XiM : X (Scanning Probe) iMproved

*nano*REV™ AFM Specification Sheet
Version 7.x

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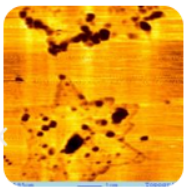
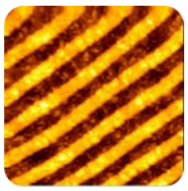
Cover Image: (Left) Inside view of the AFM Accoustic Hood of the nanoREV AFM with illuminated scanner and approach assembly, top-view microscope camera. (Right) Acoustic Hood with its front door of the closed during the AFM scans. (Right Bottom) An array of Quartz Tuning fork cantilevers used as self-sensing probes for scanning. The etched tunsgten tips mounted at the QTF end and the tip-sample junction are shown in the insets.

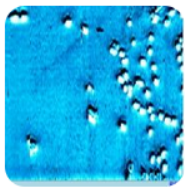
S1 AFM Technique and Modes

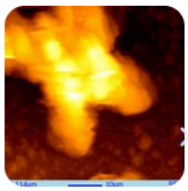
	Features	Description
1	Cantilever	Quartz Tuning Fork (QTF) with etched Tungsten Tip[1]. *See cover page image for details. All AFM scans shown in this document are with this CL.*
2	Cantilever Holder	Quick and Easily Removable (with drive piezo).
3	Laser Optics	Not required (self-sening piezo cantilever) .
4	Sensor Pre-Amplifier	10^8 V/A gain, high bandwidth, trans-impedence amplifier.
5	Imaging modes	Fully Non-Contact, (Frequency-Modulated) FM-AFM:
		- Topography (simultaneous with phase imaging)
		- Constant Frequency Mode
		- Constant Excitation Mode
6	Z Coarse Sample Approach	Stepper Motor.
7	XYZ Scanner Design	Piezo-actuated, flexure-guided, serial kinematics *(more details below).*
8	Sample XY Stage (Coarse)	Precision Micrometer based *(more details below).*
9	Sample View (Top)	Both for coarse approach & tip-location on sample, a computer-interfaced digital microscope camera with 300× magnification.
10	Sample Illumination	Independent position-adjustable illumination of tip-sample junction (mounted inside accoustic-shielding hood)
11	Microscope XY Stage (Top)	Micrometer Stage, precision 50μm (manual).
12	Microscope Z Stage (Top)	Computer-controlled focus-adjustment (stepper motor)


Star Shaped MoS2 Crystals on Si(Sample grown on Qrystal CVD)


Rewritable DVD Tracks

Top Metallization layer of an IC

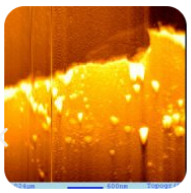

Red Blood Cells on Mica


Micro-flower-like structures made of silver nano-particles

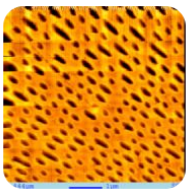
[1] *AFM probe cantilever is similar to qPlus^{TM} style sensors invented by Dr. Franz J. Giessibl. See https://doi.org/10.1063/1.5052264 for more details*

S2 Electronics

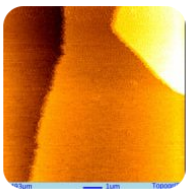
	Features	Description
1	Main Power Supply Input[2]	220-240V AC/50 Hz, 15 W.
2	Power Supply outputs	+5V DC, ±15V DC, +150V DC.
3	Computer Interface	USB 2.0 Port.
4	Measurement Channels	8-channels, 16-bit simultaneous sampling ADC.
5	Scan generator	8-channels, 16-bit D/A converter.
6	Scan speed	Upto 77ms/line (13Hz) for 256 pixel scan and retrace image.
7	Scan drive signals	0 to +150V DC.
8	Slope compensation	Digitally-controlled slope compensation.
9	Δf Set Point Adj.	Up to ±300Hz
10	Servo Control	Digital Feedback Parameter (Gain, Time Constant) Adjustments.
11	Sample Bias Settings	-10V to +10V in Steps of 0.3mV,
		-100V to +100V in Steps of 3mV.
12	Δf-z Spectroscopy	Frequency-shift (Force) vs tip-sample distance plots both approach and retract directions.
13	Auxillary Channel Imaging	Signals from one other/auxillary ADC channel can be acquired simultaneously while taking scans in the regular imaging modes.



