

The background is a dark blue gradient with a pattern of white circular lines and arrows, suggesting a technical or scientific theme. A large circular scale is visible on the left side, with numbers ranging from 140 to 260. The scale has major tick marks every 10 units and minor tick marks every 2 units. The numbers are: 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260. The title "Atomic Force Microscopy" is centered in a large, white, sans-serif font.

Atomic Force Microscopy

Jacob Grant

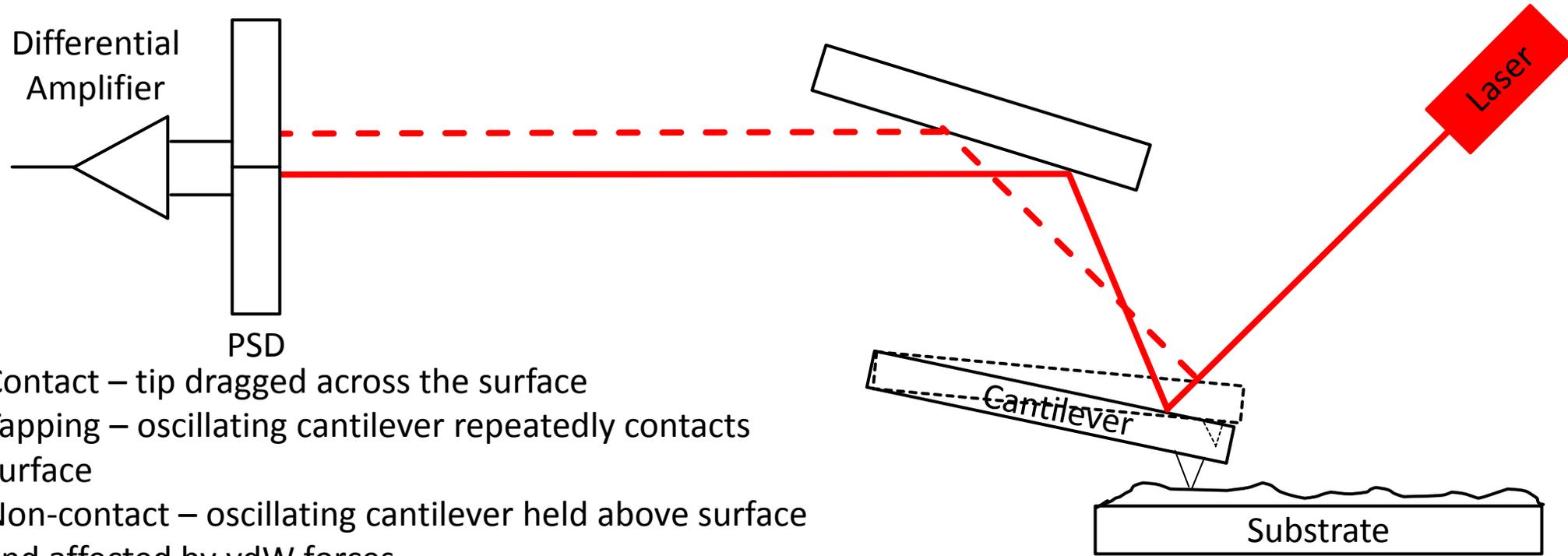
Shaw Group Meeting: How-To Talk

140901



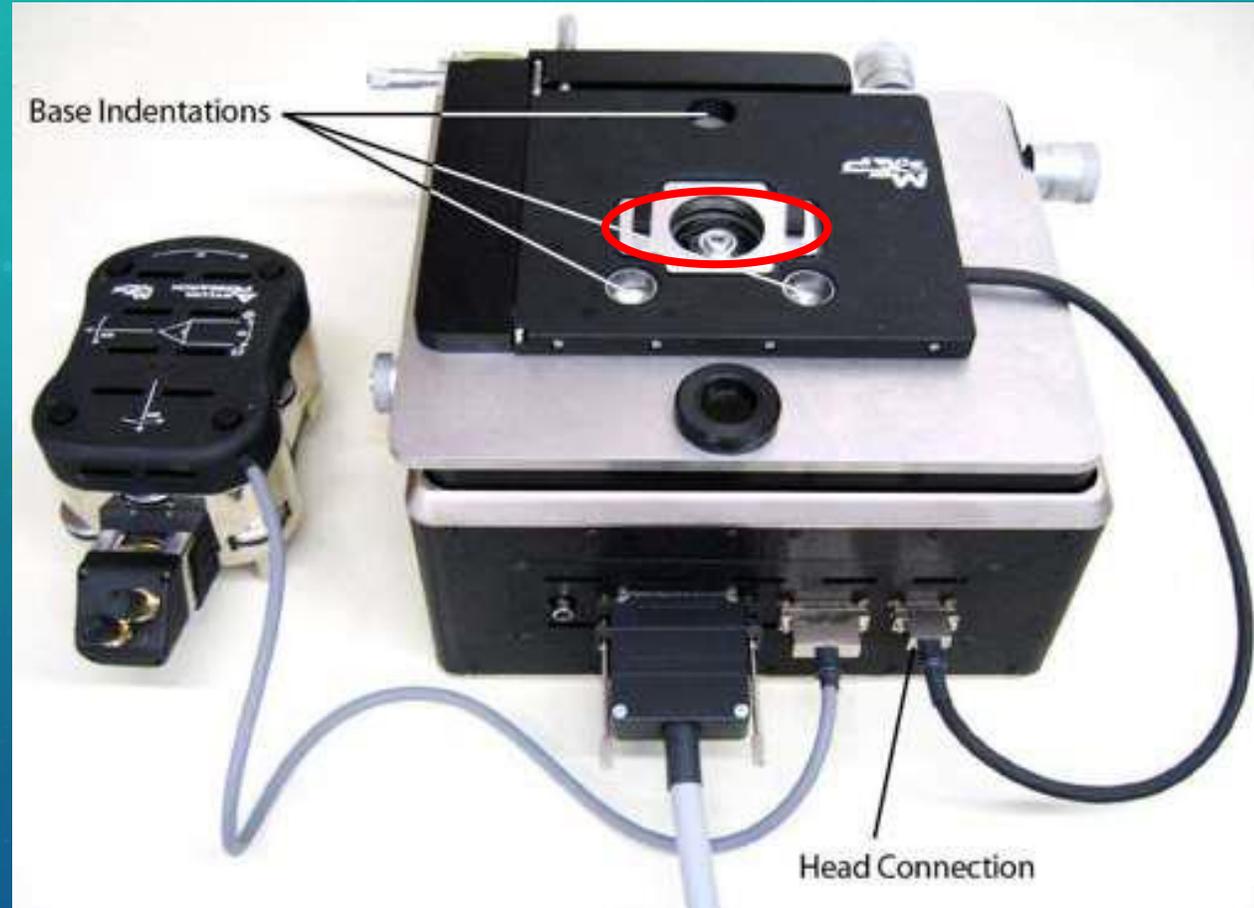


THEORY



- Contact – tip dragged across the surface
- Tapping – oscillating cantilever repeatedly contacts surface
- Non-contact – oscillating cantilever held above surface and affected by vdW forces

