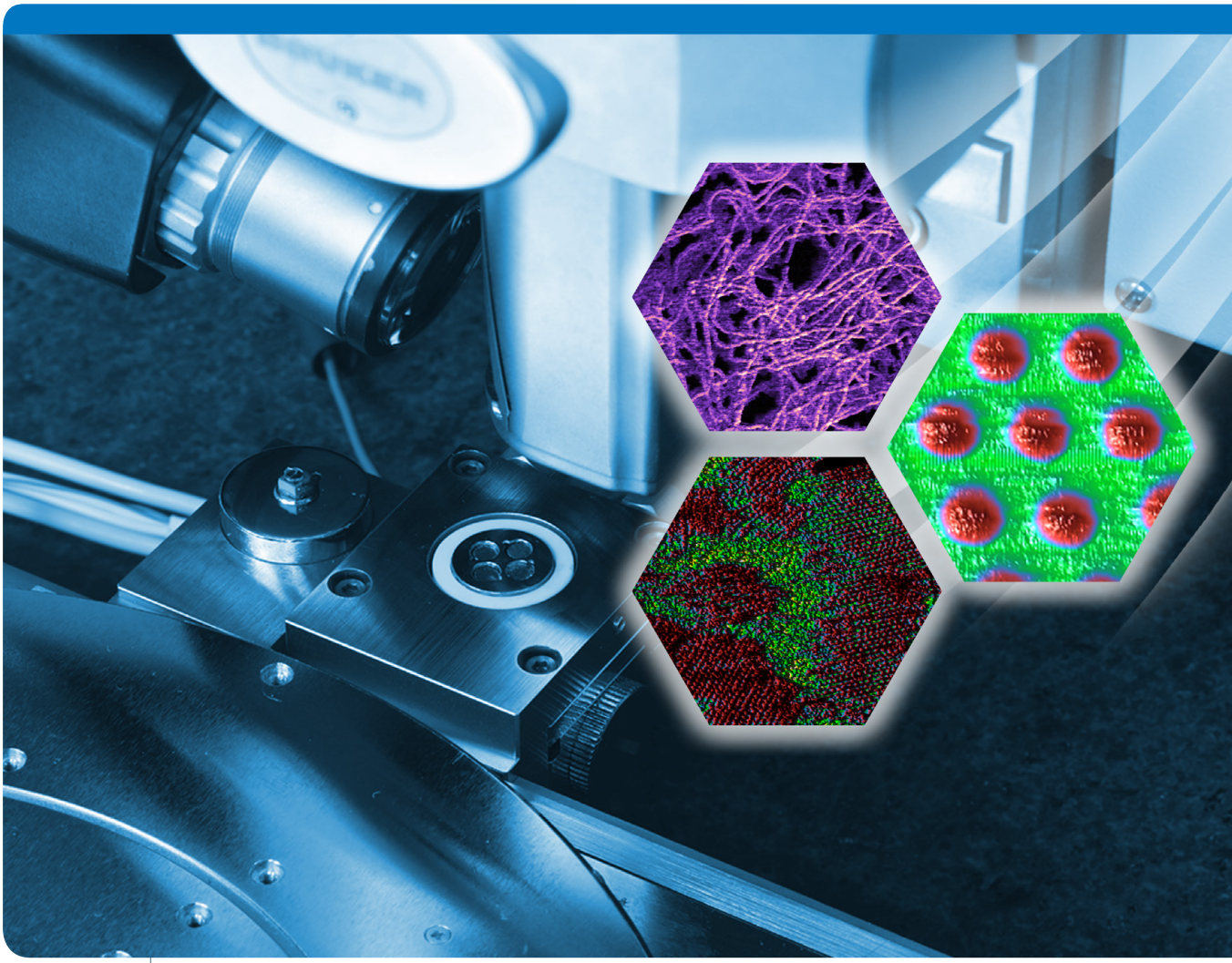


Dimension XR Scanning Probe Microscopes

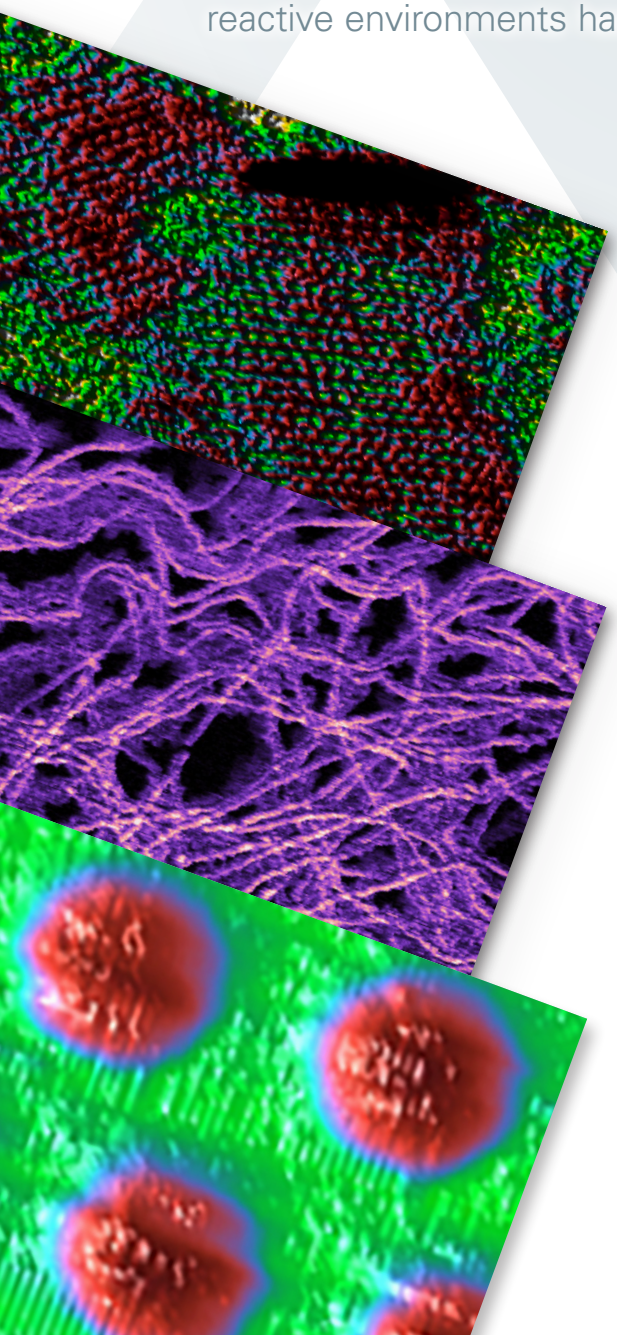
Extreme Research Systems for Nanomechanics, Nanoelectrical, and Nanoelectrochemistry

Innovation with Integrity

Atomic Force Microscopy

Enabling First-and-Only AFM Capabilities and Performance

Bruker's Dimension XR scanning probe microscope (SPM) systems incorporate decades of research and technological innovation to deliver the utmost performance, functionality, and capability in nanoscale investigation. The extreme research (XR) family of SPMs for FastScan® and Icon® AFM platforms provides unique packaged solutions for advanced research in nanomechanical, nanoelectrical, and nanoelectrochemical characterization. Quantification of materials and active nanoscale systems in air, fluid, electrical or chemically reactive environments has never been easier.