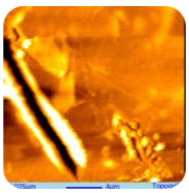
Al2O3 thin-film edge (deposited on Si with AtomiQ ALD)



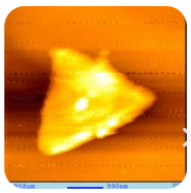
Pits and Lands on an optical storage media



Layers seen on Muscovite Mica



Indentation on PMMA surface, with graphite flakes near its upper end.



Triangular MoSe2 Crystals with debris on top (Sample from Qrystal CVD)

[2] *Due to senitive measurements, the setup requires a properly grounded voltage between supply lines Neutral and Earth* $< 5V_{rms}$.

S3 XYZ Scanner

XYZ Sample Positioner Stage (Fine)			
	Axes	**Range** $\pm 10\%$	**Resolution** $\pm 10\%$
1	**XY Ranges**	$80\mu m \times 80\mu m$ (Piezo, Flexure)*	$1.2nm$
2		$50\mu m \times 50\mu m$ (Piezo, Flexure)	$0.7nm$
3		$7\mu m \times 7\mu m$ (Piezo)	$0.1nm$
4	**Z Range**	$2\mu m$ (Piezo)	$0.03nm$
5		$4\mu m$ (Piezo, Flexure)	$0.06nm$
6		$8\mu m$ (Piezo, Flexure)*	$0.1nm$
7		$18\mu m$ (Piezo, Flexure)	$0.3nm$
	Features	**Description**	
8	Z-resolution	Analog Mode : $\leq 0.1nm$	
		Digital : $0.05nm$ (in Fine Mode, using 16-bit DAC)	
9	Scan orientation	Horizontal, Vertical, Rotation $0° - 90°$	
10	Sample size	Sample disc dia. 10mm.	
11	Sample Thickness	$\leq$ 3mm	
XYZ Sample Positioner Stage (Coarse)			
12	Motion Control	Micrometer XY Stages (manual), Z-stage (motorized)	
13	Resolution	$\pm 10\mu m$	
14	Range	0-6mm sample-movement in X, Y and Z directions.	
15	Control	Manual Mode	
16	Dimensions	Each stage is 35mm $\times$ 35mm $\times$ 12mm	
17	Weight	Stages $<$ 0.5kg	
18	Sample Mounts	Sample Discs $\phi 10mm$, 10 units	

1. *The* **asterisk (*) marked** *scanners, among options listed above, are the ones that are regularly supplied models with AFM Scan-Head. These scanners are optimal for a wide range of AFM samples, while working under different feeback control parameters.*
2. *At a time, only one model of scanner can be fitted and used inside the AFM Scan-Head.*
3. *A trained personnel at the user end can replace an existing scanner model with a different one inside the AFM Scan-Head.*
4. *Please specify the required X/Y/Z ranges while ordering. For additional information on scanner model-selection, please get in touch with us.*

S4 Acoustic Shielding Hood

1	Tip-Sample Access	Opening Front Door (latchable)
2	Dimensions	Within 2.5ft $\times$ 2.5ft $\times$ 2.5ft.
3	Isolation	Fully padded with accoustic dampers.
4	Instrument Rack	Contains all electronics modules.

