

SUMMER WORKSHOP ON BIOAFM MICROSCOPY 2023, BRNO CZECH REPUBLIC

## **The Fundamentals of AFM Probe Selection**

Dr Alexander Dulebo Application Scientist

Innovation with Integrity

## Outline

Manufacturing a probe

How to select a probe

Recommended probes for bio applications

#### Probe artefacts, probe cleaning

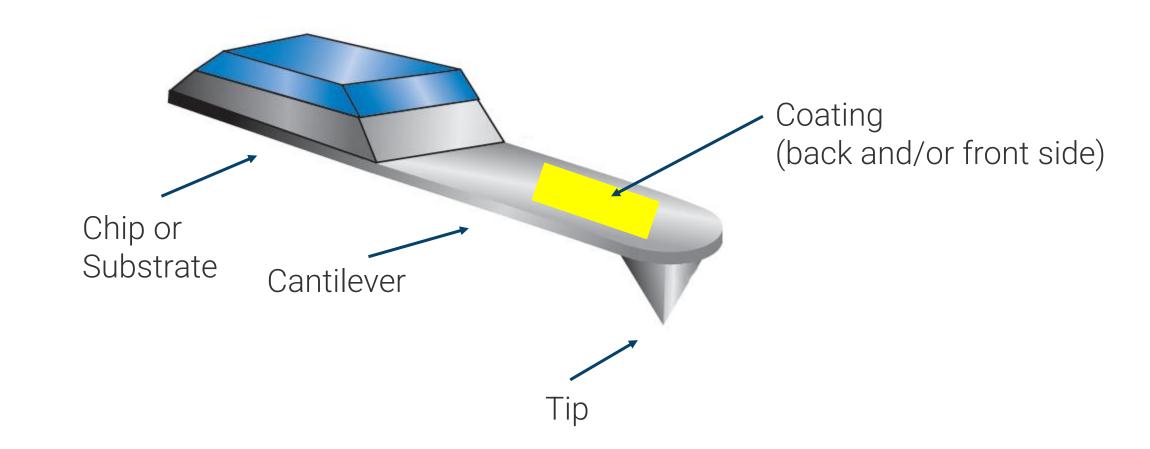




01 Manufacturing a probe

# BRUKER

#### Anatomy of the probe





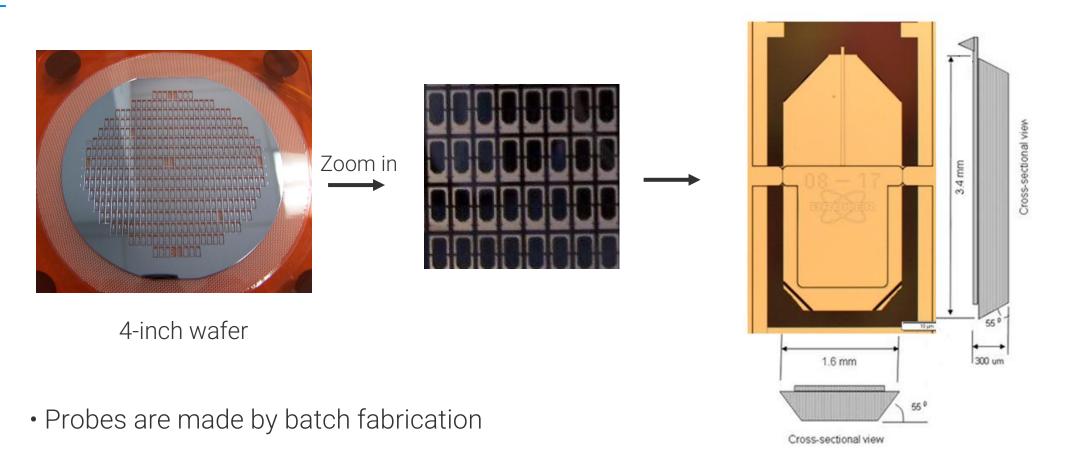
#### **Bruker Nanofabrication Center in Camarillo, CA, USA**







#### **Probes Fabrication – batch fabrication**



• Each 4-inch wafer holds about 400 probes



Wafer 4" <100>

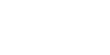
Si Wafer













Backside Photosensitive resin coating





Photolithography (Photosensitive resin is exposed through a Chrome/Quartz mask)







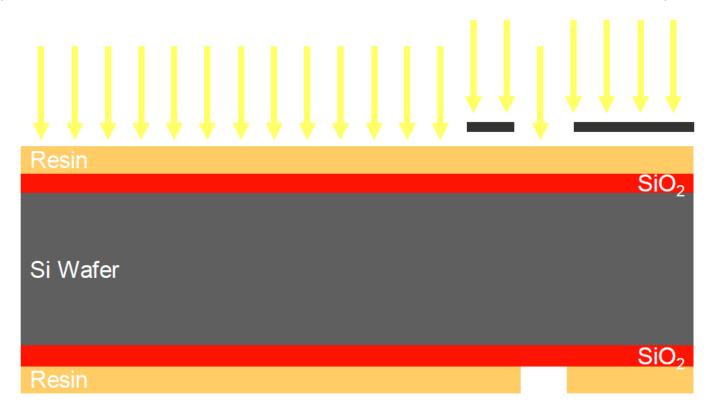




Front side photosensitive resin coating



Photolithography (photosensitive resin is exposed through a chrome/quartz mask)









Lift off



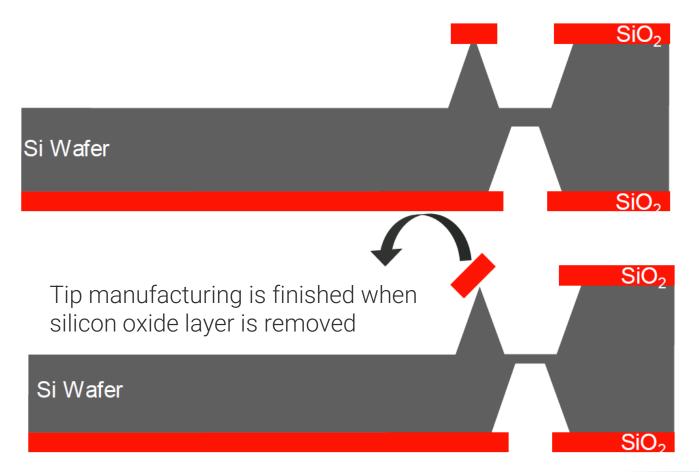
• Silicon Oxide isotropic wet etching with BHF



Photosensitive resin dissolved in acetone



• Silicon anisotropic wet etching with KOH (this is critical and made in several step)







• Silicon oxide isotropic wet etching with BHF





• Silicon nitride coating to protect the tip





• Silicon anisotropic wet etching with KOH (cantilever thickness is controlled there)





Silicon nitride isotropic wet etching withH<sub>3</sub>PO<sub>4</sub>





Silicon nitride isotropic wet etching withH<sub>3</sub>PO<sub>4</sub>





#### Wafer Fab

- Process Capabilities:
  - Lithography: From < 1 mm to 35 mm</li>
     Photoresist Thicknesses and 1 mm
     Linewidths
  - Stochiometric and Super Low Stress Silicon Nitride
  - Thermal Oxidation
  - Wet Etch: Silicon, Oxide, Silicon Nitride, Metals
  - Dry Etch: Silicon, Oxide, Silicon Nitride
  - Metallization: Magnetic Films, Titanium, Chrome, Aluminum, Gold, Platinum, & Metal Alloys
  - Focused Ion Beam
  - Electron Beam Deposition