Three distinct Dimension XR configurations, available on either a FastScan or Icon AFM platform, provide advanced research capabilities in optimized packages:

XR Nanomechanics

- Provides a range of modes to comprehensively detect the smallest structures with spatial resolution down to sub-molecular units of polymer chains
- Enables correlative nanomechanics characterization to bulk DMA and nanoidentation methods with NEW AFM-nDMA™ mode
- Performs quantifiable nanoscale characterization extending from soft sticky hydrogels and composites to stiff metals and ceramics

XR Nanoelectrical

- Covers the broadest array of electrical AFM techniques in a single system
- Provides electrical spectra in every pixel correlated with mechanical property measurements with NEW DataCube modes
- Delivers previously unattainable information from a single measurement

XR Nanoelectrochemical

- Enables robust AFM-based scanning electrochemical microscopy (AFM-SECM) and electrochemical AFM (EC-AFM)
- Acquires electrochemical information with <100 nm spatial resolution
- Performs simultaneous electrochemical, electrical, and mechanical mapping in solution

Complete Characterization with Highest Spatial Resolution

With thousands of peer-reviewed scientific papers around the world, the large-sample Icon and FastScan AFMs have helped change the landscape of both atomic force microscopy and materials science. The new Dimension XR configurations of these legendary platforms take the fullest advantage of the over 30 years of AFM innovation to enable out-of-the box tailored characterization for breakthrough nanomechanics, nanoelectrical, and nanoelectrochemical research. Whichever platform and configuration you choose, you will benefit from the highest performance features and latest technological advances in the industry, along with the highest measurement reproducibility and easiest workflow of any commercial AFM.

Dimension Icon is the world's most utilized large-sample AFM platform, featuring industry-leading application flexibility, exceptional performance, and productivity:

- Unmatched flexibility via measurement modes and correlative techniques for large, small, or multiple samples, all on a single AFM platform
- Highest performance and repeatability with lowest noise and drift, proven through a vast publication record of scientific discovery and development of innovative materials
- Exceptional productivity, from one to multiple samples, with fast scanning and automated measurement recipes for thousands of unattended measurements into preconfigured settings

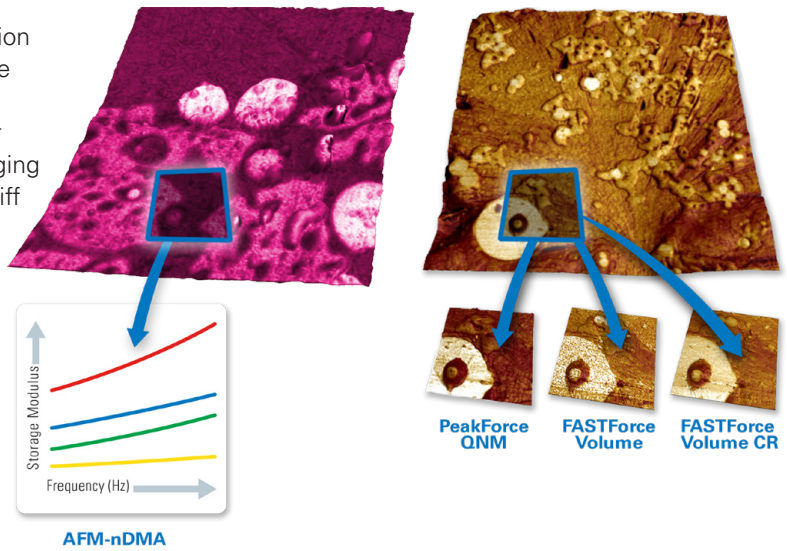
Dimension FastScan is the industry standard for the ideal balance of scan speed, resolution, accuracy, drift and noise, making fast scanning atomic force microscopy a practical commercial reality:

- Incorporates all the benefits of Dimension Icon with use of Icon scan head
- Fastest scanning rates in air and fluid, with automated laser, up to laser and detector alignment, comprehensive work flow, and "smart engaging" for unprecedented productivity
- High resolution and long tip-life via the industry's most precise force control at the tip

Quantitative Analysis for Nanomechanical Applications

The Dimension XR Nanomechanics configuration for Icon and FastScan AFM systems provides the complete set of capabilities necessary to rapidly and quantitatively characterize materials for their nanomechanical characteristics, on samples ranging from soft, sticky hydrogels and composites to stiff metals and ceramics.

