NANONICS Ltd.

Shedding light on the unseen

NSOM & SPM Probes

Introduction

Nanonics designs and manufactures unique NSOM and SPM probes based on glass pulling technology. Such probes include:

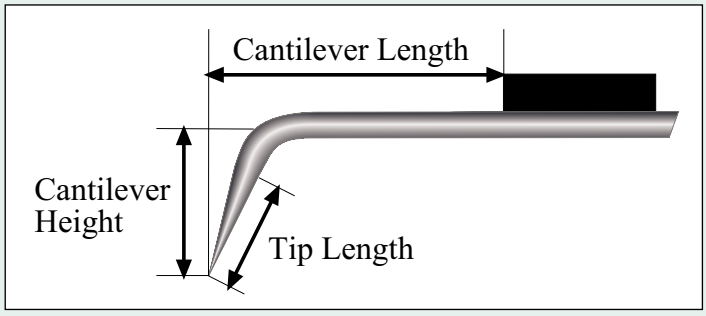
- NSOM Probes
- AFM Probes
- Specialized AFM Probes with ultra-low force constants, medium to high force constants, high resonance frequencies and high aspect ratios
- Deep Trench AFM Probes
- Hollow AFM Probes
- Glass Insulated AFM Sensing Nanowires
- Double-Wired Glass Insulated Probes
- Custom-Made SPM Probes

The Nanonics in-house clean room and probe-making facility produces standard probes of the highest quality.

The close association between our probe-designing division and our NSOM/SPM imaging research team drives Nanonics to both improve and find new applications for our probes.

Attractively priced probe contracts are available for medium to large quantity orders.

General diagram of Nanonics cantilevered glass SPM probe.



The black box on the right is the tip holder. The angle, tip length and cantilever length can be varied depending on the type of probe and the research application of the user. The cantilever does not obscure the optical axis of a microscope, and can be used in SPM systems designed to work with upright or inverted optical microscopes.

All the images in this brochure were obtained using Nanonics MultiView Microscopy Systems.
See our website for details on www.nanonics.co.il

N S O M P r o b e s

Nanonics is the only supplier of the entire spectrum of probes used in NSOM today. Our probes perform all current modes of NSOM operation and are breaking new ground with exciting new techniques.

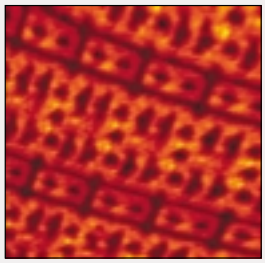
Nanonics holds the exclusive right to produce cantilevered optical fiber probes. In this pioneering probe technology, the fiber tip is bent and coated with metal. Therefore light can be transmitted to the aperture with the same efficiencies and polarization properties as those of conventional, straight near-field optical elements. As a result, near-field optics can benefit from the user-friendly normal-force feedback technique employed with much success in standard AFM systems.

Our straight NSOM probes are also ideal for performing simultaneous NSOM and shear-force AFM.

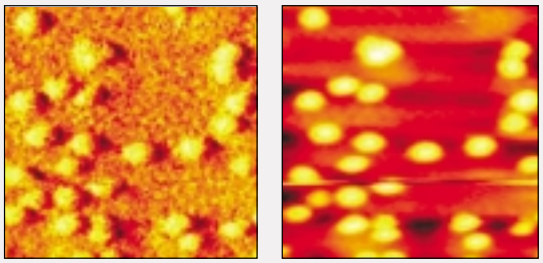
All our probes have the highest throughputs and can achieve the highest resolutions with apertures down to 50nm.

Nanonics range of NSOM probes includes all of the following:

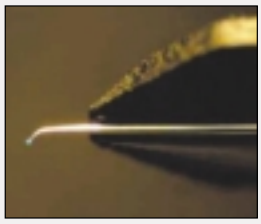
- Cantilevered fiber probes
- Straight tapered fiber probes
- Silver and gold nanoparticle probes
- Probes with roughened probe tips coated with silver or gold
- Hollow normal force sensing probes
- Deep UV NSOM probes
- Polarization preserving NSOM probes with large extinction ratios
- Probes for producing nanometric shadow or reflection
- Active light sources and ion sensing NSOM probes



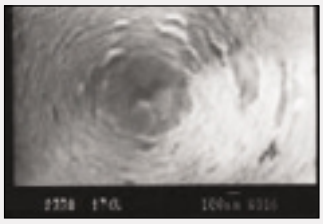
Reflection mode image of a SRAM after CMP. Image size: 12 x 12 µm



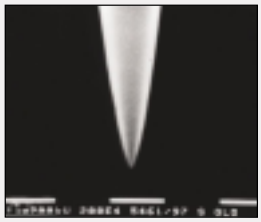
1 x 1µm reflection mode NSOM (left) and AFM (right) image of 30 nm gold balls



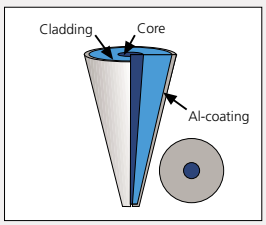
Cantilevered NSOM Probe: opening the way to reflection NSOM imaging