#### FIB and EBD System



Wet Process Stations



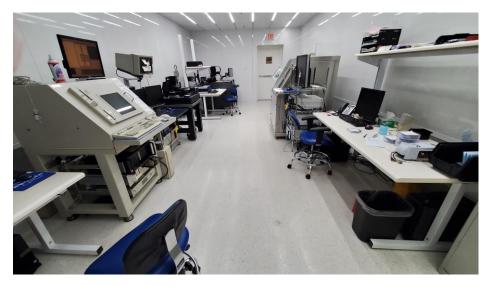
**Contact Aligners** 

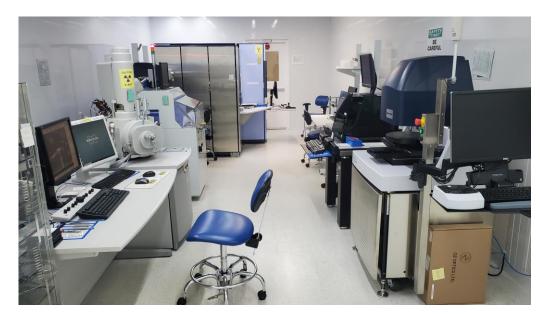


Photoresist Spin Coat & Developer Track



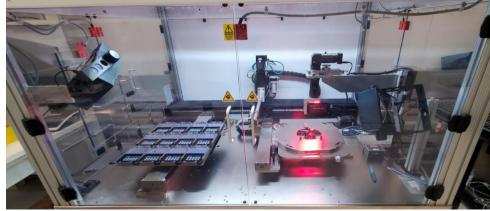
#### Final test and assembly room





AFM & Vibrometer

SEM & ContourGT

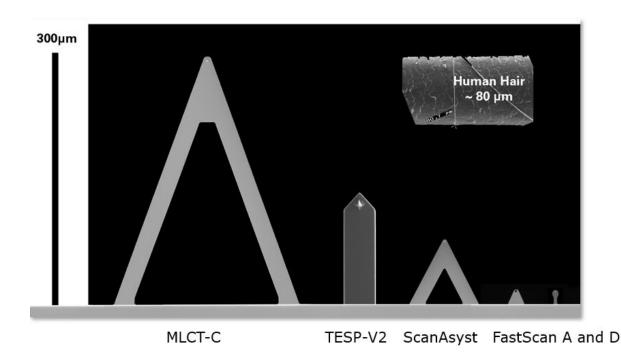


Pick & Place System



02 How to select a probe

## How to select a probe: Cantilever shape affects sensitivity and hydrodynamic





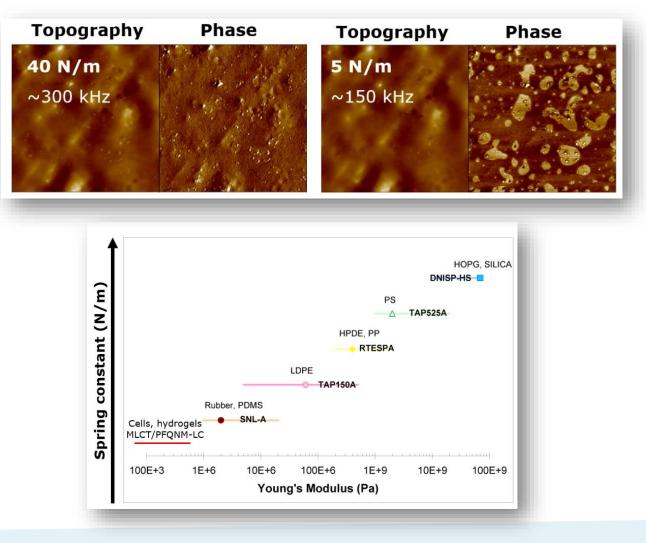


- The probe's cantilever is usually rectangular, triangular, or special
- The width (W), length (L), and thickness (t) of the cantilever will influence spring constant k (N/m), resonance frequency f (kHz), and deflection sensitivity d (nm/V)
- Short cantilevers are usually better
  - Have lower deflection sensitivity
  - Have lower hydrodynamic drag in liquid
  - Be aware of laser spot size!

Model	Length	Defl. Sens.
FastScan-C	40 µm	12 nm/V
ScanAsyst-Fluid+	70 µm	22 nm/V
SNL-C	120 μm	30 nm/V

## How to select a probe: Spring constant (k, N/m) affect imaging force

- Contact mode: low spring constant (<1N/m)</li>
- Tapping mode air: high spring constant (>20N/m)
- Tapping mode air (phase imaging): medium spring constant (4-40N/m)
- Tapping mode liquid: low-high spring constant (depends on other factors)
- PeakForce Tapping/ScanAsyst/QI: low spring constant (<1N/m)</li>
- PeakForce QNM/QI/Force Mapping: spring constant to match material modulus





## How to select a probe: Resonance frequency (kHz-MHz) and Q affect imaging speed

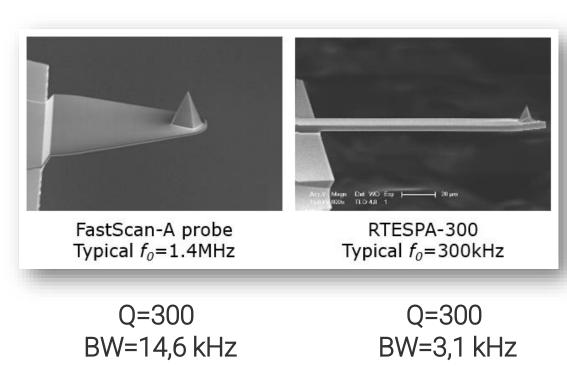
- Resonance frequency (f<sub>res</sub>): speed to reach equilibrium oscillation
- Quality factor (Q): number of cycles to reach cantilever equilibrium
- Cantilever bandwidth (BW): determine the imaging speed

 $BW = \frac{\pi f_{\rm res}}{Q}$ 

How to achieve that? Smaller cantilever!

29

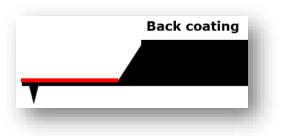






## How to select a probe: Coatings enable specific property measurements

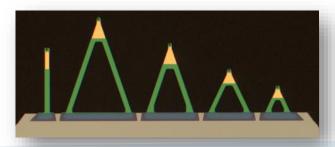




- Back side coating (Al, Au), improve laser reflection
- DO NOT use aluminum backside coated probe in fluid

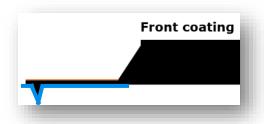
Cantilever Thickness (Nom):	0.65 µm
Cantilever Thickness (RNG):	0.6 - 0.7 µm
Back Side Coating:	Reflective Aluminum

 Back side coating could cause cantilever to bend when temperature changes

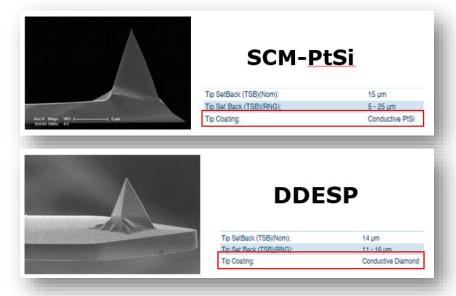


MLCT-BIO-DC probe -

partial coating minimize thermal drift

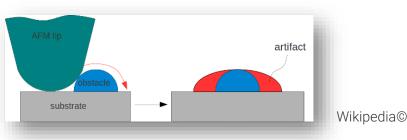


 Front side coating (conductive, chemical, hardened) enable specific applications (electrical, magnetic measurements)

