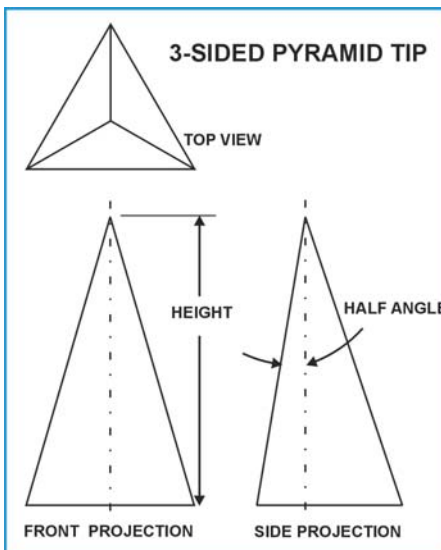


# AFM DIAMOND PROBES

## THE DIAMOND TIP

Micro Star diamond tips are made from a single crystal diamond which is shaped as a 3-sided symmetrical pyramid terminating on a sharp point. Only a single crystal diamond can be honed to nanometer scale sharpness. This is not possible with diamond coatings or polycrystalline diamonds.

The advantages of diamond probes over standard silicon tips are durability and defined tip geometry. Depending on care, a diamond tip lasts many more scans than a silicon tip, especially on hard specimens. The predictable diamond tip geometry also allows more precise definition of specimen features.



Diamond Tip Geometry

The 3-sided symmetrical pyramid profile is defined by the half angle, which is the angle between the pyramid center line and any of its three faces. A given half angle determines the front and side projection angles. The table shows typical half angles used on Micro Star diamond tips with their front and side projections.

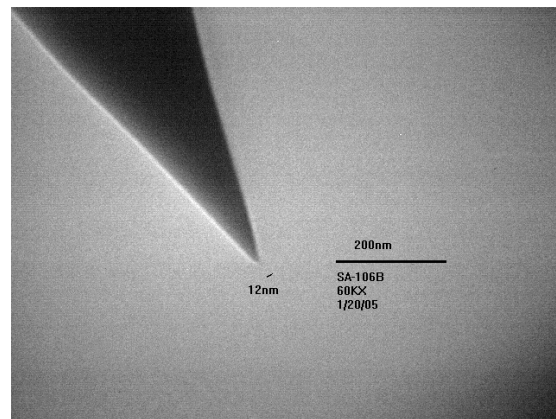
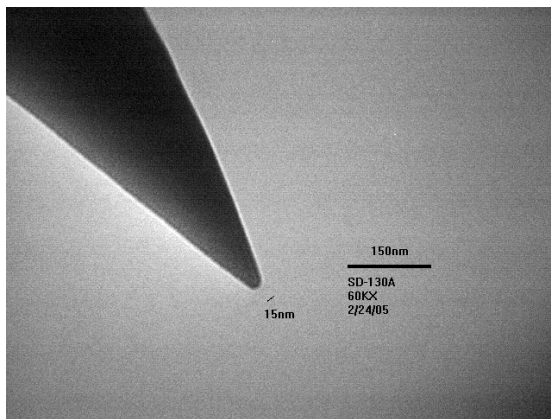
# AFM DIAMOND PROBES

HALF ANGLE	FRONT	SIDE
13°	45°	39°
9°	32°	28°
7°	24°	21°

## Standard Diamond Tip Half-Angles and Their Projections

The diamond tip height is normally between 50 and 100 $\mu\text{m}$ , but it can be made up to 300 $\mu\text{m}$ . A diamond tip radius at the apex is normally less than 20 nm. One TEM or SEM micrograph showing the side projection at 60,000X is included with each tip.