SEM of NSOM Probe tip with a 100 nm aperture



SEM profile of NSOM Probe: The bar is 1 µm long



Sketch of NSOM Probe

Cantilevered Contact and Non-Contact NSOM Probes*

Coatings	Input Power	Total Fiber Length	Connectors	Aperture Diameter	Transmission Efficiency
Cr (~0.02µm)/ Al (~0.2µm)	5mW typicall (20mW maximum)	1 meter standard (Up to 5 meters upon request)	bare or FC	50 nm 100 nm 200 nm 500 nm	$\sim 10^{-5}$ $\sim 10^{-4}$ $\sim 10^{-3}$ $\sim 10^{-1}$
Cr (~0.02µm)/ Au(~0.2µm)	≤50mW	1 meter standard (Up to 5 meters upon request)		>λ/2	$\sim 10^{-1}$

Cantilevered Contact and Non-Contact NSOM Probes*

Mode	Wavelength	Core Diameter	Cladding Diameter	Cantilever Length	Cantilever Height ***	Force Constant	Resonant Frequency
Single	488-514 nm	3.4 µm	125 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Single	630 nm	4.3 µm	125 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Single	780 nm	5.4 µm	125 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Single	820 nm	5.7 µm	125 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Single**	1300-1550 nm	9 µm	125 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Multi	200-1200 nm	50-200 µm	125, 220 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Multi	350 nm	200 µm	220 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Multi	350 nm	105 µm	125 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz
Multi	850-1300 nm	50 µm	125 µm	300-1000 µm	50-200 µm	3-20 N/m	80-390 kHz

Special Cantilevered Contact and Non-Contact NSOM Probes with Large Bend Radius*

Mode	Wavelength	Core Diameter	Cladding Diameter	Cantilever Length	Cantilever Height ***	Force Constant	Resonant Frequency
Single	488-514 nm	3.4 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Single	630 nm	4.3 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Single	780 nm	5.4 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Single	820 nm	5.7 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Single	1300-1550 nm	9 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Polarization Maintaining	488 nm	2.75 - 3 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Polarization Maintaining	630 nm	3-3.4 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Polarization Maintaining	820 nm	3.5 - 4.5 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Polarization Maintaining	1300 nm	8.3 - 10.3 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.
Polarization Maintaining	1550 nm	9.5 - 11.5 µm	125 µm	1 - 2 mm	2 - 3 mm	≥15 N/m	N.A.

Cantilevered Deep Trench NSOM Probes*

Mode	Wavelength	Core Diameter	Cladding Diameter	Cantilever Length	Cantilever Height ***	Force Constant	Tip Length
As above	As above	As above	As above	>1 mm	>0.5 mm	≥5 N/m	≥0.5 mm

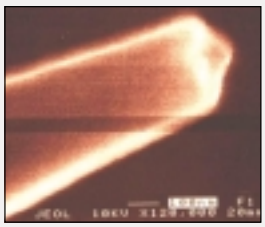
Special Straight NSOM Probes* (Supplied Unmounted)

Mode	Wavelength	Core Diameter	Cladding Diameter
Single	488-514 nm	3.4 µm	125 µm
Single	630 nm	4.3 µm	125 µm
Single	780 nm	5.4 µm	125 µm
Single	820 nm	5.7 µm	125 µm
Single**	1300 - 1550 nm	9 µm	125 µm
Multi	200 - 1200 nm	50 - 200 µm	125, 220 µm
Multi	350 nm	200 µm	220 µm
Multi	350 nm	105 µm	125 µm
Multi	850 - 1300 nm	50 µm	125 µm
Polarization Maintaining	488 nm	2.75 - 3 µm	125 µm
Polarization Maintaining	630 nm	3 - 3.4 µm	125 µm
Polarization Maintaining	820 nm	3.5 - 4.5 µm	125 µm
Polarization Maintaining	1300 nm	8.3 - 10.3 µm	125 µm
Polarization Maintaining	1550 nm	9.5 - 11.5 µm	125 µm

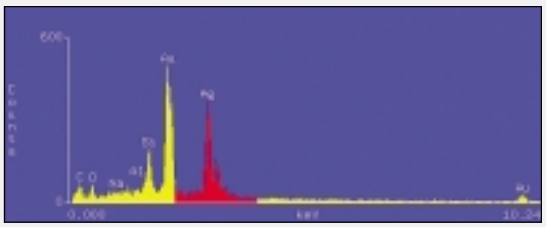
* Aperture diameters available in 50nm increments from 50-300nm, 100nm increments from 300-1000nm and 500nm increments from 1000-5000nm
** Standard fiber
*** Other heights of cantilever available

> NSOM Raman Enhancement and Apertureless Probes

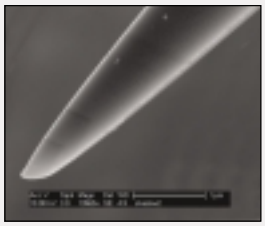
Gold or silver nanoparticle probes are especially useful for research with enhanced Raman imaging and apertureless NSOM.



Nanopipette with silver nanoparticles held in tip



Material composition at the tip of a micropipette containing silver nanoparticles measured by EDX



SEM image of apertureless NSOM probe. The wide tip is used for Shadow NSOM imaging.