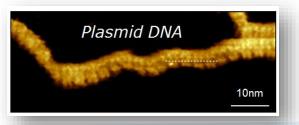


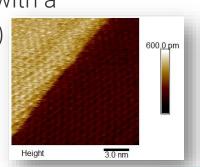
## How to select a probe: Tip shape and radius determine resolution

 AFM topography is always a convolution of tip shape and sample surface structure



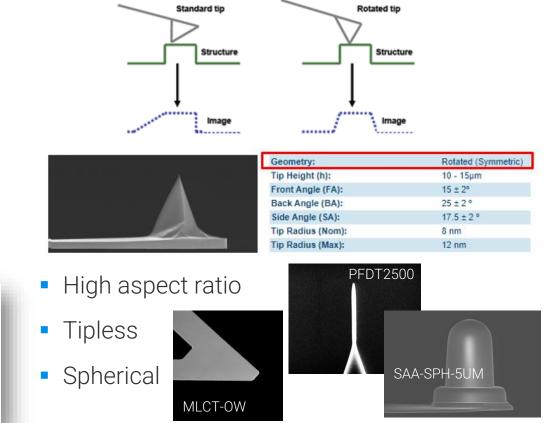
- High resolution on rough samples require a sharp tip (e.g. DNA double helix)
- High resolution on flat samples is possible with a regular tip (e.g. atomic resolution on calcite)



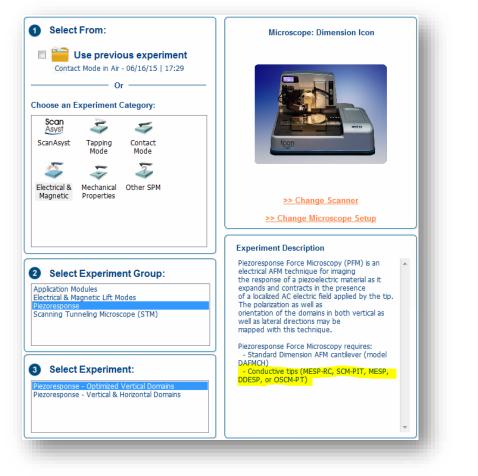




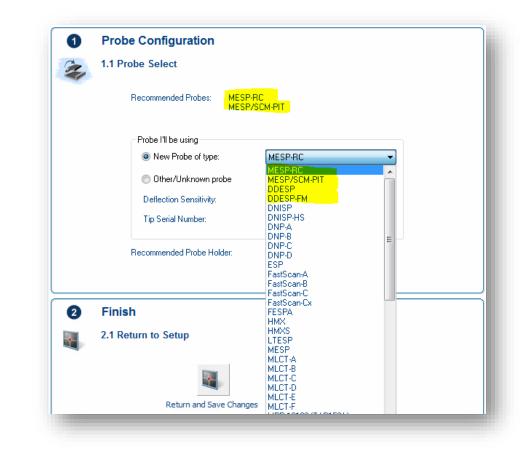
Rotated tip for accurate topography tracking



### How to select a probe: Guidance from the AFM software



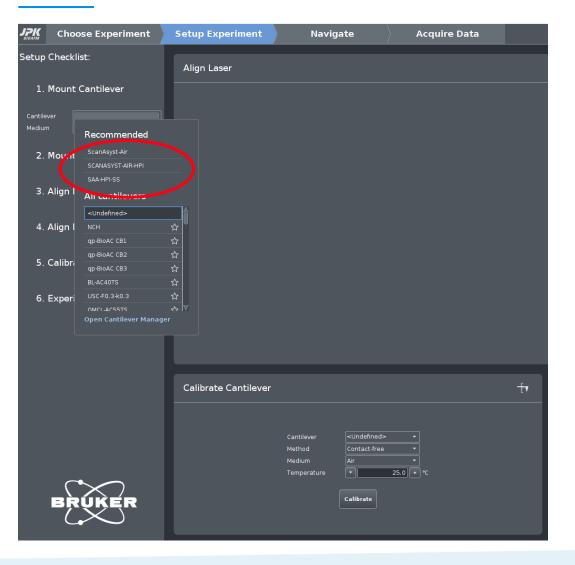
Probe Suggestions in Loading Experiment



Probe Suggestions in Probe Configuration



#### How to select a probe: Guidance from the AFM software

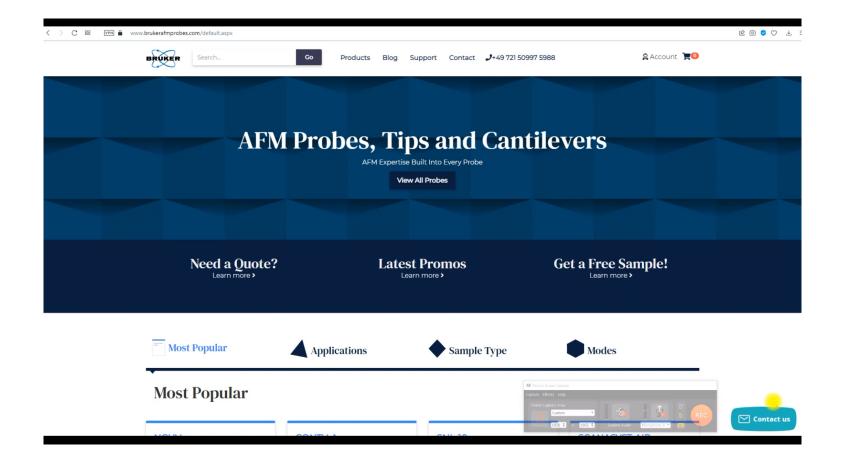


 Probe Suggestions in BioAFM probe database (version 8.0 to be released)



#### How to select a probe? Probe selection on www.BrukerAFMProbes.com





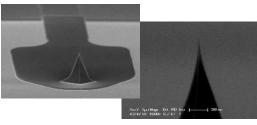


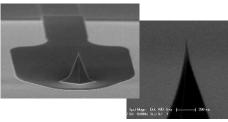
03 Recommended probes for bio applications

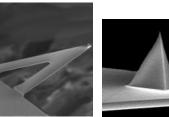
## Bio Applications – recommended probes High resolution imaging

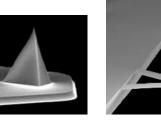


	PEAKFORCE-HIRS-F-A	PEAKFORCE-HIRS-F-B	ScanAsyst-Fluid+	SNL
Purpose	Extreme resolution, 2D crystals, DNA origami	Extreme resolution, single molecules	High resolution, general	High resolution, general
End radius	1-2 nm	1-2 nm	2-12 nm	2-12 nm
Spring constant	0.35 N/m	0.12 N/m	0.7 N/m	0.06-0.35 N/m
Mode	PFT/ScanAsyst/Tapping/QI	PFT/ScanAsyst/Tapping/QI/CM	PFT/ScanAsyst/Tapping/QI	PFT/ScanAsyst/Tapping/QI/CM