The following images are two examples:

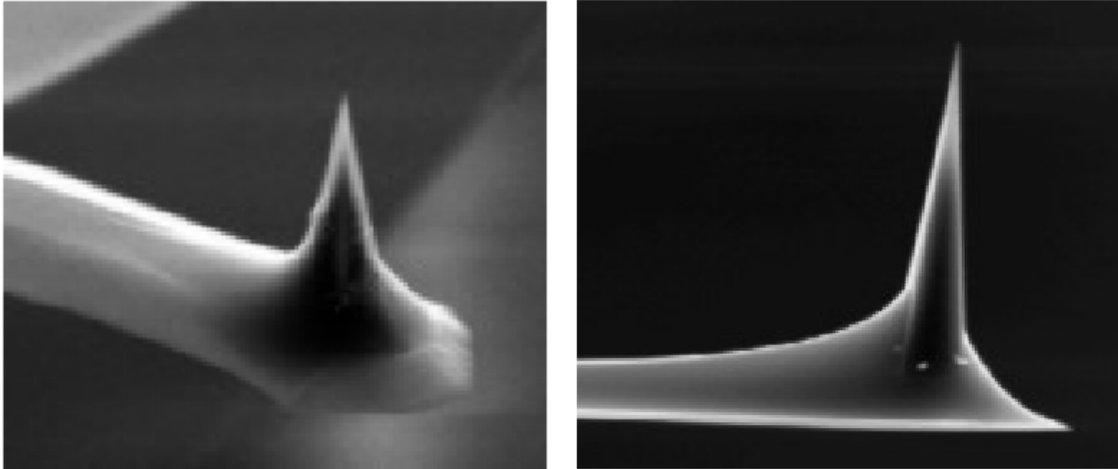


Tem Images of Diamond Tips at 60,000X

## DIAMOND TIPS ON SILICON CANTILEVERS

Micro Star can attach a diamond tip to any standard silicon cantilever. The cantilever may be tip-less or may have the original silicon tip. Micro Star will remove the silicon tip and attach the diamond. The SEM images show an example.

# AFM DIAMOND PROBES



SEM Images of Diamond Tip on Silicon Cantilever

The diamond is attached with a hard polymer adhesive. The polymer durometer hardness is 80. In the same scale a bowling ball is 90.

Micro Star has some silicon cantilevers available as shown in the table. There are many types of silicon cantilevers made with different properties.

The main properties of interest are: cantilever stiffness measured in N/m, resonant frequency in KHz and the cantilever length in microns.

TYPE	STIFFNESS N/m	FREQUENCY KHz	LENGTH $\mu$
M	1	45	225
N	4	80	225
P	40	170	225
Q	40	320	125

Types of Silicon Cantilevers Available From Micro Star

The values in the table are approximations. The frequency provided is that of a cantilever before a diamond is attached. After a diamond tip is attached, the resonant frequency is reduced by as much as 50% of the original value. The stiffness value provided on the card is supplied by the cantilever manufacturer. All AFM diamond probes are supplied with a specification card indicating the actual measured values.

# AFM DIAMOND PROBES

**NOTE:** Adding the diamond tip to the cantilever can sometimes reduce the resonant frequency by as much as half.

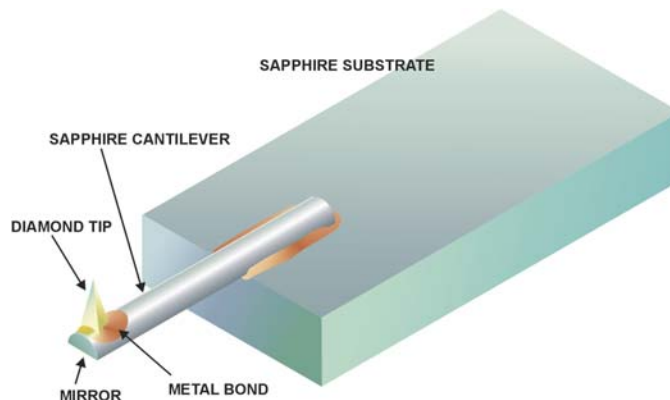
## Selection of Diamond Tip on Silicon Cantilever

- A) Select a diamond tip by specifying the Half Angle: 13, 9, or 7°.
- B) Select a type of silicon cantilever: M, N, P, or Q.
- C) Alternatively, you can send us a silicon cantilever with the known properties you want (include 2 extra ones to allow for failures). Since the silicon tip is removed, it does not matter if the cantilever you send is already worn.
- D) Let us know if you have other requirements.