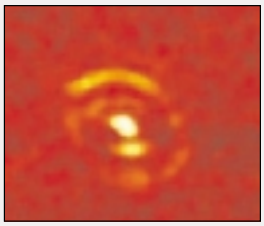


Image of a gold-tipped probe in close proximity to a styryl dye.
The enhancement of the second harmonic generation signal can be clearly seen in the image.

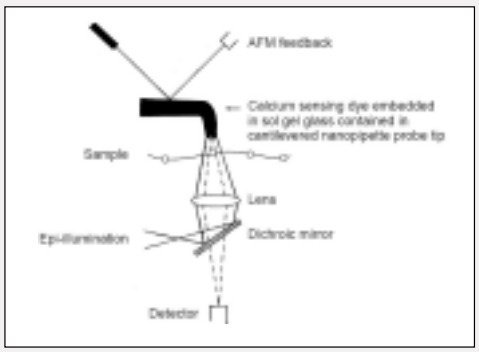
Gold and Silver Nanoparticles and Roughened Probes

Type	Cantilever Length	Cantilever Height	Tip Length	Force Constant	Resonant Frequency	Details
Cantilevered Probes	300-1000 µm	50-1000 µm	50-500 µm	5-20 N/m	N.A	Nanoparticle Size* 50 - >200nm
Roughened Probes	300-1000 µm	50-1000 µm	50-500 µm	<1N/m	20-390 kHz	Surface Roughness: 20 - 200nm

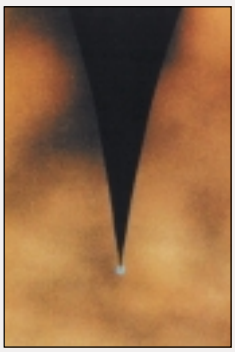
* Nanoparticle Sizes available in 50nm increments from 50 - 200nm

> Active NSOM Probes for Imaging and Ion Sensing Probes

Cantilevered and straight nanopipette probes can be filled with fluorescent materials. These active light sources can be provided with a variety of sensing capabilities. Sensors are currently available for H^+, Na^+, K^+, Ca^{2+} and Cl^-, other sensors are also available upon request.



Experimental arrangement of external illumination NSOM mode for ion sensing. A cantilevered nanopipette tip is used as a nanovessel for an ion-sensing dye, which is excited in epi-illumination. The AFM function is used to provide unprecedented control of a dye in an optical microscope.



Fluorescent material can be seen at the tip of a nanopipette as a result of external epi-illumination

Cantilevered and Straight Active Nanopipette Probes

Nanopipette Material	Outer Diameter	Tip Diameter	Tip Length	Cantilever Length	Cantilever Height	Force Constant	Resonance Frequency	Coating
Borosilicate	1 mm	≥100 nm	30 - 500 µm	300-1000 µm	100-500 µm	≥1N/m - 20N/m	20-390 kHz	Cr (thickness 0.02 µm)
Quartz	1 mm	≥20 nm	30 - 500 µm	300-1000 µm	100-500 µm	≥1N/m - 20N/m	20-390 kHz	Al (thickness 0.2 µm)

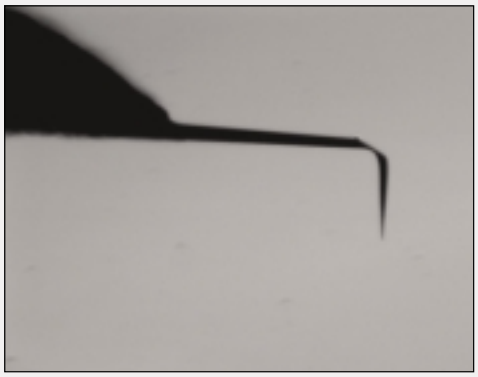
Ion sensing probes can be provided with multiple channels

> Hollow NSOM Imaging Probes

These probes are useful for high peak power laser pulses and can be used in the IR and very deep UV regions where regular fiber probes do not transmit, for example, 10 micron IR wavelengths or vacuum UV wavelengths below 180nm. These probes have a high threshold for damage making them especially useful for nanolithography and for highly localized metal removal using femtosecond laser pulses.

These probes are not recommended for general imaging applications because they can generate higher noise levels due to their immobility, lack of waveguiding and inability to view the probe tip on line.

Intermittent contact mode of operation is not possible with hollow probes because of the need to illuminate the aperture with a lens. Intermittent contact mode results in additional noise under such conditions.



Polished Nanopipette probe for NSOM Lithography and IR / deep UV operation

Hollow NSOM Imaging and Ablation Probes

Type	Cantilever Length	Cantilever Height	Force Constant	Resonant Frequency	Aperture Size*	Transmission Wavelength
Cantilevered Nanopipettes	300-1000 µm	60-500 µm	≥ 3 N/m	80-390 kHz	≥50 nm	0.193 - >10.5 µm
Straight Nanopipettes	N.A	N.A	N.A	N.A	≥50 nm	0.193-10.5 µm

*Aperture diameters available in 50nm increments from 50-300nm, 100nm increments from 300-1000nm and 500nm increments from 1000-5000nm

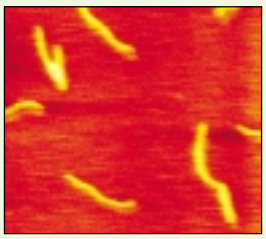
A F M P r o b e s

Nanonics AFM glass probes are used for imaging surface topography with nanometric resolution and better characteristics than silicon atomic force sensors. Contact, non-contact, and intermittent contact probes are available for a variety of surfaces and for a range of materials and structures.

