



High Aspect Ratio Probes

AR5, AR5T, AR10, AR10T

High Aspect Ratio Silicon-SPM-Probes

For measurements on samples with high aspect ratio features and sidewall angles approaching 90° like trenches and contact holes in semiconductor device technology NANOSENSORS™ has designed High Aspect Ratio tips AR5, AR5T, AR10 and AR10T showing near-vertical tip sidewalls.

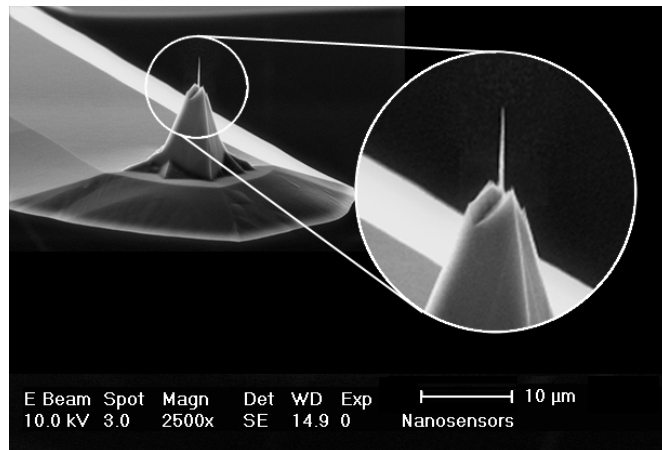
All models are based on NANOSENSORS™ PointProbe® Plus technology. Those tips have an overall height of 10 - 15 μm which allows measurements on highly corrugated samples. At the last few micrometers the tips show a high aspect ratio portion that is radially symmetrical. The tip radius is typically 10 nm. We guarantee at least 15 nm.

Tip Features AR10

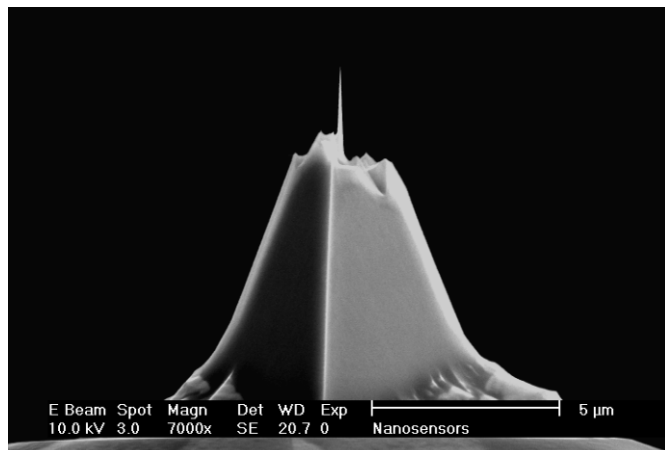
The high aspect ratio portion of the AR10 tip is longer than 1.5 μm and shows an aspect ratio better than 10:1 (typically 12:1) at a tip height of 1.5 μm . This corresponds to a tip diameter of less than 150 nm at a tip height of 1.5 μm and a tip half cone angle of smaller than 2.8° .

Tip Features AR5

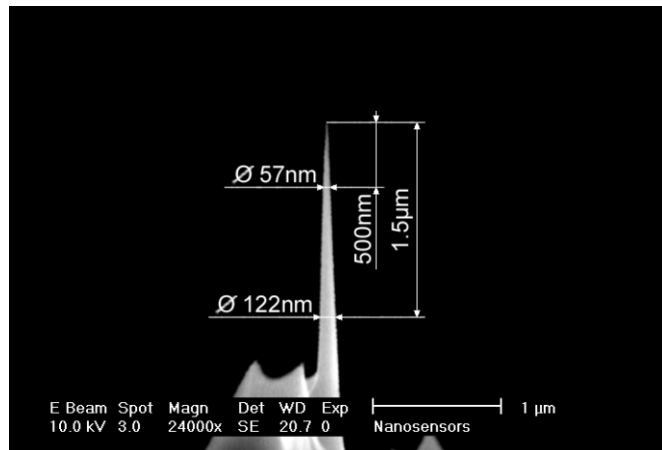
The high aspect ratio portion of the AR5 tip is longer than 2 μm and shows an aspect ratio better than 5:1 (typically 7:1) at a tip height of 2.0 μm . This corresponds to a tip diameter of less than 400 nm at a tip height of 2 μm and a tip half cone angle of smaller than 5° .



