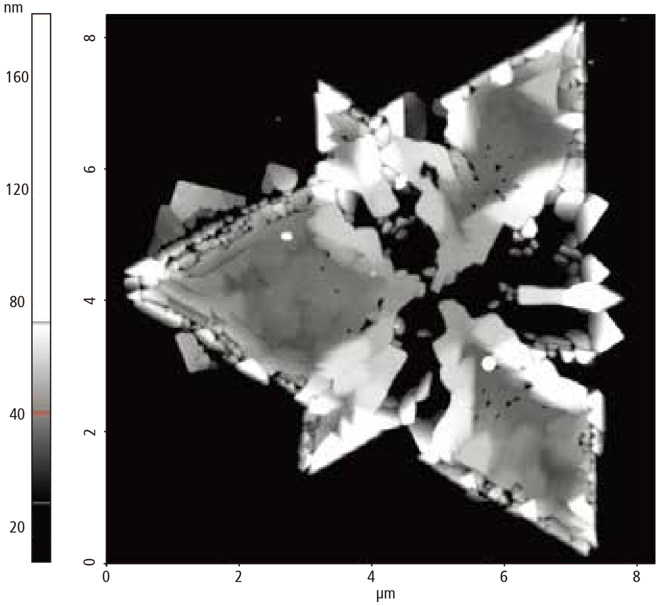
- System: NX-Mask
- Scan Size: 1.8 μm × 1.8 μm, crop (0.8 μm x 1.8 μm)
- Scan Mode: Non-contact
- Scan Rate: All 0.5 Hz
- Cantilever: AD-40-AS (k=40 N/m, f=200 kHz)
- Pixel Size: All 512 × 128

Defects of LiNbO$_3$ wafer



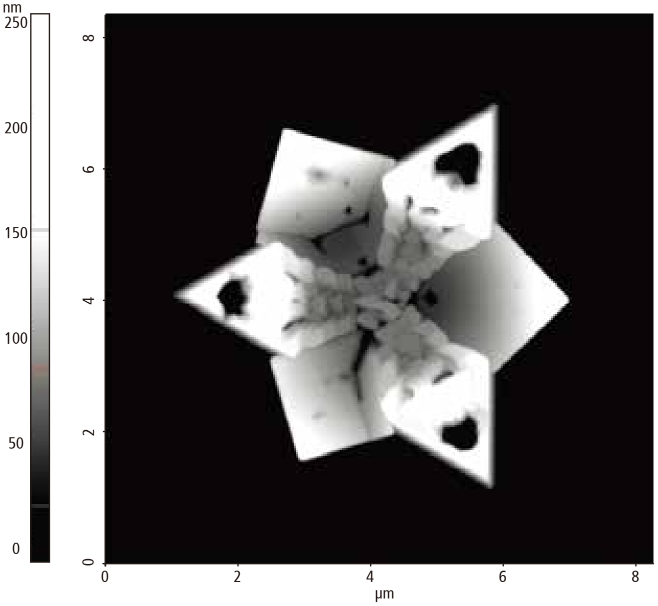
Non-contact

Height of defect 1



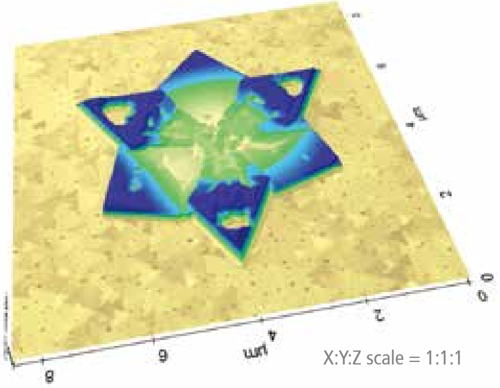
Peak to valley: 263.3 nm

Height of defect 2



Peak to valley: 264.0 nm

3D of defect 2

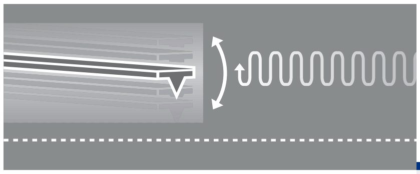


X:Y:Z scale = 1:1:1

Scanning conditions

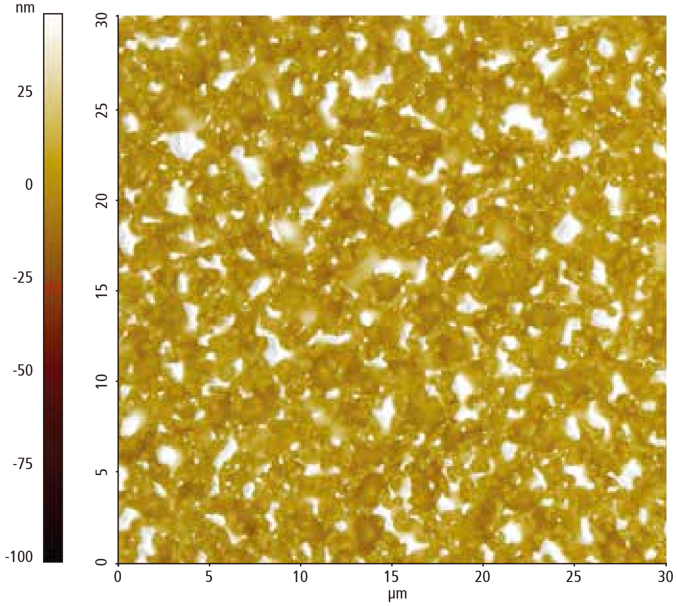
- System: FX40
- Scan Size: All 8.5 µm × 8.5 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.3 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f=320 kHz)
- Pixel Size: All 512 × 256

Poly Silicon (p-Si)



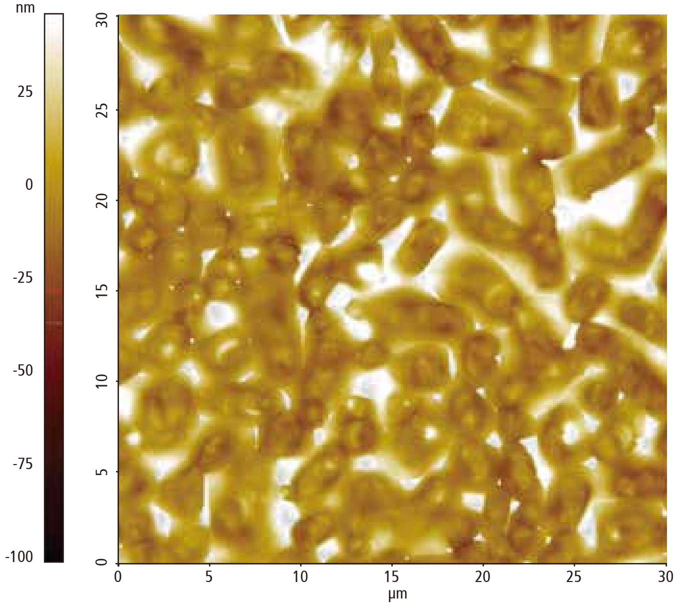
Non-contact

Height with condition 1



Peak to valley: 315.1 nm

Height with condition 2



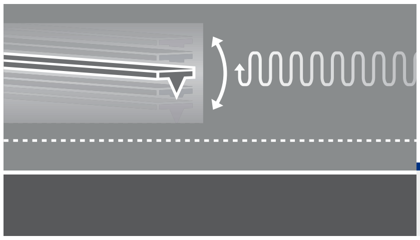
Peak to valley: 360.1 nm

- The surface morphology of poly silicon undergoes significant changes depending on the crystallization conditions employed during its formation. Optimal crystallization conditions often result in well-defined grain boundaries and a smooth, uniform surface, indicative of a high-quality crystalline structure. Surface imaging by AFM can clearly show changes according to crystallization conditions.

Scanning conditions

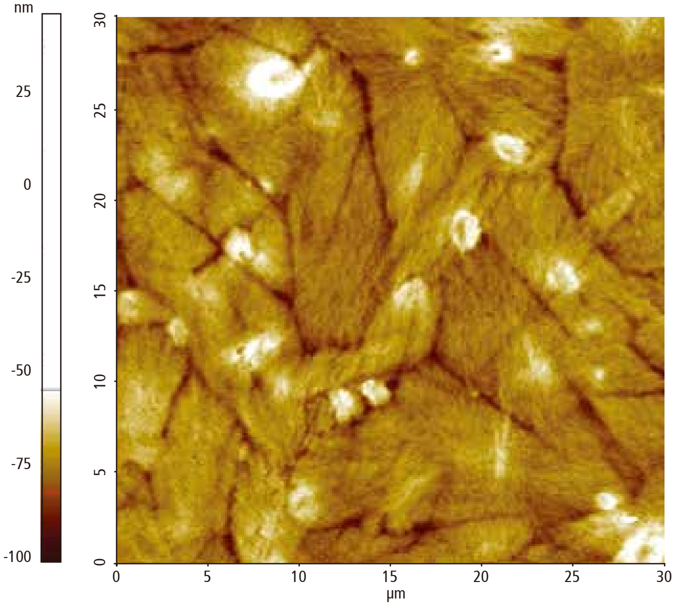
- System: NX10
- Scan Size: All 30 µm × 30 µm
- Scan Mode: Non-contact
- Scan Rate: 0.12 Hz, 0.15 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f=320 kHz)
- Pixel Size: All 1024 × 1024

Zirconia (ZrO_2)



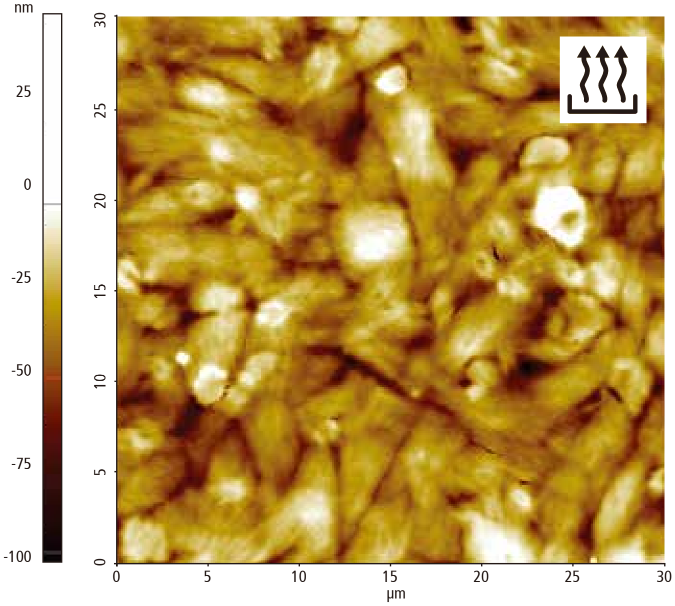
Non-contact

Height before heating



Peak to valley: 53.2 nm

Height after heating to 300 °C



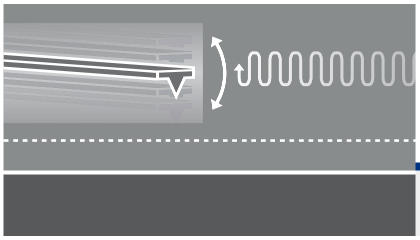
Peak to valley: 55.5 nm

- The surface of zirconia (ZrO_2) undergoes temperature-dependent changes that impact its properties and structure. At higher temperatures, ZrO_2 can experience phase transitions, transforming from a monoclinic to a tetragonal or cubic crystal structure. These temperature-induced changes influence the material's mechanical, thermal, and electrical characteristics.

Scanning conditions

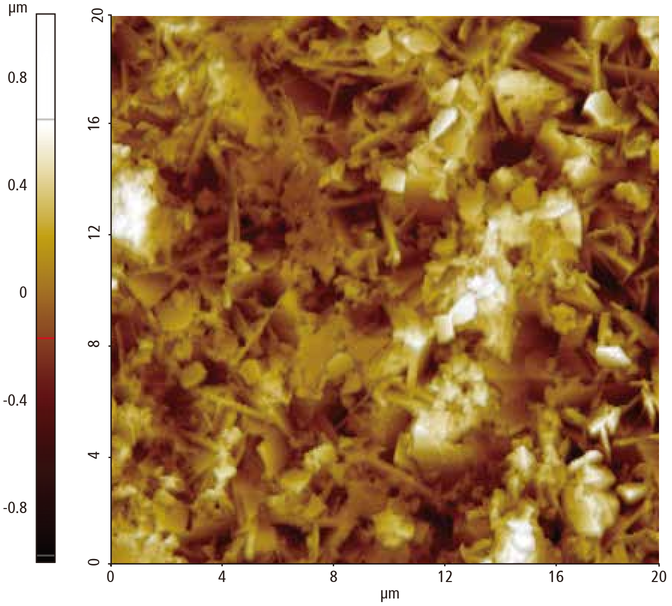
- System: NX7
- Scan Size: All 10 μm × 10 μm
- Scan Mode: Non-contact
- Scan Rate: All 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 256 × 256

Steel (1/2)



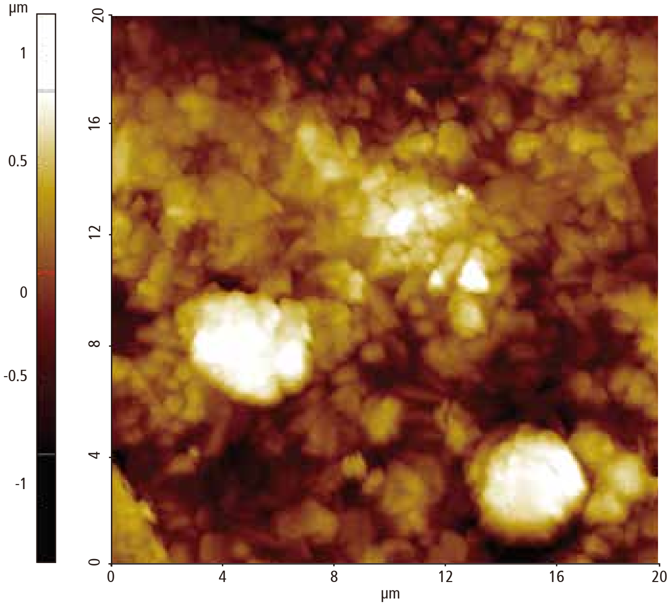
Non-contact

Height of phosphate coated steel



Peak to valley: 1.9 µm

Height of rusty steel



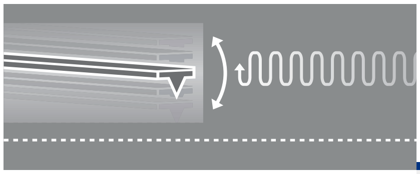
Peak to valley: 2.5 µm

- Phosphate coating on steel, called ‘Parkerizing’ is a method to protect a steel surface from corrosion by reacting the metal surface chemically with dilute phosphoric acid to change the surface property of the metal into a crystalline phosphate. The left images show the surface changes with and without phosphate coating while corrosion test.

Scanning conditions

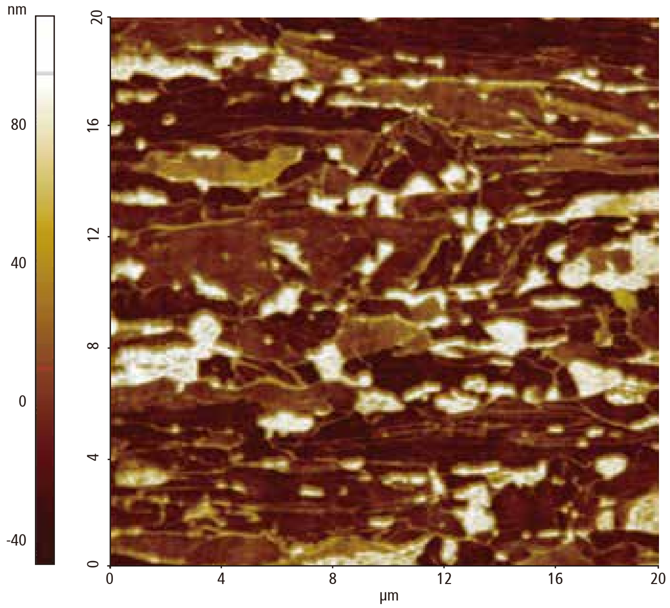
- System: FX40
- Scan Size: All 20 µm × 20 µm
- Scan Mode: Non-contact
- Scan Rate: 0.1 Hz, 0.3 Hz
- Cantilever: PPP-NCHR (k= 42 N/m, f= 320 kHz)
- Pixel Size: All 512 × 256

Steel (2/2)



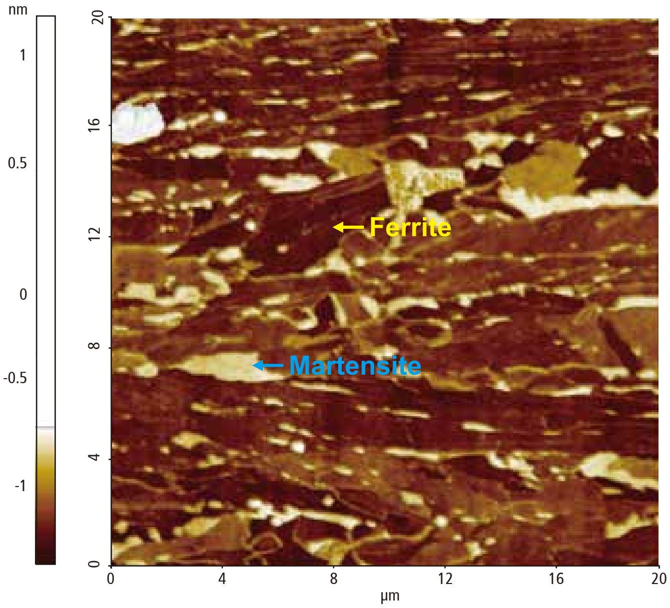
Non-contact

Height of position 1



Peak to valley: 168.2 nm

Height of position 2



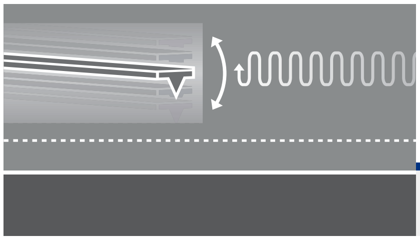
Peak to valley: 657.7 nm

- Stainless steel has a crystal structure of ferrite, austenite and martensite.
  Each has different metallurgical stages that affect the mechanical and corrosive properties of the metal.
  The ferrite-martensite dual phase steel microstructure, which has been studied over the past few decades, offers improved mechanical properties such as superior strength-ductility and continuous yielding behavior.

Scanning conditions

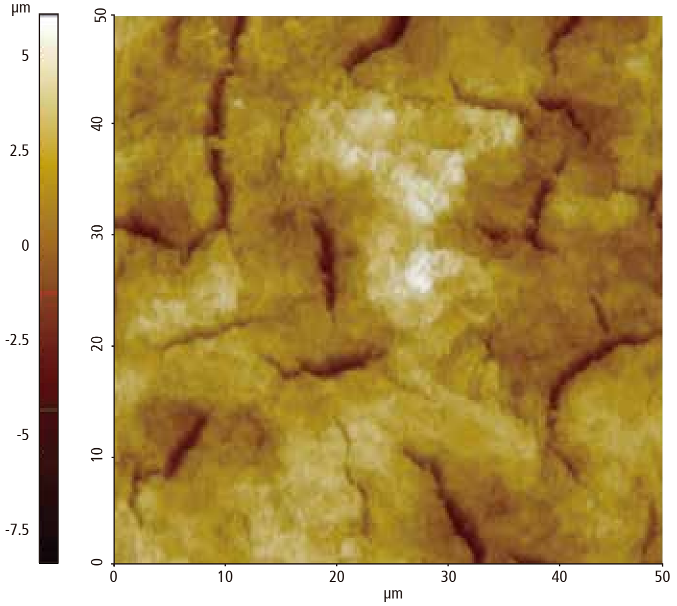
- System: FX40
- Scan Size: All 20 µm × 20 µm
- Scan Mode: Non-contact
- Scan Rate: 1 Hz, 0.3 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: All 256 × 512

AgCl/Al_2O_3 catalyst treated metal surface



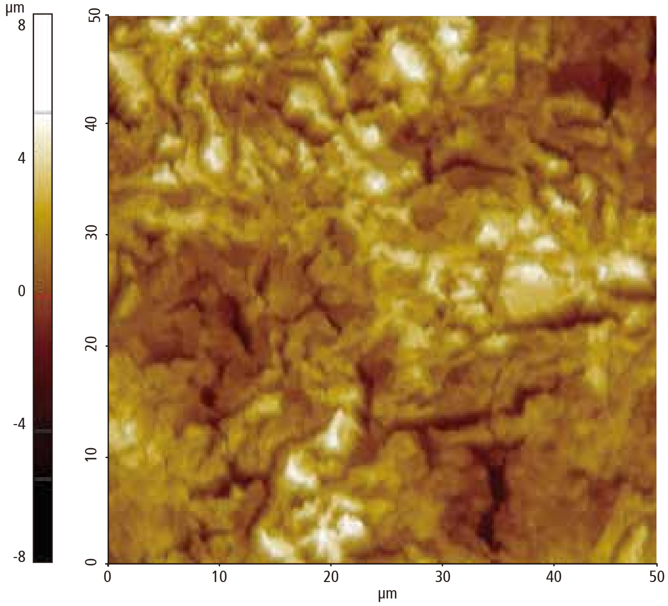
Non-contact

- **Height before treatment**



Peak to valley: 9.9 µm

- **Height after treatment**



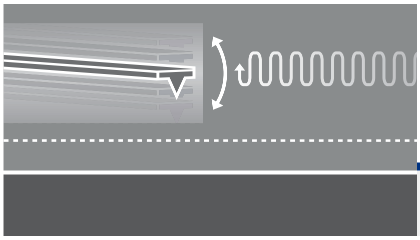
Peak to valley: 9.1 µm

- The AgCl/Al_2O_3 catalyst treated metal surface offers advantages such as heightened catalytic activity and selectivity due to the presence of AgCl. The alumina support enhances stability and durability, providing a high surface area for increased catalytic efficiency. This tailored catalyst system allows for precise control over reactivity, making it well-suited for specific reactions

Scanning conditions

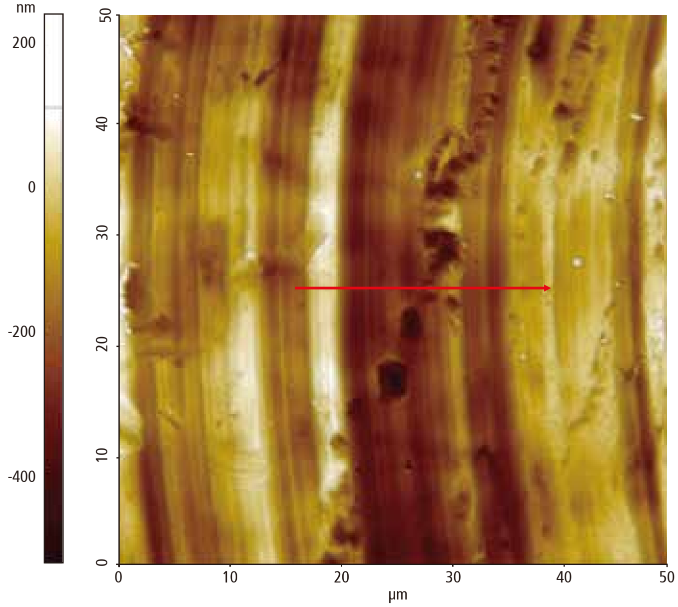
- System: FX40
- Scan Size: All 50 µm × 50 µm
- Scan Mode: Non-contact
- Scan Rate: 0.58 Hz, 0.15 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: All 512 × 256

Dental implant screw



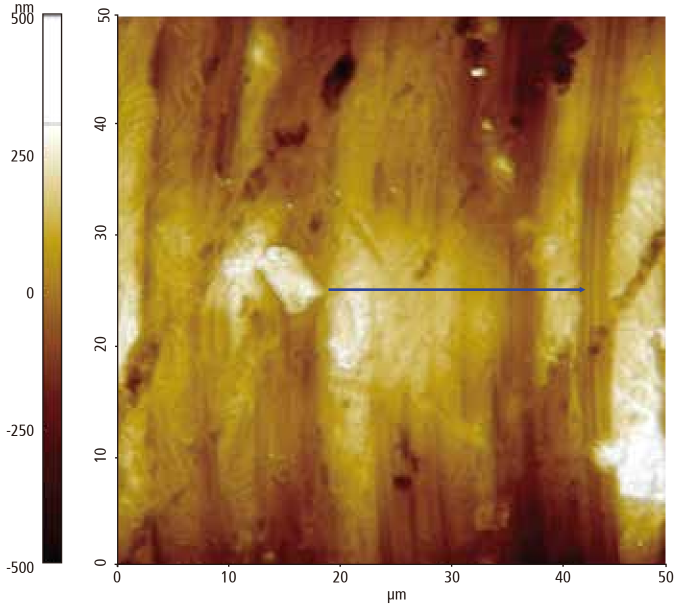
Non-contact

Height before treatment



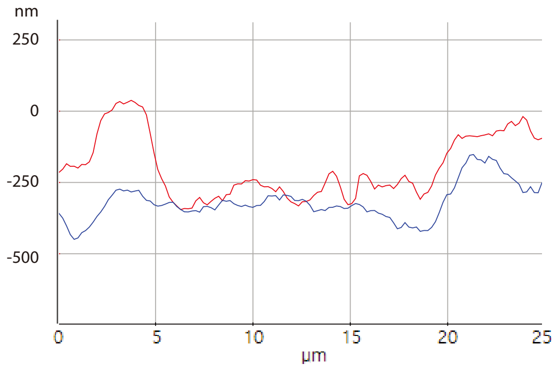
Peak to valley: 798.0 nm

Height after acid treatment



Peak to valley: 1.01 µm

Multi-line profile

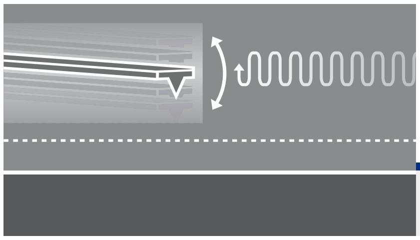


- Surface morphology changes of dental implant screw by HCl acid treatment for 10 minutes. The screw features have been notably dulled by the acid.