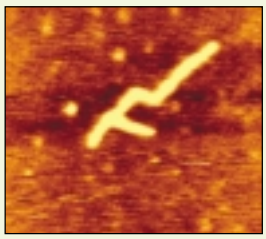
Nanonics Visible-Probe Tips are cantilevered probes, which use normal-force feedback and leave the probe tip exposed for maximum visibility. They have high aspect ratios (10:1) and can be customized to provide unique profiling possibilities.

Specialized AFM probes include:

- Deep Trench probes that can be used for imaging the bottom or side walls of deep pits.
- Hollow AFM probes that can be used as NanoFountainpens™ pens or for gas/liquid delivery and polymer molecular imaging.
- Electrical probes
- Probes with hard to achieve force constants and resonant frequencies.



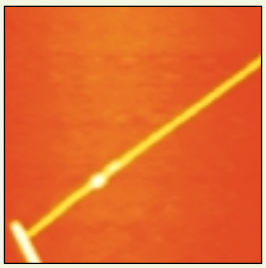
AFM Topography of DNA 1.6x1.6 µm, z-range 5 µm



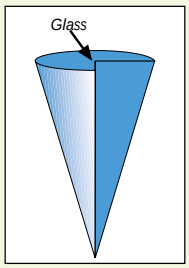
AFM Topography of DNA 900x900 nm, z-range 2.5 µm

Cantilevered AFM Probe: note that the angle of the cantilever enables viewing the sample underneath the AFM tip

SEM of AFM Probe: line is 100nm, and tip is 30 nm with gold and 10nm after removal of gold



AFM of Carbon Nanotube 1.6 x 1.4 µm z- range 15nm



Sketch of AFM Probe

AFM Probes

Type	Tip Diameter	Tip Length	Cantilever Length	Cantilever Height	Force Constant	Resonant Frequency
Cantilevered AFM Probes	≥10 nm	30-500 µm	300-1000 µm	50-500 µm	≥1-20 N/m	20-390 kHz
Straight AFM Probes	≥10 nm	30-1000 µm	N.A	N.A	N.A	N.A

> Hard to Achieve Force Constants and Resonance Frequencies

For cutting edge AFM research, such as molecular imaging and dynamic force imaging, it is often critical to use probes with specific combinations of resonance frequency and force constants. The Nanonics production technology is capable of producing glass cantilevers with resonance frequencies and force constants which are extremely difficult to achieve with silicon cantilevers.

In addition, glass cantilevers have dynamic response capabilities far beyond those of silicon cantilevers. Response times of 1µs are achievable, three orders of magnitude faster than the best silicon cantilevers. Such response times can monitor a variety of dynamic events including protein conformational dynamics.

Hard to Achieve Force Constants and Resonance Frequencies

Type	Tip Diameter	Tip Length	Cantilever Length	Cantilever Height	Force Constant	Resonant Frequency
Cantilevered AFM Probes	≥10 nm	30-500 µm	300-1000 µm	50-500 µm	<1 N/m to >10 N/m	20-390 kHz

* Contact us for further information on these values.

Guide to Choosing the Right Nanonics AFM Tip

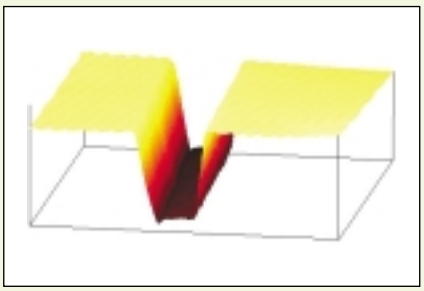
Nanonics produces a large range of AFM tips with a variety of force constants and resonant frequencies. The table below provides guidelines to help you choose the probe best suited to your application.

Guidelines for Choosing Nanonics AFM Probe Characteristics

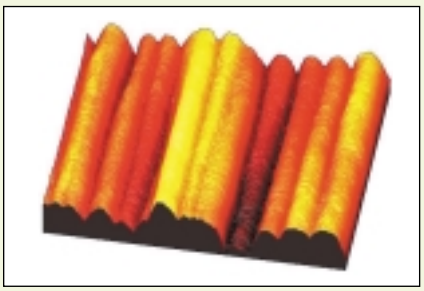
Application	Mode	Recommended Force Constant	Recommended Resonant Frequency
General imaging	Intermittent Contact	40 N/m	300 kHz
Soft biological imaging	Soft Intermittent Contact	5 N/m	150 kHz
Light tapping, fluid tapping	Force Modulation	3 N/m	75k Hz

> Deep Trench Profiling and Sidewall Imaging AFM Probes:

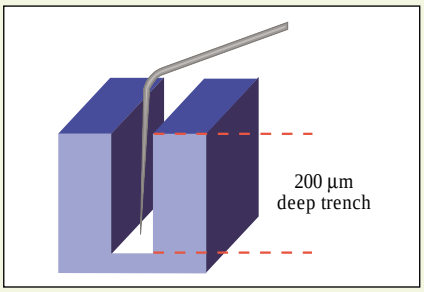
The unique technology Nanonics uses to create cantilevered fiber probes enables us to manufacture Deep Trench AFM Probes. For example, a cantilevered AFM tip can be specially designed to probe inside a trench that is 1.5 mm deep and only 100 µm wide. In addition, Nanonics probes for other types of imaging, such as NSOM and electrical/thermal, can be designed as deep trench probes, giving these imaging modalities access to a wide range of sample topographies.