The XR Nanomechanics bundled solution encompasses the full evolution of nanoscale AFM nanomechanical measurement techniques, including Bruker's new, revolutionary AFM nano-dynamic mechanical analysis. This is the first and only AFM solution that ties to bulk DMA.



Revolutionary AFM-nDMA

For the first time an AFM can provide complete and quantitative viscoelastic analysis of polymers at the nanoscale, probing materials at rheologically relevant frequencies, in the linear regime. Proprietary dual-channel detection, phase-drift correction, and reference frequency tracking enable a small strain measurement in the rheologically relevant 0.1 Hz to 20 kHz range for nanoscale measurements of storage modulus, loss modulus, and loss tangent that tie directly to bulk DMA.

Exclusive PeakForce QNM

Quantitative characterization of nanomechanical properties—including modulus, adhesion, dissipation, and deformation — while simultaneously imaging sample topography at atomic-scale resolution has become a routine endeavor with this mode. Now Bruker's frequency-calibrated probes enable defined geometry and adhesion to track probe-sample contact with the lowest uncertainty in measurements of sticky-soft materials in the <1 kPa to 100 GPa range, while rendering results with high-resolution nanoscale mapping.

FASTForce Volume

This mode extends the operating frequency of linear ramps by >400 Hz, closing the frequency gap between PeakForce QNM and standard Force Volume mapping. The overlap of operating frequencies facilitates nanomechanical correlative studies between modes, rendering greater measurement confidence while allowing investigation of property material frequency dependency.

Innovative FASTForce Volume CR

Due to its ability to measure a wide range of moduli, contact resonance is a powerful tool for nanomechanical measurements. However, until now, its implementation has been hampered by contact mode's limitations, including slow imaging speed, complex analysis, and the requirement of specialized hardware for full spectrum acquisition. XR Nanomechanics resolves these issues, providing consistent data of both elastic and viscoelastic properties.

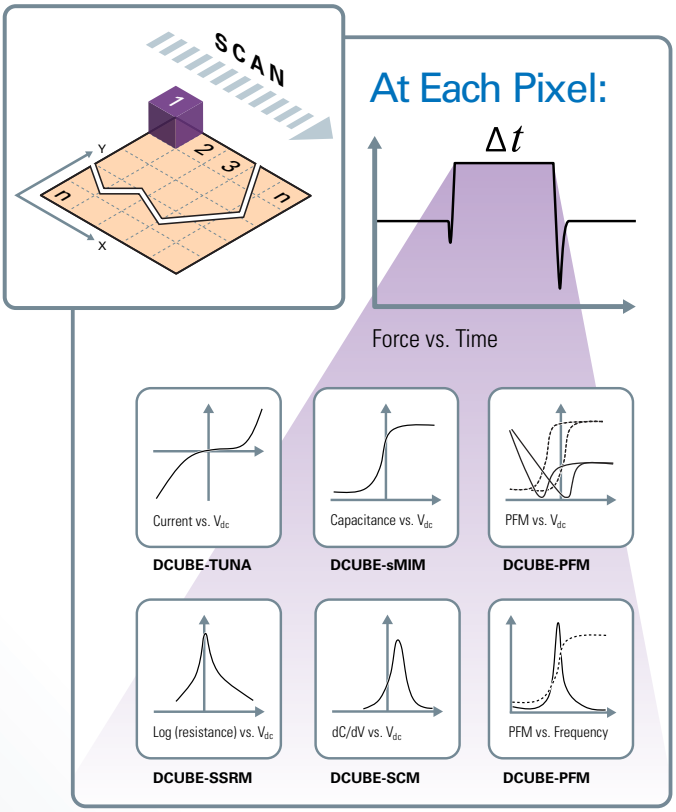
— Quantifies force

— Tracks and quantifies adhesion

— Requires no reference sample

Multi-Dimensional Nanoelectrical Characterization

The Dimension XR Nanoelectrical configuration for Icon and FastScan AFM systems includes the most complete array of electrical AFM techniques on a single system. PeakForce TUNA™ and PeakForce KPFM™ have already built an impressive publication record of expanding materials research, from conventional contact-based electrical modes to correlative electrical and mechanical data. Now, Bruker's new DataCube modes provide multidimensional nanoscale information at every pixel, simultaneously capturing in a single measurement both electrical and mechanical characteristics.