Scanning conditions

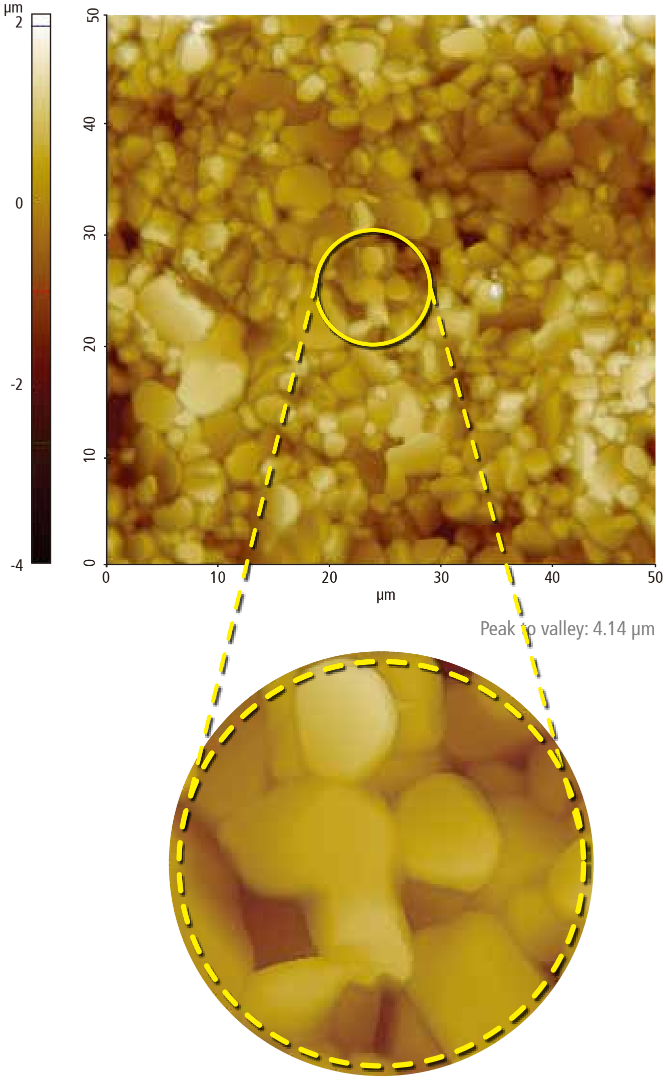
- System: FX40
- Scan Size: All 50 µm × 50 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.2 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 256 × 256

Ceramic



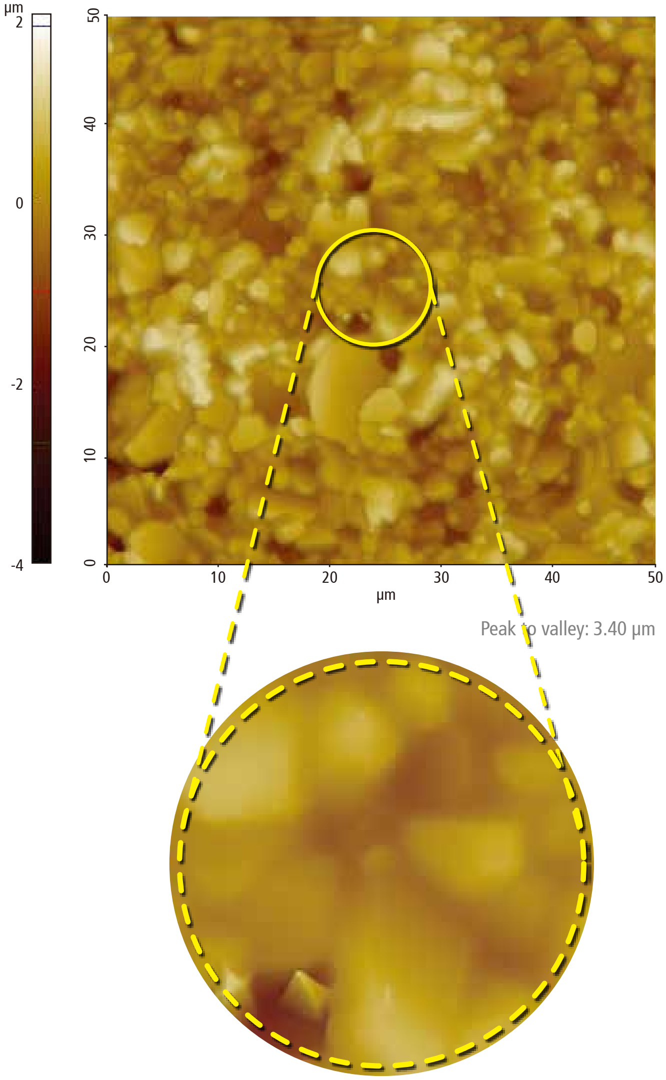
Non-contact

Height before coating



Peak to valley: 4.14 μm

Height after organic coating

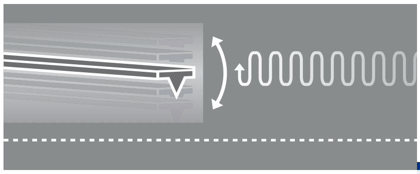


Peak to valley: 3.40 μm

Scanning conditions

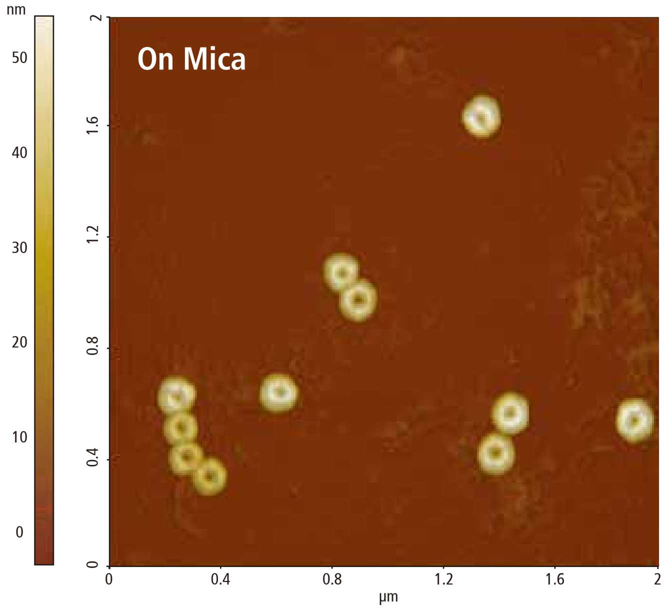
- System: FX40
- Scan Size: All 50 μm × 50 μm
- Scan Mode: Non-contact
- Scan Rate: All 0.7 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 1024 × 512

Nano Au on epithelial cells



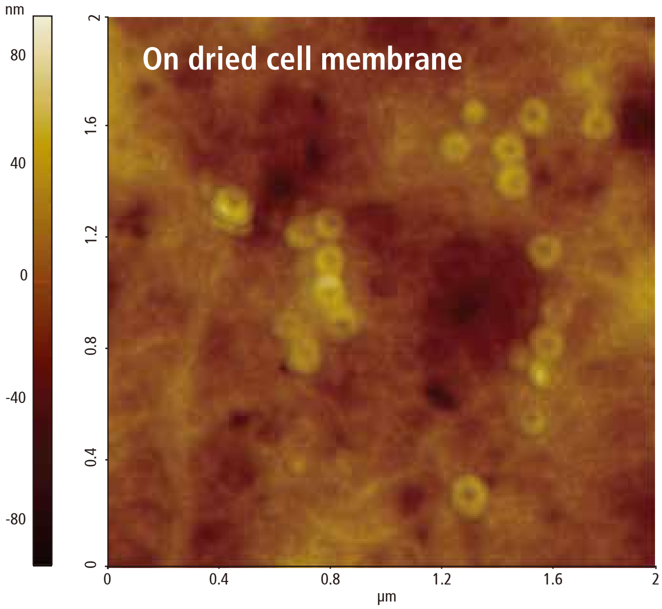
Non-contact

■ Height on Mica



Peak to valley: 56.3 nm

■ Height on Epithelial cells



Peak to valley: 182.7 nm

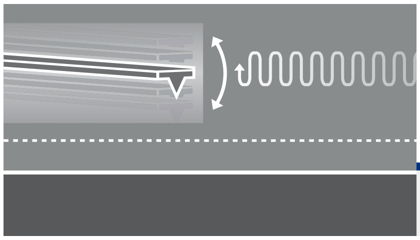
- The application of nano-sized gold particles on epithelial cells presents several advantages in biomedical and therapeutic contexts. Gold nanoparticles can be functionalized for targeted drug delivery, allowing for precise and controlled release of therapeutic agents to epithelial tissues.
  Their biocompatibility and low toxicity make them suitable for use in medical applications.

• Sample courtesy: Prof. Jin Ah Cho, Department of food and nutrition, College of human ecology, Chungnam national university, Korea

Scanning conditions

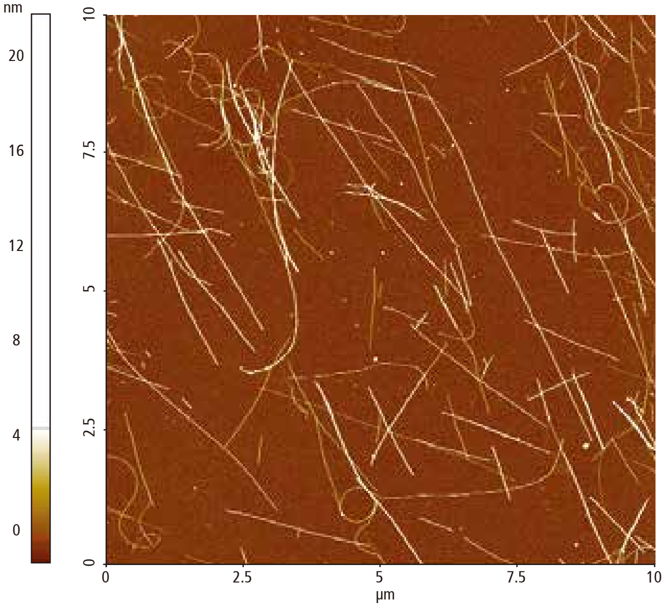
- System: FX40
- Scan Size: All 2 µm × 2 µm
- Scan Mode: Non-contact
- Scan Rate: 0.3 Hz, 0.1 Hz
- Cantilever: : BL AC40 (k=0.09 N/m, f=110 kHz)
- Pixel Size: All 512 × 256

Plant protein amyloid fibril



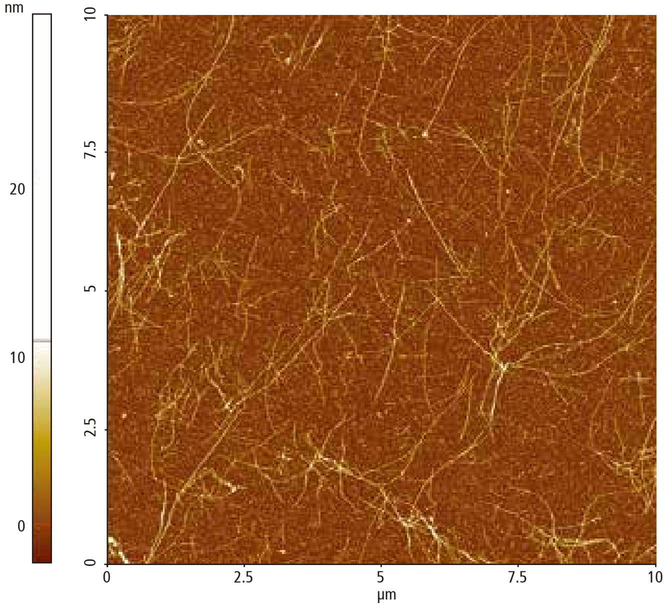
Non-contact

Height of peanut amyloid fibril



Peak to valley: 25 nm

Height of sunflower amyloid fibril



Peak to valley: 25 nm

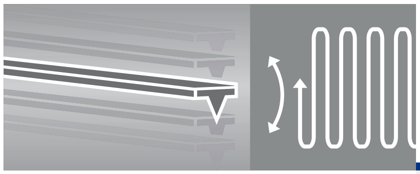
- Among biological materials, proteins serve as promising tools for heavy metal adsorption due to the multitude functional groups on amino acids that exhibit metal-binding abilities. Amyloid fibrils self-assembled such as sunflower and peanut can be shown the ability to purify wastewater contaminated with heavy metals. AFM is used to optimize the amyloid fibrillization conditions.

• Sample courtesy: Image courtesy: School of materials science & engineering, Nanyang Technological University, Singapore
Ref. Chemical Engineering Journal 445 (2022) 136513

Scanning conditions

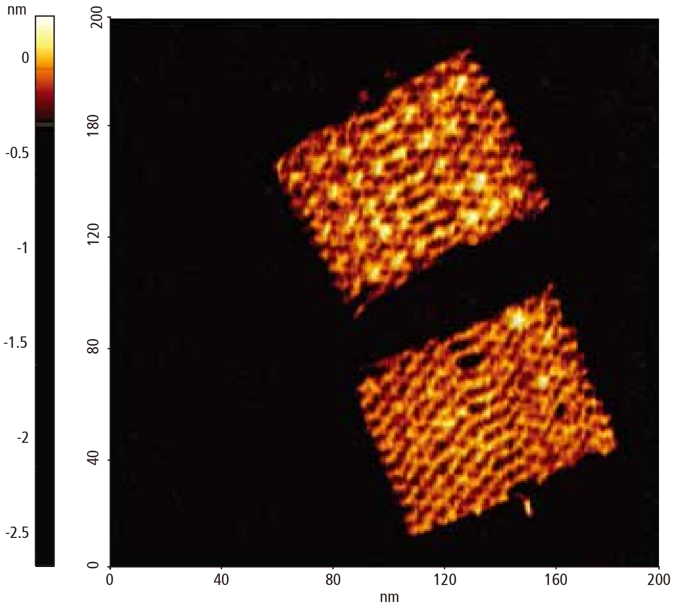
- System: NX10
- Scan Size: All 10 µm × 10 µm
- Scan Mode: Non-contact
- Scan Rate: 0.5 Hz, 1 Hz
- Cantilever: Arrow-NCR (k=42 N/m, f=285 kHz)
- Pixel Size: All 512 × 512

DNA origami (1/2)



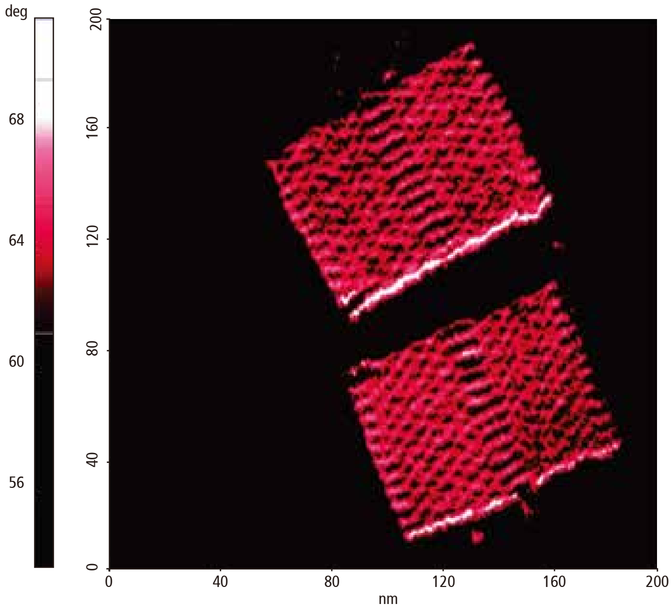
Tapping

- **Height of 200 nm scan**

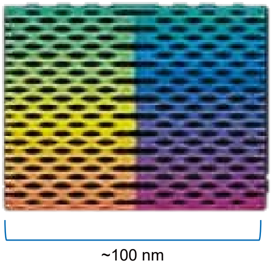


Peak to valley: 2.9 nm

- **NCM Phase**



- **Origami DNA design**



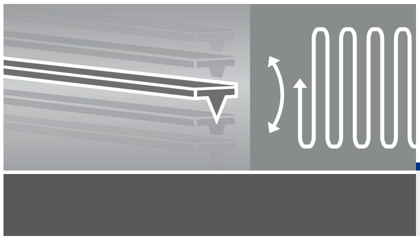
- Rectangle shaped origami.
  DNA sequence was designed
  to form a honeycomb structure.

• Sample courtesy: PhD. Luca Piantanida from Micron School of Materials and Engineering at Boise State University, USA

Scanning conditions

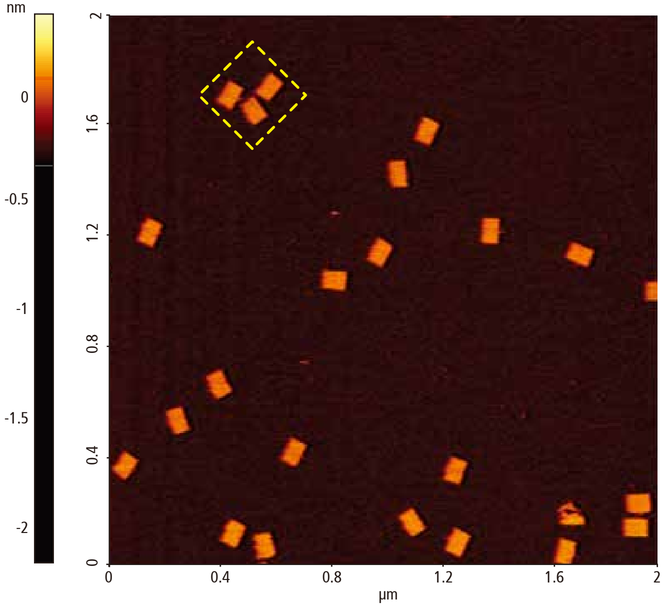
- System: FX40
- Scan Size: 0.2 µm × 0.2 µm
- Scan Mode: Tapping in liquid
- Scan Rate: 4 Hz
- Cantilever: USC-f0.3-k0.3 (k=0.3 N/m, f=300 kHz)
- Pixel Size: 256 × 512

DNA origami (2/2)



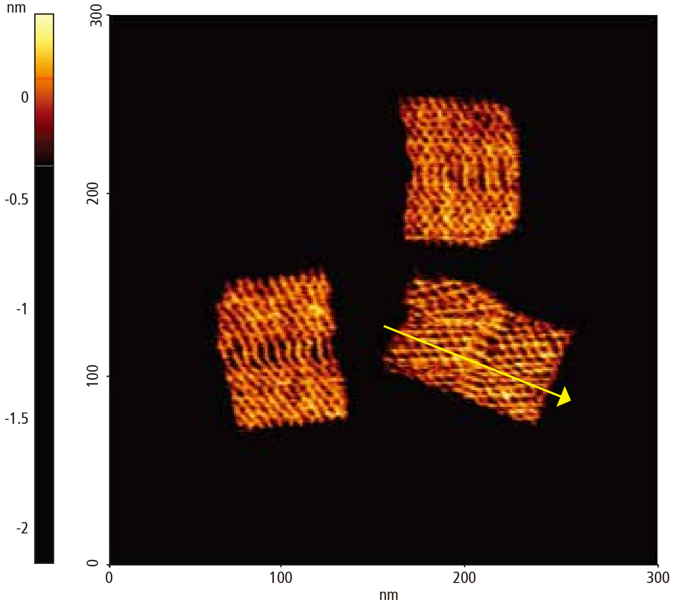
Tapping

■ Height



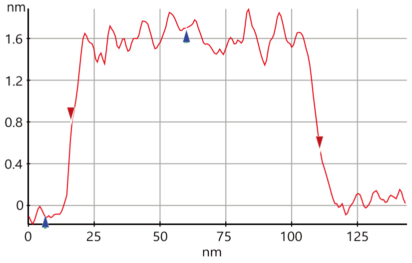
Peak to valley: 3.1 nm

■ Zoom in Height (300 nm scan)



Peak to valley: 2.6 nm

■ Line profile



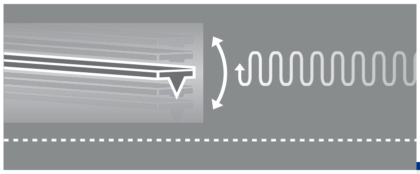
Cursor	ΔX (nm)	ΔY (nm)
🟥 Red	94.44	0.28
🟦 Blue	53.59	1.82

• Sample courtesy: PhD. Luca Piantanida from Micron School of Materials and Engineering at Boise State University, USA

Scanning conditions

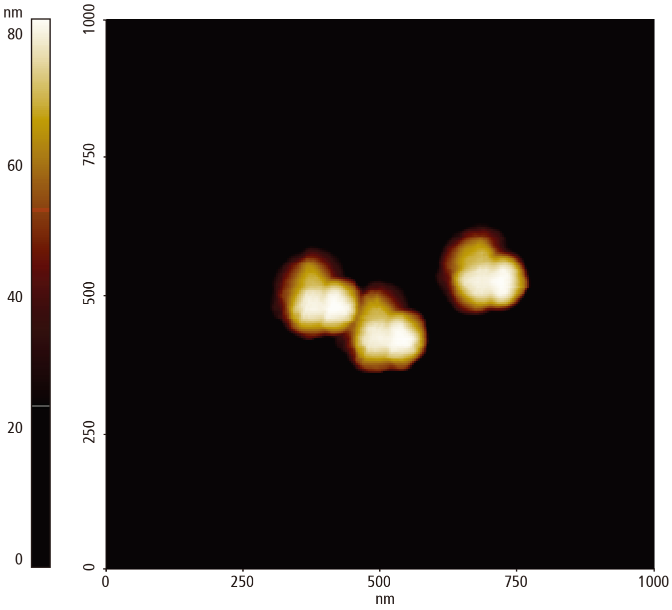
- System: NX10
- Scan Size: 2 µm × 2 µm, 0.3 µm × 0.3 µm
- Scan Mode: Tapping in liquid
- Scan Rate: 2 Hz, 6 Hz
- Cantilever: USC-f0.3-k0.3 (k=0.3 N/m, f=300 kHz)
- Pixel Size: All 512 × 512

Adenovirus



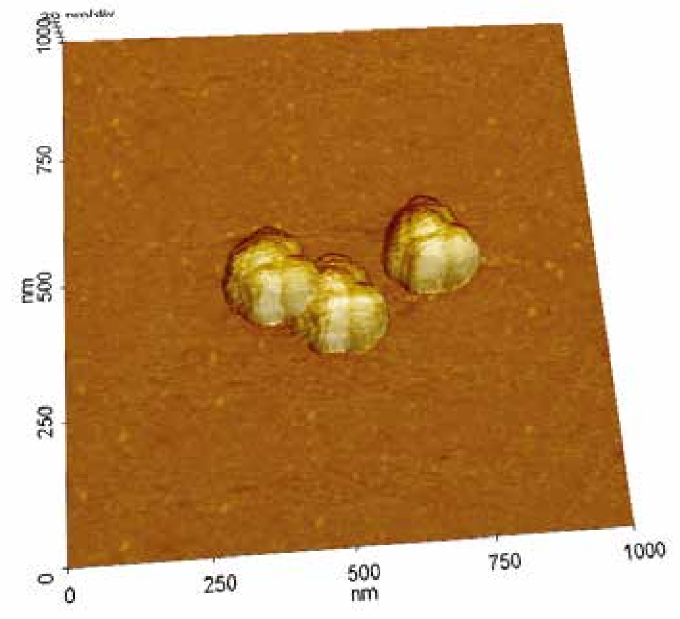
Non-contact

Height



Peak to valley: 85.4 nm

3D



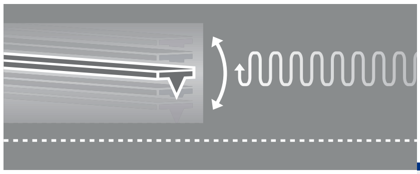
X:Y:Z scale = 1:1:1

- Adenovirus imaging by AFM allows for the high-resolution visualization of the viral structure. AFM reveals intricate details of the adenovirus capsid, including its size, shape, and surface features, without causing damage to the delicate viral particles. The 3D image on the left shows the surface morphology colored by the phase signal.