1. *The entire scanner and its vibration platform together with all the camera optics are kept inside an accoustic-shielding hood with a latchable front door.*
2. *The necessary lighting arrangements are also made inside this hood.*

S5 Vibration Isolation Platform (Inside Accoustic Shield)

1	Cut-off frequency	<10 Hz. Vibration suppression ensures specified resolution imaging[3] with the Scanner.
2	Isolation method	Passive.
3	Dimensions	Within 1ft × 1ft × 1ft
4	Weight	7 kg.
5	Handling	Ergonomic handles for easy portability.
6	Platform	Detachable scanner arrangement (limit-less mating cycles).

S6 QOKE-PLL (Phase-Locked Loop) Specifications (Basic)

1	Reference Generator	10Hz to 1MHz
2	Frequency Sweep Utility	For resonance charactertics of cantilever.
3	Locking Harmonics	$f/2f$
4	Phase Lock Loop (PLL)	Yes
5	PLL Bandwidth	Up to 100-500 Hz
6	VCO Tracking Range	Selectable ranges: $\pm 75Hz$, $\pm 150Hz$, $\pm 300Hz$
7	VCO Resolution	Selectable ranges: $2.3mHz$, $4.6mHz$, $9.2mHz$
8	Full Digital Control	Software control of all parameters of the reference generator, amplifier gains and low-pass filter (LPF) cut-off frequency.
9	Software Interface	Python and C++ SDK library for LIA control.
10	Main Power Supply input	220-240V AC/50 Hz
11	Computer Interface	USB 2.0 Port.

Some key specifications given above, please get in touch for additional details.

S7 QOKE PLL (Phase Locked Loop) Software Integration

1	Multi-channel Imaging	Simultaneous acquisition and display of PLL outputs as images or plots.
2	User Interface	Seamless control of all PLL parameters from AFM software:
		- Frequency, amplitude and phase of the reference signal.
		- Amplifiers gain-settings, ac/dc coupling, LPF cut-offs.
		- VCO Sensitivity, Phase Offset auto-Correction etc.
3	I/O Signals Interfacing	Front panel accessibility of modulation input and PLL output signals on AFM .
4	Digital Phase Control	Auto phase-offset (due to external network) compensation.
5	Harmonic Modes	Software selectable $f/2f$ harmonic locking modes.
6	Data Integration	For multi-channel modes, all the related PLL parameters stored along with AFM images and plots data.

[3] *Preferably keep the AFM setup away from mechanical pumps, vibrating machinery, frequent activity or traffic zones, and avoid strong air-currents (from fans or air-vents) directed towards the scan-head.*

S8 Software: XiM

	Features	Description
1	Image Display	Dual Imaging Window for Scan and Retrace Image Display (Image size: 256×256 to 7750×7750 pixels)
2	Oscilloscope	Multi-channel in-built software CRO for plotting signals from different ADC channels.
3	Movie Mode	Repetitive scan captured as frames of a movie, Movie processing, split into individual images and export to GIF format.
4	Sample Navigator	Graphical assistant for localized zooming w.r.t. a large area scan
5	3D	Colored 3D renderings, selection of color look-up tables
6	Data Export	Export to standard image file formats like jpg, ASCII, postscript format. Splits simultaneous channel data into individual image files.
7	Analysis Functions	Line (Single line profile) Extraction, localized Zooming, Roughness Display, Measure length and angles on the images, Spatial and Fourier Filtering, 2D-FFT with distance measurements.
8	Calibration	X/Y/Z-Calibration Utility.
9	Image Processing Tool	Slope and Z-drift Correction, Spatial and Fourier Low-Pass Filtering, Background Subtraction, Histogram Equalization, Zooming, Contrast, Contrast, Invert, Spike-noise Filter etc.
10	Batch Processing	Batch export to ACII, jpg. Export a batch or a sequence of scans into GIF animation.
11	Image Viewing	For quickly reviewing, basic processing, ranking and sorting *nano*REV™ images (`*.npic`).
12	Tip Locator Window	Displays current position of the tip over the sample.
13	Nano-Lithography	In-situ tip cleaning & restructuring utility by applying voltage pulses to the sample
14	Color Mode Selection	Customizable gray-scale and color modes for the image (both in 2D and 3D)
15	Installer flash-drive	With drivers and software packages for the entire set-up.