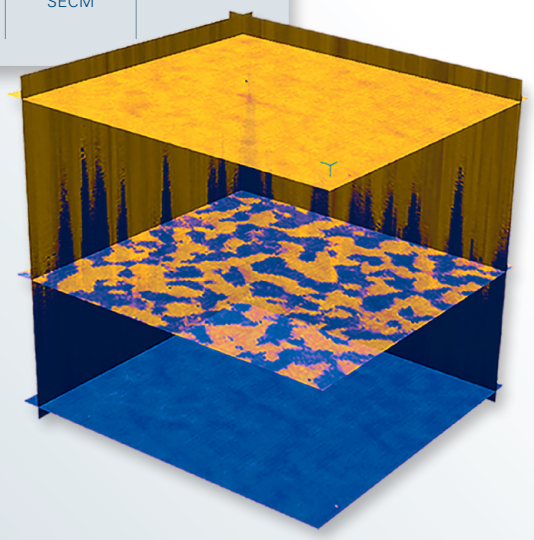


Proprietary DataCube Modes

These modes utilize FASTForce Volume to perform a force-distance spectrum in every pixel, with a user-defined dwell time. Using high data capture rates, a multitude of electrical measurements are performed during the dwell time, resulting in electrical and mechanical spectra at every pixel. DataCube modes provide full characterization in a single experiment, which is unheard of in a commercial AFM.

Nanoelectrical modes

Techniques	Conductivity	Impedance	Carrier Density	Piezoelectricity	Local EC Activity	Potential/ Field
DataCube Mode	DCUBE-TUNA DCUBE-CAFM DCUBE-SSRM	DCUBE-sMIM	DCUBE-SCM DCUBE-sMIM DCUBE-SSRM	DCUBE-PFM DCUBE-CR-PFM	DCUBE-SECM	DCUBE-EFM
PeakForce Tapping (PF)	PF-TUNA	PF-sMIM	PF-sMIM		PF-SECM	PF-KPFM
Tapping Mode		sMIM				EFM KPFM
Contact Mode	TUNA C-AFM SSRM	sMIM	SCM sMIM SSRM	PFM	SECM	



A DCUBE-PFM measurement clearly shows the domains flipping at different potential levels for each discrete pixel on a $BiFeO_3$ thin film.

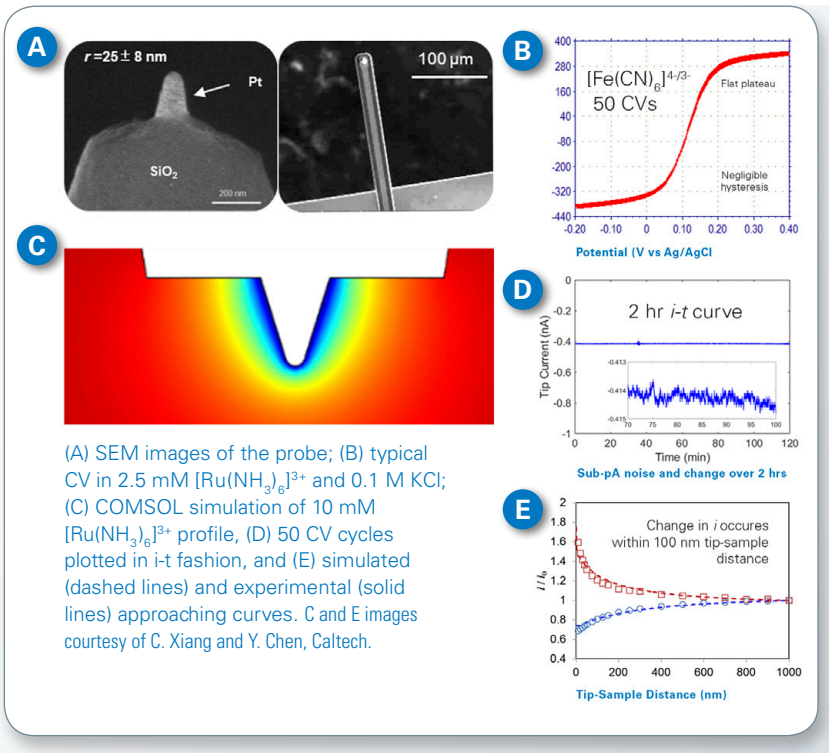
Highest Resolution Scanning Electrochemical Imaging