MOUNTING SURFACE ON BASE

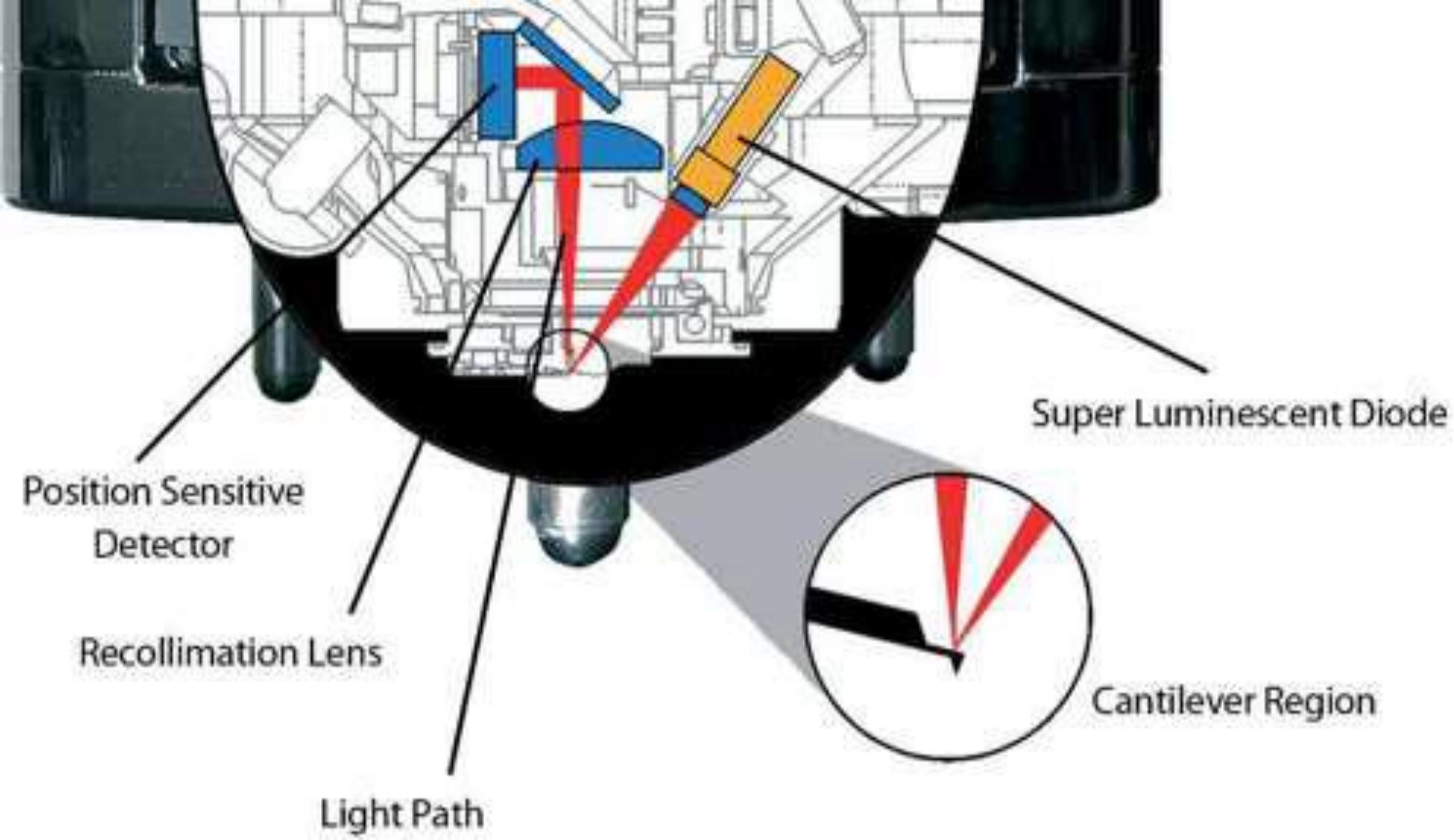


- Attach surface to glass or aluminum slide with double stick tape
- Two magnets secure slide to base
- Center the area where imaging is desired

ATTACHING AFM TIP TO HEAD



- Secure AFM tip into holder (tip must be straight and immobile)
- Holder locks onto the bottom of the AFM head



ATTACHING HEAD TO BASE



- #1: Front vertical adjustment
- #3, #5: Rear vertical adjustments
- Notes
 - Raise all adjustments before placing head on base to avoid crashing the AFM tip
 - Place head on base rear legs first

OPENING ASYLUM RESEARCH SOFTWARE

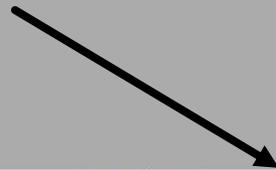
MFP3D 120804+2209 | Igor Pro 6.34A

File Edit Data Analysis Macros Windows Notebook Misc Help AFM Controls AFM Analysis Programming User Settings

Master Panel ...