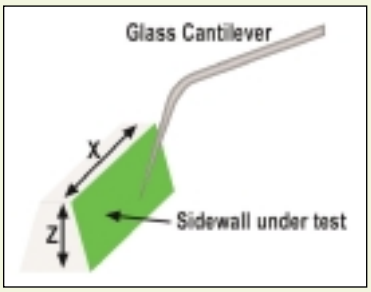
AFM image (20x20µm, z-range 10µm) of a 2µm wide deep trench



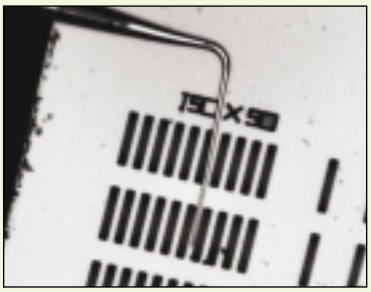
Z-X image of the right sidewall clearly showing the nature of the etching



Sketch of Deep Trench Probe



Schematic view of sidewall imaging along z and x



Deep Trench AFM Probe lying across 150µm lines to show its length

Deep Trench Probes

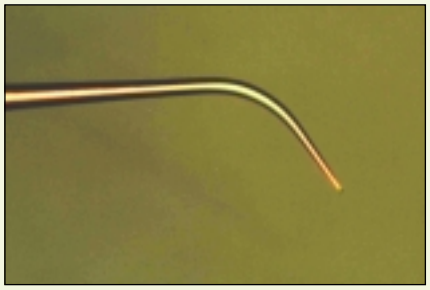
Type	Tip Diameter	Tip Length	Cantilever Length	Cantilever Height	Force Constant	Resonant Frequency
Deep Trench AFM Probes	≥10 nm	30-500 µm	300-1000 µm	500-1500 µm	≥1-20 N/m	≥390 kHz

Tips with high aspect ratios can easily be manufactured using glass pulling techniques. AFM tips (including Deep Trench Probes) with aspect ratios up to 10:1 are available. These probes have tip angles of 6°.

> Electrical Probes:

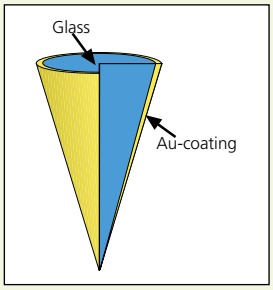
Gold-coated Nanonics glass AFM fiber tips can serve as excellent electrical probes for spreading resistance microscopy and AFM imaging, allowing electrical characteristics of a sample to be correlated with its surface topography.

The proximity of the surface being measured to the cantilever of regular AFM electrical probes is an important source of noise in the measurements. This noise can be significantly reduced by the cantilever height of Nanonics glass cantilevered probes.



Electrical and STM Probe with a conductive gold coating

SEM of Electrical and STM Probe: line is 100 nm and gold-coated tip is 30 nm



Sketch of Electrical and STM Probe

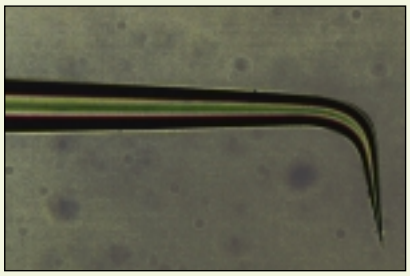
Electrical Probes

Type	Tip Diameter	Tip Length	Cantilever Length	Cantilever Height	Force Constant	Resonant Frequency	Conductive Coating
Cantilevered AFM Probes	≥10 nm	30-500 µm	300-1000 µm	50-500 µm	≥1- 20 N/m	80-390 kHz	Au (~20nm)
Straight AFM Probes	≥10 nm	30-1000 µm	N.A	N.A	N.A	80-390 kHz	Au (~20nm)
Deep Trench AFM Probes	≥10 nm	>500 µm	500-1000 µm	50-1500 µm*	≥1- 20 N/m	80-390 kHz	Au (~20nm)

*Other heights of cantilever available

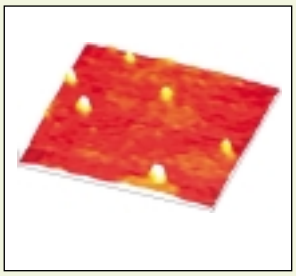
> NanoFountainpens™ for Gas or Chemical Delivery

Cantilevered and straight nanopipettes can be used as NanoFountainpens™ for controlled chemical delivery to or removal from regions as small as 20 nanometers, thus opening up the world of SPM to unique avenues in nanochemistry.



