Sharp Single Crystal Diamond AFM Probes

Single crystal diamond (SCD) probes for atomic force microscopy are diamond tips specially grown by CVD and attached to silicon cantilevers[1]. The typical radius of SCD tip is the same as that of a silicon AFM probe, i.e. better than 10 nm.

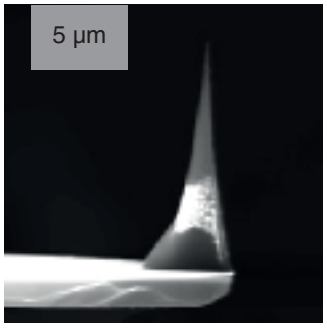


Fig.1. SEM image of SCD probe tip.

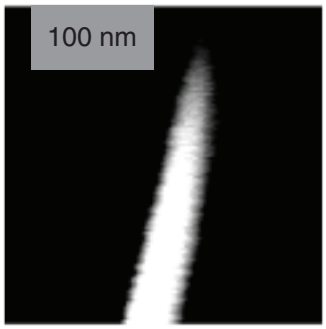


Fig.2. SEM image of SCD tip end.

Applications

The tip is robust, resistant to contamination, and forgiving operation mistakes, while it is sharp enough to provide high resolution on DNA or lamellar structures easily (Fig. 3, 4, 5). As a result, SCD tip can be used to make many scans, which is especially advantageous when tip relpacement is hard, time-taking, or not compatible with the experiment.

SCD tip is hard enough to induce plastic deformation on almost any surface, including metals, silicon and glass, making force lithography[2] and scratching experiments accessible and easy on your SPM (Fig.6).

Because of the high hardness, SCD tip is also useful for SPM nanoindentation and mapping mechanical properties of hard materials with high resolution (Fig.7).

You can also benefit from the high aspect ratio of the diamond tip to image corrugated samples or reach the bottom of the pores (Fig.8). The full cone angle of SCD tip ranges from 5° to 10° on at least 1 micron from the end.

It was also reported that SCD probes were used for long-time scanning of sticky biological samples without tip contamination (Fig.9), which can be related to the low surface energy of diamond.

Long-Time Scanning

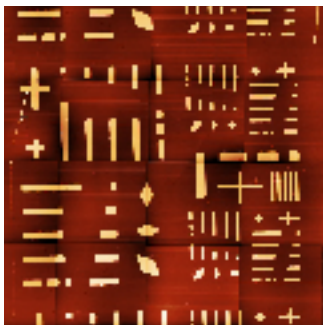


Fig.1. Fragment of a mosaic of 121 scan of Co islands on Si obtained automatically in contact mode using SCD probe. Total mosaic size is 1x1 mm, total path of the probe is 6 meters long, which demonstrates the tip durability. Courtesy of Alexei Temiryazev, IRE RAS.

1. A.N. Obraztsov et al. Single crystal diamond tips for scanning probe microscopy. Rev. Sci. Instrum. 81, 013703 (2010)
2. A. Temiryazev. Pulse force nanolithography on hard surfaces using atomic force microscopy with a sharp single-crystal diamond tip. Diamond & Related Materials 48 (2014) 60–64.

Applications

SCD tip is:

- Resistant to wear and durable, while sharp enough to provide high resolution.
- Good for nanoindentation, mapping properties of hard materials and material contrast.
- Good for scratching and pulse force lithography on hard materials.
- Good for imaging high aspect ratio features on surface.
- Can be used for long-time scanning of sticky biomaterial and cleanable.

Resolution on Lamellae

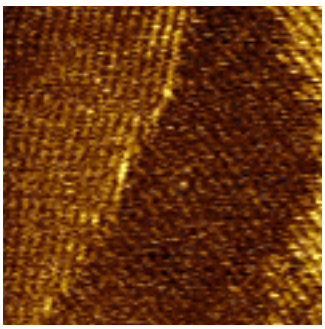


Fig.4. AFM scan of Melissa acid lamellar structure that shows high resolution attainable by SCD tip on flat surfaces. Scan size 250x250 nm, height 1.5 nm. Courtesy of Alexei Temiri-azev, IRE RAS.

Topography of Biomolecules

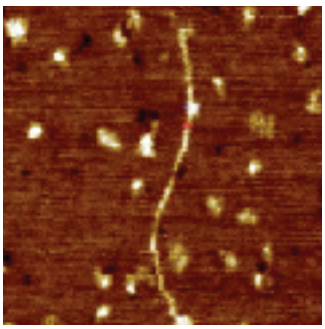


Fig.5. AFM topography of a collagen biomolecule made using SCD probe. Scan size 320 nm, height 0.8 nm. The blobs seen on the collagen are proteins attached to it. The tip lasted for about a day of imaging. Courtesy of Sidney Cohen, WIS.

SPM Force Nanolithography

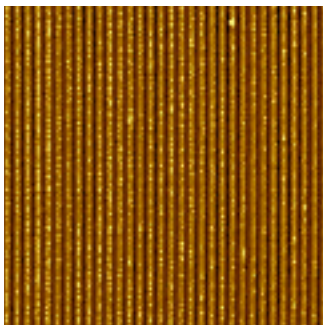


Fig.6. AFM scan of a grating made on metal film using force lithography by SCD probe. Period 100 nm, depth more than 20 nm (scan size 3.5 µm, height 35 nm). Courtesy of E. Huseynov, T. Mekhtiyev, Institute of Physics of ANAS.