## DIAMOND TIPS ON SAPPHIRE CANTILEVERS

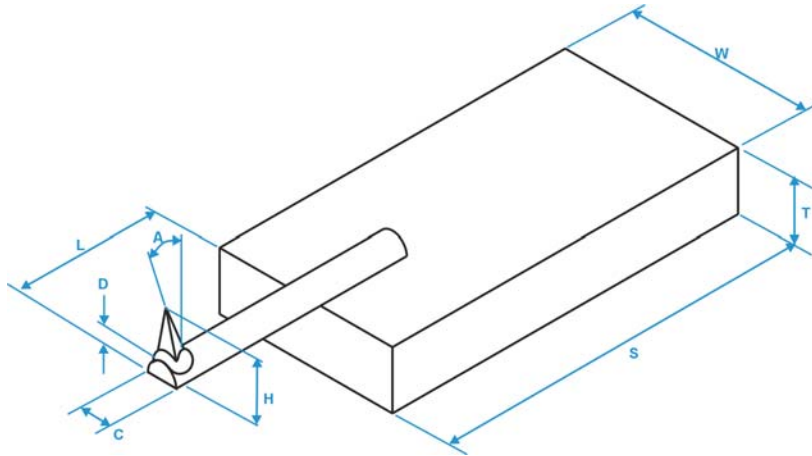
Micro Star has developed a technique to fabricate single crystal diamond probes on sapphire cantilever beams. The extreme hardness of diamond offers increased durability and consistency over silicon probes. The sapphire beam with its high modulus provides a sharp resonant frequency peak and is considerably stronger than silicon. A wide range of beam stiffness and resonant frequencies is available as shown in the table below. These probes are ideal for long life, hard samples and micro machining applications.

The diamond tip can be metal bonded to a sapphire cantilever. The cantilever is also metal bonded to a sapphire substrate. The metal has yield strength of 0.4GPa (60,000psi) up to 500°C. For laser reflection, the top side of the cantilever is a plated optical flat.



Sapphire Cantilever with Diamond Tip

# AFM DIAMOND PROBES



SYMBOL	DESCRIPTION	STANDARD RANGE
L	CANTILEVER LENGTH	* 200 TO 1,000 $\mu$
C	CANTILEVER WIDTH	35 TO 70 $\mu$
D	CANTILEVER THICKNESS	* 14 TO 46 $\mu$
A	TIP ANGLE TO PERPENDICULAR	12° or * 0 TO 13°
H	TOTAL TIP HEIGHT	80 TO 300 $\mu$
S	SUBSTRATE LENGTH	2.8mm
T	SUBSTRATE THICKNESS	0.4mm
W	SUBSTRATE WIDTH	1.5mm
K	STIFFNESS	* 10 TO 10,000 N/m
F	RESONANT FREQUENCY	* 20 KHz TO 1.0 MHz