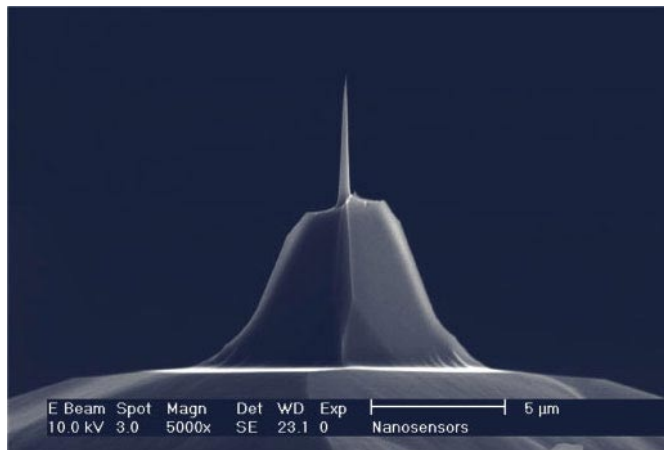
SEM image of an AR10 High Aspect Ratio tip with cantilever. 3D view.



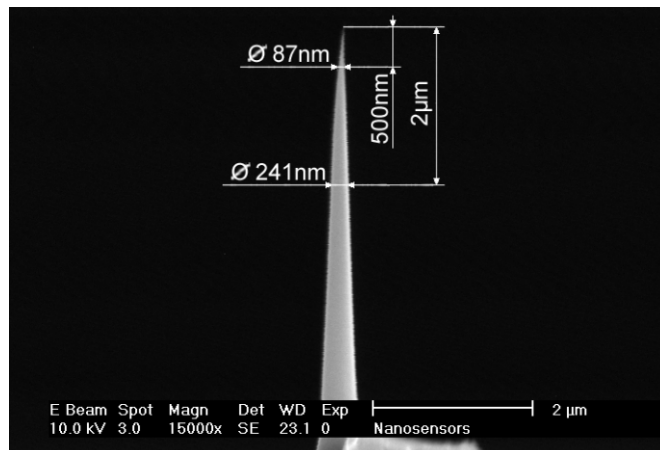
SEM image of an AR10 High Aspect Ratio tip. Front view.



SEM image close-up of the AR10 high aspect ratio portion with dimensioning. Front view.



SEM image of an AR5 High Aspect Ratio tip. Front view.



SEM image close-up of the AR5 high aspect ratio portion with dimensioning. Front view.

Tilt Compensated High Aspect Ratio Silicon Probes

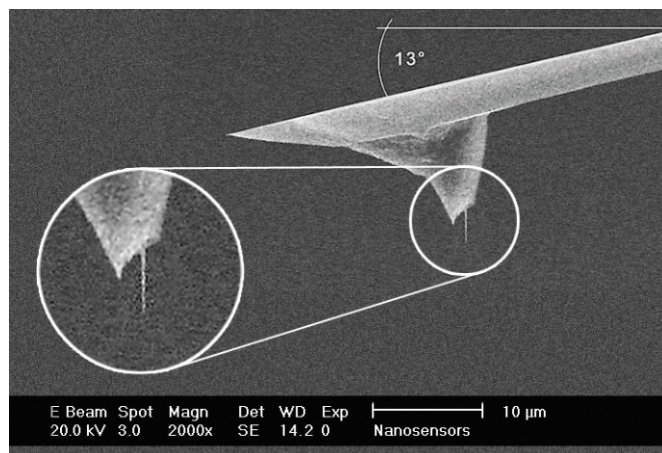
In order to compensate the tilt angle caused by the mount of the Atomic Force Microscope head (commonly 13°) we offer our AR5 and AR10 tips as a tilt corrected AR5T and AR10T version respectively (high aspect ratio portion of the tip tilted 13° to the center axis of the tip). As a result of the tilt correction the high aspect ratio portion of the tip will stand exactly perpendicular to the sample surface and will be able to measure deep and narrowest features as well as near vertical sidewalls and will prove an absolutely symmetrical imaging.