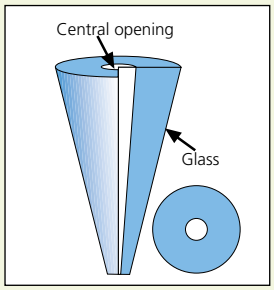
Nanopipette for chemical delivery: almost 90° angle of cantilever permits more precise delivery of chemicals

Video still of nanopipette used to etch a chrome film. Two etch lines are visible on the right side of the image and a third line is being etched



4x4µm image (z-range: 10 nm) of protein dots printed using a NanoFountainpen™

SEM of nanopipette probe with an aperture of less than 10nm



Sketch of NanoFountainpens™

NanoFountainpens™ for Gas or Chemical Delivery with Fountain Pen Nanochemistry

Type	Tip Length	Cantilever Length	Force Constant	Resonant Frequency	Aperture Size
Cantilevered Nanopipettes	30-500 µm	300-1000 mm	≥3-20 N/m	20-390 kHz	≥20 nm

Ion sensing probes can be provided with multiple channels. However, single channel NanoFountainpens™ can suffice for writing multiple chemicals because they are readily connected to high performance liquid chromatographs which separate chemical species.

Glass Insulated AFM Controlled Nanowires

> Single Wire Nanopipette Probes

Nanonics produces a variety of glass insulated nanowires. New worlds of research have been opened up by these unique AFM sensors. These include:

- The first normal force sensing probes for Scanning Electrochemical Microscopy (SECM).
- The first shielded STM probes that can provide combined AFM and STM.
- AFM sensing thermocouples with the highest sensitivity and resolution available today.

With these new probes, capacitance measurements of surfaces without oxide coatings are possible for the first time. Such shielded metal nanowires also make impedance microscopy a reality.

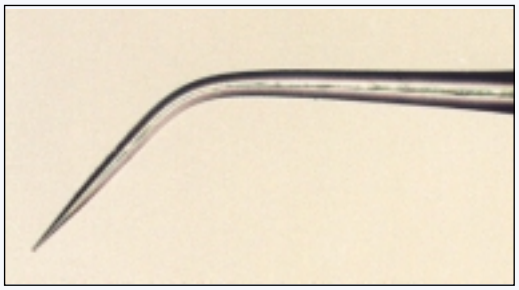
General Pipette Characteristics

Pipette Material	Shank Diameter	Taper Length	Total Length	Tip Profile
Borosilicate glass	1.0-1.5 mm	3-10 mm	5 mm - 5 cm	Flat end or up to 1µm protrusion (custom designs available)

Type	Cantilever Length	Cantilever Height	Force Constant	Resonant Frequency
Cantilevered Probes	300-1000 µm	50-500 µm	5-20 N/m	20-300 kHz
Straight Probes	N.A	N.A	N.A	N.A

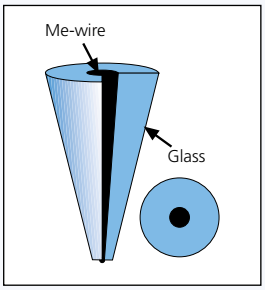
> Electrochemical & Scanning Electrochemical Microscopy Probes

Nanonics is the only provider today of Scanning Electrochemical Microscopy Probes (SECM) probes with normal force sensing capabilities. Electrochemical & SECM probes consist of a tapered metal wire running through a glass nanopipette. These probes are produced with the metal flush with the glass tip and protruding slightly from its aperture. They aid in the performance of localized electrochemistry experiments and can also be used as electron sources.



Electrochemical and SECM Probe:
A wire runs down a cantilevered nanopipette

SEM of Electrochemical and SECM Probe with 7nm wire tip



Sketch of Electrochemical and SECM Probe with wire flush with the glass nanopipette

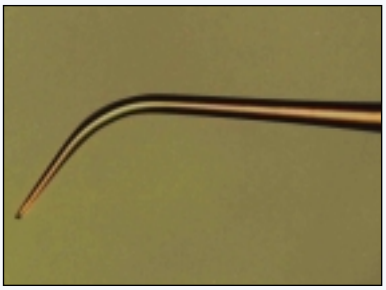
Electrochemical & SECM Probes*

Wire Material	Starting Wire Diameter	Electrode Diameter	Insulator Thickness
Pt, Ag, Au	25 µm or 50 micron	> 50 nm	≥200 nm
Custom Metal	25 µm or 50 micron	> 50 nm	≥200 nm

*These probes can be designed as straight, cantilevered or deep trench probes with the characteristics mentioned above

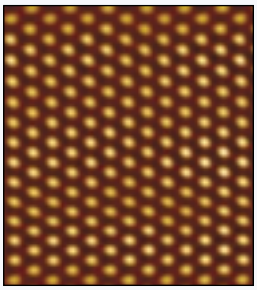
> Coaxial Probes / Shielded Scanning Tunneling Microscopy Probes

Coaxial probes consist of a tapered metal wire running through a metal-coated, glass nanopipette. The wire may protrude slightly from the coated nanopipette edge and it remains exposed at the tip. The metal coating on the insulating glass provides the wire with the necessary electrical shielding required for sensitive STM measurements.