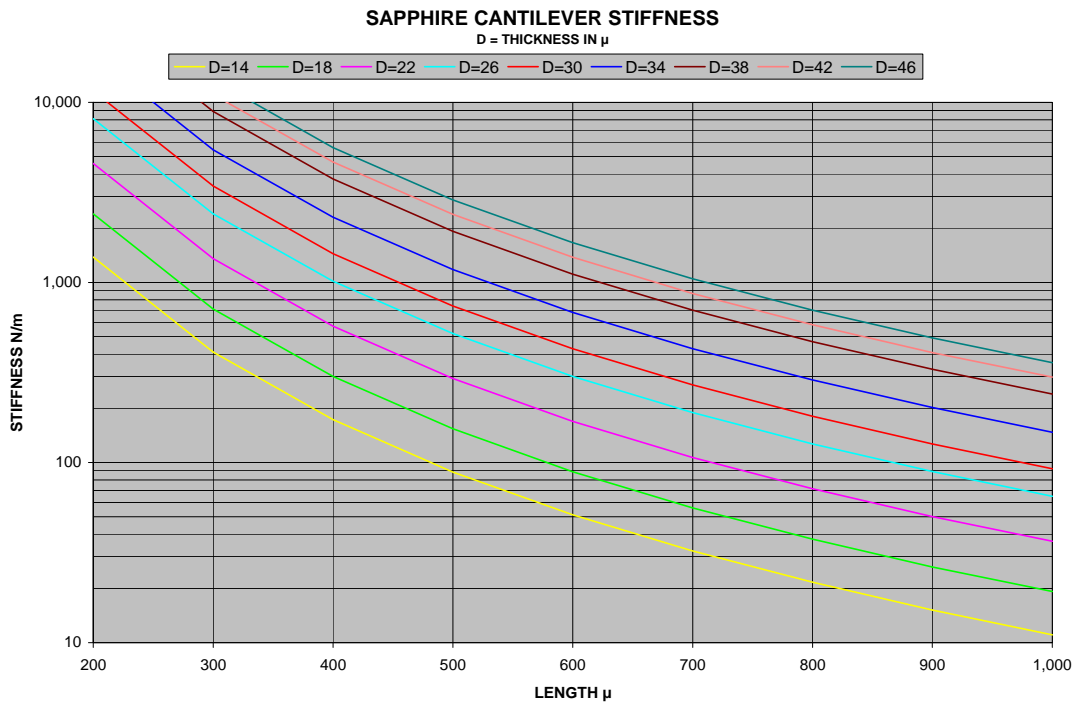
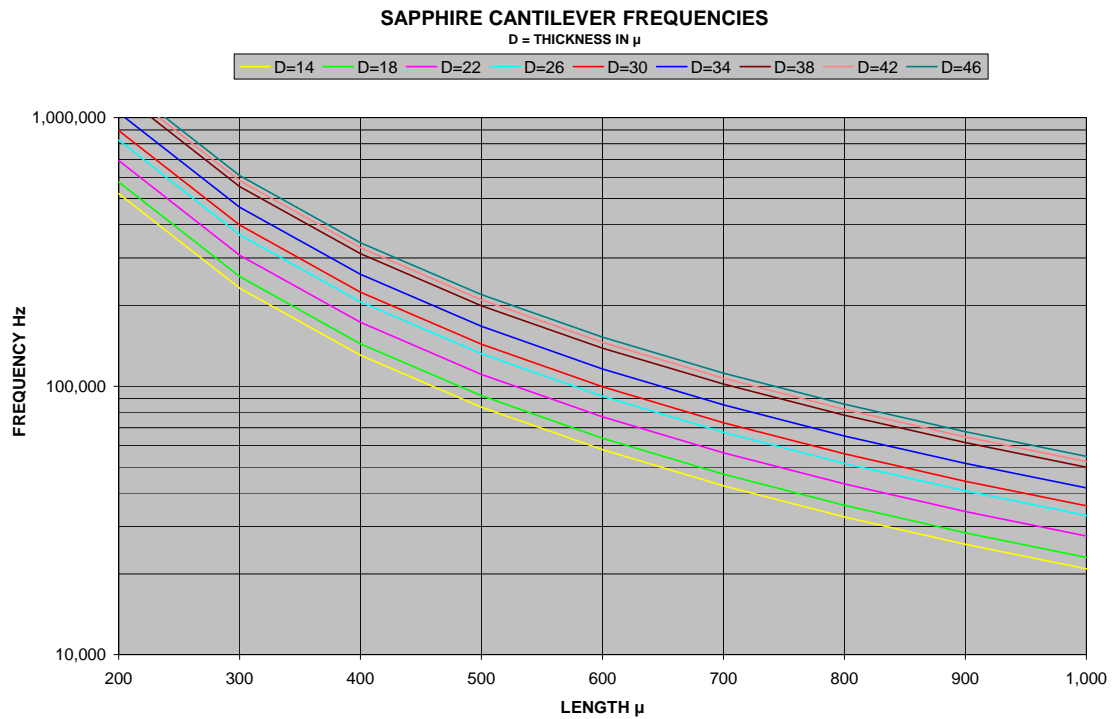
Cantilever dimensions and parameters (\*set per customer specifications)

## Selection of Diamond Tip on Sapphire Cantilever

- A) Select a diamond tip by specifying the Half Angle: 13, 9, or 7°.
- B) Select the most important parameter for your application: length L, stiffness K or frequency F. These three values and the cantilever thickness D are interrelated, so once one is selected the other two will have a limited range. For a more detail evaluation of these parameters see the selection graph (next page).
- C) Let us know if you have other requirements.