The Dimension XR Nanoelectrochemical (NanoEC) configuration for Icon and FastScan AFM systems provides a turnkey solution for real-time quantitative analysis of electrochemical reactions. These systems utilize EC-AFM and PeakForce SECM™ modes to perform in-situ topography scans in the electrochemical cell, and are specifically designed for long-term in situ electrode studies under electrochemical control and in volatile solvents.

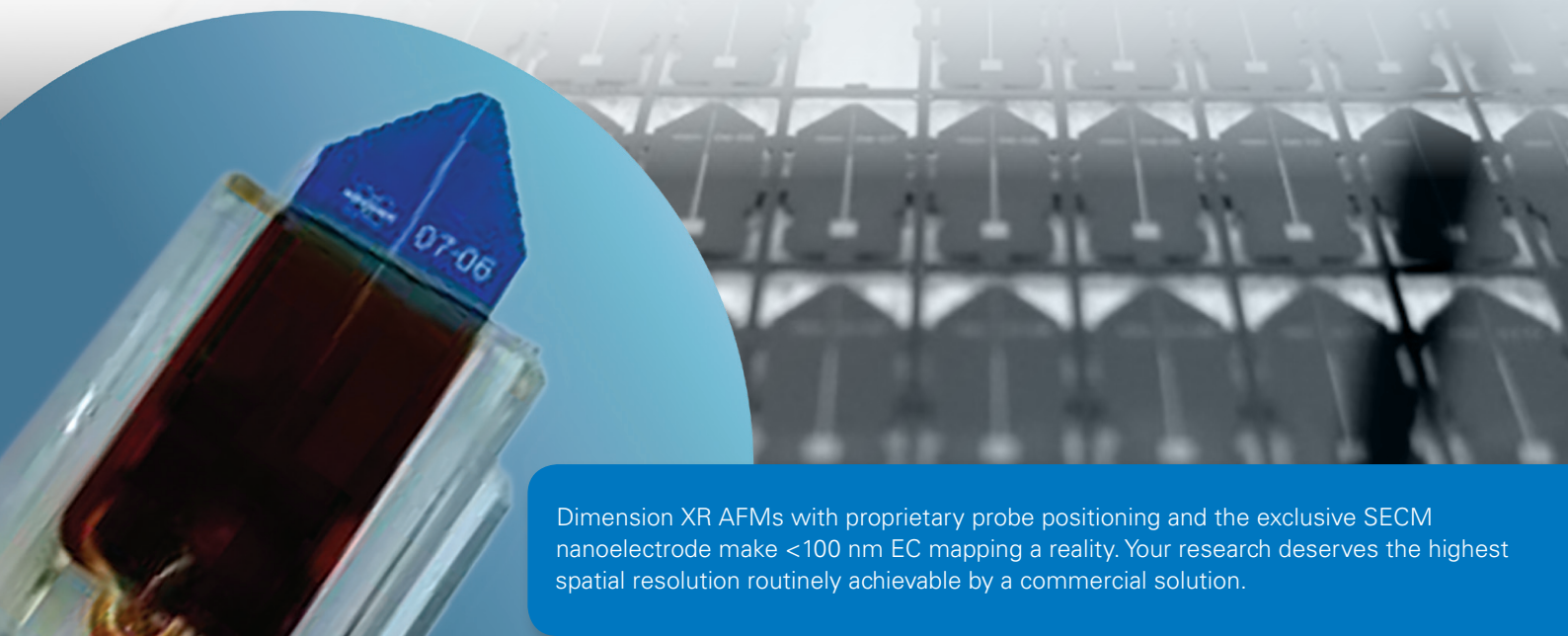
Exclusive PeakForce SECM

With a spatial resolution less than 100 nm, this mode redefines what is possible in the nanoscale visualization of electrical and chemical processes in liquid. PeakForce SECM dramatically improves, by orders of magnitude, the resolving power over traditional approaches. This enables entirely new research into energy storage systems, corrosion science and biosensors, opening the door to novel measurements on individual nanoparticles, nanophases, and nanopores. Only, PeakForce SECM provides simultaneous capture of topographic, electrochemical, electrical, and mechanical maps with nanometer-scale lateral resolution.

Bruker's premounted PeakForce SECM probes offer easy and safe handling, and the optimized holder delivers an electrically stable architecture for sensitive signal processing. Extremely stable probe performance has been demonstrated for over 10 hours of EC testing and multiple reuse cleaning cycles.