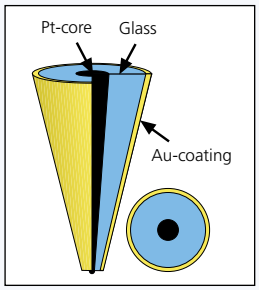


Cantilevered Coaxial Probe for sensitive STM measurements

SEM of the 7nm metal tip of a Cantilevered Coaxial Probe



Unfiltered 1.6x1.2nm STM image of HOPG



Sketch of Coaxial Probe with gold coating for electrical shielding

Coaxial Probes*

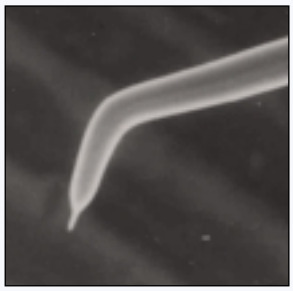
Wire Material	Starting Wire Diameter	Electrode Diameter	Insulator Thickness	External Coating
Ag, Au, Pt, Pt-Ir	25 µm or 50 micron	> 10 nm	≥200 nm	Ag, Au, Al, Cr or Ni
Custom Metal	25 µm or 50 micron	> 10 nm	≥200 nm	Ag, Au, Al, Cr or Ni

*These probes can be designed as straight, cantilevered or deep trench probes with the characteristics mentioned above

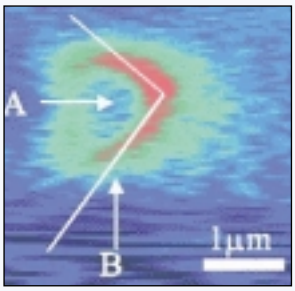
> Thermocouple Probes

Thermocouple probes consist of a tapered wire running through a metal-coated, glass nanopipette. The external metal coating extends over the protruding wire to create a junction across which the voltage drop is temperature dependent. The time response of this thermocouple is orders of magnitude higher than any other thermocouple in existence. Thus, one gains the ability to perform both static and dynamic thermal measurements in very localized regions with high precision.

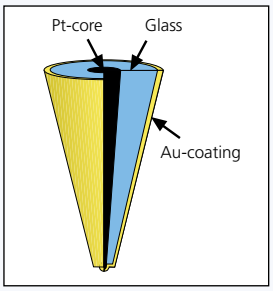
Thermocouple probe with large cantilever angle



SEM of Thermocouple probe:
The tip is approximately 200 nm and entire SEM is approximately 100x200µm



4x4µm Thermal image of V Grooved Quantum Wire Laser taken during operation



Sketch of Thermocouple probe with Pt/Au junction at tip

Thermocouple Probes*

Wire Material	Starting Wire Diameter	Coating Material	Junction Material	Thermal Response Time	Minimum Sensing Area	Temperature Sensitivity	Operating Range
Pt	25 µm or 50 µm	Au	Pt/Au	>0.5 µs	> 100 nm	< 10 milli-degrees	≤ 500°C

* These probes can be designed as straight, cantilevered or deep trench probes with the characteristics mentioned above.

> Double-Wired Nanopipette Probes

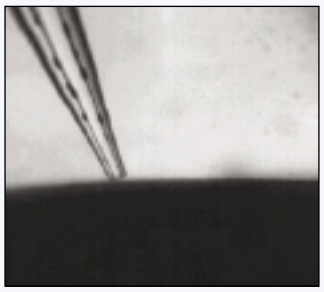
General Probe Characteristics

Pipette Material	Shank Diameter	Taper Length	Total Length
Borosilicate glass	1.0 -1.5 mm	3-5 mm	10 mm - 5 cm

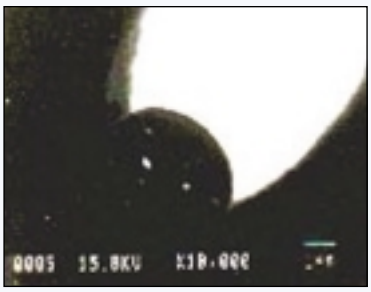
Type	Tip Length	Cantilever Length (LC)	Cantilever Height (HC)	Force Constant	Resonant Frequency
Cantilevered Probes	30-500 µm	300-1000 µm	50-500 µm	≥5-20 N/m	≥390 kHz
Straight Probes	30-1000 µm	N.A	N.A	N.A	N.A
Deep Trench Probes	30-500 µm	300-1000 µm	500 - 1500 µm	≥5-20 N/m	≥390 kHz

> Double-Wire Electrodes

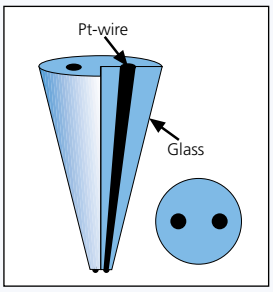
In the Double-Wire Electrode probe, two platinum wires are tapered inside a dual-channel nanopipette and kept electrically isolated. They can be used to perform electrical measurements, such as resistance and capacitance measurements on submicron-scale devices. Because the probes use normal-force feedback to stay in contact with the surface, these electrical measurements can be correlated with the surface topography obtained through simultaneous AFM imaging.



Double-Wire Electrode Probe with two tapered wires running through a dual channel nanopipette



SEM of Double-Wire Electrode Probe: line is 1µm long



Sketch of Double-Wire Electrode Probe

Double-Wired Electrode*

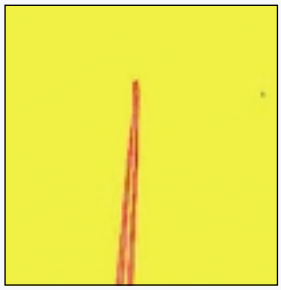
Wire Material	Starting Wire Diameter	Diameter of wire at Probe tip	Distance Between Wires	Length of Wires Outside Glass
Pt-Pt	25 µm or 50 µm	0.2 - 10 µm	0.3 - 100 µm	0.5 - 10 µm

*These probes can be designed as straight, cantilevered or deep trench probes with the characteristics mentioned above.