Main	Thermal	Force	Tune	FMap
Scan Size	20.00 μm			?
Scan Rate	1.00 Hz			?
X Offset	0 nm			?
Y Offset	0 nm			?
Scan Angle	0.00 °			?
Points & Lines	256			?
Width:Height	1 : 1			?
<input type="checkbox"/> Delay Update				?
Set Point	800.00 mV			?
Integral Gain	10.00			?
Feedback Filter	5.000 kHz			?
Drive Amplitude	100.00 mV			?
Drive Frequency	75.000 kHz			?
Input Range	Auto [$\pm 10\text{V}$]			?
Slow Scan Disabled <input type="checkbox"/> Clear Image				?
Imaging Mode	AC Mode			?
Auto Tune	Engage			?
Do Scan	Stop!!!			?
Frame Up	Frame Down			?
Base Name	Image			?
Base Suffix	0000			?
Note				?
Save Images <input checked="" type="checkbox"/> Path... Save Image				?
Save Status: Save Current Save Prev.				?
Main Panel	Setup			?

- Master Panel (AFM Controls > Master Panel)
- Scan Size: 20 μm (scratch test), 5 μm or 1 μm
- Scan Rate: 1 Hz or 0.5 Hz
- Points & Lines (resolution): Low (256) to verify good image location, high (512, 1024) for legitimate image
- Set Point: Proportional to force between tip and surface
- Imaging Mode: AC mode (tapping)
- Choose path for saving images (will need a flash drive)
- Bring up camera