Scanning conditions

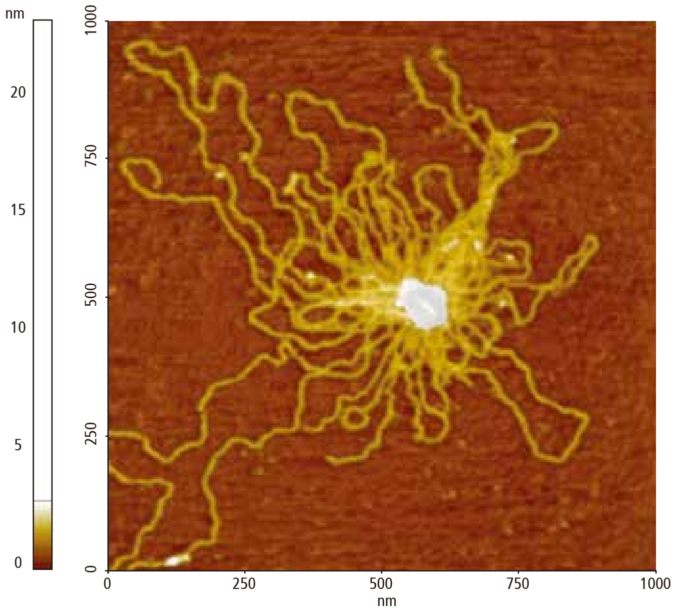
- System: FX40
- Scan Size: 1 µm × 1 µm
- Scan Mode: Non-contact
- Scan Rate: 0.4 Hz
- Cantilever: BL AC40 (k=0.09 N/m, f=110 kHz)
- Pixel Size: 512 × 256

Adenovirus with DNA bundle



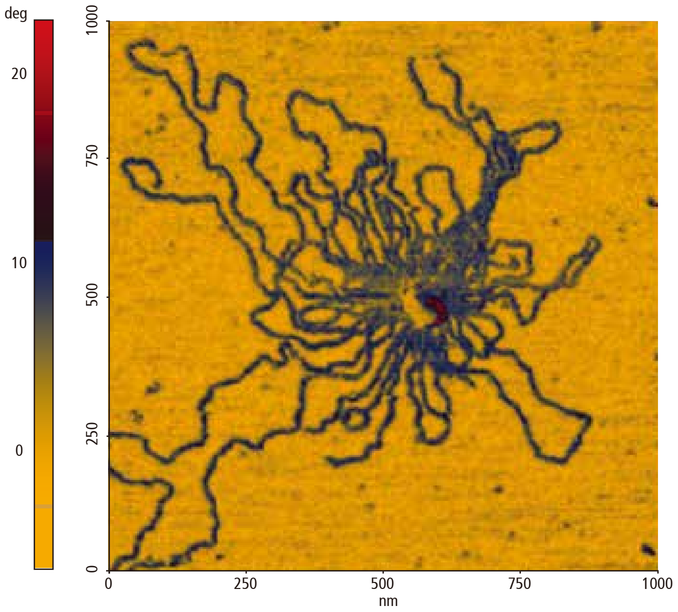
Non-contact

- **Height after heating**



Peak to valley: 24.5 nm

- **NCM Phase**

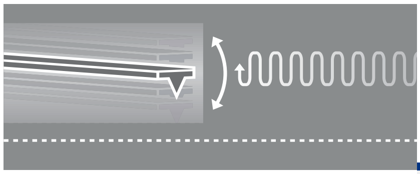


- The effects of heat on the anatomy of the adenovirus involves alterations in the viral structure and functionality. Elevated temperatures lead to denaturation of viral proteins and disruption of the viral envelope, affecting the virus's ability to attach to host cells. Changes in the adenovirus's capsid structure due to heat stress influence its stability and overall infectivity. AFM can visualize fine details of structures without causing harm.

Scanning conditions

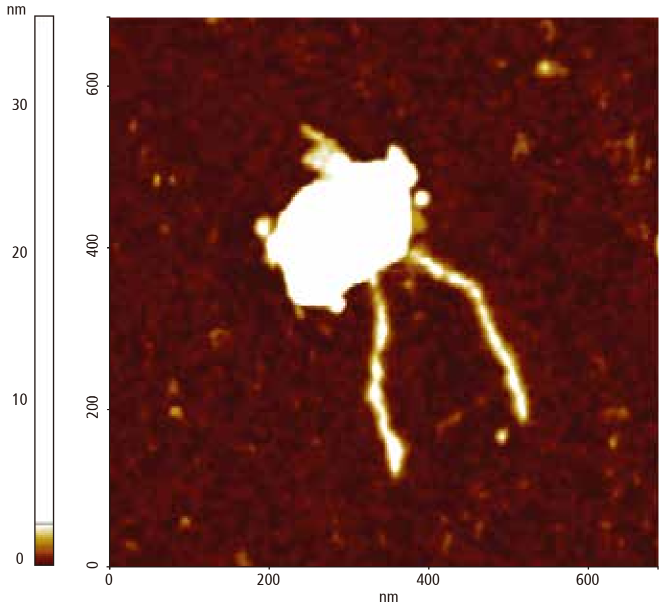
- System: FX40
- Scan Size: 1 μm × 1 μm
- Scan Mode: Non-contact
- Scan Rate: 1.87 Hz
- Cantilever: BL AC40 (k=0.09 N/m, f=110 kHz)
- Pixel Size: 256 × 256

Bacteriophage



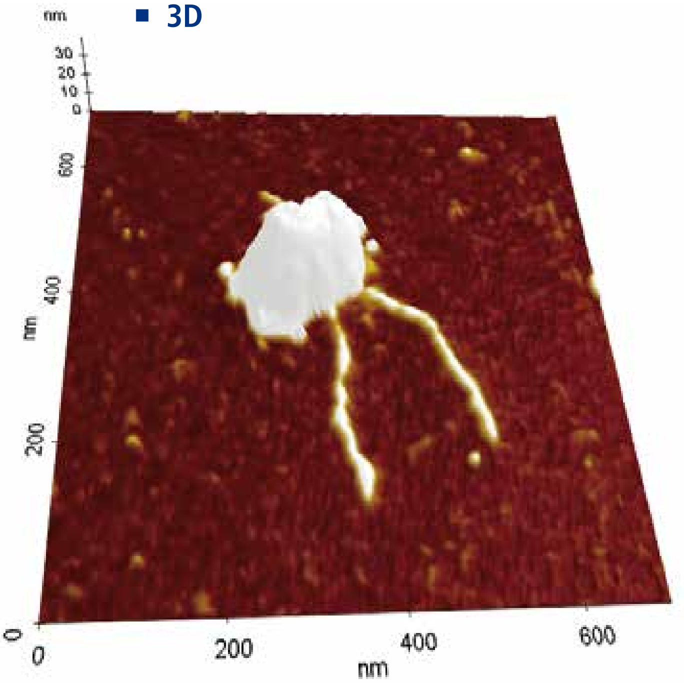
Non-contact

- **Height**



Peak to valley: 24.5 nm

- **3D**



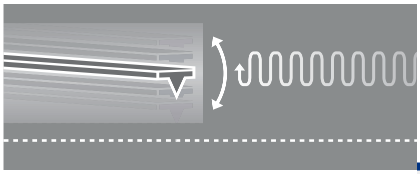
X:Y:Z scale = 1:1:3

- In the realm of micro-biological research, the fastidious examination and quantification of bacteriophage morphology, the distinct shapes and structures of bacteriophages influence their ability to infect specific bacteria, determining host specificity. A task of paramount importance for unraveling the intricate details of these viral entities, are undertaken through the innovative application of AFM.

Scanning conditions

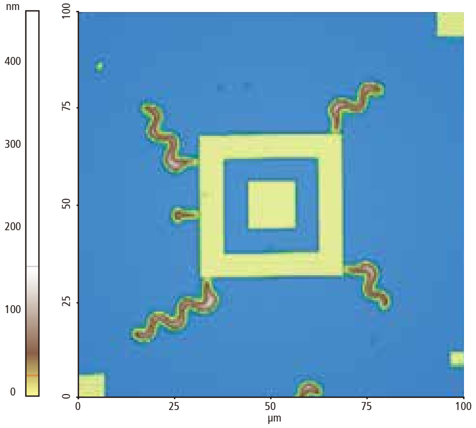
- System: FX40
- Scan Size: 0.7 µm × 0.7 µm
- Scan Mode: Non-contact in liquid
- Scan Rate: 1 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f=320 kHz)
- Pixel Size: 256 × 256

Mycelium growth on pattern



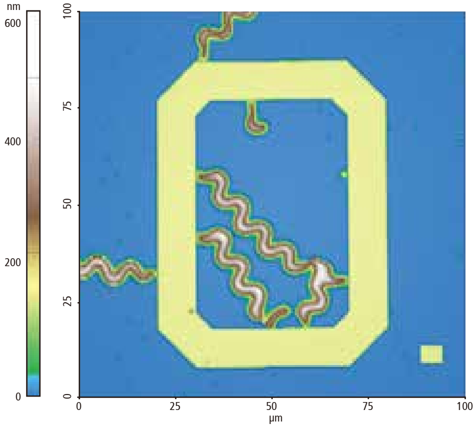
Non-contact

Height of position 1



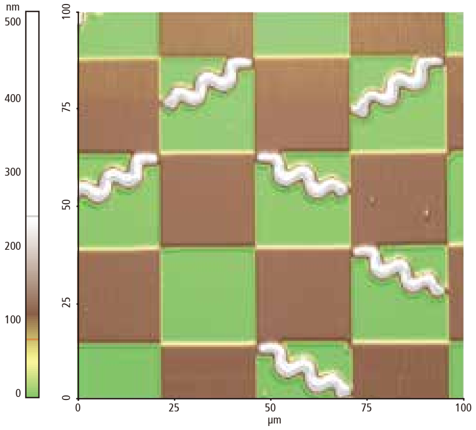
Peak to valley: 469.6 nm

Height of position 2



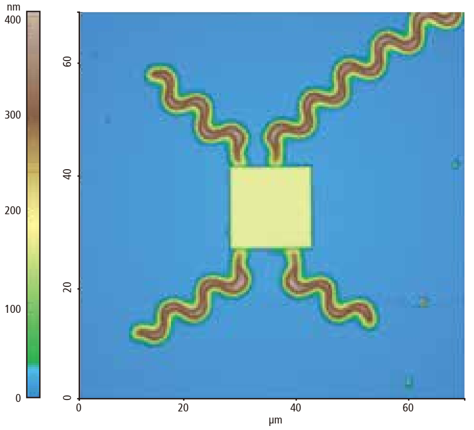
Peak to valley: 609.1 nm

Height of position 3



Peak to valley: 533.7 nm

Height of position 4



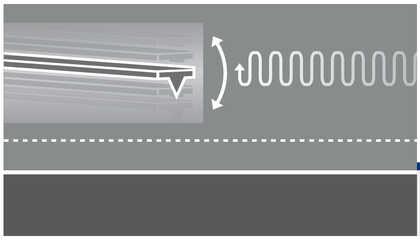
Peak to valley: 424.1 nm

- Mycelium growth on patterns involves the colonization and expansion of fungal mycelium, typically from spores, along a predetermined design or substrate. This process is characterized by its ability to conform to intricate patterns, forming a network of thread-like structures. Non-contact mode can successfully monitor such a delicate biological materials in hard patterns without any distortion.

Scanning conditions

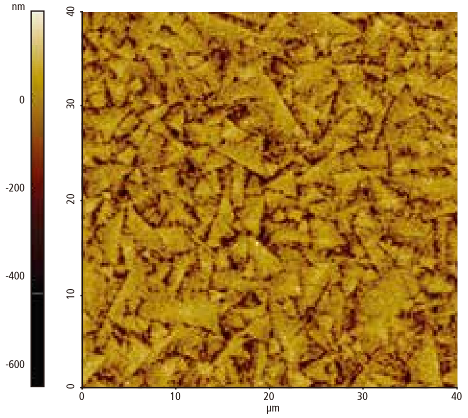
- System: NX20
- Scan Size: 100 µm × 100 µm, 70 µm × 70 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.5 Hz
- Cantilever: : AC240TS (k=2 N/m, f=70 kHz)
- Pixel Size: All 512 × 256

PCB

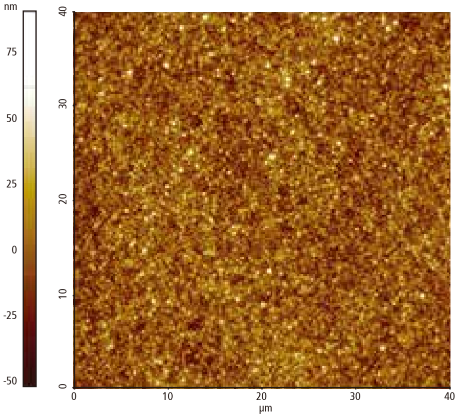


Non-contact

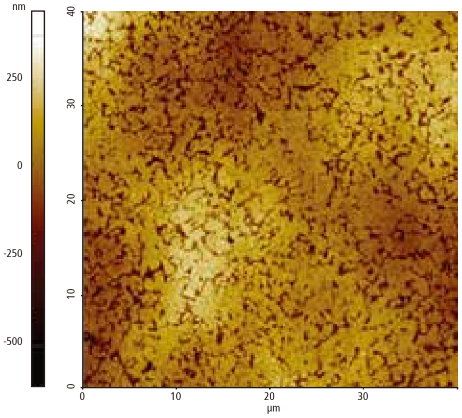
- **Height of fresh sample**



- **Height with coating**



- **Height without coating**

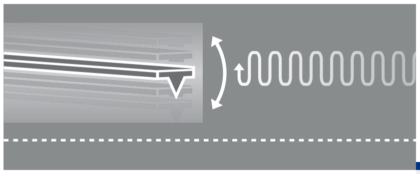


- The first sample is a fresh status by etching solution treatment.
  The second and third sample are PCB surface with electroplating and without electroplating.

Scanning conditions

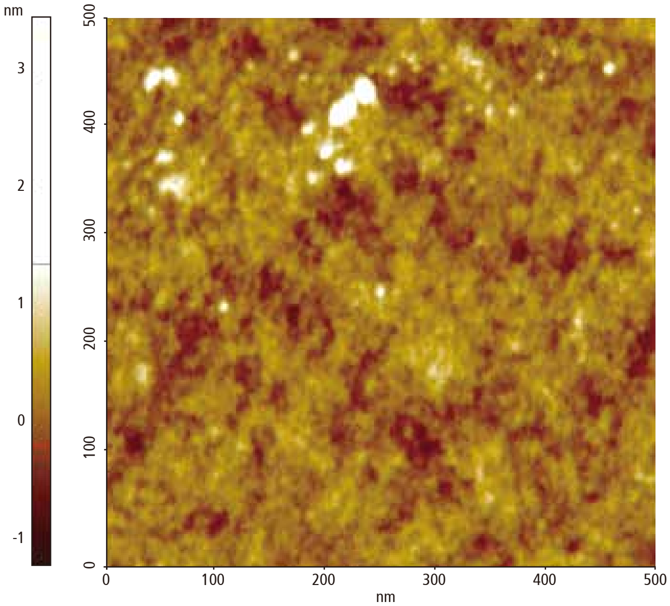
- System: NX-Wafer
- Scan Size: All 40 µm × 40 µm
- Scan Mode: Non-contact
- Scan Rate: All 0.5 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: All 512 × 256

PCB treated by silver nanoparticles



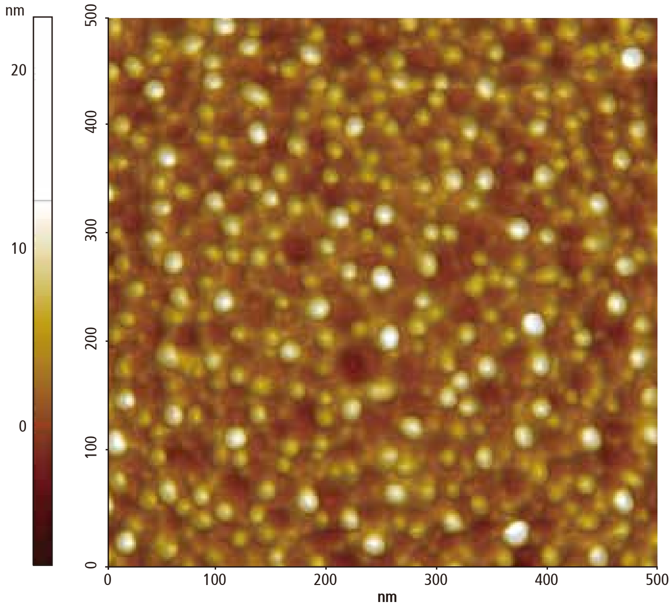
Non-contact

Height before treatment



Peak to valley: 4.7 nm

Height after treatment



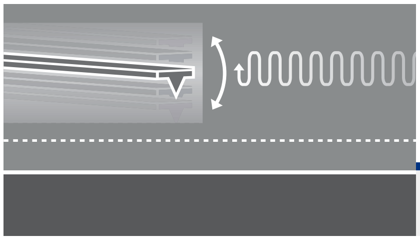
Peak to valley: 32.8 nm

- The above images are Cu pad of a PCB after treatment with the organic metal/silver nanoparticle finish. Treating the surface of the Cu pad with silver nanoparticles can effectively prevent oxidation and preserve solderability, eventually improve the overall electrical performance of the circuit.

Scanning conditions

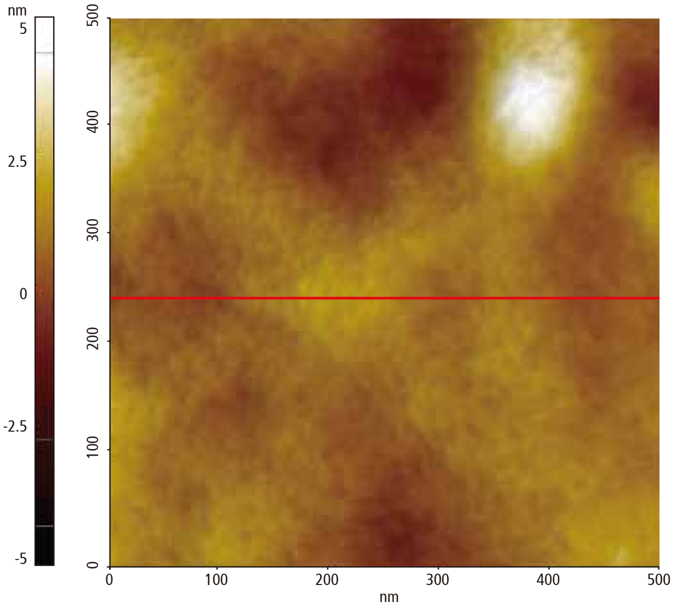
- System: FX40
- Scan Size: All 0.5 μm × 0.5 μm
- Scan Mode: Non-contact
- Scan Rate: All 2 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f= 320 kHz)
- Pixel Size: 256 × 256, 512 × 256

Poly (allylamine hydrochloride) (PAH)



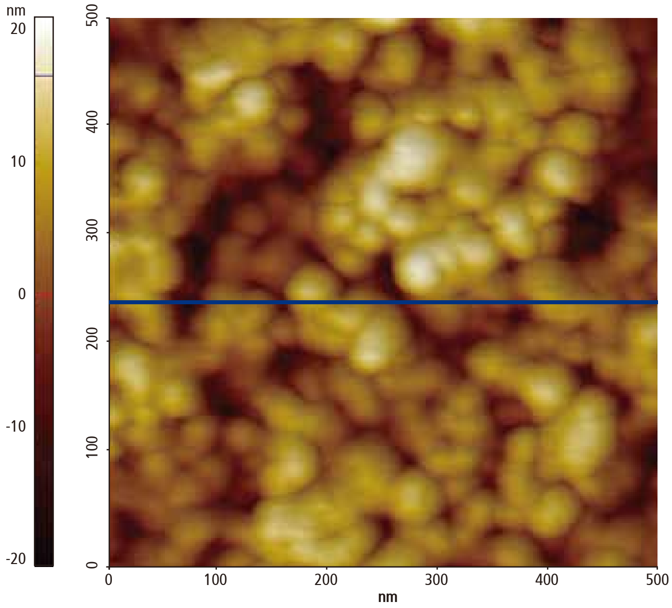
Non-contact

Height as assembled



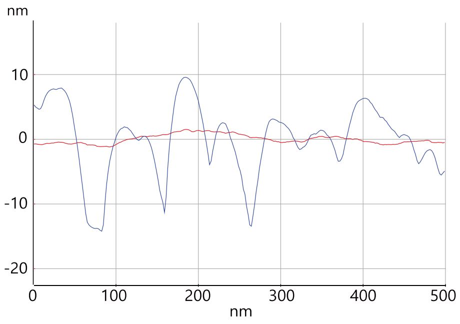
Peak to valley: 6.9 nm

Height after porous treatment



Peak to valley: 40.5 nm

Multi-line profile



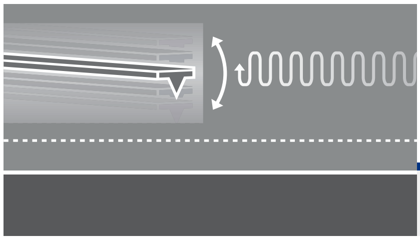
Roughness of whole region	Rq (nm)	Ra (nm)
PAH	0.984	0.707
Porous PAH	6.381	5.139

- Sample courtesy: Eun Kyung Lee, Biofunctional polymer lab., Chungnam national university, Korea

Scanning conditions

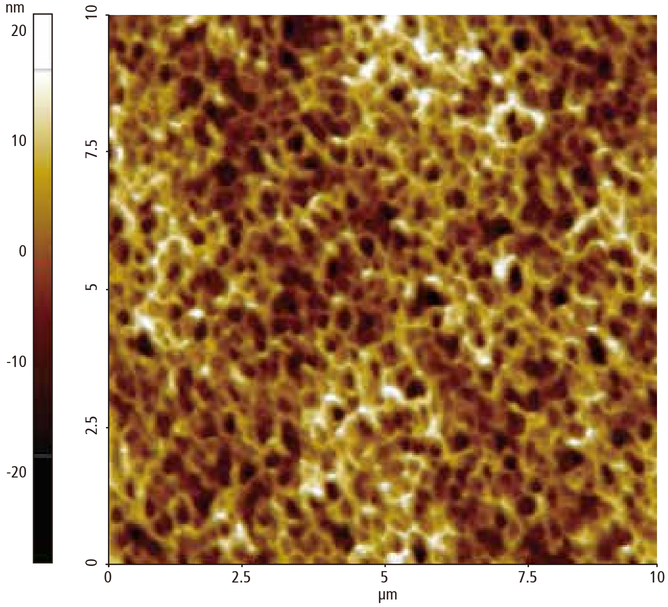
- System: FX40
- Scan Size: All 0.5 µm × 0.5 µm
- Scan Mode: Non-contact
- Scan Rate: All 1 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: All 256 × 256

Membrane filters in liquid



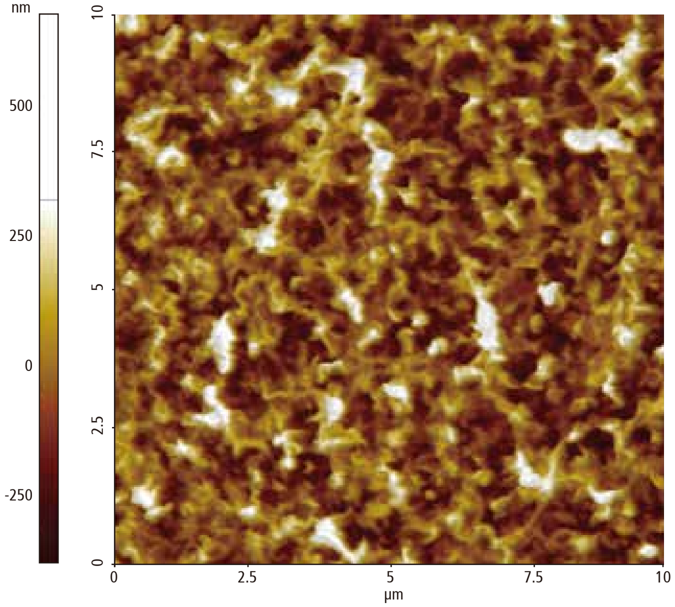
Non-contact

Height of UF membrane



Peak to valley: 50.9 nm

Height of RO membrane



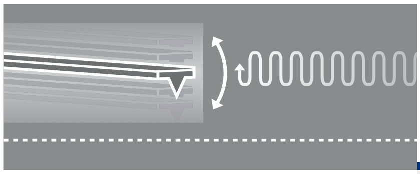
Peak to valley: 1.01 µm

- Membrane filters act as a microporous barrier of polymer, ceramic, or metallic material used to separate dissolved materials, colloids, or fine particles in solution. The filtration accuracy of ultrafiltration (UF) membrane is 10 to 100 nm, and that of reverse osmosis (RO) membrane is less than 1 nm. The differences in pore size for each membrane are shown in the above images.