# AFM DIAMOND PROBES

## MICRO STAR AFM DIAMOND-SAPPHIRE PROBES CANTILEVER PARAMETER SELECTION GRAPHS \*



\* Actual frequencies may vary as much as 30% of values in the graph because the diamond tip weight is estimated.

# AFM DIAMOND PROBES

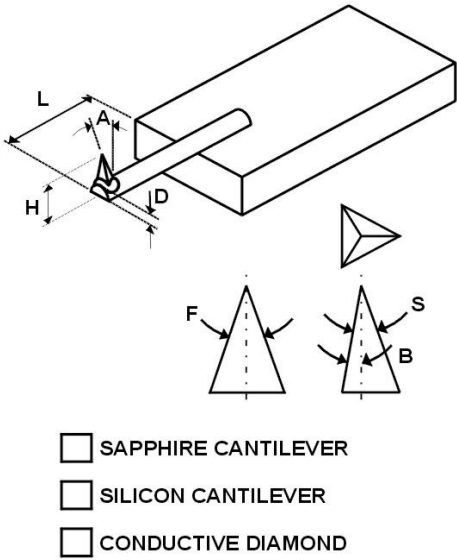
## DIAMOND TIP CARE AND RESHARPENING SERVICE

**Diamond is the hardest material but the probe is delicate due to its nanometer size. Rough contact can damage the probe or the specimen. An important value when using Micro Star diamond probes is the total tip height (H in the card) which is considerably larger than in standard silicon tips. Make sure that the safety distance parameter in your microscope is set at a larger value than the tip height. This will insure that the tip does not contact the specimen while at the high approach speed.**

**Micro Star diamond probes can be resharpened as long as the worn or broken tip end is not larger than 1 $\mu$ . Send us the probe for a free inspection to determine if it can be resharpened.**