Tip Features AR10T

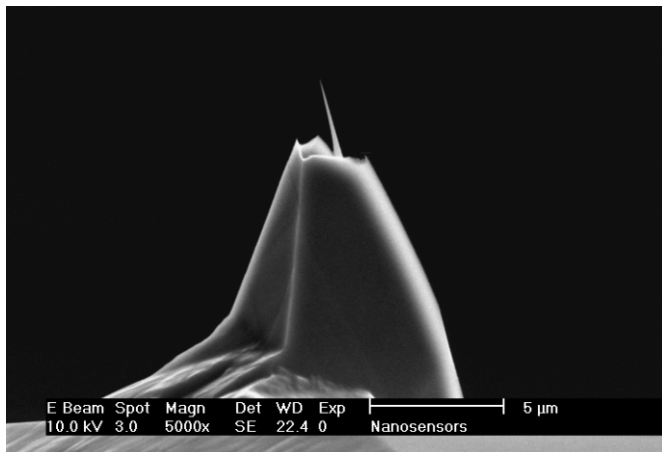
The high aspect ratio portion of the AR10T tip is longer than $1.5 \mu\text{m}$ and shows an aspect ratio better than 10:1 (typically 12:1) at a tip height of $1.5 \mu\text{m}$. This corresponds to a tip diameter of less than 150 nm at a tip height of $1.5 \mu\text{m}$ and a tip half cone angle of smaller than 2.8° . The high aspect ratio portion of the tip is tilted $13 \pm 1^\circ$ with respect to the center axis of the tip. Other tilt angles are available on request.

Tip Features AR5T

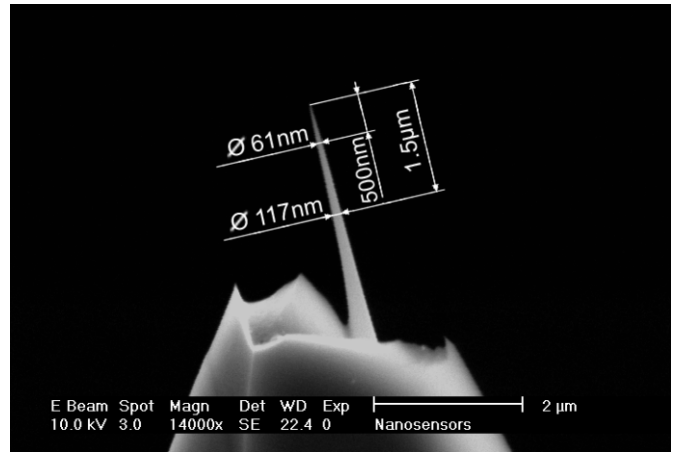
The high aspect ratio portion of the AR5T tip is longer than $2 \mu\text{m}$ and shows an aspect ratio better than 5:1 (typically 7:1) at a tip height of $2.0 \mu\text{m}$. This corresponds to a tip diameter of less than 400 nm at a tip height of $2 \mu\text{m}$ and a tip half cone angle of smaller than 5° . The high aspect ratio portion of the tip is tilted $13 \pm 1^\circ$ with respect to the center axis of the tip.



SEM image of tilt compensated AR10T High Aspect Ratio tip with cantilever. Side view.



SEM image of AR10T High Aspect Ratio tip. Side view.



SEM image of tilt compensated AR10T high aspect ratio portion with dimensioning. Side View.

Tip Features / Specifications

	AR5	AR5T	AR10	AR10T
Length of High Aspect Ratio Portion	> 2.0 μm	> 2.0 μm	> 1.5 μm	> 1.5 μm
Aspect Ratio	> 5:1	> 5:1	> 10:1	> 10:1
Half Cone Angle of the High Aspect Ratio Portion	< 5°	< 5°	< 2.8°	< 2.8°
Tilt Angle	0 ± 1°	13 ± 1°	0 ± 1°	13 ± 1°
Tip Radius	< 15 nm	< 15 nm	< 15 nm	< 15 nm

The diameter of the high aspect ratio portion at a requested height can be calculated including the tip radius as follows:

$$\text{Diameter} < \frac{\text{Distance from Apex}}{\text{Aspect Ratio Factor}} + 2 \times \text{Tip Radius}$$

The aspect ratio factor takes into account the finite tip radius. The aspect ratio factor is 12.5 for AR10 and 5.4 for AR5 probes. Example: In a requested height of 600 nm the AR10 has a diameter of less than 78 nm.

Support Chip

The cantilever is fixed to a silicon support chip (which can be seen in the sketch of the SPM probe assembly in the PointProbe® Plus flyer). The support chip as an integral part of the probe is designed for manipulating the probe and fixing it to the SPM. The geometric dimensions of the support chip are very reproducible enabling the replacement of the probes without major readjustment of the laser. This is further improved by the alignment grooves on the support chip's backside in combination with our alignment chip. The chamfered edges of the support chip avoid contact between chip and sample if either of them is tilted.