Scanning conditions

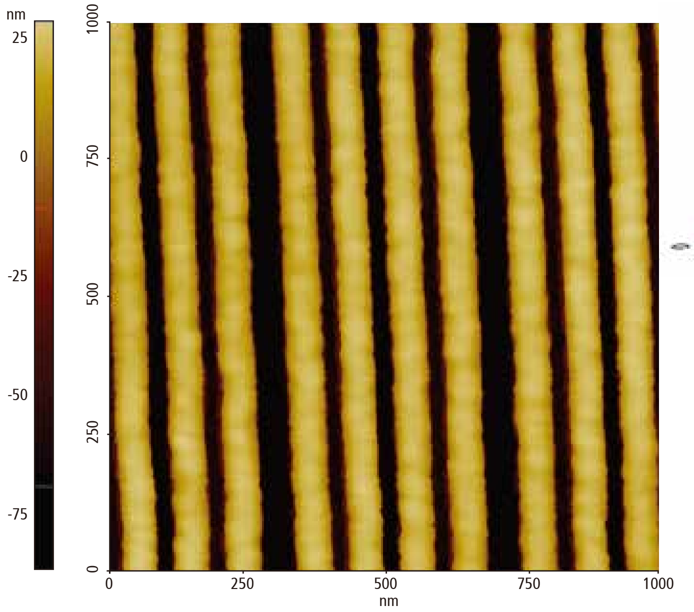
- System: FX40
- Scan Size: All 10 µm × 10 µm
- Scan Mode: Non-contact in liquid
- Scan Rate: All 1 Hz
- Cantilever: SCOUT 350 (k=42 N/m, f=350 kHz)
- Pixel Size: 512 × 512

Polymer electrolyte membrane (PEM)



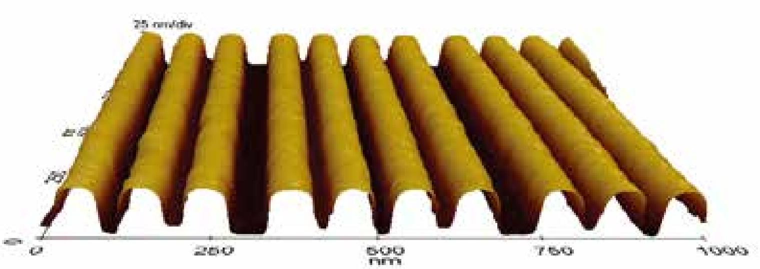
Non-contact

▪ Height

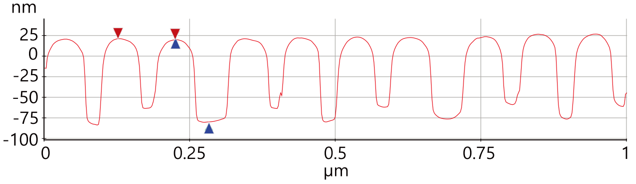


Peak to valley: 113.2 nm

▪ 3D & Line profile



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



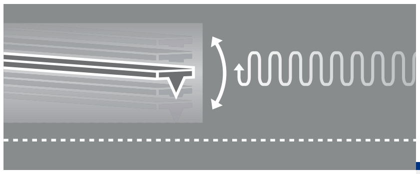
Cursor	ΔX (nm)	ΔY (nm)
🟥 Red	98.80	1.29
🟦 Blue	55.96	99.55

- Polymer electrolyte membrane (PEM) is a core material that makes up hydrogen fuel cells.
  It functions as a separation membrane that separates oxygen and hydrogen and as an electrolyte that transfers hydrogen cations from the anode electrode to the cathode electrode.
  The performance of PEM fuel cells can be improved with shape-controlled patterns.

Scanning conditions

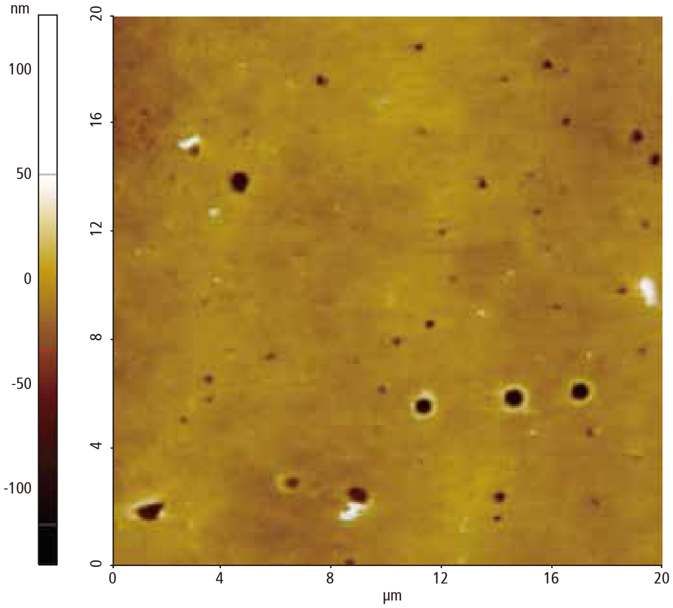
- System: FX40
- Scan Size: 1 µm × 1 µm
- Scan Mode: Non-contact
- Scan Rate: 0.3 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 512 × 256

Contact lens



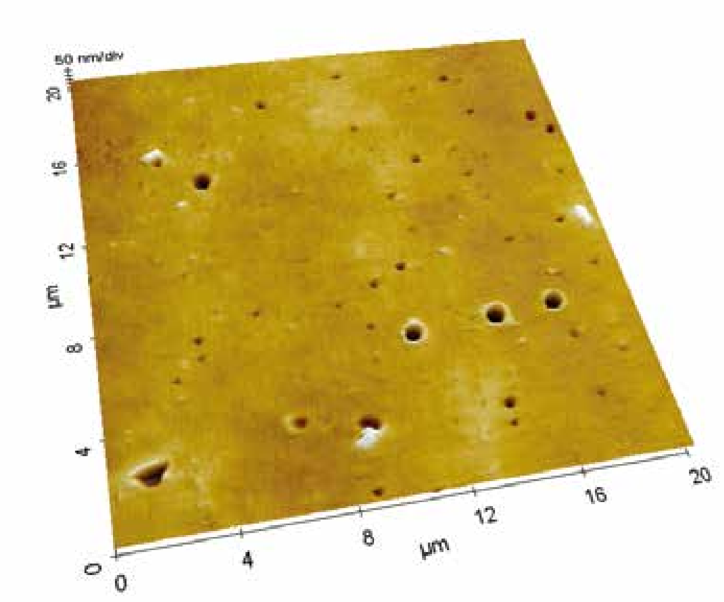
Non-contact

Height



Peak to valley: 286.4 nm

3D



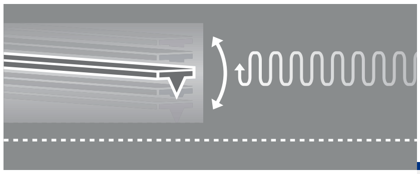
X:Y:Z scale = 1:1:5

- Contact lenses made of hydrogels or silicone hydrogels are designed for comfort, oxygen permeability, and optical performance. The surface morphology is critical for interactions with the tear film.
  The image measured using a liquid cell specifically designed to hold hemispherical contact lenses in liquid.

Scanning conditions

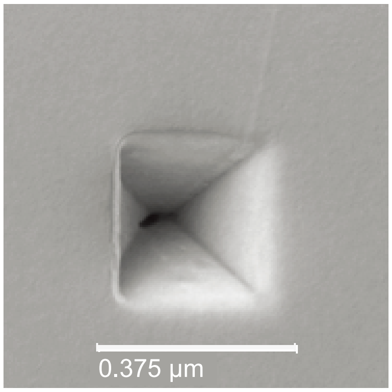
- System: NX10
- Scan Size: 20 µm × 20 µm
- Scan Mode: Non-contact in liquid
- Scan Rate: 0.7 Hz
- Cantilever: PPP-NCHR (k=42 N/m, f=320 kHz)
- Pixel Size: 512 × 256

Crystal originated particle (COP) defect

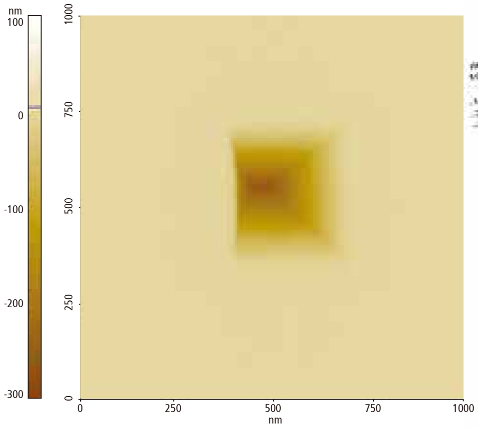


Non-contact

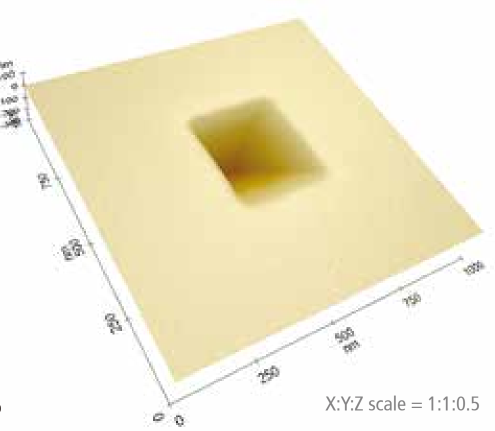
SEM



Height



3D



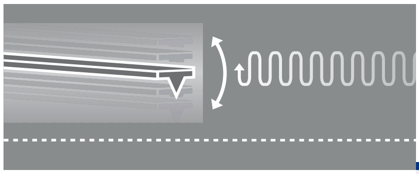
X:Y:Z scale = 1:1:0.5

- Crystal grown-in defect such as the Crystal Originated Particles (COPs), is the vacancy type of point defect delineated on the wafer surface and have the greatest impact on the quality of device performance.

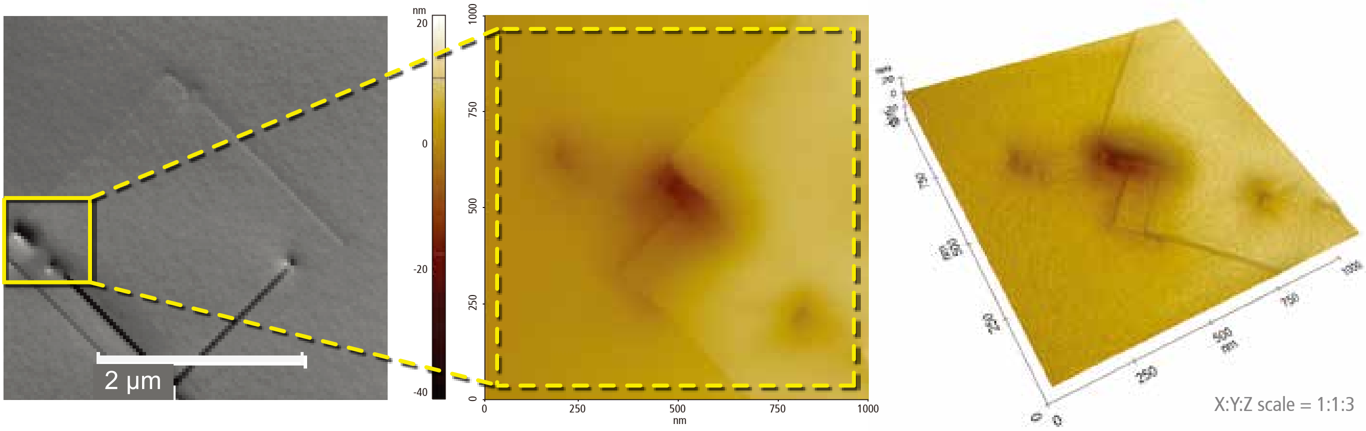
Scanning conditions

- 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: 256 × 256

Epi stacking fault (ESF) defect



Non-contact



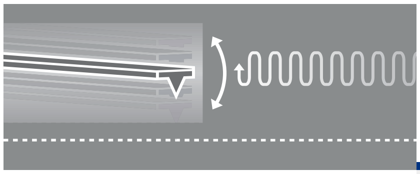
- **SEM**
- **Height**
- **3D**

- Epi Stacking Fault (ESF) is the most common crystallographic defect in epitaxial silicon wafers and is generated by various causes such as substrate particles, thermal stress, and lattice mismatch between the substrate and the epi layer.

Scanning conditions

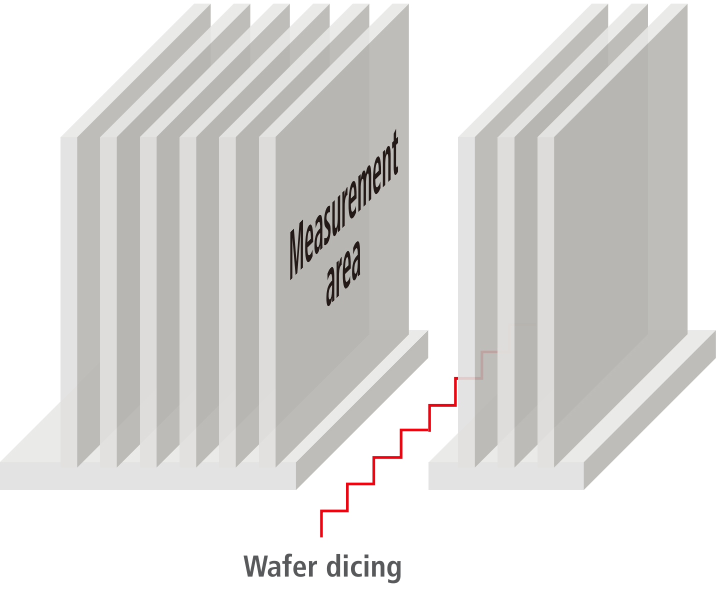
- System: NX-Wafer
- Scan Size: 1 µm × 1 µm
- Scan Mode: Non-contact
- Scan Rate: 1 Hz
- Cantilever: AC160TS (k=26 N/m, f=300 kHz)
- Pixel Size: 256 × 256

Diced silicon wafer with etched trench

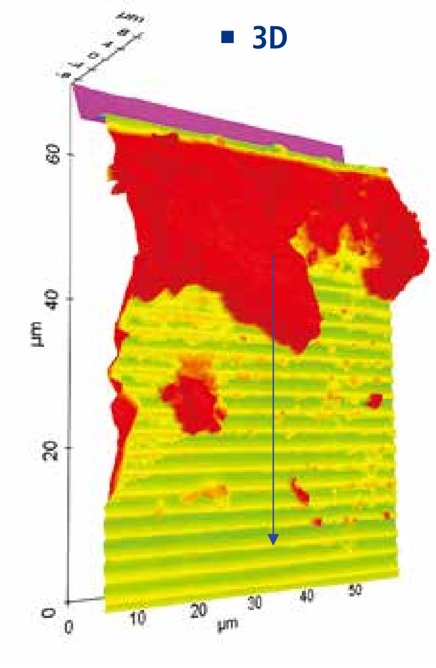


Non-contact

■ Measurement area

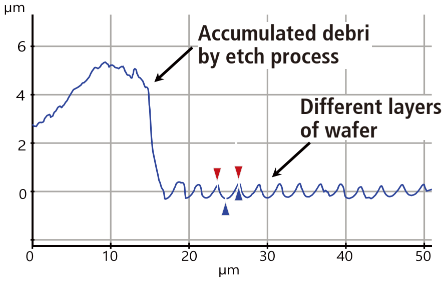


■ 3D



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

■ Line profile



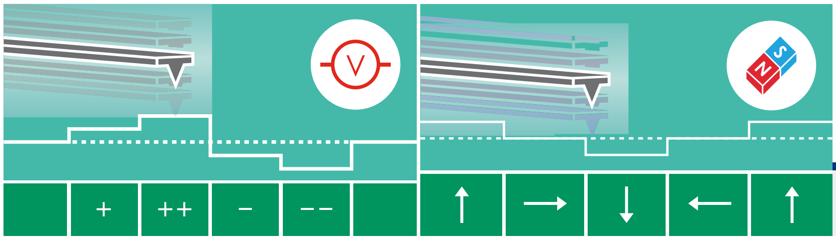
Cursor	ΔX (μm)	ΔY (μm)
🟥 Red	2.76	0.06
🟦 Blue	1.67	0.62

- Sample courtesy: Plasma Therm, USA

Scanning conditions

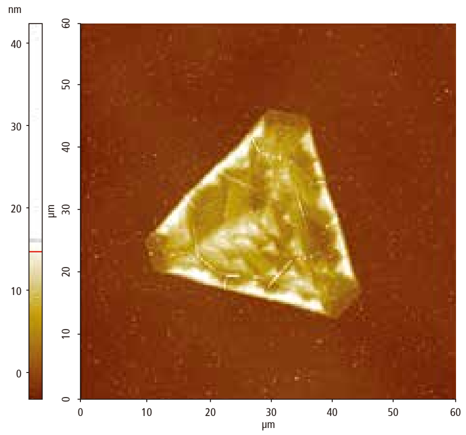
- System: NX20
- Scan Size: 50 μm × 70 μm
- Scan Mode: Non-contact
- Scan Rate: 0.1 Hz
- Cantilever: EBD4-200 (k=40 N/m, f=320 kHz)
- Pixel Size: 256 × 1024

Tungsten disulfide (WS_2)



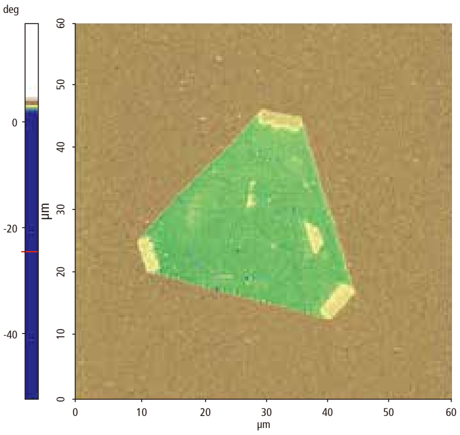
Sideband KPFM, MFM

■ Height

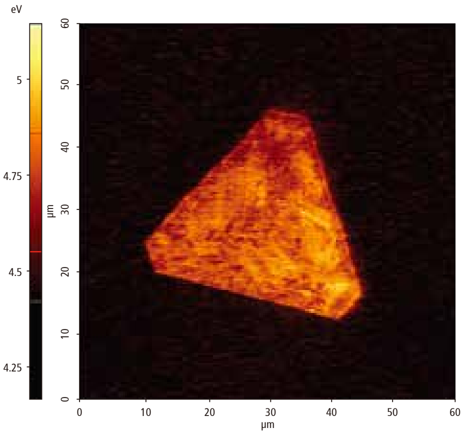


Peak to valley: 3.7 nm

■ MFM Phase



■ Work Function



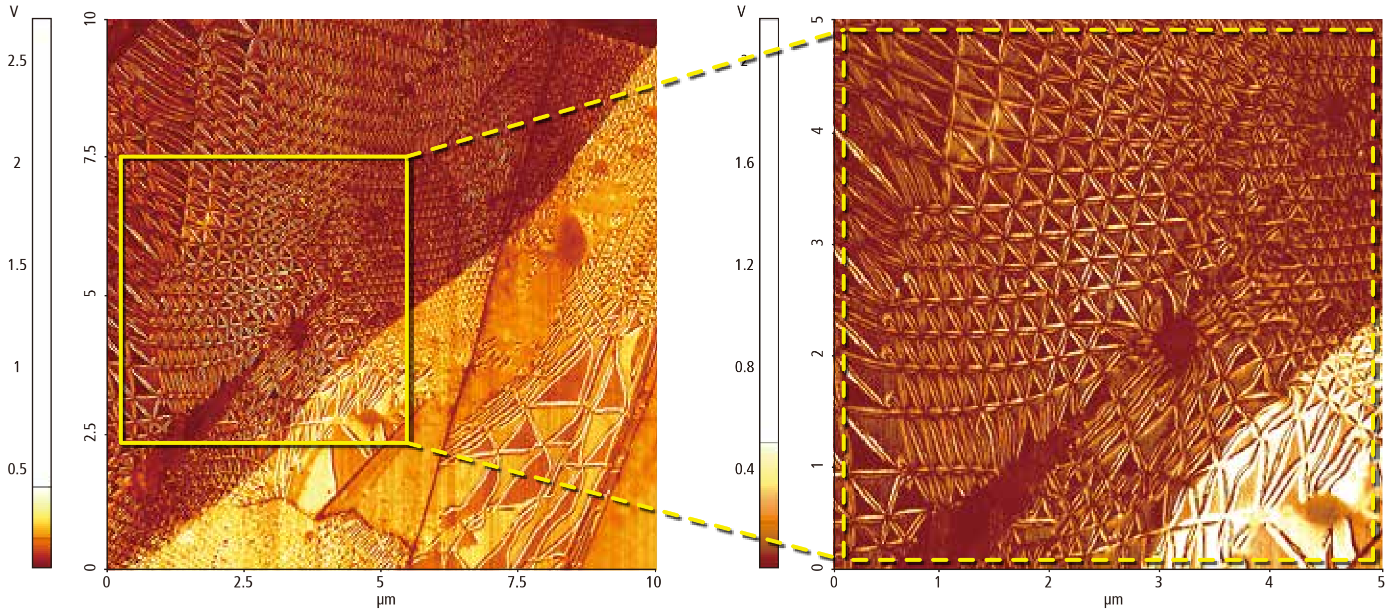
Mean: 4.51 eV

Scanning conditions

- System: NX20 Lite
- Scan Size: 60 µm × 60 µm
- Scan Mode: Sideband KPFM, MFM
- Scan Rate: 0.4 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 512 × 256

Twisted hBN bilayer

Piezoresponse Force Microscopy (PFM)



- **PFM Amplitude**
- **Zoom in PFM Amplitude**

Mean: 183.84 mV

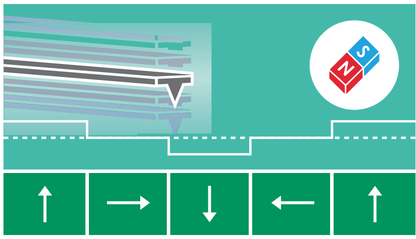
Mean: 127.02 mV

- Contact resonance PFM (CR-PFM) was used to visualize ferroelectric superlattices within a vertical homostructure of marginally twisted hBN flakes.
  The interfacial ferroelectricity arises due to the registry of the top and bottom hBN layers, leading to net out-of-plane electric fields in the parallel stacking configuration.