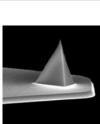


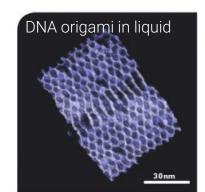


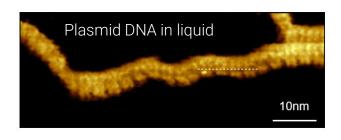


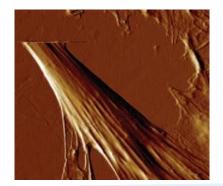








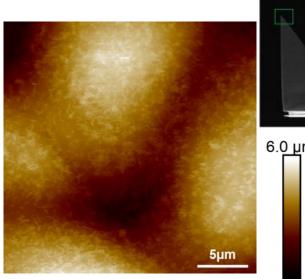




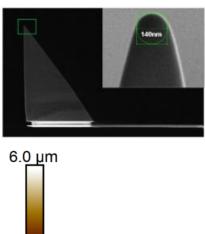
## **Bio Applications – recommended probes** Imaging cells

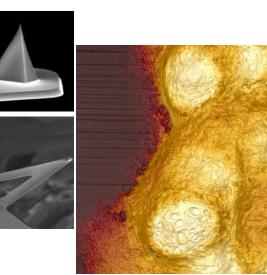


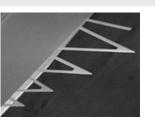
	PFQNM-LC-A-CAL	ScanAsyst-Fluid	MLCT-(BIO-DC)
Purpose	Living cells, bacteria	Fixed cells, yeasts, bacteria	Various cells
End radius	70 nm	20-60 nm	20-60 nm
Spring constant	0.1 N/m (pre-calibrated)	0.7 N/m	0.01-0.6 N/m
Mode	PFT/ScanAsyst/Tapping/QI	PFT/ScanAsyst/Tapping/QI	PFT/ScanAsyst/Tapping/Contact mode

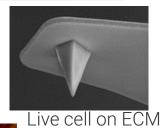


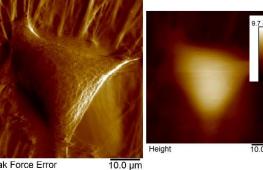
Living MDCK cells











Fixed MCF7 cells

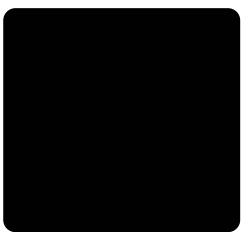
Peak Force Error

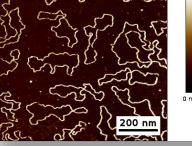


## **Bio Applications – recommended probes** High speed imaging



	FASTSCAN-D	FASTSCAN-D-SS	FASTSCAN-C	HIGHSPEED-FLUID
Purpose	Extreme resolution, 2D crystals, DNA origami	Extreme resolution, single molecules	High resolution, general	High resolution, 2D crystals, DNA origami
End radius	5-8 nm	1-2 nm	5-12 nm	4-12 nm
Spring constant, f	0.25 N/m, 110kHz liquid	0.25 N/m, 110kHz liquid	0.7 N/m, 70kHz liquid	0.35 N/m, 120kHz liquid
Mode	PFT/ScanAsyst/Tapping	PFT/ScanAsyst/Tapping	PFT/ScanAsyst/Tapping	PFT/ScanAsyst/Tapping





Plasmid DNA

Height Sensor 20.0 nm

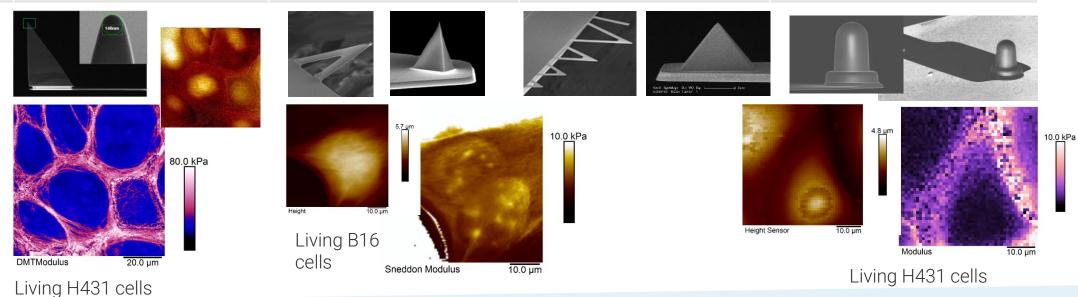
DNA mini circles. Data courtesy of Dr. Alice Pyne, University of Sheffield, UK

E. Coli bacteria

## Bio Applications – recommended probes Mechanical mapping



	PFQNM-LC-A-CAL	ScanAsyst-Fluid	MLCT-BIO-(DC)	SAA-SPH
Purpose	Living cells, hydrogels	Bacteria, fibrils	Living cells, hydrogels	Cells, tissues, hydrogels
End radius	70 nm	20-60 nm	20-60 nm	1, 5, 10 µm
Spring constant	0.1 N/m (pre-calibrated)	0.7 N/m	0.01-0.6 N/m	0.17 N/m (pre-calibrated)
Mode	QNM/QI/Force Volume/Force mapping/Force Curves	QNM/QI/Force Volume/Force mapping/Force Curves	QNM/QI/Force Volume/Force mapping/Force Curves	Force Volume/Force mapping/Force Curves



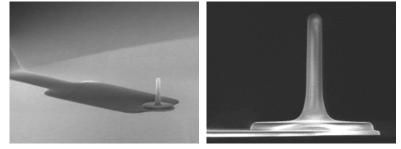
## Hemispherical probes: Accurate mechanical and rheological measurements

- SiN probe on SiN lever design
- No glue used
- Tall tip (19-28 µm) minimal interference between cantilever and high roughness cellular or tissue samples
- Soft lever (k~0.25N/m) always comes LDV pre-calibrated
- Dedicated to very soft samples (sub-kPa to 100kPa)
- Different radii (R=1, 5, 10µm)
- Patented

© 2021 Bruker

Available at <u>www.brukerafmprobes.com</u>



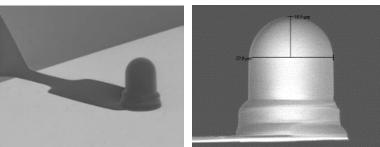


SAA-SPH-1UM





SAA-SPH-5UM

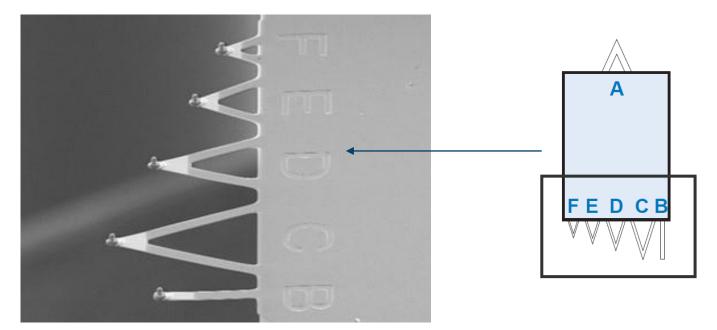


SAA-SPH-10UM



#### **New MLCT-DC-SPH**

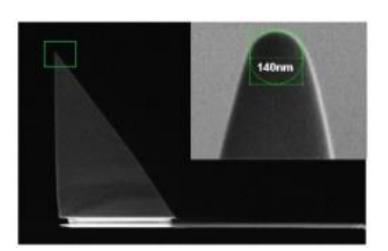
- For extremely soft samples
- 6 hemispherical probes on one chip!
- 6 different spring constants
- All levers LDV pre-calibrated
- Drift Compensated (DC) levers
- Different radii (R=1, 5, 10µm)
- Available at <u>www.brukerafmprobes.com</u>