S9 Tool Kit

1	Pre-mounted Samples	Gratings (DVD(1) and BluRay^{TM}(1).
2	Tools	Tweezer sets (2)
3	Spares	Blank sample disc (8 pcs).

S10 AFM Tip Kit

1	AFM Sumiprobe QTF Tips	10 no.s (ready to scan).

Piezo Scanner

Vibration Isolation

Controller Electronics

S11 Computer (Third Party Supply)

1	System Configuration[4]	RAM ≥8GB, Resolution: FHD (1920 × 1080).
2	Interface Ports	USB 2.0 ports for all controllers.
3	OS	Linux (runs on latest Ubuntu Long Term Support distribution).

S12 User Manual

1	AFM User Manual	English (1 hard-copy)

S13 Tuning Forks (Optional)

1	Bare QTF (unmounted)	20 no.s. (without PCB)
2	Bare QTF (mounted)	10 no.s. (on Sumiprobe Tip PCB)

S14 Tip/Sample Inspection Microscope (Optional, Recommended)

Since sample surface nature and tip-sharpness are two most critical parameters that determine the quality of AFM imaging, it is frequently required to quality check both. This microscope becomes a very useful and time-saving tool to inspect regions of interest on the sample, apparent distortion or rough patches, observable in the the optical range. High-quality photographs of the sample surface and tip can also be acquired using the camera attached on the eyepiece.

1	Type	Inclined Monocular Metallurgical Microscope.
2	Illumination	Both top- and bottom-illuminated.
3	Magnification	50×-450×.
4	Objective	5×, 10× and 45× on a quadruple revolving nose-piece.
5	Eyepiece	5-Megapixels Camera, USB interface.

[4] *Refer the quote for the detailed specs. of the computer being supplied. A regular computer table (about* $3ft \times 4.5ft$*) to be supplied by the user at the installation site.*

S15 Vibration Isolation Table (Optional)

1	Isolation method	Passive
2	Top	$\sim$ 100kg heavy Top (granite / metal).
3	Vibration Isolation	The table top is place on 4 air-dampers.
4	Base Feet	Adjustable, additionally fitted with material-dampers.
5	Weight	100-150 kg
6	Dimensions	$\sim$ 2.5ft $\times$ 2.5ft $\times$ 4ft.

Some key specifications given above, please get in touch for additional details.

S16 nanoETCH Tip Fabrication Unit (Optional)

1	AFM Tip Etching Technique	Double-Lamelle drop-off.
2	Tip Etching	Precision Micrometer slides in XYZ directions.
3	Tip Mounting	Controlled application of glue using XYZ stages.
4	Controller Electronics	Voltage control (0-12 Vdc), pulse-mode and dc-mode etching.
5	Camera View Assist	USB interface, with 300$\times$ magification.
6	Accessories	Tip tungsten wire, tip-mounting adhesive etc..
7	User Manual	English (with the tip-fabrication procedure).

Some key specifications given above, please get in touch for additional details.

S17 Sample Kit (Optional)

1	Pre-mounted Samples	10 no.s (Gratings like optical storage media: DVD, BluRay^{TM} etc.)

S18 Online UPS (Optional, Third Party Supply)

Power glitches/outages/spikes etc. are not only detrimental to the controller electronics, furthermore, the AFM tip is lost. Since they are limited in supply and costly, it is always better to save them against accidental power failures. The online UPS gives sufficient time to safely retract and save the AFM tip all in such scenarios.

1	UPS	Online, Pure sine-wave.
2	Power Rating	1000VA (1 kVA).
3	Back-up Devices	AFM Controller and Interfacing Computer.
4	Back-time Time	20-25min.

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