(A) SEM images of the probe; (B) typical CV in 2.5 mM $[Ru(NH_3)_6]^{3+}$ and 0.1 M KCl; (C) COMSOL simulation of 10 mM $[Ru(NH_3)_6]^{3+}$ profile, (D) 50 CV cycles plotted in i-t fashion, and (E) simulated (dashed lines) and experimental (solid lines) approaching curves. C and E images courtesy of C. Xiang and Y. Chen, Caltech.



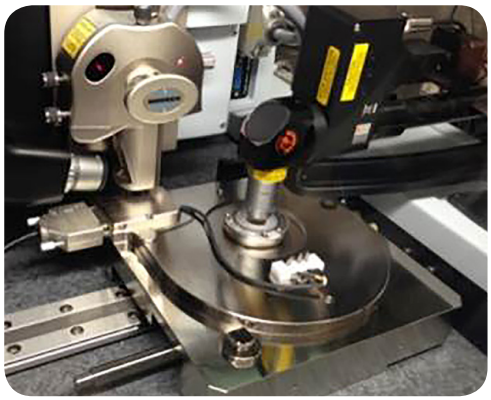
Dimension XR AFMs with proprietary probe positioning and the exclusive SECM nanoelectrode make <100 nm EC mapping a reality. Your research deserves the highest spatial resolution routinely achievable by a commercial solution.

Unlimited Flexibility to Expand Your Research

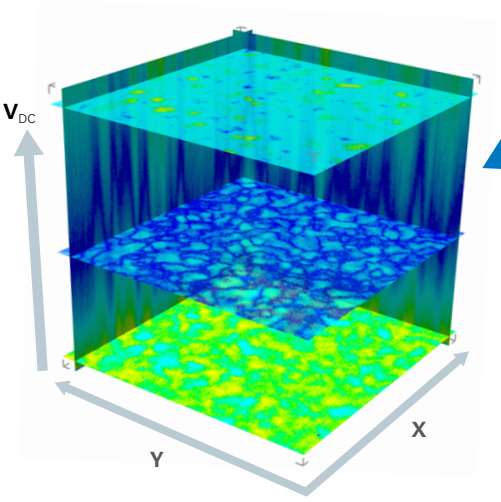
Any Dimension XR configuration you chose for your research enables the addition of many other a la carte capabilities to further tailor your system for your exact application needs, now and in the future. Combined with our many proprietary AFM techniques, modes, and mode enhancements, the Dimension XR systems provide the unique capabilities that can take your nanoscale research to the next level.

```
port nanoscope as ns
port numpy as np
m nanoscope import files
m nanoscope.constants import FORCE, METRIC, VOLTS, PLT_kwargs

me = "DCUBE_TUNA_Iron_Oxide.spm"
h = "C:\\Users\\ DataCubesPFM \\Desktop\\codes\\" + fname
e_ = ns.files.ForceVolumeHoldFile(path)
e_.open()

es = file_[0].number_of_lines
 = file_[0].samples_per_line
d_len = len(file_[3].get_force_hold_data(0, METRIC))

acube = np.zeros((lines, spl, hold_len))
 i in range(lines):
 for j in range(spl):
```

Software toolboxes for MatLAB and Python, along with custom programming tools, offer exceptional flexibility while maintaining ease of use in multi-user environments.