Scanning conditions

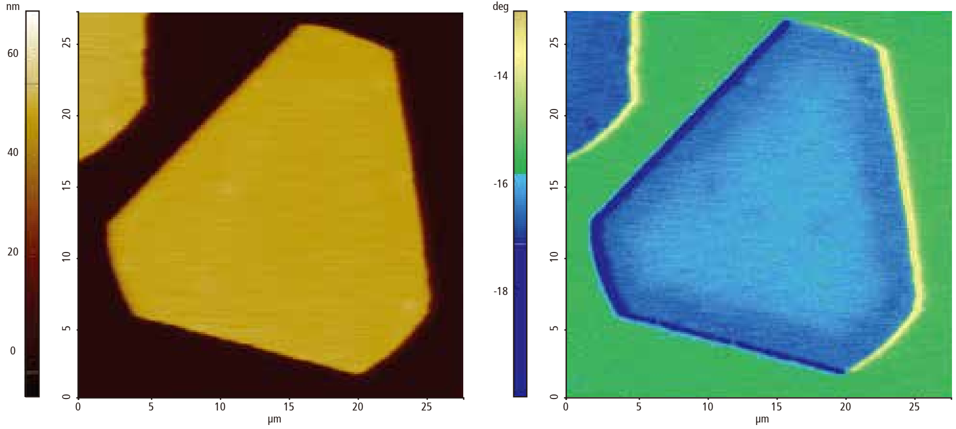
▪ System: NX10	▪ Scan Mode: Contact Resonance PFM	▪ Cantilever: ElectriMulti 75-G (k=2.5 N/m, f=75 kHz)
▪ Scan Size: 10 µm × 10 µm, 5 µm × 5 µm	▪ Scan Rate: All 0.5 Hz	▪ Pixel Size: 1024 × 2048, 512 × 1024

CVD-grown MoS_2



Magnetic Force Microscopy (MFM)

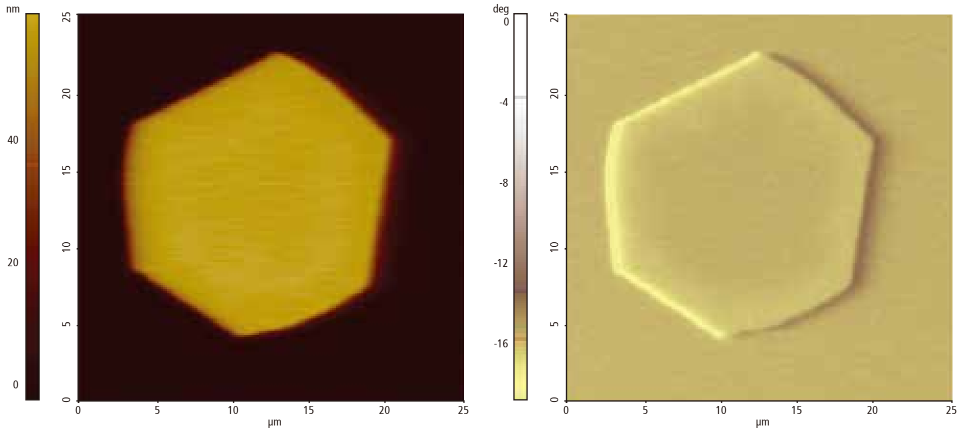
Concave triangle shaped MoS_2



- **Height**
- **MFM Phase**

Peak to valley: 56.6 nm

Hexagon shaped MoS_2



- **Height**
- **MFM Phase**

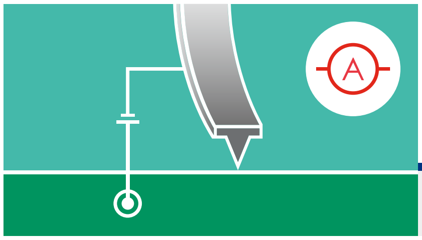
Peak to valley: 62.1 nm

- Two-Dimensional Transition Metal Dichalcogenides (TMDs).

Scanning conditions

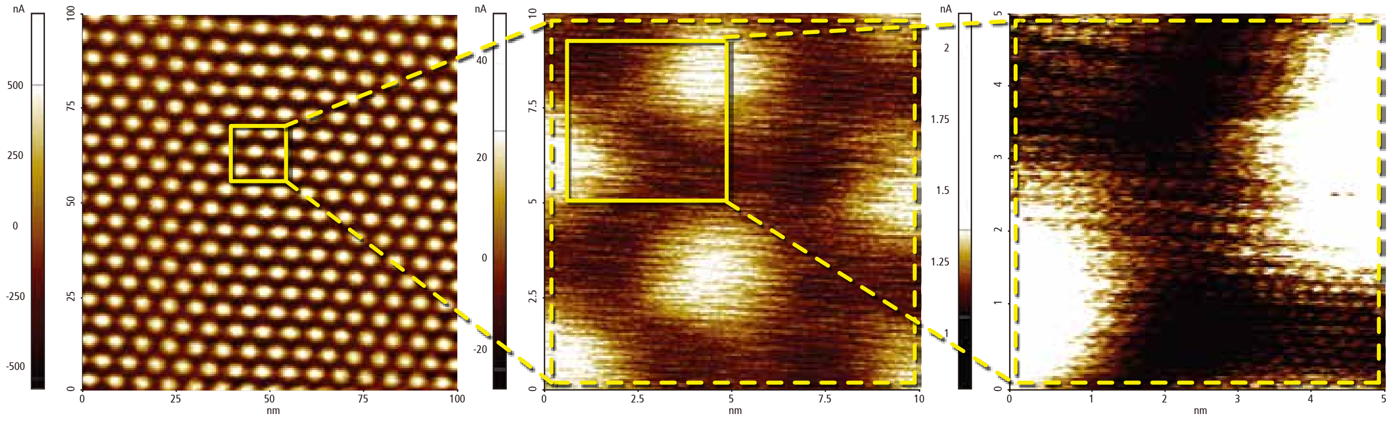
- System: NX10
- Scan Size: 28 µm × 28 µm, 25 µm × 25 µm
- Scan Mode: MFM
- Scan Rate: All 1 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 512 × 512, 256 × 256

Graphene on hBN (1/3)



Conductive Atomic Force Microscopy (C-AFM)

- Current of 100 nm scan
- Zoom in Current (10 nm scan)
- Zoom in Current (5 nm scan)



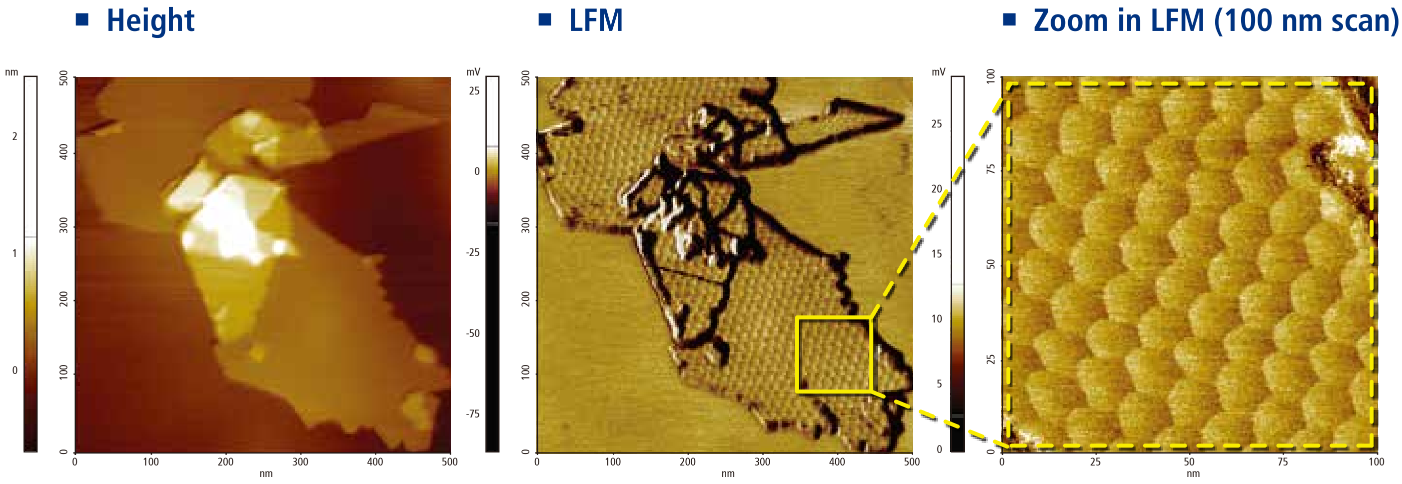
- The images above show a finer periodicity that can be attributed to the graphene lattice.

Scanning conditions

- System: NX10
- Scan Size: 100 nm × 100 nm, 10 nm × 10 nm, 5 nm × 5 nm
- Sample bias: 0.5 V, 1 V, 0.29 V
- Scan Mode: C-AFM
- Scan Rate: 35 Hz, 30 Hz, 30 Hz
- Cantilever: NSC36/Pt C type (k=0.6 N/m, f=65 kHz)
- Pixel Size: All 256 × 256

Graphene on hBN (2/3)

Contact, LFM



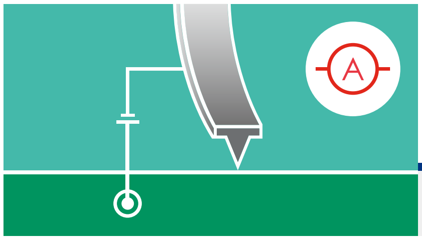
- **Height**
- **LFM**
- **Zoom in LFM (100 nm scan)**

- The images above were measured on a 10 µm scanner with closed loop, XY servo gain set to 0.1.

Scanning conditions

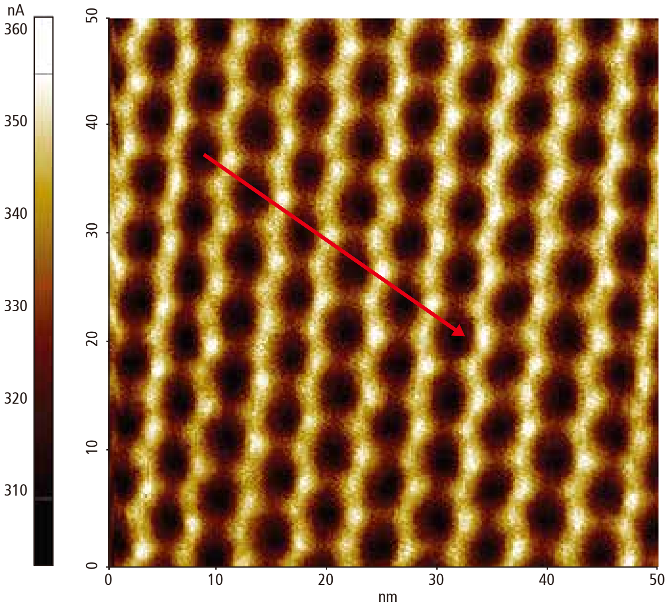
- System: NX10
- Scan Size: 0.5 µm × 0.5 µm, 0.1 µm × 0.1 µm
- Scan Mode: Contact, LFM
- Scan Rate: 3 Hz, 10 Hz
- Cantilever: NSC19/Al BS (k=0.6 N/m, f=65 kHz)
- Pixel Size: 1024 × 1024, 512 × 512

Graphene on hBN (3/3)

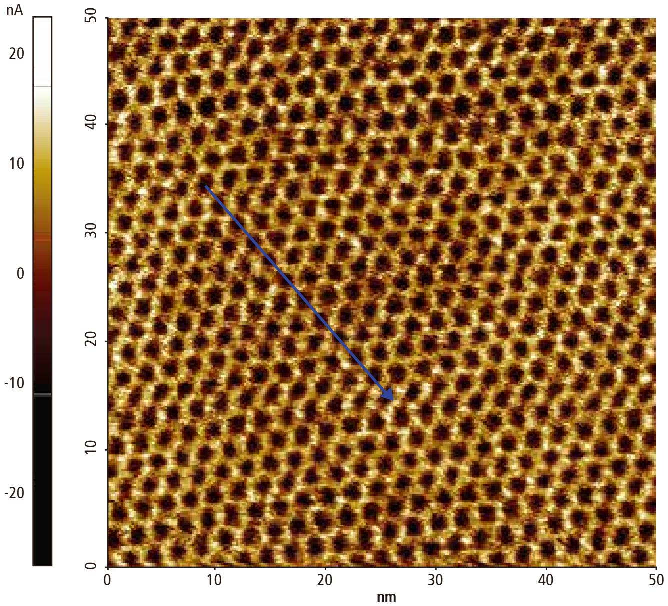


Conductive Atomic Force Microscopy (C-AFM)

Current of position 1

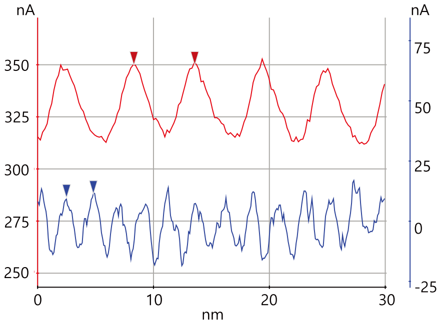


Current of position 2



- The images above were measured on a 10 μm scanner with closed loop, XY servo gain set to 0.1.

Multi-line profile

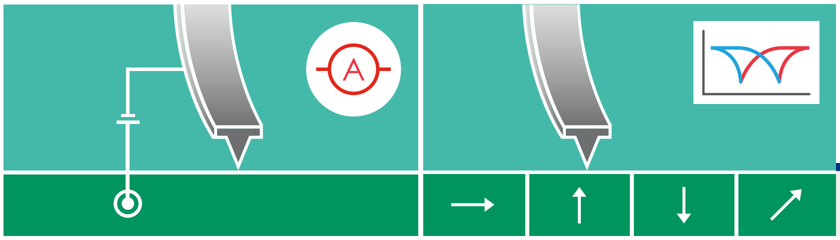


Cursor	ΔX (nm)
🟥 Red	5.5
🟦 Blue	2.2

Scanning conditions

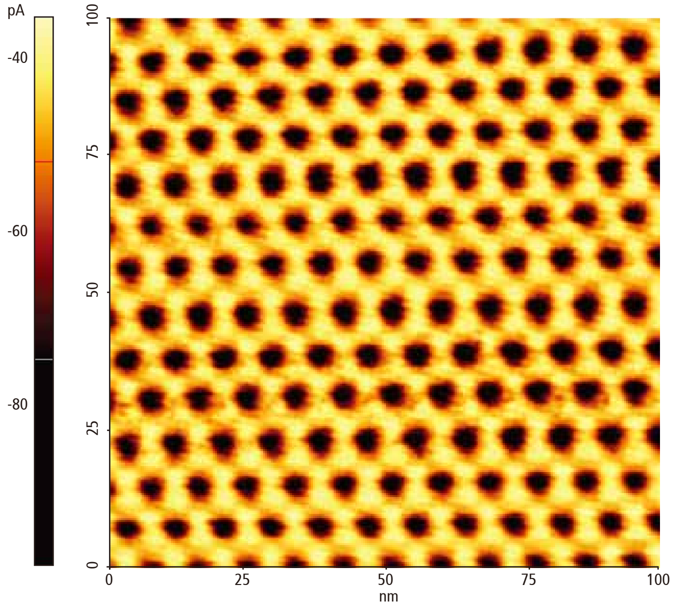
- System: NX10
- Scan Size: All 50 nm × 50 nm
- Scan Mode: C-AFM
- Scan Rate: All 20 Hz
- Cantilever: NSC36/Pt C type (k=0.6 N/m, f=65 kHz)
- Pixel Size: 256 × 256, 512 × 512

Twisted bilayer graphene on hBN (1/2)



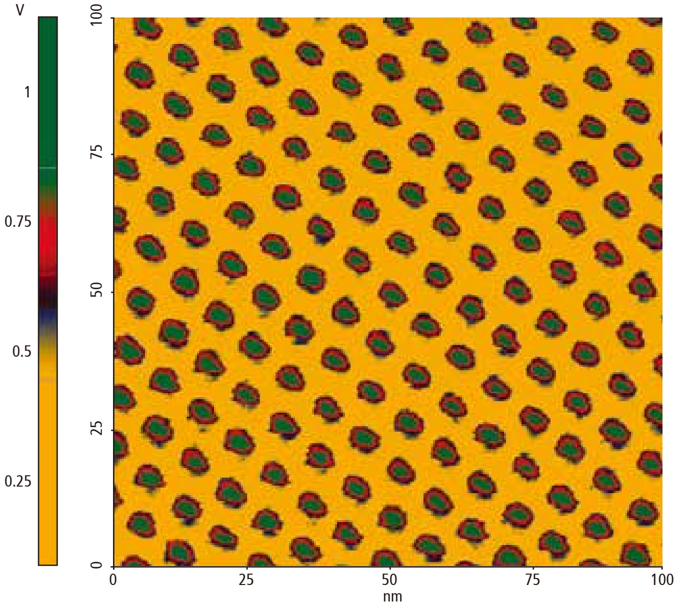
Conductive AFM (C-AFM), CR-PFM

Current of 100 nm scan

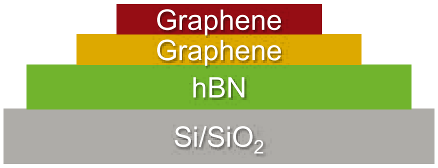


Mean: 65.4 pA

PFM Amplitude of 100 nm scan



Sample structure



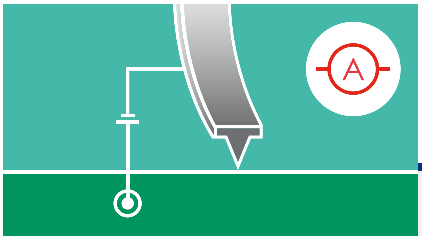
- The moiré pattern in twisted bilayer graphene results from the interference between the hexagonal lattices of two graphene layers that are rotated at a specific angle relative to each other. This rotation creates a superlattice with a characteristic spatial modulation, giving rise to a visually striking pattern observable in AFM, particularly C-AFM and PFM.

• Sample courtesy: Yuta Seo, Jimpei Kawase, Tomoki Machida, Institute of Industrial Science, The University of Tokyo, Japan

Scanning conditions

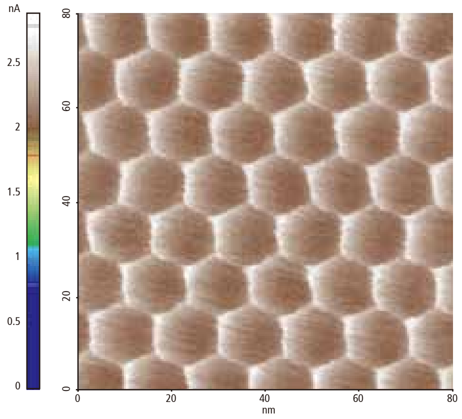
- System: FX40
- Scan Size: All 100 nm × 100 nm
- Scan Mode: C-AFM, CR-PFM
- Scan Rate: 1.5 Hz, 2.5 Hz
- Cantilever: SPARK 70 Pt (k=2 N/m, f=70 kHz)
- Pixel Size: All 256 × 256

Twisted bilayer graphene on hBN (2/2)



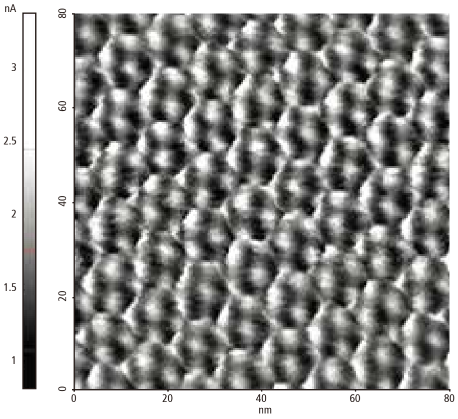
Conductive Atomic Force Microscopy (C-AFM)

Current @ P1 (80 nm scan)



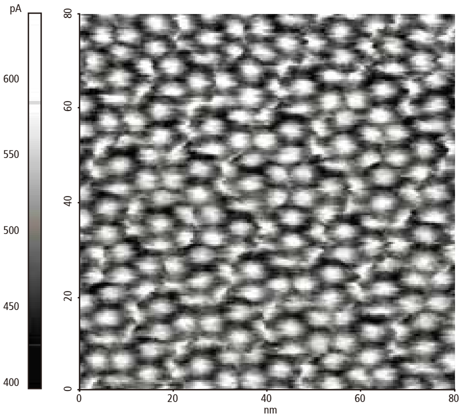
Mean: 0.92 nA

Current @ P2 (80 nm scan)



Mean: 2.6 nA

Current @ P3 (80 nm scan)



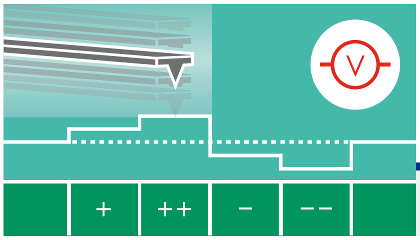
Mean: 5.6 nA

- Sample courtesy: Yuta Seo, Jimpei Kawase, Tomoki Machida, Institute of Industrial Science, The University of Tokyo, Japan

Scanning conditions

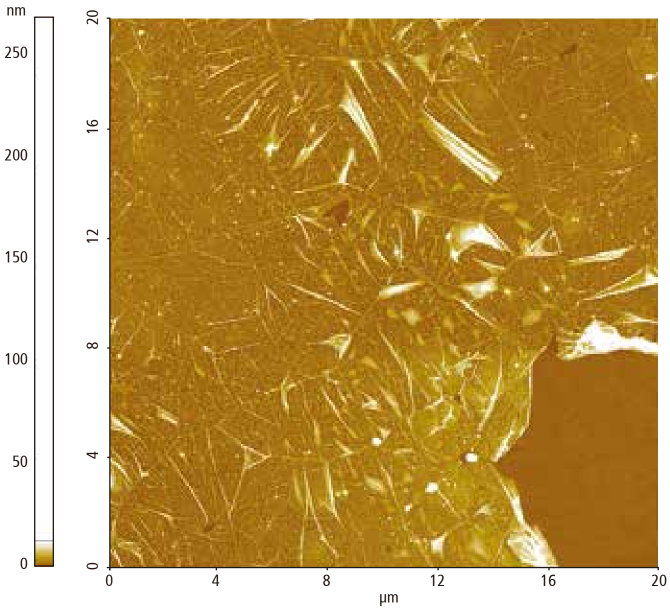
- System: FX40
- Scan Size: All 80 nm × 80 nm
- Scan Mode: C-AFM
- Scan Rate: 1 Hz, 1 Hz, 1.5 Hz
- Cantilever: SPARK 70 Pt (k=2 N/m, f=70 kHz)
- Pixel Size: All 256 × 256

Multi-layer graphene (1/2)



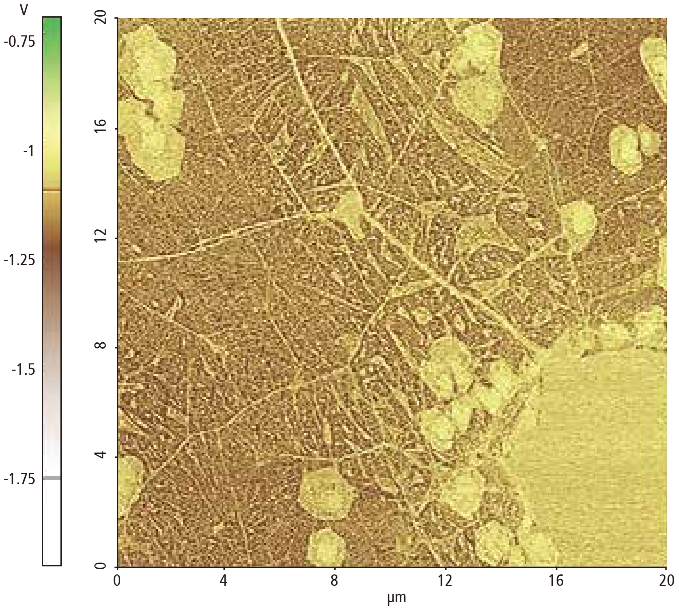
Kelvin Probe Force Microscopy (KPFM)

■ Height



Peak to valley: 280.1 nm

■ Potential



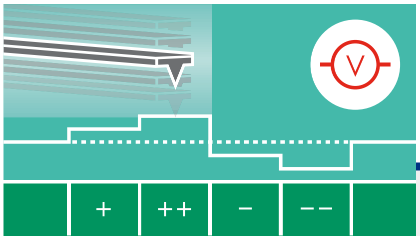
Mean: -1.14 V

- KPFM measurement on multi-layer graphene involves probing the potential variations across the material's surface with high spatial resolution.
Graphene flakes, which are difficult to clearly see in the height image, can be more obviously distinguished in the potential image.