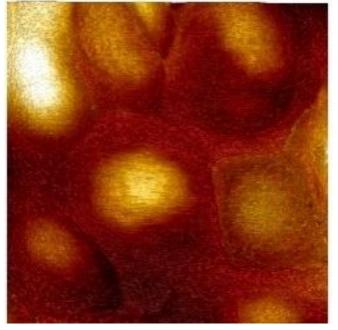




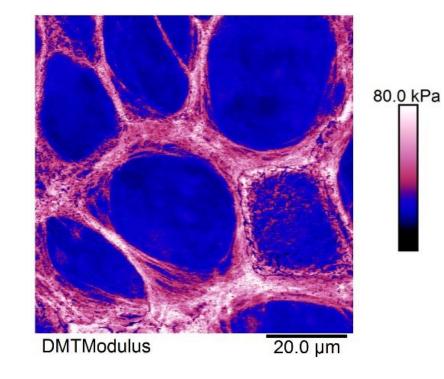
#### PFQNM-LC-A-CAL probe for cell imaging and mechanical mapping



PFQNM-LC-A-CAL probe



Height Sensor

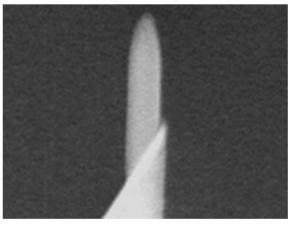


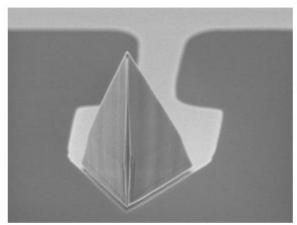
#### Living H431 cells

NOT at www.brukerafmprobes.com but available for order!

## **PFQNM-LC-version 2**

(Old)

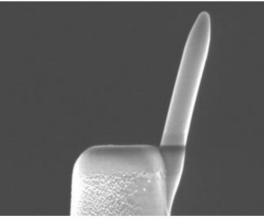


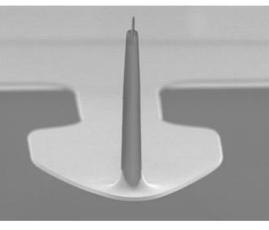


#### PFQNM-LC-A-CAL

- Technically a Visible Tip Probe, but users still need to perform some alignment of tip-to-sample.
- Tip has large mass, resulting in lower Frequencies.
- Tip is not tilted, so it doesn't compensate for the tilt in holder.
- The fabrication process is very complicated, resulting in added cost and lower yields.

#### (New)





#### PFQNM-LC-V2

- Tip has very small mass, resulting in nearly 2X higher Frequency.
- Tip is tilted 11° to compensate for the 10° – 12° holder tilt.
- The fabrication process is very simple, and cuts fabrication time by 50%.
- Not a Visible Tip design, but Tip Set Back is minimal, averaging about 3μm.

NOT at www.brukerafmprobes.com but available for order!



#### **2023 AFM Probes Selector Guide**



RECOMMENDED	PEAKFORCE-HIRS-F-E	B PEAKFORCE-HIRS	-F-A SCANA	ASYST-FLUID	0+ SNL-10	PEAKFORCE-HIRS-F-B:					_			-									
f (KHz)	1	105		150	18-65	best-in-class for ultra-sharp PeakForce Tapping-based sing)																	
k [N/m]	0.12	0.35		0.7	0.05-0.35	blomolecule imaging in fluid																	
Mode	PeakForce Tapping	PeakForce Tappin	ig PeakP	Force Tapping	g Tapping	PEAKFORCE-HIRS-F-A:	STM, nanoIR, an	d More						- 80									
Igami DNA Imaged	In liquid using PeakFor	rce Tapping mode.	No			optimized for molecular Lattice imaging SNL-10: Industry standard for high- performance imaging with tapp mode in fluid	FEOCWARNED r [mm] f [1042] Mode	TT10 d50 nm Na STM	VITA-DM- NANOTA-20 15 65 Themai	PR-UM: 20 72 nanolR, 1	5	NP.010 n/a 18-65 Force Carvas	TTID: a time-long. 8.25mm-diameter, ethnet lungsten tip, perfect for 5TM imaging NP-DID: substrate clipwith four V-shaped castiliwers, almody Au costed and reacy for bespike tip or carditiwer constraintizion	L									
ALTERNATIVES	Descrip	tions	Tip Radius	Frequency [KHz]	Spring Constant [Nim]		Sec. 199						for specific experiments		× 1.	NdeAbbas		AMINA		Unition	to Sergina	North C	
CANASYST-FLUID	High Res, Lower		[nm] 20	[KHz] 150	[Nim] 0.7			_					PR-UM-Init: probes with front and backside	Probe Mode	els 🚦			<b>8</b> 8 8 8	10 10				- 1
MLCT	Multi-lever, Lowe		20	7-125	0.01-0.6		STM image of grapher						gold coating for use with nanoscale infrared spectroscopy	RTESPA	L300 40 50	1 1 5	2 43 4 5 Alma 5 Alma		1		•		
MSCT	Multi-lever, Hig		10	7-125	0.01-0.6		ALTERNATIVES		Descriptions		Frequency [KHz]	Spring Constant [N/m]	enabled platforms	TESP	9.112 S7 S	8 6 5 8 7 5	S Alvana	:		:		•	- 1
MSNL-10 DNP-S10	Multi-lever, Ultra Multi-lever, High Res		2	7-125	0.01-0.6		PT10 PR-UM-CniR-B		m, STM, Electrical Studi nanoIR Studies, High Res	s <50 20	n/a 13	n/a 0.2		SCANASYSTAN		5 2 SN 5 10 SN	S Alvere DLC Alvere	:	•	:	:	:	:
2117-010		, cow Porce, and	10	.8-00	0.00-0.35		PR-UM-TriB-D CLFC-N0CAL	Au-Coated,	nanoIR Studies, High Res ar, Low Force, Tipless		300	40 0.15-10.4		HB1 TESTA BNT50	2 9 A00	0 10 S	S Alvere S Alvere	:				:	
FEDOM/JENDED           r [nm]           f [KHz]           k [N/m]           Mode	70 B5 0.1 PeatForce Tapping USING PeatForce T Descrip Coloid-Lke, Lor	SCANASYST-FUID 20 0.7 PeatForce Tapping Repting mode (20 µm rtions w Farce, SPH	10000 13 0.25 Force Curv	vus B	T.SRH-10UM.DC 10080 3-125 0.01-0.7 Force Curves Spring Constant (Mon) 0.73 0.01-0.7	Promoto-V2: constant with an Upun-tail par- port turning in a sectors bound reported by the sectors bound reported by the sectors bound reported by the sectors of the sectors and the sectors of the sectors and the sectors bound the sectors and the sectors bound the sectors and the sectors in the sectors and the sectors in the sectors and the sectors in the sectors and the sectors the sectors and the sectors and the sectors in the sectors and the sectors and the sectors the sectors and the sectors and the sectors and the interval of the sectors and the sectors and the sectors the sectors and the sectors and the sectors and the sectors in the sectors are settors and the sectors and the sectors the sectors are settors and the sectors and the sectors and the sectors in the sectors are settors and the sectors and the sectors in the sectors are settors and the sectors and the sectors and the sectors in the sectors are settors and the sectors and the sectors and the sectors in the sectors are settors and the sectors and the sectors are settors and the sectors and the sectors are settors are settors and the sectors are settors a	MLCF-DIS Samples SAFF4EE-tal FEA-SMARL FEA-SMARL RS Substrates MCA HOPG-tal M	Description Sapphin s deflection Periodical A samplo A samplo A semplo and a samplo probe shap probe shap Description Graphine for and confus Description	ample (12 mml mountaid worstnicky determination probald filterium minister fo wirk Au, Au, and existers probal microscopy. (KEP) mogenesis sample used a diagnosis n fa misia daste 12 mm da da diagnosis n fa misia daste 12 mm da daste 12 mm da das	use with piezofor tures able to be so 0 mode with tip evaluation materil for use as a fee s AFM samples or S. P.S. P.S.LDPE. s	settate for te microscopy canned in a sin software for in atomically fli nto to have a cl	jla imago for usa t substrate os aan, atomically flat,		налоска или казачата и или или или или или или или или или или	I         I           I         I         I           I         I         I         I           I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I           I         I         I         I         I	5         1         54           2         2         54           2         2         54           4         7         54           5         1000         54           5         1000         54           6         2         5           6         2         5           6         2         5           6         3         5           6         5         5           5         5         5           6         5         5           6         5         5           7         5         5           8         5         5           9         5         5           9         5         5           10         5         5           10         5         5           10         5         5           10         5         5           10         5         5           10         5         5           10         5         5           10         5         5           10         5	Alman         2           Alman         2           S         Alman           S         Alman           S         Alman           S         Alman           Alman         32           S         Alman           S </th <th></th> <th>• •</th> <th>· · · · · ·</th> <th>· · ·</th> <th>: .</th> <th>· · · · · · · · · · · · · · · · · · ·</th>		• •	· · · · · ·	· · ·	: .	· · · · · · · · · · · · · · · · · · ·
ILCT-SPH-1UM-DC	Multi-lever, Colloid-Lik Multi-lever, Colk		1000	3-17.5	0.01-0.7		SD-101	titanium sa	mples for various AFM a meter steel discs on whi	ies .				N	010 125 10	e na sn	M. Auflina	• • •	•	•	• •	•	
ILCT-SPH-10UM	Multi-lever, Colk		10000	3-17.5	0.01-0.7		VGRP-16M		n artifiact, 190 nm depth,														
DNP-10	Multi-lever, Low		20	18-65	0.06-0.35											oes Nanofabr							
-	-								-				,	Carry Phon	arilo, CA + US le +1.800.715. IProbeOrders	A 8440			۷	rww.Bruł	terAFMpr	obes.coi	n