# AFM DIAMOND PROBES

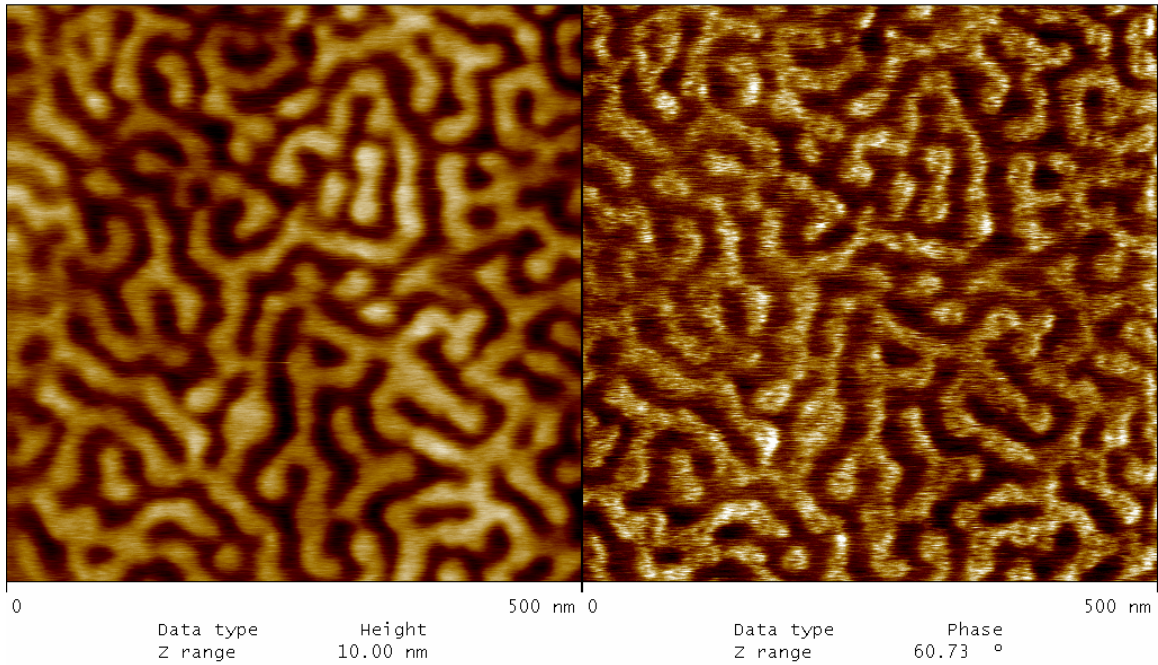
## AFM DIAMOND PROBE SPECIFICATION CARD

AFM DIAMOND PROBE		SN #
		MEASURED
STIFFNESS	N/m	 <p> <input type="checkbox"/> SAPPHIRE CANTILEVER  <input type="checkbox"/> SILICON CANTILEVER  <input type="checkbox"/> CONDUCTIVE DIAMOND         </p>
TIP RADIUS	nm	
TOTAL TIP HEIGHT H	$\mu$	
CANTILEVER THICKNESS D	$\mu$	
LENGTH L	$\mu$	
FREQUENCY	KHz	
HALF ANGLE B	$^{\circ}$	
FRONT ANGLE F	$^{\circ}$	
SIDE ANGLE S	$^{\circ}$	
INCLINATION ANGLE A	$^{\circ}$	
ELECTRIC RESISTANCE	$K\Omega$	

Specification Card Provided with Every Micro Star Probe

AFM SCAN IMAGES MADE WITH MICRO STAR DIAMOND PROBES -  
 Courtesy of Dr. Sergei N. Magonov.

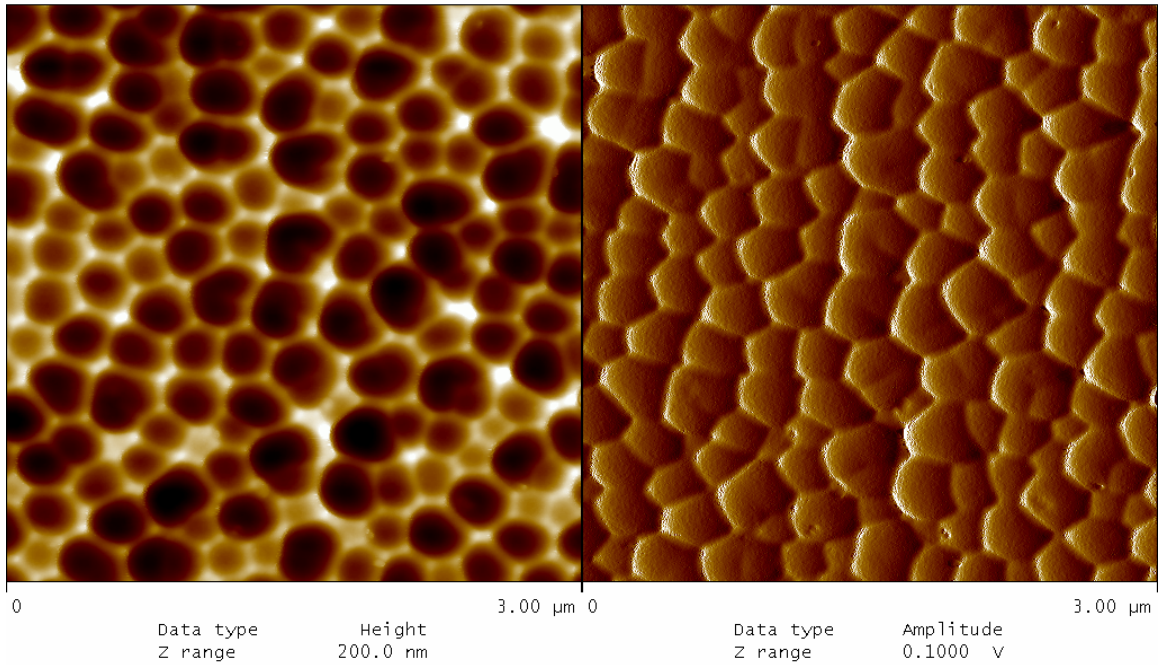
# AFM DIAMOND PROBES



03-29-142-sbs.f13  
SD-142

**Tapping mode image of soft sample of triblock copolymer film using a diamond probe on sapphire cantilever with 23 N/m stiffness**