Scanning conditions

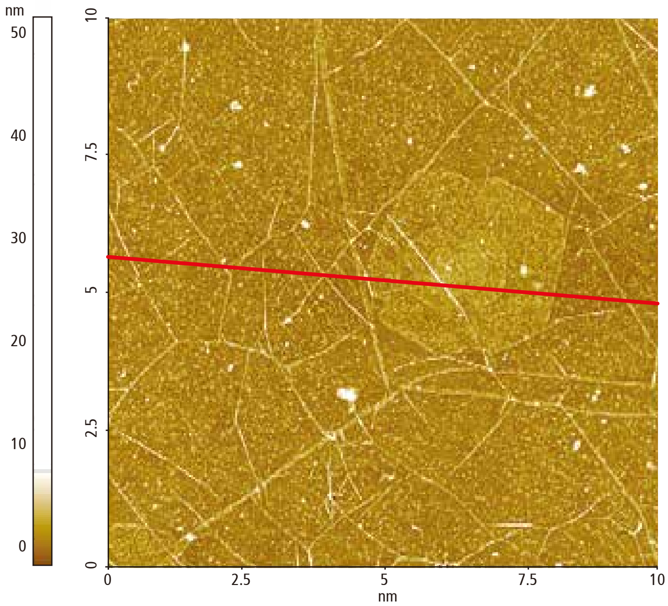
- System: FX40
- Scan Size: 20 µm × 20 µm
- Scan Mode: Sideband KPFM
- Scan Rate: 0.4 Hz
- Cantilever: NSC36/Cr-Au C type (k=0.6 N/m, f=65 kHz)
- Pixel Size: 1024 × 512

Multi-layer graphene (2/2)



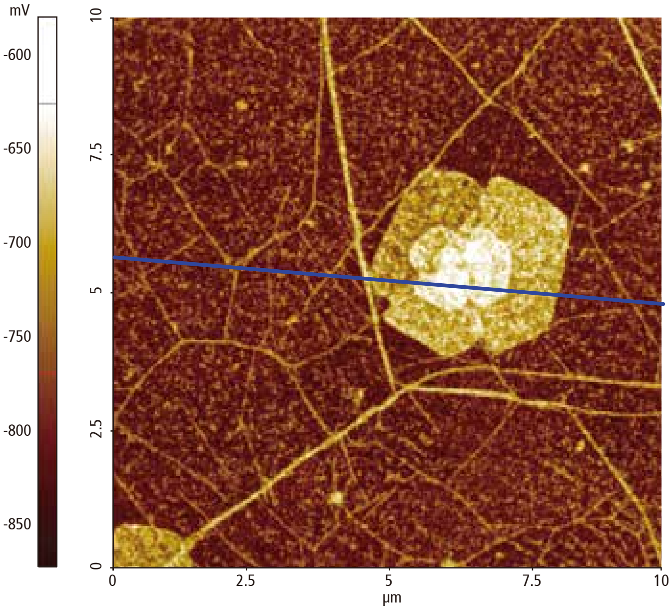
Kelvin Probe Force Microscopy (KPFM)

▪ Height



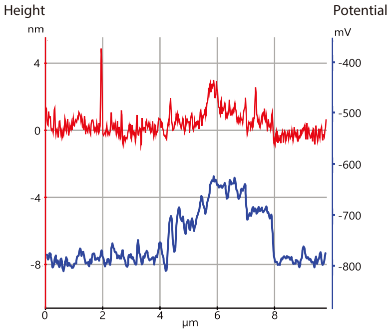
Peak to valley: 53.2 nm

▪ Potential



Mean: -777.94 mV

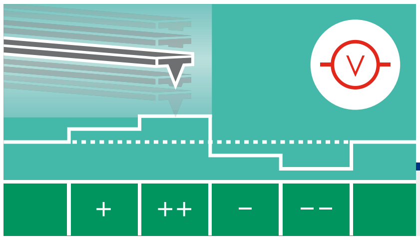
▪ Multi-line profile



Scanning conditions

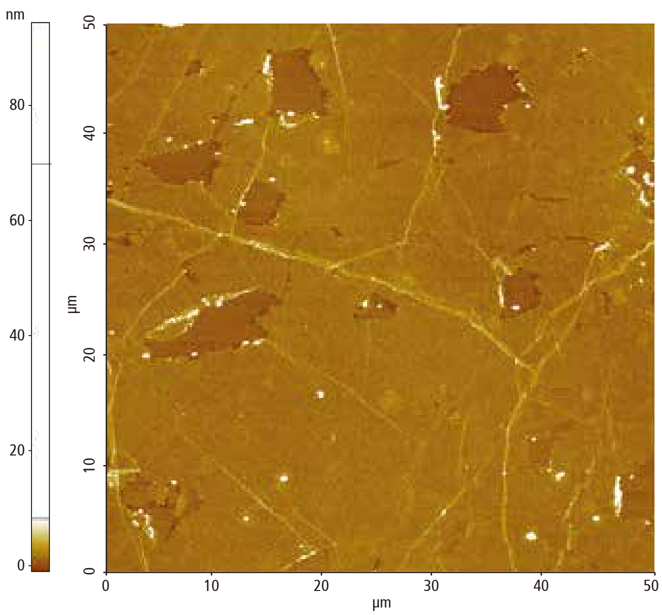
- System: FX40
- Scan Size: 10 μm × 10 μm
- Scan Mode: Sideband KPFM
- Scan Rate: 0.6 Hz
- Cantilever: NSC36/Cr-Au C type (k=0.6 N/m, f=65 kHz)
- Pixel Size: 512 × 256

Graphene transferred wafer



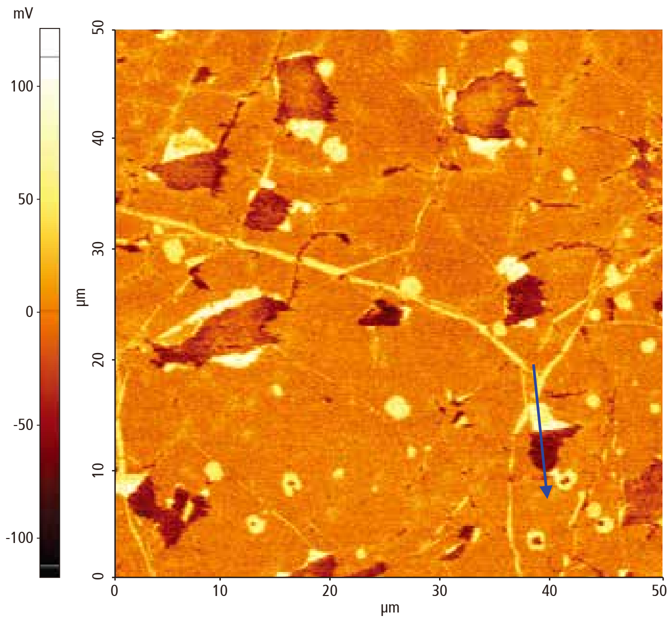
Kelvin Probe Force Microscopy (KPFM)

Height



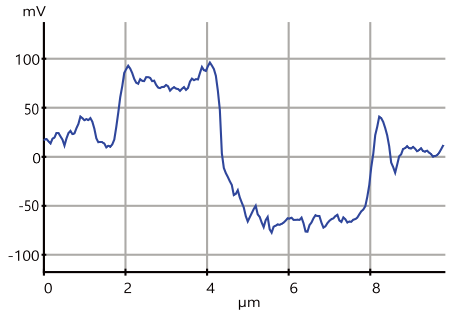
Peak to valley: 99.0 nm

Potential



Mean: -20.27 mV

Line profile

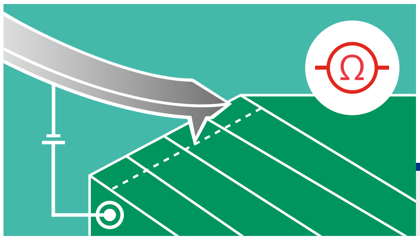


- AFM can measure the morphology of graphene transferred wafer and the potential difference between graphene and substrate.

Scanning conditions

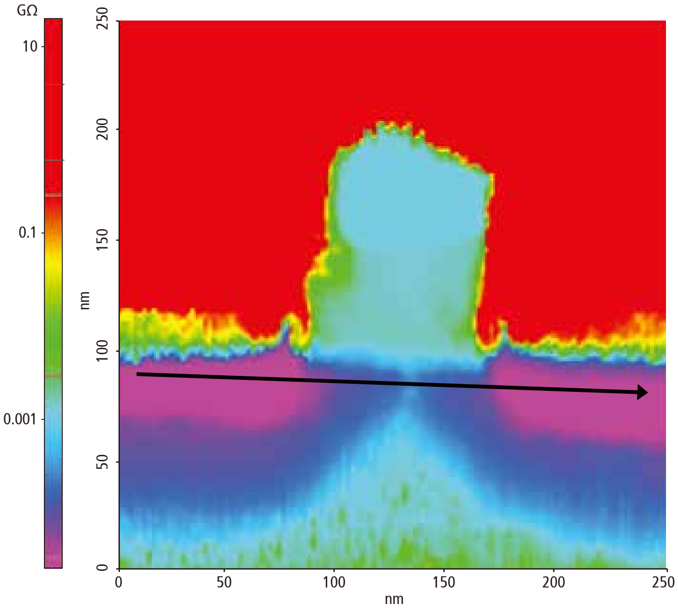
- System: FX40
- Scan Size: 50 µm × 50 µm
- Scan Mode: Sideband KPFM
- Scan Rate: 0.3 Hz
- Cantilever: NSC36/Cr-Au C type (k=0.6 N/m, f=65 kHz)
- Pixel Size: 1024 × 256

DRAM test sample with 68 nm channel



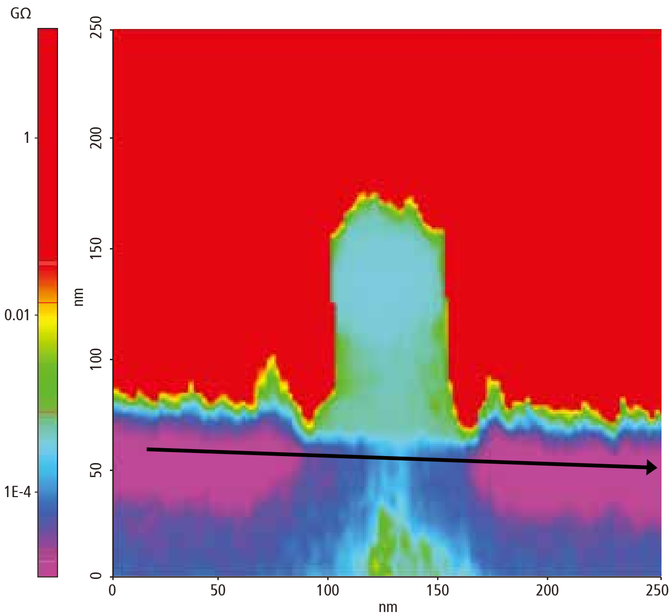
Scanning Spreading Resistance Microscopy (SSRM)

▪ Resistance of position 1



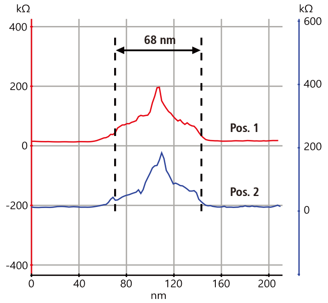
Peak to valley: 27.5 GΩ

▪ Resistance of position 2



Peak to valley: 18.1 GΩ

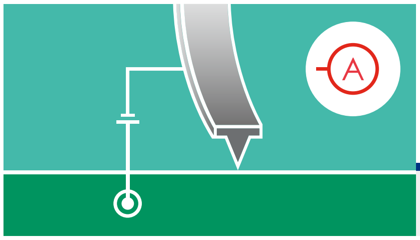
▪ Multi-line profile



Scanning conditions

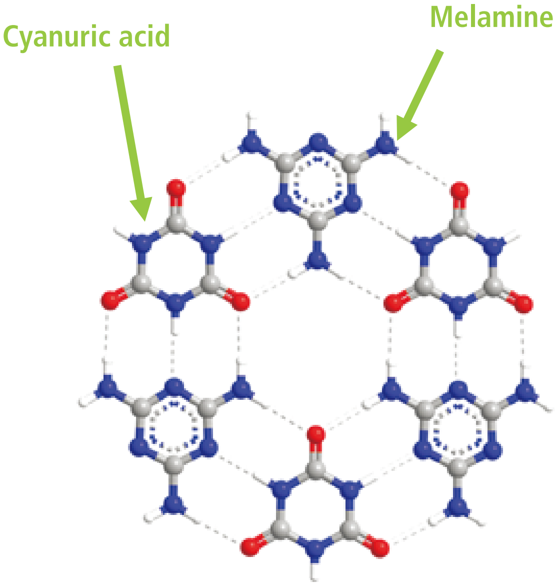
- System: NX-Hivac
- Scan Size: All 250 nm × 250 nm
- Sample Bias: 1 V
- Scan Mode: SSRM
- Scan Rate: All 2 Hz
- Cantilever: CDT-NCHR (k=72 N/m, f=210 kHz)
- Pixel Size: All 128 × 128

Melamine cyanurate

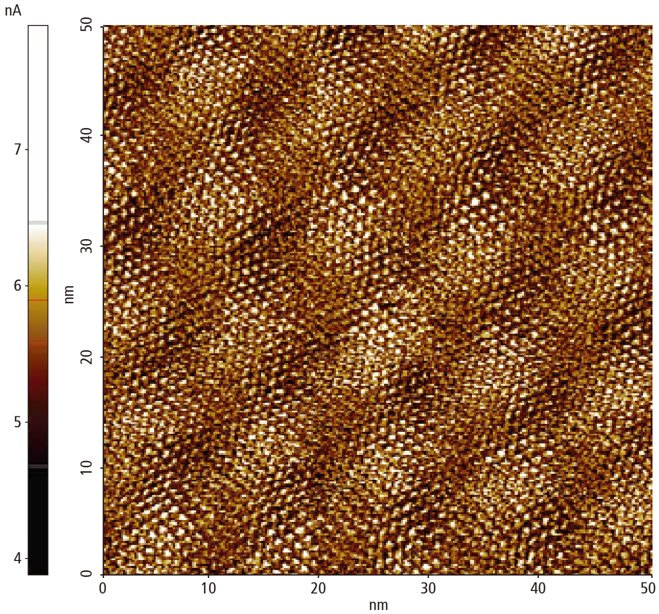


Conductive Atomic Force Microscopy (C-AFM)

▪ Theoretical model



▪ Current of 50 nm scan



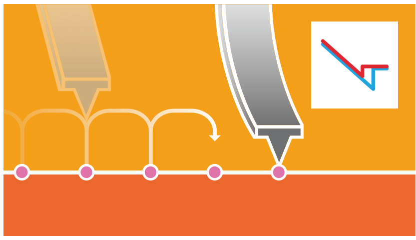
Mean: 5.59 nA

- A conductive AFM scan of melamine-cyanuric acid network on HOPG acquired with internal C-AFM on NX10. This is a remarkable image, since previously only STM was able to achieve such resolution in electrical modes, shows molecular structures of cyanuric acid and melamine.

Scanning conditions

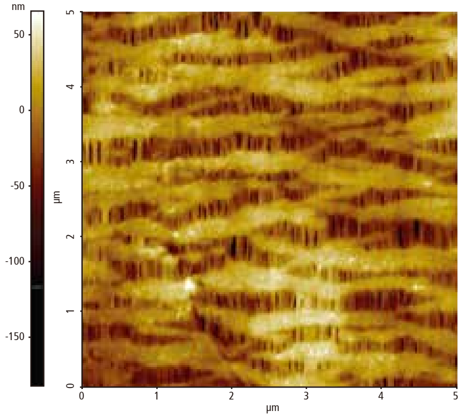
- System: NX10
- Scan Size: 50 nm × 50 nm
- Sample Bias: 0.17 V
- Scan Mode: C-AFM
- Scan Rate: 20 Hz
- Cantilever: NSC36/Pt C type (k= 0.6 N/m, f= 65 kHz)
- Pixel Size: 512 × 512

Lithium battery diaphragm (Separator)



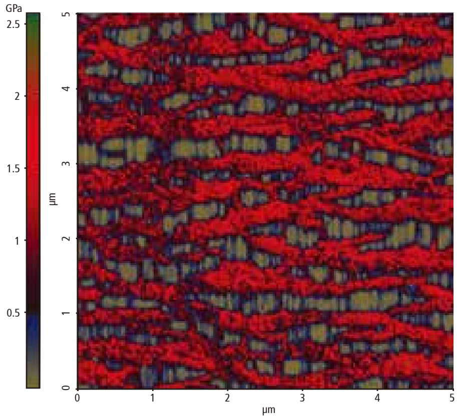
PinPoint Nanomechanical

Height



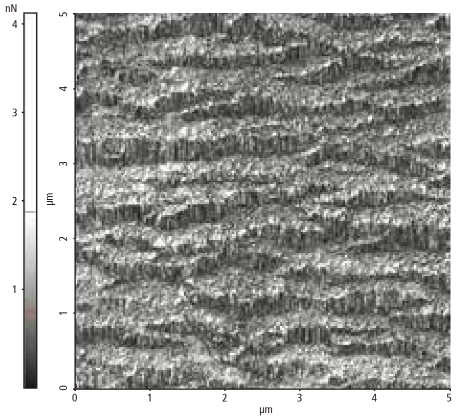
Peak to valley: 109.8 nm

Modulus



Mean: 800.2 MPa

Adhesion

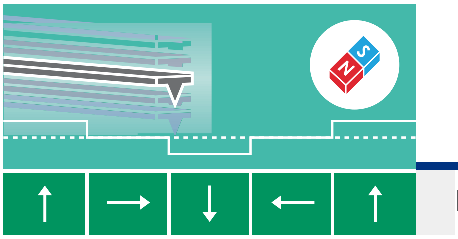


Mean: 0.77 nN

Scanning conditions

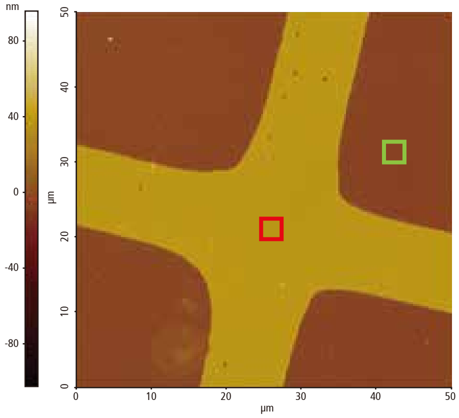
- System: FX40
- Scan Size: 5 µm × 5 µm
- Scan Mode: PinPoint nanomechanical
- Scan Rate: 0.4 Hz
- Cantilever: NSC36/Al BS A type (k=1 N/m, f=90 kHz)
- Pixel Size: 256 × 256

$SrRuO_3$ (SRO) on $SrTiO_3$ (STO) substrate



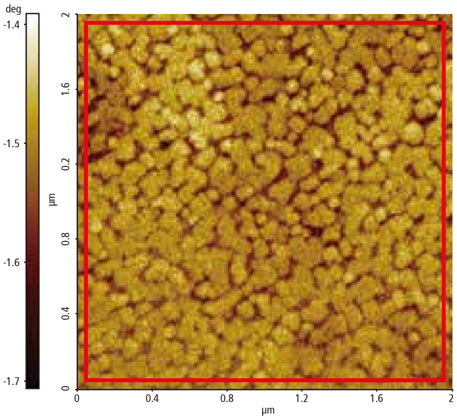
Magnetic Force Microscopy (MFM)

Height

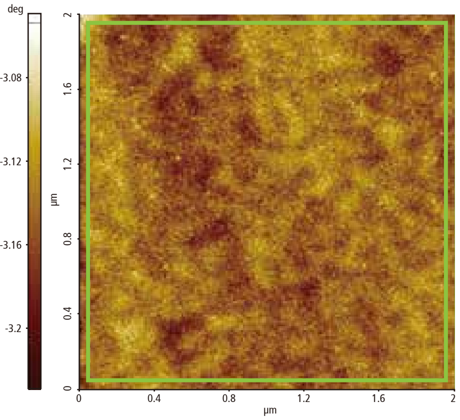


Peak to valley: 108.3 nm

MFM Phase on SRO



MFM Phase on STO

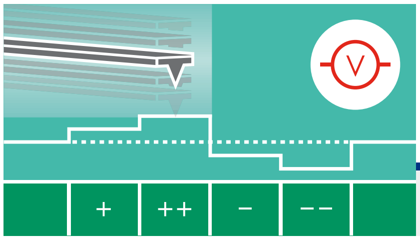


• Sample courtesy: Mi Jin Jin, Center for multidimensional carbon materials, Institute for basic science, Korea

Scanning conditions

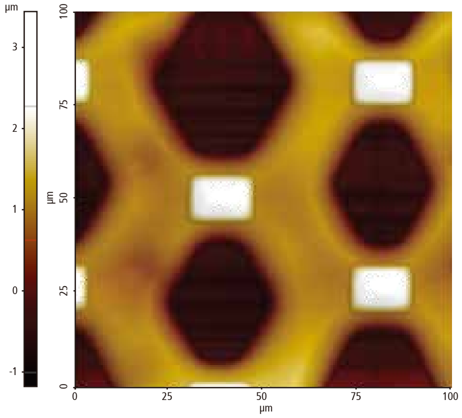
- System: FX40
- Scan Size: 50 μm × 50 μm, 2 μm × 2 μm
- Scan Mode: MFM
- Scan Rate: 0.25 Hz, 0.5 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: All 512 × 256

LCD panel



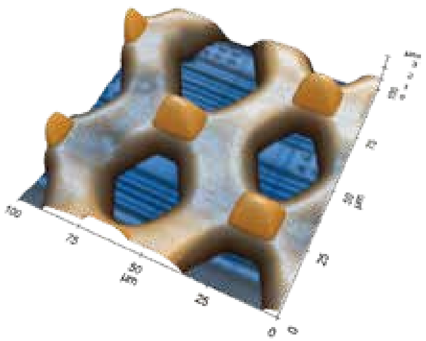
Kelvin Probe Force Microscopy (KPFM)