04 Probe artefacts, probe cleaning



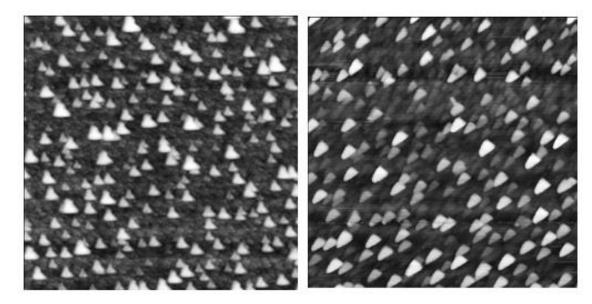
## Tip artefacts



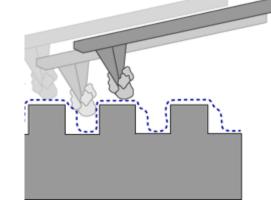
#### Double tip image of DNA

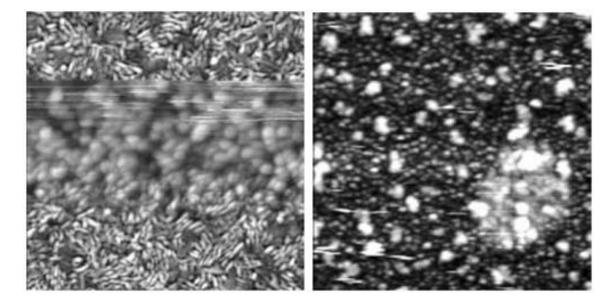


## **Tip artefacts**



#### Dull or dirty tip





#### Tip contamination

#### **Probes cleaning**

- Yes, you can clean probes
- Yes, you can re-use probes
- Cleaning solutions: water, Tergazyme®, organic solvents (EtOH/IP), "piranha", peroxide, etc.
- Physical treatments: UV/ozone, plasma



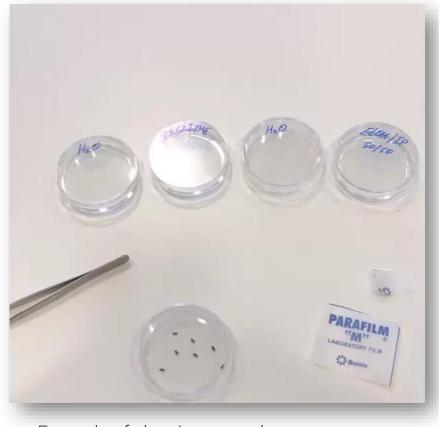
TERGAZYME

is a concentrated, anionic detergent with protease enzyme for manual and ultrasonic cleaning. Excellent for removal of proteinaceous soils,tissue, blood and body fluids from glassware, metals, plastic, ceramic, porcelain, rubber and fiberglass with no

interfering residues. Ideal as a cleaning agent in Reverse Osmosis and Ultra-Filtration Systems. USDA authorized. Dilute: 1:100. pH 9.5