Open-platform hardware customization, limited only by your imagination, adapts to most environments and enables the highest performance available in a commercial AFM.



More Modes for Higher Productivity

- Contact Mode
- PeakForce Tapping®
- PhaseImaging™
- ScanAsyst®
- TappingMode™

- AFM-nDMA™
- Contact Resonance (FFV-CR)
- Fast-Force Volume (FFV)
- Force Modulation™ (FMM)
- HarmoniX®
- Lateral Force Microscopy (LFM)
- Nano-Indentation
- PeakForce QNM®

- Dark Lift
- DataCubes:
  - DCUBE-TUNA
  - DCUBE-SSRM
  - DCUBE-SCM
  - DCUBE-sMIM
  - DCUBE-PFM
  - DCUBE-CR-PFM
- Electrostatic Force (EFM)
- LiftMode™
- Magnetic Force (MFM)
- PeakForce KPFM™
- PeakForce sMIM™
- PeakForce SSRM™
- PeakForce TUNA™
- Piezo Response (PFM)
- Scanning Capacitance (SCM)
- Scanning Spreading Resistance (SSRM)
- STM

- AFM-SECM (PF-SECM)
- Electrochemistry (EC-AFM)

Dimension XR Configurations

		XR Nanomechanics	XR Nanoelectrical	XR NanoEC
Nanomechanics capabilities	AFM nanoDMA (0.1 - 300 Hz)	●	○	○
	RampScripting	●	○	○
	MIROView	●	○	○
Nanoelectrical capabilities	PeakForce TUNA (CAFM)	○	●	○
	DataCube TUNA	○	●	○
	PeakForce KPFM	○	●	○
	Dark Lift	○	●	○
	Electrical TUNA in Liquid	○	●	○
Nano-electrochemical capabilities	PeakForce SECM /Electrochemistry	○	○	●
	DataCube SECM	○	○	●
Other features	Icon FastTapping	●	●	●
	SAMV	●	●	●

Legend
Standard ●
Optional ○

Dimension XR Specifications

	Icon Scan Head	FastScan Scan Head
X-Y Scan Range	90 µm x 90 µm typical, 85 µm minimum	35 µm x 35 µm typical, 30 µm minimum
Z Range	10 µm typical in imaging and force curve, 9.5 µm minimum	≥3 µm modes
Vertical Noise Floor	<30 pm RMS, height in appropriate environment, typical imaging BW (≤625 Hz)	<40 pm RMS, sensor in appropriate environment (up to 625 kHz)
X-Y Position Noise (closed-loop)	≤0.15 nm RMS typical imaging BW (≤625 Hz)	≤0.20 nm RMS typical imaging BW (≤2.5 kHz in adaptive)
Z Sensor Noise	35 pm RMS typical imaging BW (≤625 Hz) 50 pm RMS force curve BW (0.1 Hz to 5 kHz)	30 pm RMS typical imaging BW (≤625 Hz)
System Drift	<200 pm/min	
Sample Size / Holder	210 mm vacuum chuck for samples ≤210 mm in diameter, ≤15 mm thick	
Motorized Position	150 mm × 180 mm inspectable area with rotating chuck; 2 µm repeatability, unidirectional; 3 µm repeatability, bidirectional	
Optics	Auto Focus and digital zoom; <1 µm resolution; 180 µm to 1465 µm viewing area	Auto Focus and digital zoom; <1 µm Resolution; 130 µm to 1040 µm viewing area
EH&S	CE Certified	

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