■ Height



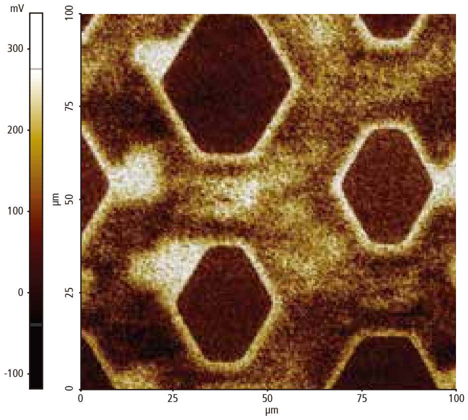
Peak to valley: 3.82 µm

■ 3D (Edge enhanced color)



X:Y:Z scale = 1:1:5

■ Potential



Mean: 101.42 mV

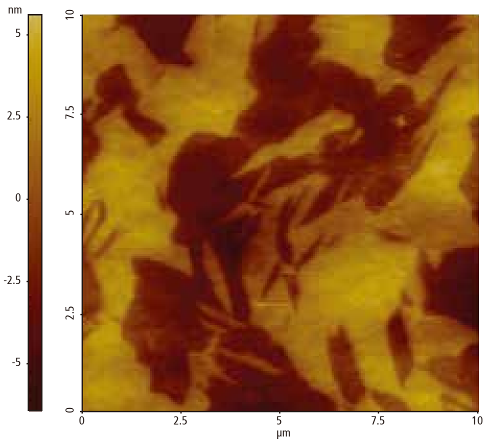
Scanning conditions

- System: NX20
- Scan Size: 100 µm × 100 µm
- Scan Mode: AM KPFM
- Scan Rate: 0.1 Hz
- Cantilever: PPP-NCSTAu (k=7.4 N/m, f=160 kHz)
- Pixel Size: 1024 × 512

PMN-PT

Piezoresponse Force Microscopy (PFM)

■ Height



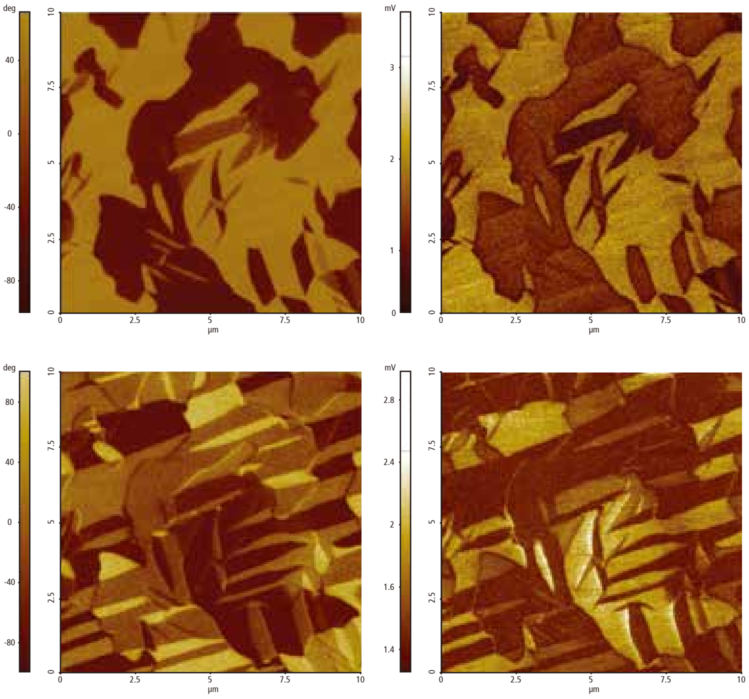
Peak to valley: 11.49 nm

■ CR-PFM Phase

■ CR-PFM Amplitude

Vertical property

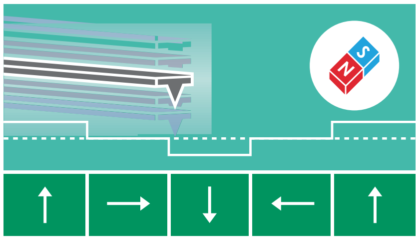
Lateral property



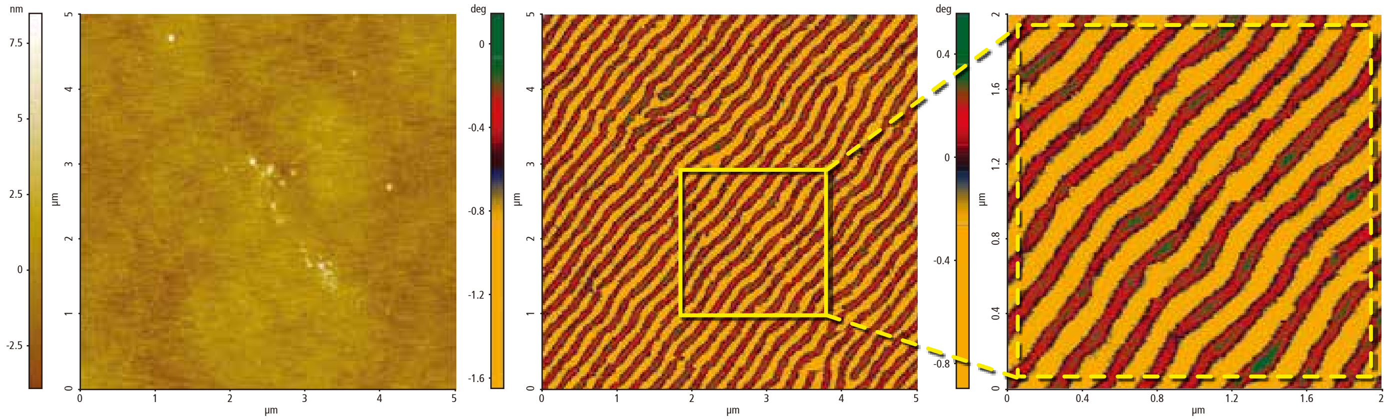
Scanning conditions

- System: NX10
- Scan Size: 10 µm × 10 µm
- Scan Mode: Contact Resonance PFM
- Scan Rate: 0.3 Hz
- Cantilever: SPARK 70 Pt (k=2 N/m, f=70 kHz)
- Pixel Size: 256 × 256

Ferrimagnetic Alloy (GdFe)



Magnetic Force Microscopy (MFM)



Height

MFM Phase

Zoom in MFM Phase

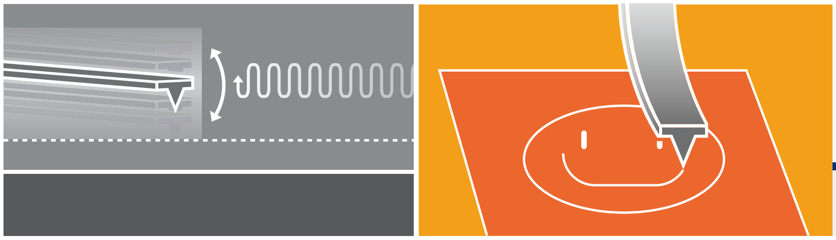
Peak to valley: 11.1 nm

• Image courtesy: Prof. Jyoti Mohanty, Physics, Indian Institute of Technology Hyderabad, India

Scanning conditions

- System: NX10
- Scan Size: 5 μm × 5 μm, 2 μm × 2 μm
- Scan Mode: MFM
- Scan Rate: 0.8 Hz, 0.5 Hz
- Cantilever: PPP-MFMR (k=2.8 N/m, f=75 kHz)
- Pixel Size: 512 × 512, 256 × 256

Portrait of Jamsetji Tata lithography



Non-contact, Nanolithography

Lithography design

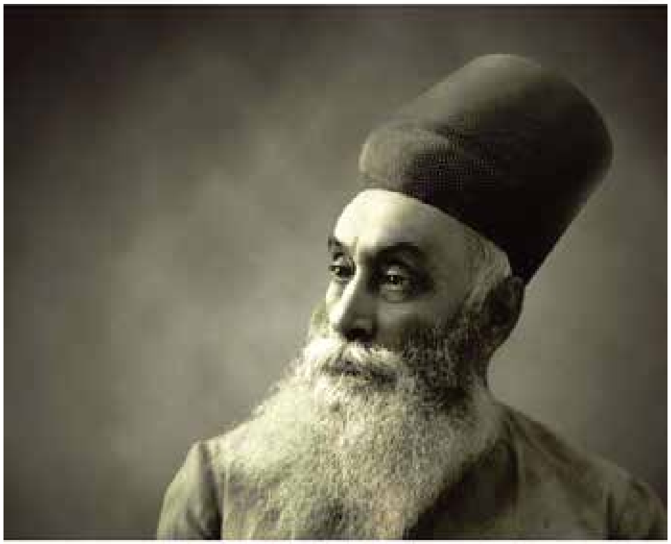
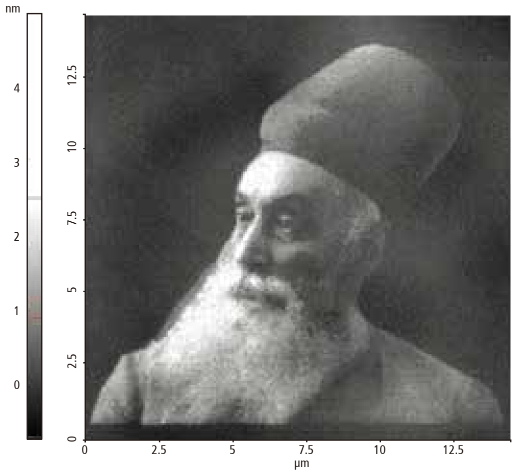


Image ref. : https://www.tata.com/about-us/tata-group-our-heritage/tata-titans/jamsetji-tata

- Oxide patterns were formed on Si surface using tip bias mode of nanolithography.

Height after lithography



Peak to valley: 5.7 nm

3D

X:Y:Z scale = 1:1:200

- Image courtesy: Sanket Jugade, Prof. Akshay Naik, Centre for nano science and engineering, Indian institute of science Bengaluru, India

Scanning conditions

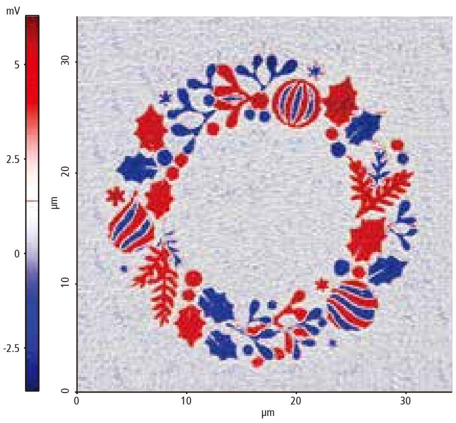
- System: NX20
- Scan Size: 14.5 µm × 14.5 µm
- Scan Mode: Non-contact after lithography
- Scan Rate: 0.6 Hz
- Cantilever: ElectriMulti 75-G (k=2.5 N/m, f=75 kHz)
- Pixel Size: 512 × 512

Wreath decoration lithography

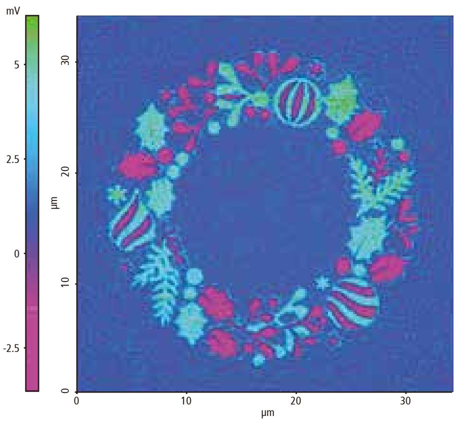
Nanolithography, PFM

- **Lithography design**

- **PFM Quad (Color 1)**



- **PFM Quad (Color 2)**



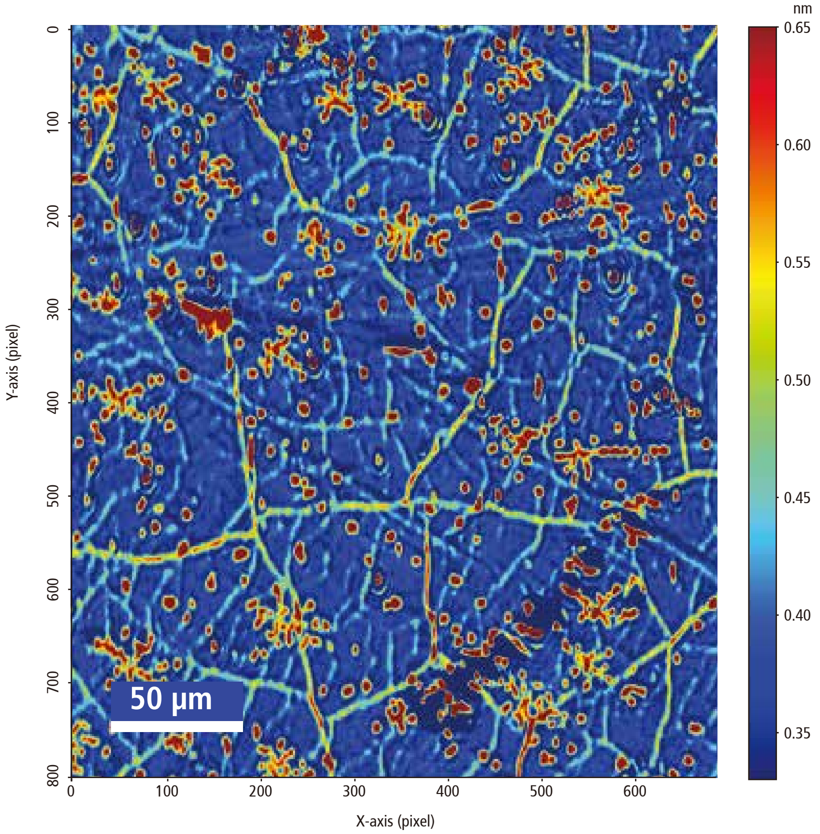
- After aligning the domain orientations on the PZT surface according to color level using tip bias mode of nanolithography, the result was confirmed by measuring piezoelectric force microscopy (PFM).

Scanning conditions

- System: FX40
- Scan Size: 35 µm × 35 µm
- Litho. Bias: Black +10 V, White -10 V
- Scan Mode: Lithography, PFM
- Scan Rate: 0.5 Hz
- Cantilever: NSC36/Pt A type (k=1 N/m, f=90 kHz)
- Pixel Size: 256 × 256

Graphene grown by CVD

- **Thickness map**



- Clear grain boundaries in graphene can be visualized through single wavelength Imaging Spectroscopic Ellipsometry (ISE).

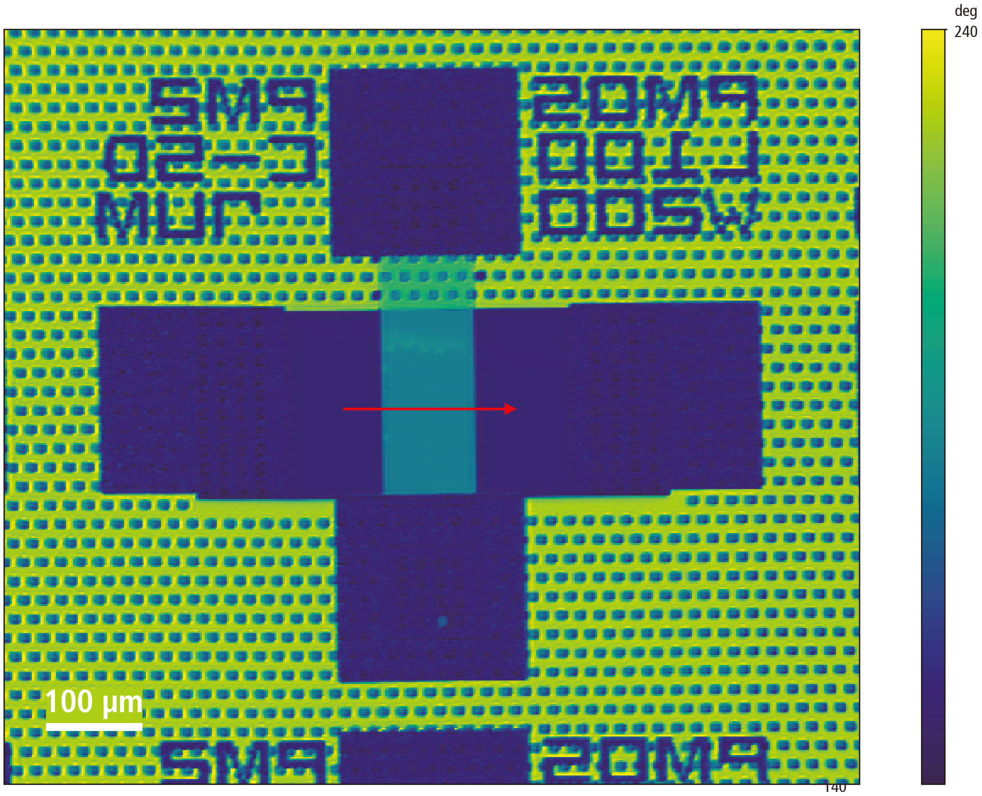
- ISE provides a lateral resolution of 1 µm, enabling precise measurement and analysis of the Graphene layer thickness on microstructures, while conventional ellipsometry operates at a lateral resolution of 60 µm.

Measurement conditions

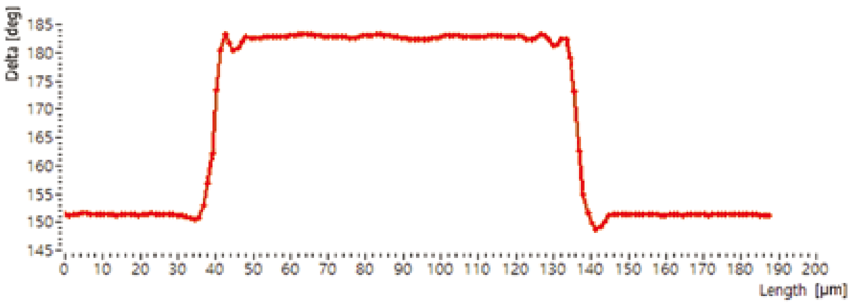
- System: EP4
- AOI: 50 °
- Wavelength: 495 nm
- Objective Lens: 20× Nikon
- Lateral Resolution: 1 µm

MOSFET device

■ Δ map



■ Line profile



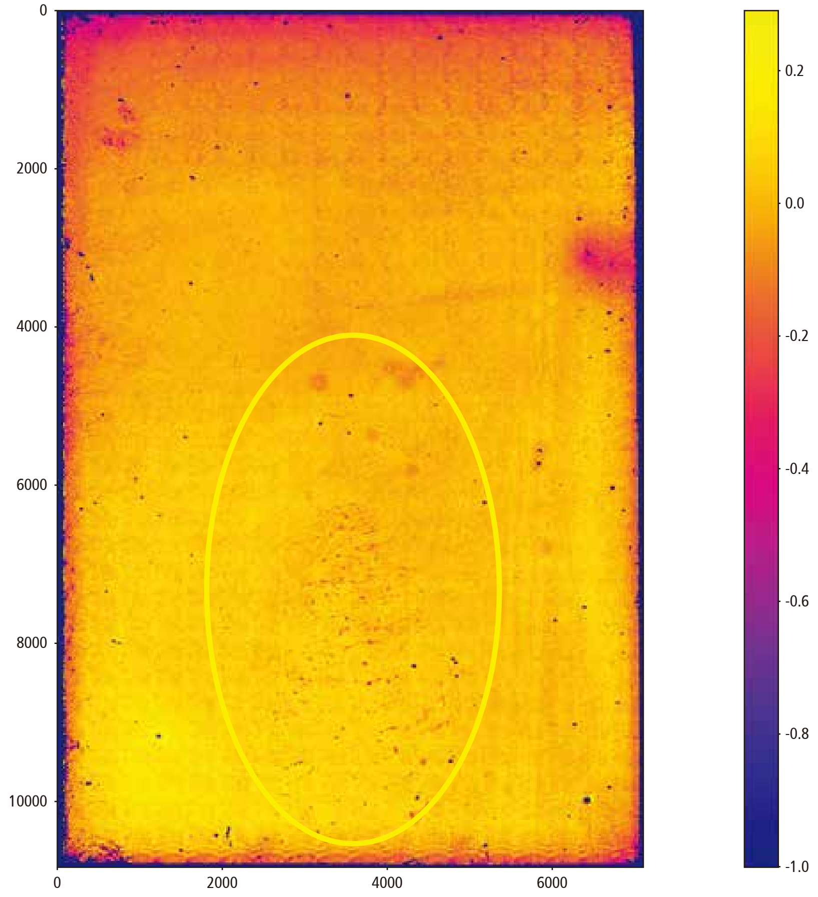
- MOSFET structure is characterized by Imaging Spectroscopy Ellipsometry (ISE).
- Optical properties and dimensional information can be measured simultaneously by ISE.

Measurement conditions

- System: EP4
- AOI: 50 °
- Wavelength: 550 nm
- Objective Lens: Nanochromat
- Lateral Resolution: 2 µm

Residual glass

- **Stiched △map**



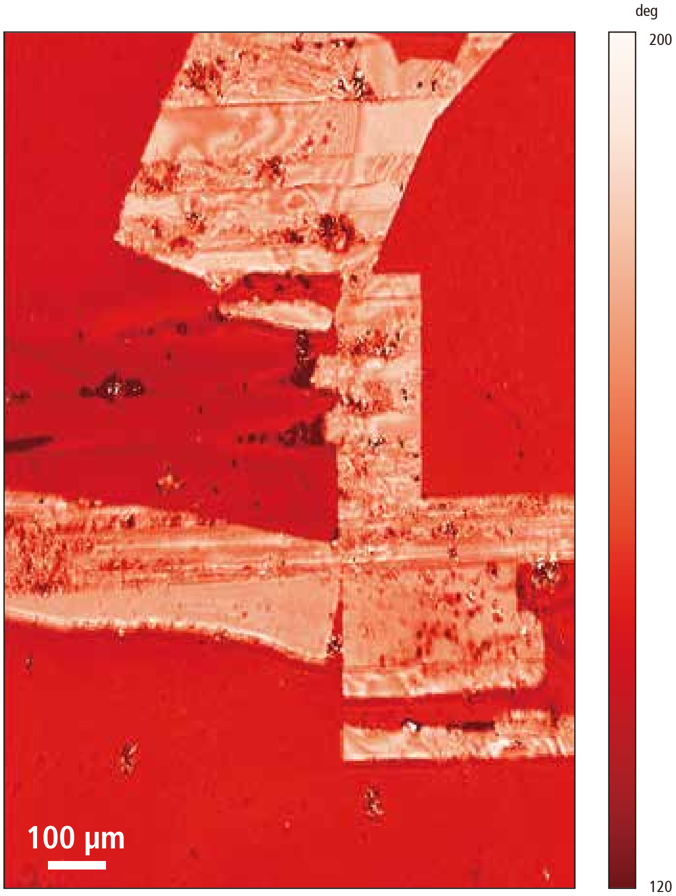
- Stitched Δ maps at a size of 11 mm×7 mm enables the identification of contaminations and droplets in the central and lower regions of the image. These contaminations may not be observed by any other optical method.
- The lateral resolution is 4 μm, and the process takes 28 minutes.
- Image stitching is a tool that allows the merging of individual images or maps based on XY stage positions, enabling large-scale analysis while maintaining microscopic resolution.