Cantilever

The cross section of the cantilever is trapezoidal which offers several advantages. The detector side of the cantilever is rather wide. This enables an easy adjustment of the optical system. However, the mean width of the cantilever, which determines the spring constant is much smaller. The small cantilever width at the tip side reduces the damping of the cantilever which is important for the operation in a dynamic (Non-Contact / Tapping Mode) mode.

Material Features

NANOSENSORS™ High Aspect Ratio SPM probes are manufactured from highly doped, single crystal silicon which leads to unique features. Silicon is a well-known and established material for semiconductor technology.



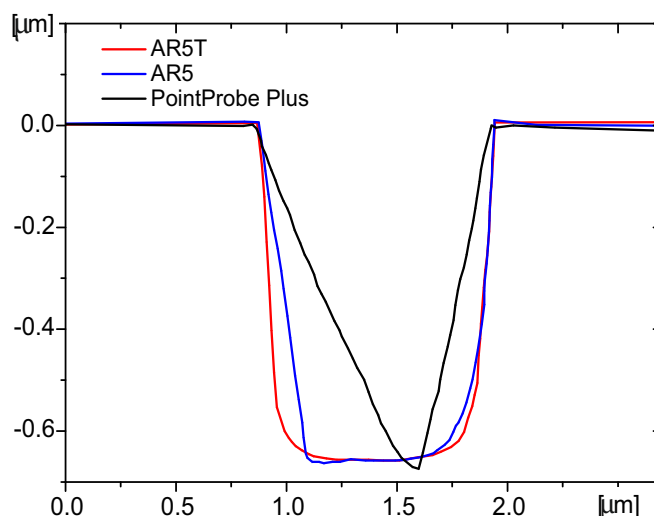
The high conductivity of the doped silicon avoids electrostatic charging. The resistivity is as low as 0.01 - 0.025 Ωcm . The fabrication out of bulk material results in a monolithic design of support chip, cantilever and tip. This avoids any intrinsic stress and leads to absolutely straight cantilevers. Even if ambient temperatures change no bending of the cantilever will occur. The chemically inert silicon allows the application in fluids or electrochemical cells.

Reflex Coating

The reflex coating is an approximately 30 nm thick aluminum coating on the detector side of the cantilever which enhances the reflectivity of the laser beam by a factor of 2.5. Furthermore it prevents light from interfering within the cantilever.

Application Example

The opposite figure is showing AFM measurements of an identical hole etched in silicon. The black line represents the measurement performed with a NANOSENSORS™ PointProbe® Plus NCH probe. The blue and red lines are representing the measurements performed with NANOSENSORS™ AR5-NCH and AR5T-NCH probes respectively. Due to the larger cone angle, compared with the AR-type probes, the PointProbe® Plus NCH probe cannot reproduce the vertical sidewalls correctly. Also, the unsymmetrical scanning picture caused by the mounting of the probes to the scanner head at an angle of about 13° is clearly visible. The AR5 probe can describe just one slope of the hole correctly. Only the tilt compensated AR5T is able to reproduce the shape of the feature correctly.



AFM measurements of an identical feature with NANOSENSORS™ PointProbe® Plus, AR5 and AR5T probes.

Product List

	Type	Application	Force Constant [N/m] (nominal)	Res. Frequency [kHz] (nominal)	Coating (backside)	Special Tip Versions
Non-Contact	AR5-NCHR	Non-Contact / Tapping Mode (high frequency)	42	330	Reflex (backside, without coating on request)	High Aspect Ratio (5:1)
	AR5T-NCHR	Non-Contact / Tapping Mode (high frequency)	42	330	Reflex (backside, without coating on request)	Tilt Compensated (13°) High Aspect Ratio (5:1)
	AR5-NCLR	Non-Contact / Tapping Mode (long cantilever)	48	190	Reflex (backside, without coating on request)	High Aspect Ratio (5:1)
	AR10-NCHR	Non-Contact / Tapping Mode (high frequency)	42	330	Reflex (backside, without coating on request)	High Aspect Ratio (10:1)
	AR10T-NCHR	Non-Contact / Tapping Mode (high frequency)	42	330	Reflex (backside, without coating on request)	Tilt Compensated (13°) High Aspect Ratio (10:1)

For more details please refer to the product datasheet on our website

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