https://alconox.com/tergazyme

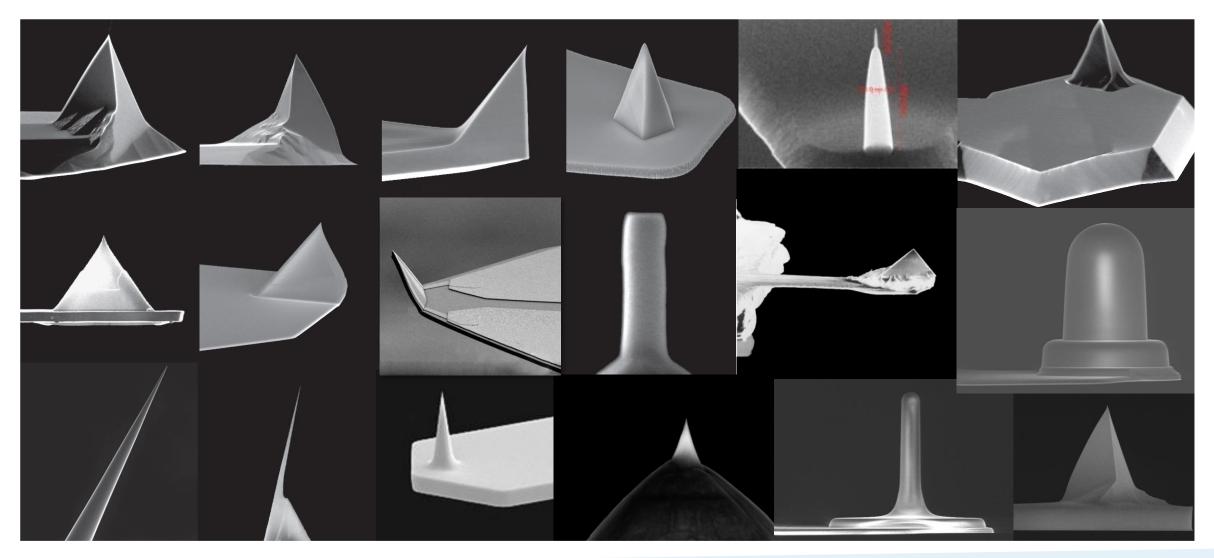




Example of cleaning procedure

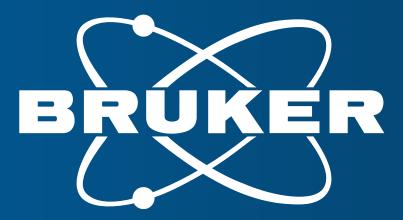


#### AFM image is a combination between tip shape and sample topography!





## Thank you!



Innovation with Integrity

Innovation with Integrity

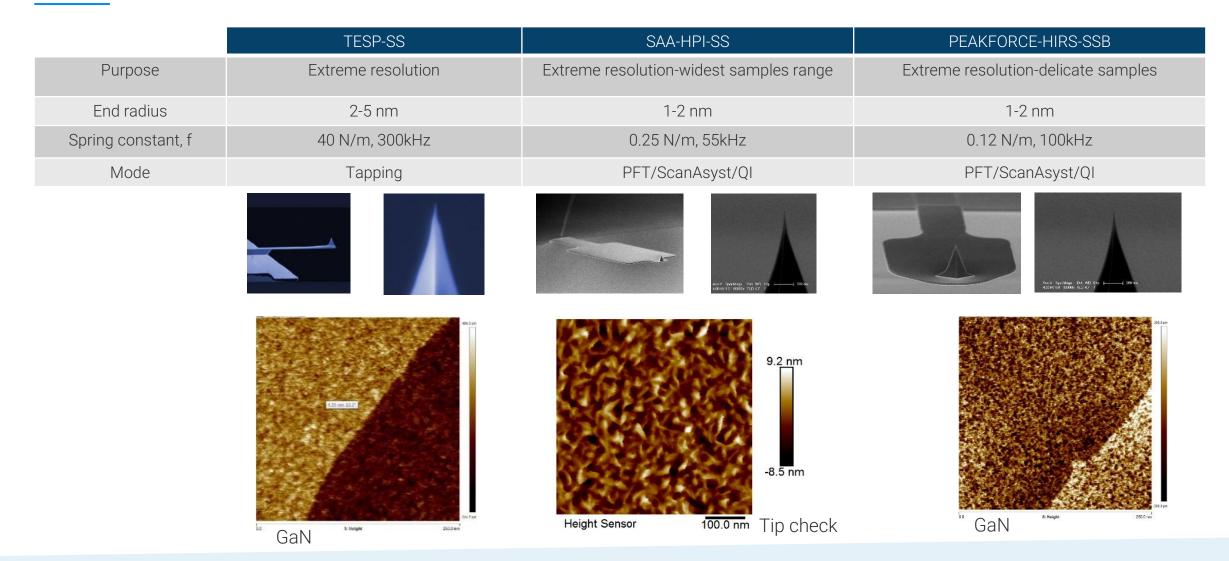
## Material Science – recommended probes Topography



	VTESP-300	RTESP-150	ScanAsyst-Air	ScanAsyst-HPI
Purpose	General use	Mechanical phase contrast	General use	General use/laser interference reduction
End radius	5-12 nm	8-12 nm	2-12 nm	2-12 nm
Spring constant, f	40 N/m, 300kHz	5 N/m, 150kHz	0.4 N/m, 70kHz	0.25 N/m, 55kHz
Mode	Tapping	Tapping/QI	PFT/ScanAsyst/Contact/QI	PFT/ScanAsyst/Contact/QI
		Any         How or, Fax		
	1: Height 500.0m		the state of the s	
	Silicon oxyde	Polymer surface	Polymer surface	<sup>60</sup> Silicon oxyde

#### Material Science – recommended probes High resolution imaging

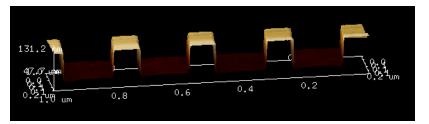


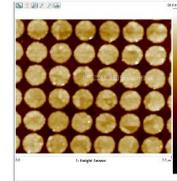


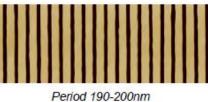
#### Material Science – recommended probes Trenches and lines



	FIB series	PFDT350	PFDT750	PFDT2500
Spike length	1-7µm	350 nm	750 nm	2500 nm
Spike base width	100-400nm	30 nm	65 nm	150 nm
End radius	10 nm	10 nm	10 nm	30 nm
Mode	Tapping	PFT/ScanAsyst/QI	PFT/ScanAsyst/QI	PFT/ScanAsyst/QI
		20000 ave and an a fin a 100 -	50/2028         100         100         100           50/1028.00         100         100         100         Assemble	
		STREE Str		







Depth 38-100nm Top surface 120nm Bottom 40-80nm Period ~600nm Depth 700nm Top ~120nm Bottom ~330nm

#### Material Science – recommended probes High speed imaging

24



	FastScan-A	FastScan-B	FastScan-C	ScanAsyst-AIR-HR
Purpose	High speed, general use	High Speed, phase contrast	High speed, general use	High speed, general use
End radius	5-12 nm	5-12 nm	5-12 nm	2-12 nm
Spring constant, f	18 N/m, 1400kHz	1.8 N/m, 450kHz	0.8 N/m, 300kHz	0.4 N/m, 130kHz
Mode	Tapping	Tapping	PFT/ScanAsyst/QI	PFT/ScanAsyst/QI
				AuV SprMay Dr H0
PHBV crystallization				

Polymer melting

Syndiotatic Polymer

Alkane

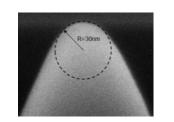
(sample courtesy of Dr. Jamie Hobbs)

PDF

# Material Science – recommended probes Force curves based mechanical measurements



	SAA-HPI-30	RTESPA-150-30	RTESPA-300-30	RTESPA-525-30
Modulus range	100kPa-15MPa	10-500MPa	300MPa-10GPa	8GPa-100GPa
End radius	30 nm	30 nm	30 nm	30 nm
Spring constant, f	0.25 N/m, 55kHz	5 N/m, 150kHz	40 N/m, 300kHz	200 N/m, 525kHz
Mode	QNM/QI/Force Volume/Force Curves	QNM/QI/Force Volume/Force Curves	QNM/QI/Force Volume/Force Curves	QNM/QI/Force Volume/Force Curves

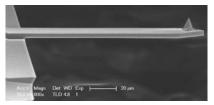


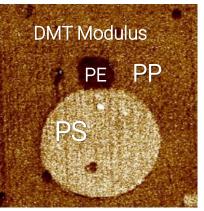


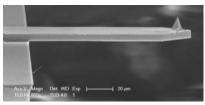
Анс.V Magn Det WD Exp
Heat-Sealed Bag
100MPa 200MPa