Measurement conditions

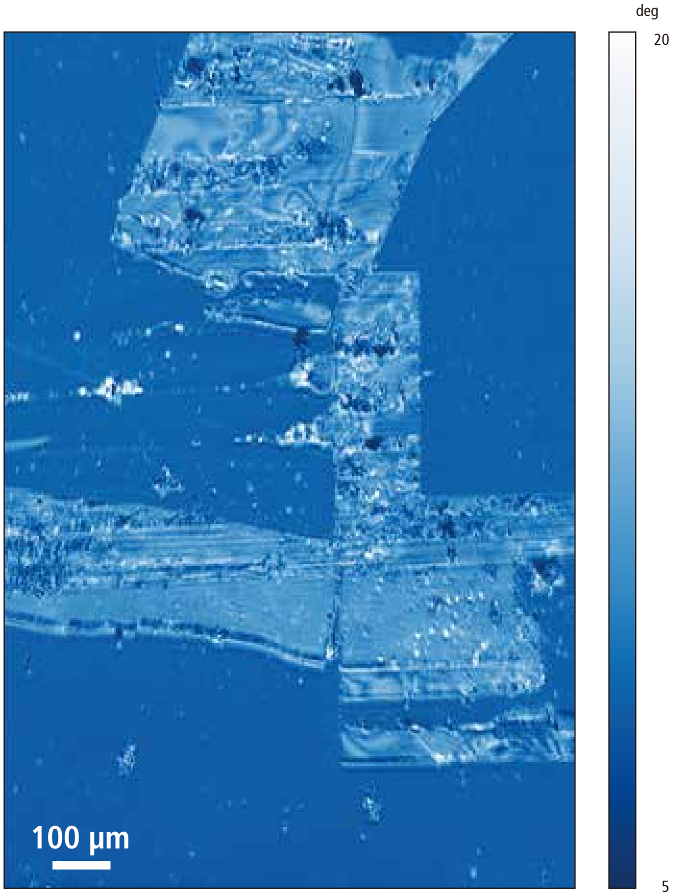
- System: EP4
- AOI: 50 °
- Wavelength: 658 nm
- Objective Lens: 5× Nikon
- Lateral Resolution: 4 μm

Methylammonium-Lead-Bromide-Perovskite

■ Δ map



■ Ψ map



- Single crystals of methylammonium-lead-bromide-perovskite is characterized by Imaging Spectroscopy Ellipsometry (ISE).
- The Δ and Ψ maps contain information about the layer thickness and refractive index of the sample.
- Differences in optical properties can be compared through Δ and Ψ maps,
  even when the sample is transparent and differences are not visible in an optical microscope image.

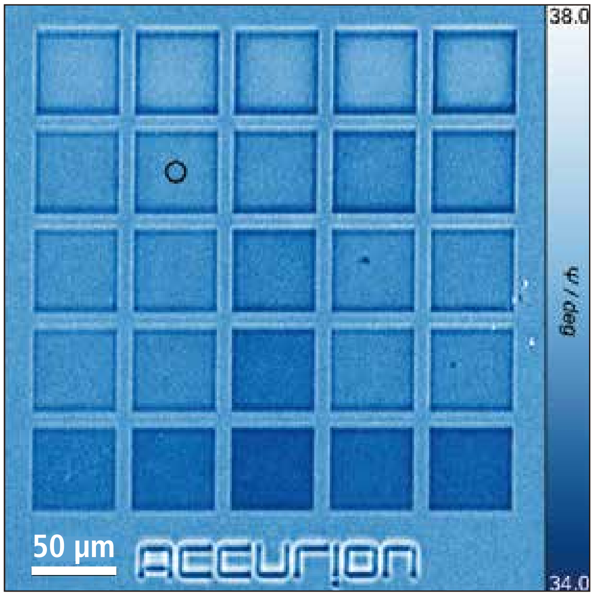
• Sample courtesy: Dr. Yeongseon Jang, Department of Chemical Engineering, University of Florida, United States

Measurement conditions

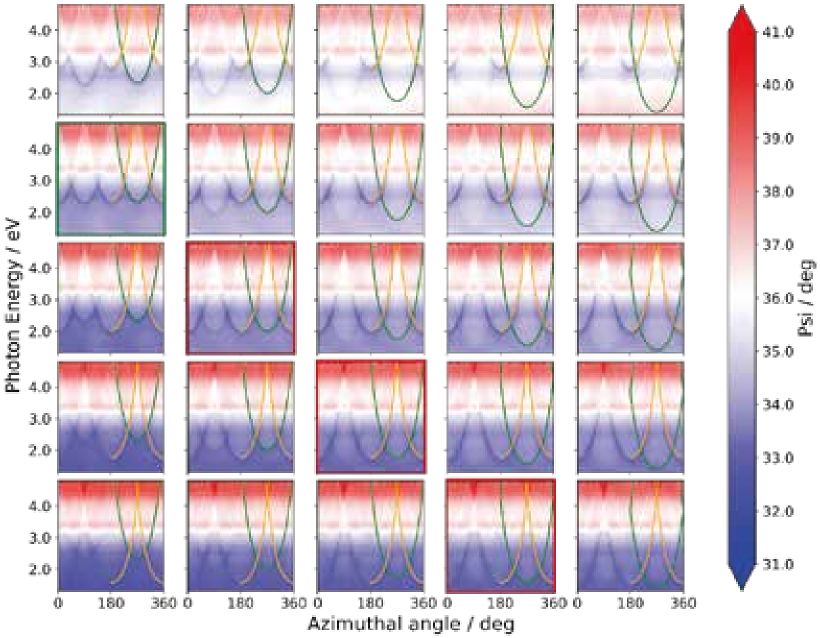
- System: EP4
- AOI: 60 °
- Wavelength: 550 nm
- Objective Lens: 5× Nikon
- Lateral Resolution: 4 µm

2D Subwavelength periodic structure

- **Ψ map**



- **Ψ spectra with Azimuthal rotation scan**



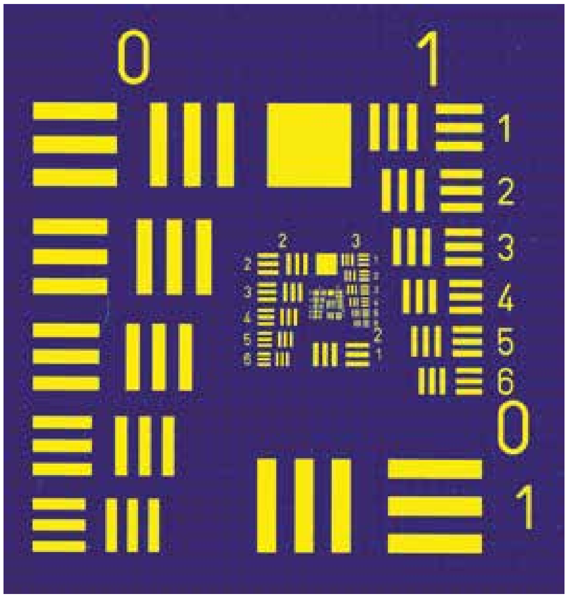
- 25 different 2D metallic periodic structures were measured simultaneously with azimuthal rotation of the sample. The Rayleigh lines that appear due to their periodicity are in perfect agreement with theoretical values.

Measurement conditions

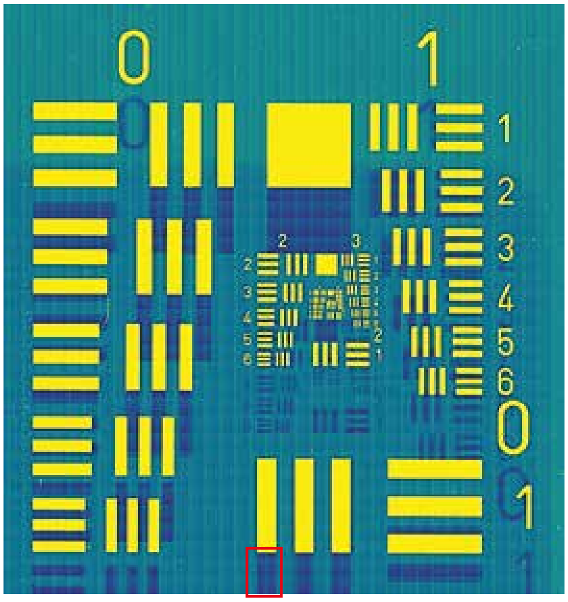
- System: EP4
- AOI: 50 °
- Wavelength: 250 nm ~ 1700 nm
- Objective Lens: Nanochromat
- Lateral Resolution: 2 μm
- Theta Scan: 0 - 360 degree

USAF1951 resolution test sample

■ With Beam cutter



■ Without Beam cutter



Effect due to backside reflection

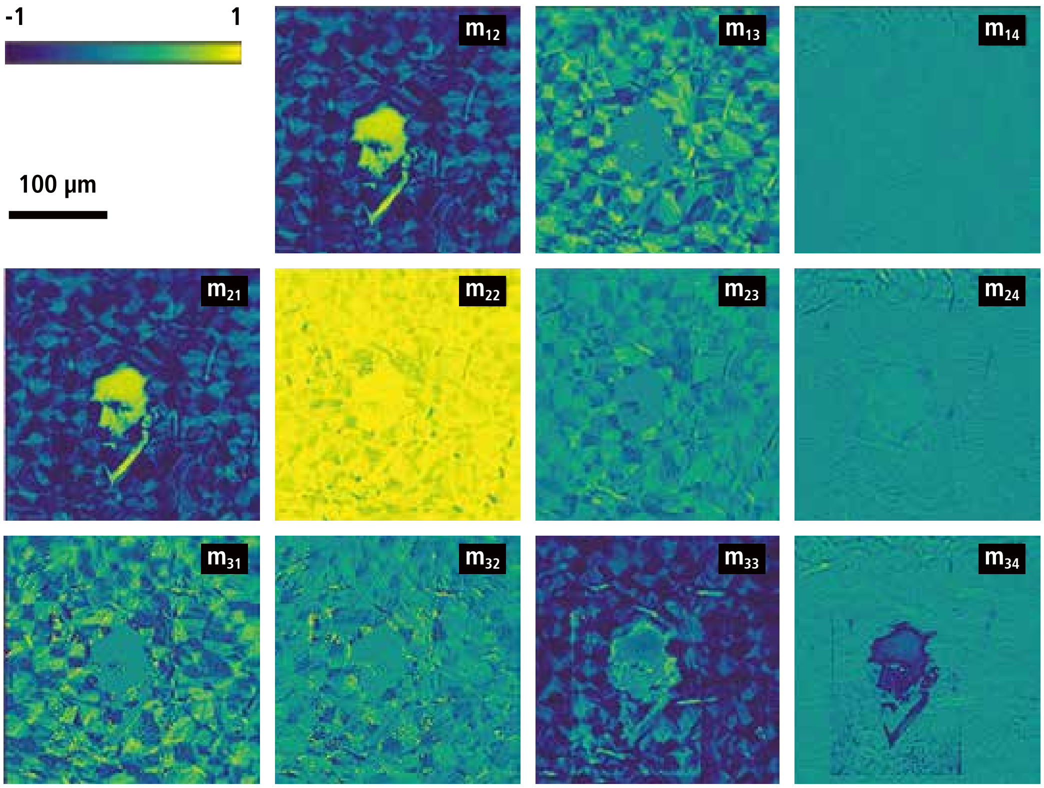
- The stitched ellipsometric contrast micrographs clearly show the effect of knife edge illumination.
- In general, back side reflection interferes with ellipsometric measurements and leads to wrong results.
- Knife edge illumination is a technique used in ISE for the non-contact removal of back side reflections when measuring transparent samples.

Measurement conditions

- System: EP4
- AOI: 50 °
- Wavelength: 550 nm
- Objective Lens: 10× Nikon
- Lateral Resolution: 2 µm

Rewritable color nano-prints in Sb_2S_3 films

Mueller Matrix map



- Crystalline, amorphous and intermediate states of Sn_2S_3 are generated by laser imprinting.
- Self-portrait of Van Gogh on crystalline Sn_2S_3 thin film is realized by variation the laser intensity.
- Different polarization states depending on the optical anisotropy are observed with high lateral resolution by Imaging Mueller Matrix.

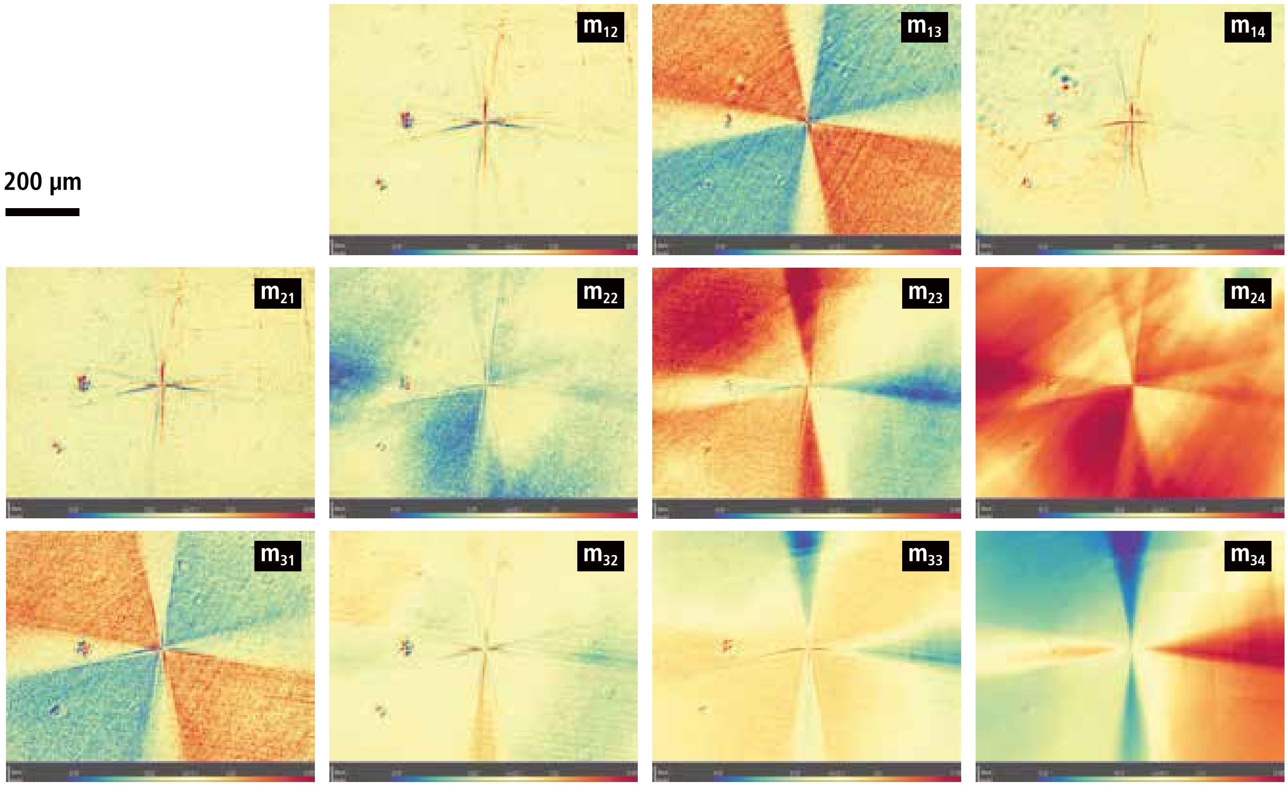
• Sample courtesy: Hailong Liu and Joel KW Yang, Singapore University of Technology and Design (SUTD), Singapore

Measurement conditions

- System: EP4
- AOI: 50 °
- Wavelength: 400 nm
- Objective Lens: 20× Nikon
- Lateral Resolution: 1 µm

Diamond defects

Mueller Matrix map



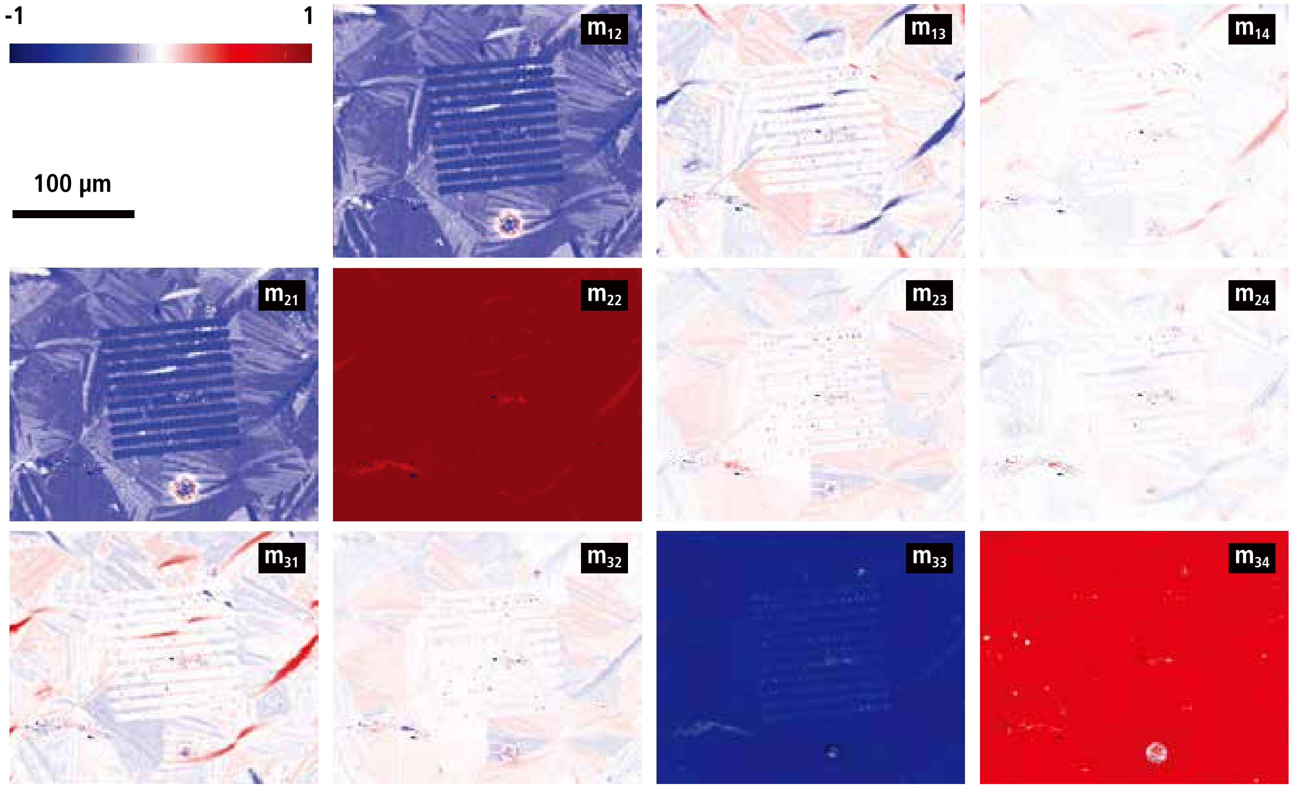
- Due to the defects that occur as the crystal grows, this HPHT grown diamond shows birefringence.
- Imaging Mueller Matrix in transmission mode reveals even small birefringence effects within the diamond sample.

Measurement conditions

- System: EP4
- AOI: 90 ° (Transmission mode)
- Wavelength: 700 nm
- Objective Lens: 5 × Nikon
- Lateral Resolution: 4 µm

Optical switch of Sb_2S_3

Mueller Matrix map



- Optical switching in Sb_2S_3 due to laser-induced phase transition is visualized by Imaging Mueller Matrix Ellipsometry.
- Mueller Matrix maps show the polarization state at each pixel and visualize isotropic regions on an anisotropic sample.

Sample courtesy: C. Laprais, C. Zrounba, L. Berguiga, N.Baboux, G. Saint Girons, S. Cueff, Institut des Nanotechnologies de Lyon, France

Measurement conditions

- System: EP4
- AOI: 50 °
- Wavelength: 420 nm
- Objective Lens: 20× Nikon
- Lateral Resolution: 1 µm

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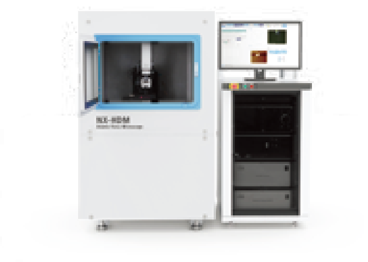

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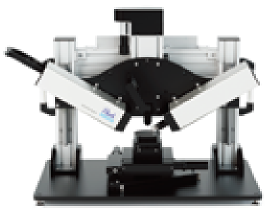
Imaging ellipsometer for
thin film visualization
and metrology with
high spatial resolution



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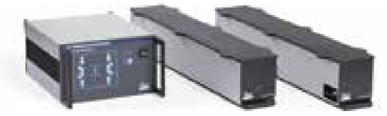

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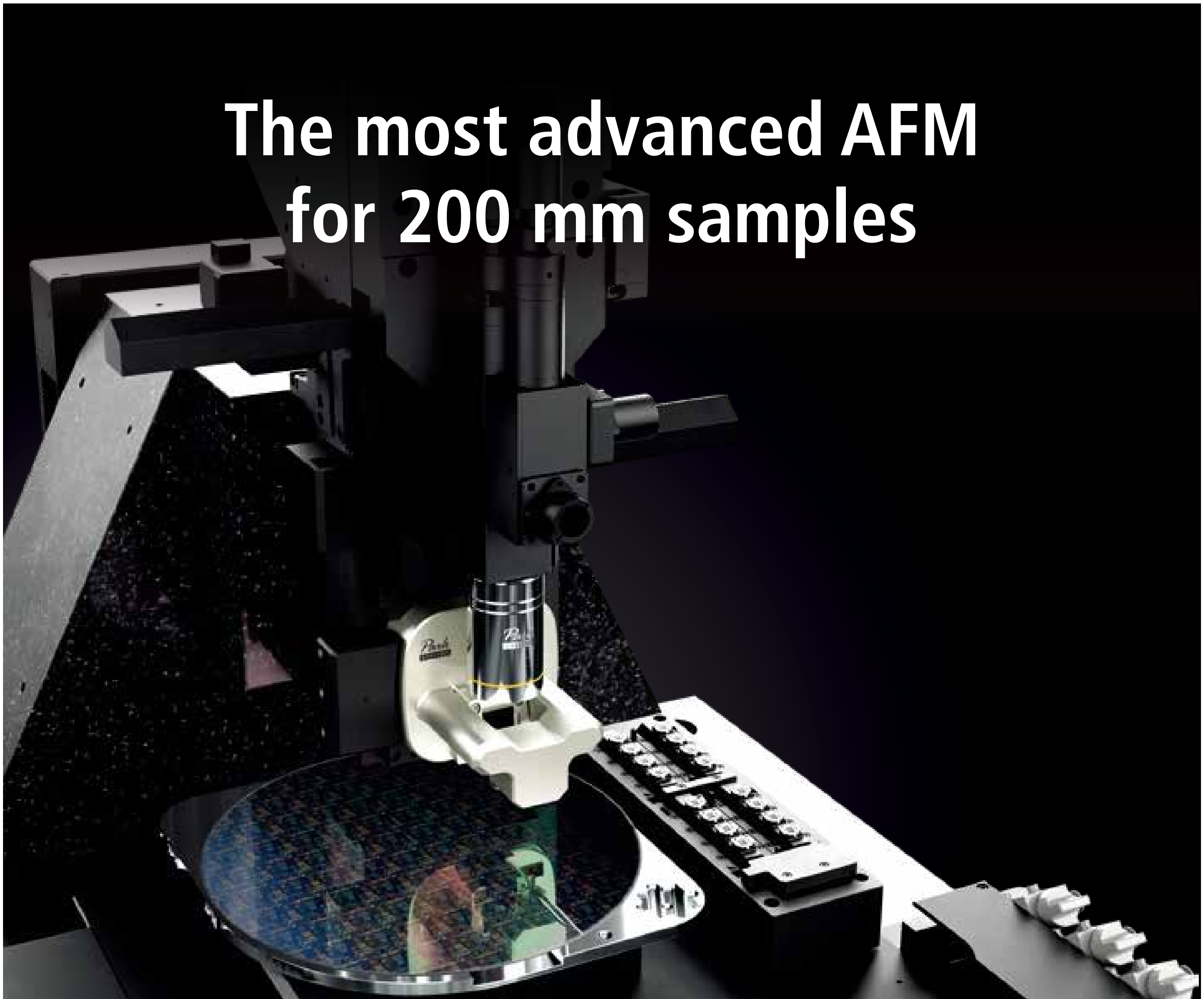

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