Material Properties Mapping

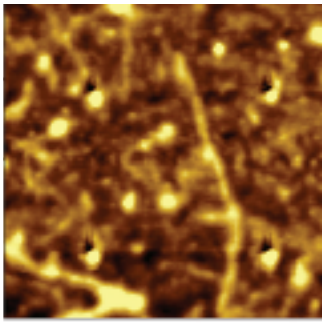


Fig.7. Fragment of an array of 64 000 indents left on Si semiconductor structure in material contrast experiment. Scan size 400 nm. Courtesy of Alexei Temiryazev, IRE RAS.

High Aspect Ratio

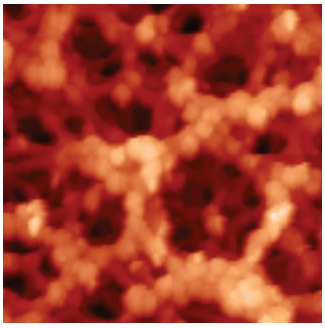


Fig.8. AFM image of nitrocel-lulose membrane that shows advantage of the high aspect ratio of SCD tip. Scan height is more than 1 µm, size 5 µm. Courtesy of Sergei Magonov, NT-MDT.

Imaging Sticky Biomaterials

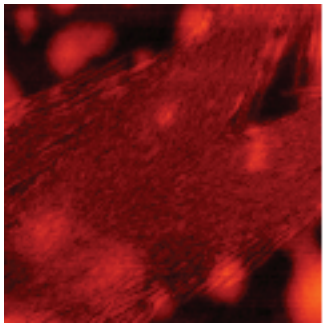


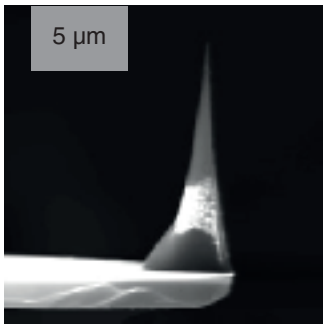
Fig.9. AFM scan of fibril and globular amyloid aggregates. The globular aggregates are very sticky samples, but SCD tip lasted more than 7 hours without any special care. Scan size 2 µm, height 20 nm. Courtesy of Mohtadin Hashemi, UNMC.

Find more scans and application notes on www.scdprobes.com/applications.htm

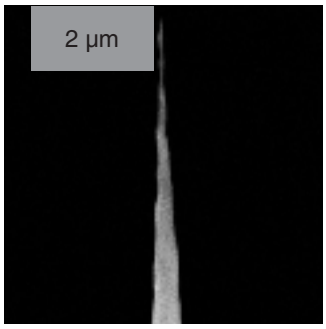
Specification

SCD probe for AFM has full cone angle from 5° to 10° when measured at least on the last 1 µm from the tip end (aspect ratio 5:1) and tip radius less than 10 nm. Crystal orientation is <100> along the tip axis. The diamond tip is glued on Si cantilever. The glue is non-conducting, stable* at temperatures up to 70°C. After gluing, each tip passes quality control on SEM before packaging.

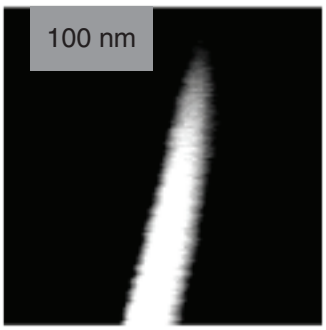
*The glue is chemically stable in water, ethanol, in presence of chloride ions, biological buffers (PBS, Hanks solution, etc); not stable in ketones, DMSO.



SEM image of SCD probe tip.



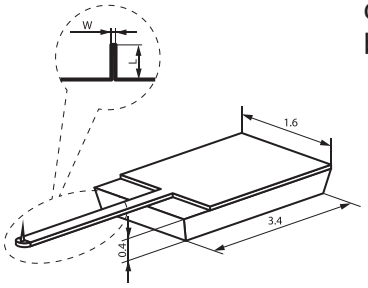
SEM image of the tip aspect ratio over 2 microns from the end



SEM image of SCD tip end.

Cantilevers

SCD probes are glued onto rectangular (diving-board) silicon etched cantilevers. The chip holder size is 1.6 mm x 3.4 mm x 0.4 mm. Cantilever backside is coated by Aluminium.



Series	Cantilever Length, l±5, µm	Cantilever Width, w±3, µm	Cantilever Thickness, µm			Resonant Frequency, kHz			Force Constant, N/m		
			min	Typical	max	min	Typical	max	min	Typical	max
D10	460	50	1.5	2	2.5	8.5	10	15	0.05	0.15	0.3
D80	230	40	2.5	4	4.5	60	80	90	2.0	3.5	5.5
D160	125	25	1.5	2	2.5	110	160	220	1.8	5.0	12.5
D300	125	35	3.5	4	4.5	265	300	400	20	40	75

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