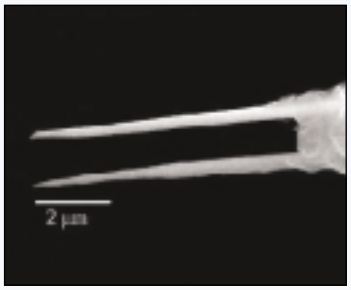
> Nanotweezers™

Nanonics Nanotweezer™ probes consists of two tapered platinum wires running through a nanopipette and kept electrically isolated. Applying a voltage of 70 V between these wires causes them to make contact in a Nanotweezer™.

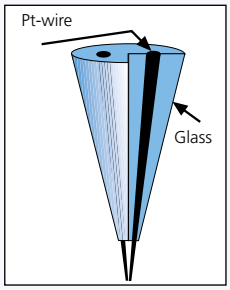
Nanotweezers™: when wires are at the same potential they are uncoupled



Nanotweezers™: when 70V is applied between the two wires they clench together



SEM of Nanotweezers™ showing length of tweezer hands: the line is 2µm long



Sketch of Nanotweezers™ with two wires extending outside nanopipette

Nanotweezers™

Wire Material	Wire Diameter	Length of Wires Outside Glass	Distance Between Wires
Pt	25 µm or 50 µm	4 – 20 µm	1 – 4 µm

*These probes can be designed as straight, cantilevered or deep trench probes with the characteristics mentioned above.

> Dual-Wire Thermoresistive Probes

Nanonics is the only supplier of thermoresistive (thermoconductivity) probes that provide intermittent contact imaging of surfaces. These probes are the first to provide thermal conductivity or resistance measurements alongside standard non-contact or intermittent contact normal force AFM. These can also be used as nanoheaters or active nanoIR NSOM sources.

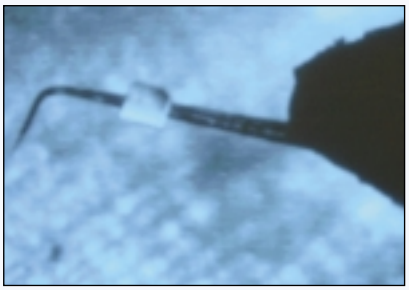
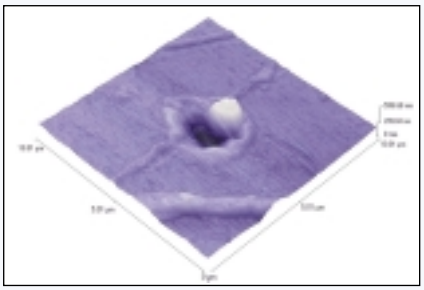
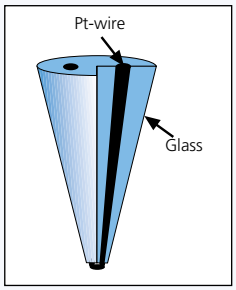


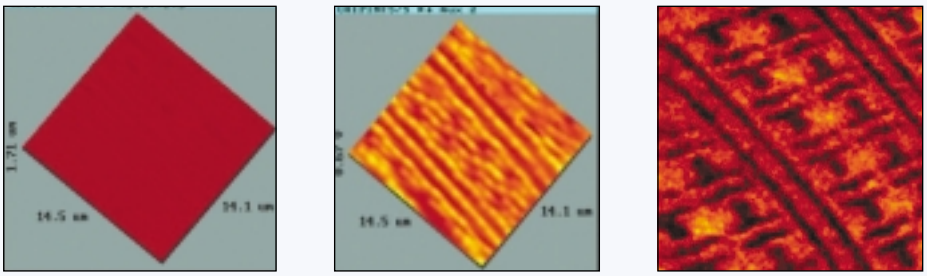
Image of a Dual-Wire Thermoresistive Probe with standard AFM characteristics for non contact imaging



Thermal image of a soft polymer surface obtained using intermittent contact AFM



Sketch of Dual-Wire Thermoresistive Probe with fused junction whose resistance is temperature-dependent



Images of the same14.5x14.1µm region of SRAM (left) AFM image showing a flat topography (center), thermal conductivivty image showing key featrures, (right) resistance image of the same region showing the same features.

Double-Wire Thermoresistive Probes*

Wire Material	Wire Diameter	Junction Material	Length Wire Protruding	Sensitive Tip Size	Minimum Sensing Area
Pt	25 µm or 50 µm	Pt	2 - 10 µm	0.1 - 4 µm	>100 nm

Resistance	Thermal Responce Time	Temperature Sensitivity	Temperature Coefficient of Resistance	Operating Range
20 - 150 Ω	>20 microseconds	<10 millidegrees	0.0038 Ω/°C	≤800°C

*These probes can be designed as straight, cantilevered or deep trench probes with the characteristics mentioned above.

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