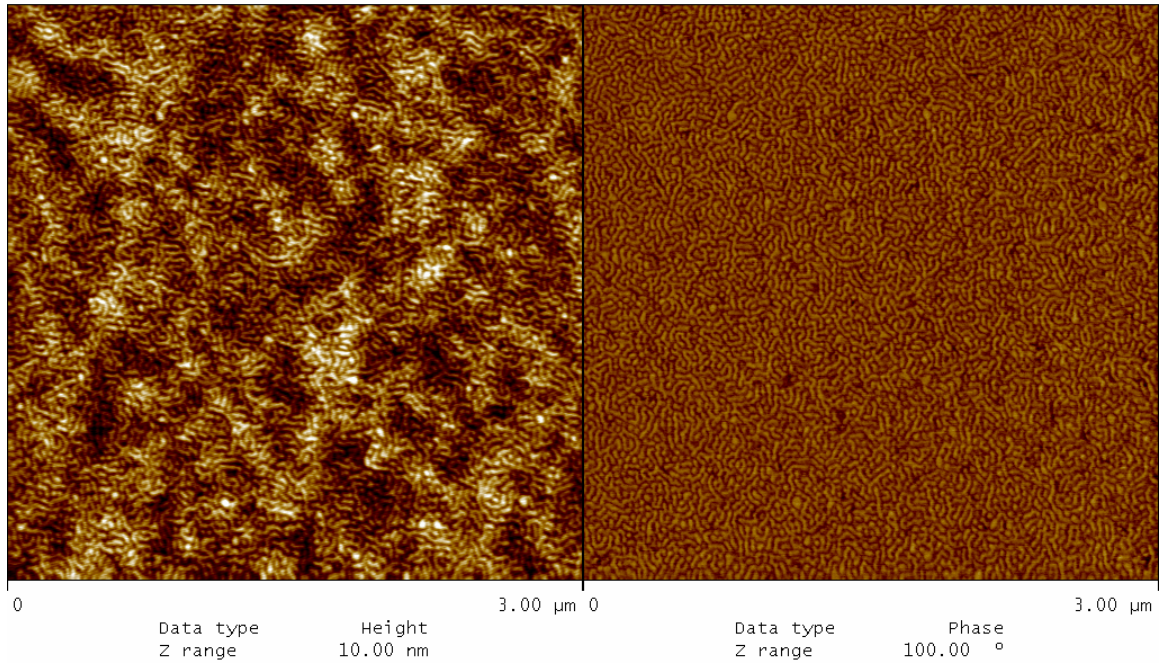
# AFM DIAMOND PROBES



8-26-a1#4-ad111.f05

**Tapping mode image obtained on etched Al<sub>2</sub>O<sub>3</sub> sample using a diamond probe on silicon cantilever with 4 N/m stiffness**

# AFM DIAMOND PROBES



sbs-on-si.f26  
RFESP-76, July 9, 2004

**Tapping mode image of soft sample of triblock copolymer film using a diamond probe on silicon cantilever 4 N/m stiffness**

# AFM DIAMOND PROBES

## PRICES

<b>Single Crystal Diamond Tip (9° or 13°) .....</b>	<b>\$790</b>
<b>Mounted on Any Cantilever</b>	
<b>Additional Costs (added to the \$790 price above):</b>	
<b>7° Diamond Tip .....</b>	<b>\$100</b>
<b>Cube Corner Indenter .....</b>	<b>\$100</b>
<b>Silicon Cantilever .....</b>	<b>\$50</b>
<b>Sapphire Cantilever .....</b>	<b>\$200</b>
<b>Diamond Probe Resharpener .....</b>	<b>\$390</b>

**For items not listed, please request a quote.**