3 DMTModulus

100MPa









#### Material Science – recommended probes Resonance based mechanical measurements



	DDLTESP-V2	DDESP-FM-V2	DDRFESPA40
Modulus range	3-300 GPa	0.5-50 GPa	0.1-10 GPa 10-200 GPa Mode2
End radius	100 nm	100 nm	100 nm
Spring constant	95 N/m, 280 kHz	6 N/m, 105 kHz	2 N/m, 60 kHz
Mode	Contact resonance	Contact resonance	Contact resonance
	Maga   5 gar		
Contact Resonance module for Icon AFM	Height Sensor 8.0 µm	33 GPa 3.6 GPa  rage Modulus 8.0 μ	0.11
Contact Resonance module			R Loss Tangent 8.0 µr

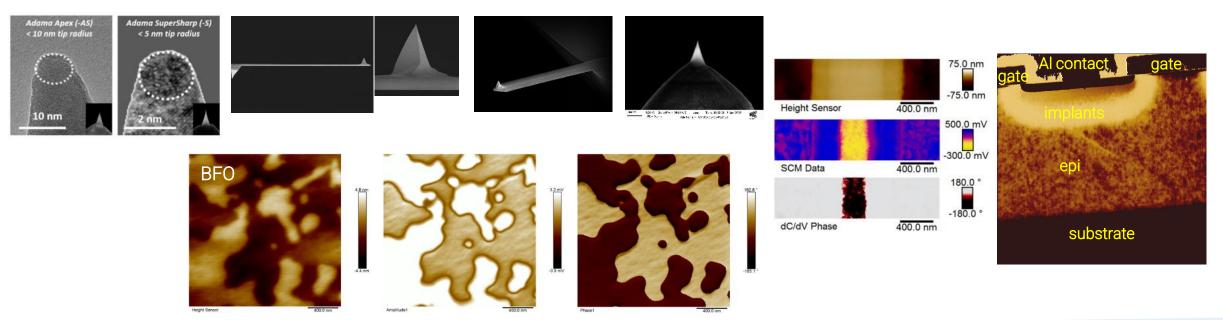
© 2021 Bruker

Contact Resonance module for NanoWizard AFM

#### Material Science – recommended probes Nanoelectrical contact mode based modes



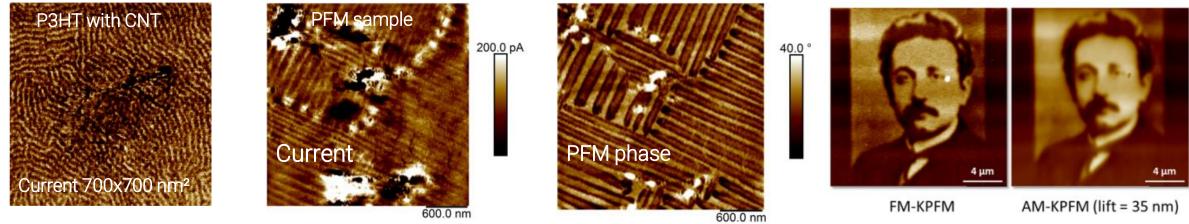
	SCM-PIT-V2	AD-0.5	AD-2.8	AD-40
Purpose	General nanoelectrical	High resolution, tip lifetime, soft sample	High resolution, tip lifetime	High resolution, tip lifetime
End radius	25 nm	10 nm	10 nm	10 nm
Spring constant, f	3 N/m, 75 kHz	0.5 N/m, 30 kHz	2.8 N/m, 65 kHz	40 N/m, 300 kHz
Mode	C-AFM, TUNA, PFM, SCM, SSRM	C-AFM, TUNA, PFM	C-AFM, TUNA, PFM, SCM	TUNA, SSRM



#### Material Science – recommended probes Nanoelectrical intermittent-contact based modes



	PF-TUNA	AD-0,5	AD-2,8	PFQNE-AL
Purpose	General nanoelectrical	High resolution, tip lifetime, soft sample	High resolution, tip lifetime	High resolution, tip accuracy
End radius	25 nm	10 nm	10 nm	30 nm
Spring constant, f	3 N/m, 75 kHz	0.5 N/m, 30 kHz	2.8 N/m, 65 kHz	0.4 N/m, 300 kHz
Mode	C-AFM, TUNA, PFM, SCM, SSRM	C-AFM, TUNA, PFM	C-AFM, TUNA, PFM, SCM, SSRM	Surface potential (KPFM)

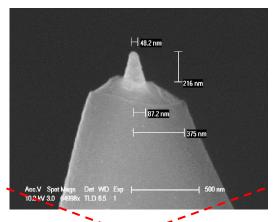


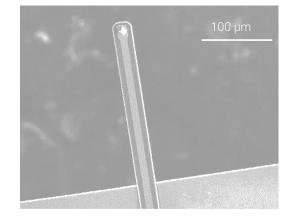
## Material Science – recommended probes Electrochemical characterization

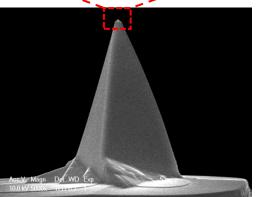


- Probe
  - Exposed tip height: ~ 200 nm
  - End tip diameter: ~ 50nm
  - Exposed tip material: Platinum
  - Passivation: silicon dioxide
  - Conducting path technique
- Package
  - Fully isolated
  - Encapsulated in two parts glass
  - Easy to handle package
  - Chemical resistant epoxy





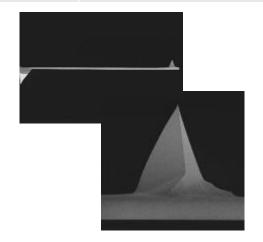


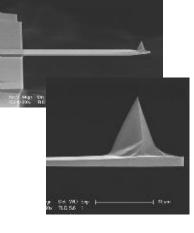


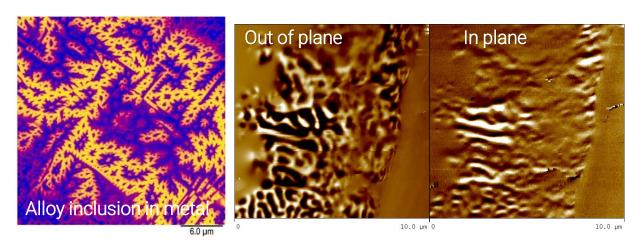
#### Material Science – recommended probes Magnetic characterization



	MESP-V2	MESP-RC-V2	MESP-LM-V2	MESP-HM-V2	MESP-LC-V2
Purpose	General MFM	Higher sensitivity	avoid modification/motion of magnetic walls	High Moment	image low magnetized materials
End radius	35 nm	35 nm	35 nm	35 nm	35 nm
Moment/coercivity	400 Oe/1e-13 EMU	400 Oe/1e-13 EMU	<400 Oe/0,3e-13 EMU	400 Oe/3e-13 EMU	<10 Oe/<1e-13 EMU
Spring constant, f	3 N/m, 75 kHz	5 N/m, 150 kHz	3N/m, 75 kHz	3 N/m, 75 kHz	3 N/m, 75 kHz







#### Material Science – recommended probes Thermal characterization



	VITA-Nano-TA-200	VITA-Nano-TA-300	VITA-GLA-1
Purpose	Nano Thermal Analysis	Nano Thermal Analysis	Scanning Thermal Microscopy (SThM)
End radius	<30 nm	<30 nm	<100 nm
Spring constant, f	2 N/m, 65 kHz	0.3 N/m, 20 kHz	0.5 N/m, 50 kHz