Igor Ready ARC not on

Ready

for offline



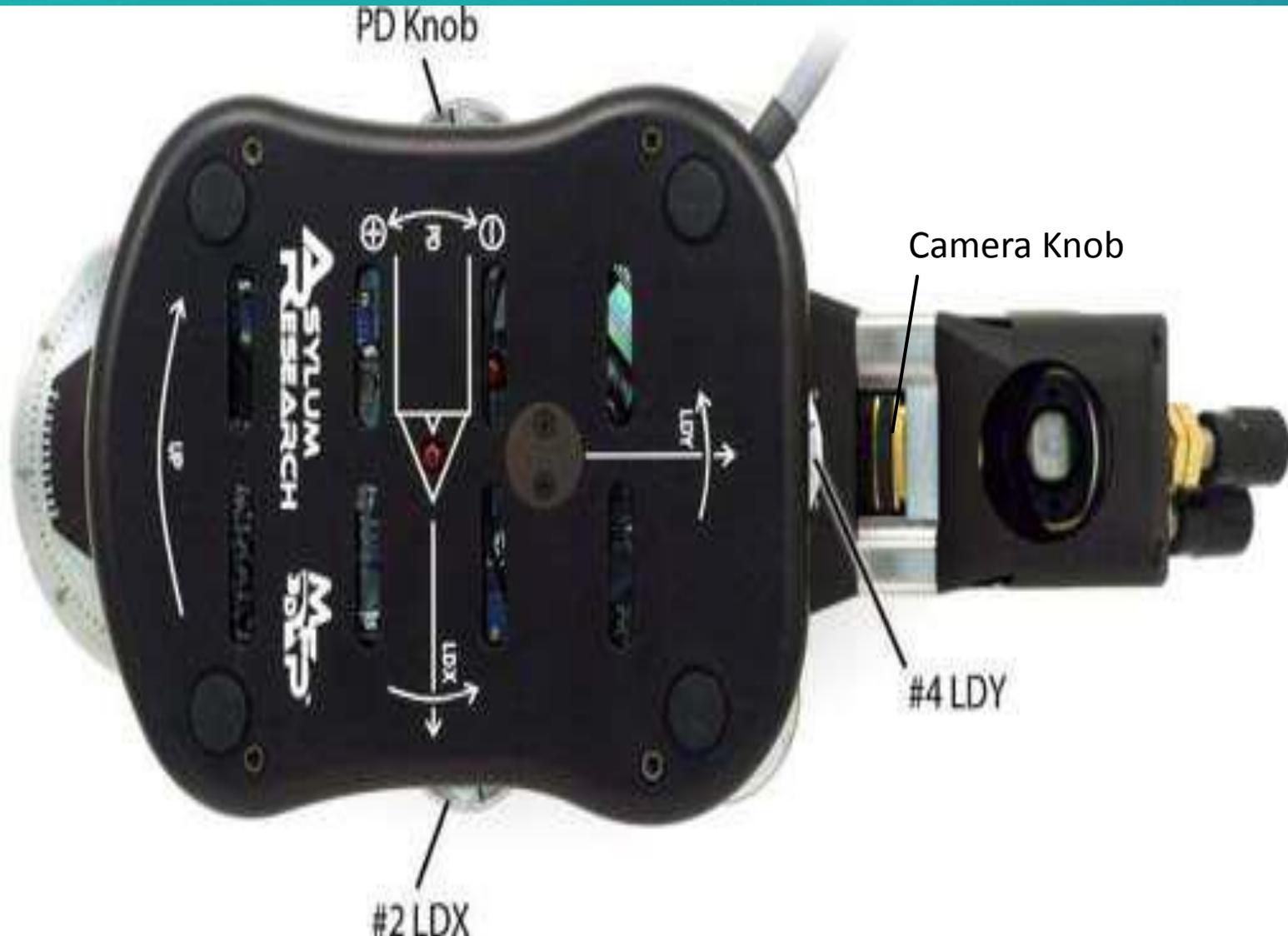
Camera Icon

MFP3DXop v31 up36

1:56 PM
8/31/2014

1:56 PM
8/31/2014

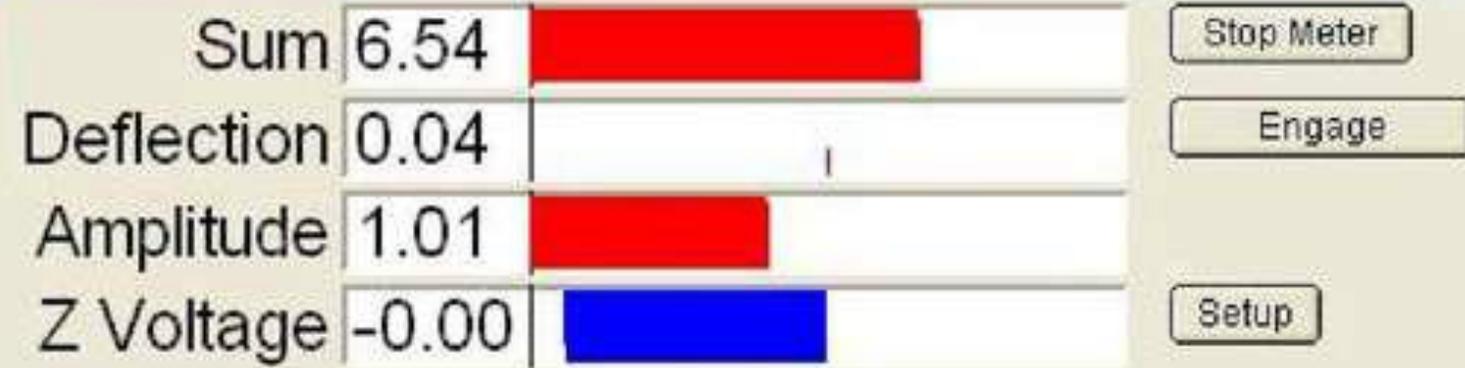
ALIGNING THE LASER



#2 LDX and #4 LDY: adjusts laser in the x- and y-directions

PD Knob: tilts the mirror that directs reflected light off the cantilever into the photodiode

Camera Knob: adjusts the camera to bring the tip into focus



AFM Controls > Sum and Deflection Meter

- Align the laser spot (LDX and LDY knobs) on the cantilever so as to give the maximum possible Sum value (want 7-10)
 - Sum is the amount of light collected by the photodetector in volts
 - If cannot attain 6-7, may need to reposition AFM tip
- Adjust the deflection to 0 with the PD knob

TUNING THE CANTILEVER

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File Edit Data Analysis Macros Windows Panel Misc Help AFM Controls AFM Analysis Programming User Settings

Master Panel ...

Main Thermal Force Tune FMap

GetReal™ Calibration Waiting... ?

Zoom Graph ?

Zoom Center 75.000 kHz ?

Zoom Width 30.000 kHz ?

Initialize Fit ?

Cal Spring Constant Cal InvOLS ?

Fit Thermal Data ?

Amp InvOLS 109.00 nm/V ?

Spring Constant 1.00 nN/nm ?

Thermal DC 1.00e-14 ?

Thermal Q 20.0 ?

Frequency 75.000 kHz ?

White Noise 5.00e-15 ?

Fit Width 20.000 kHz ?

Show Fit Show Thermal ?

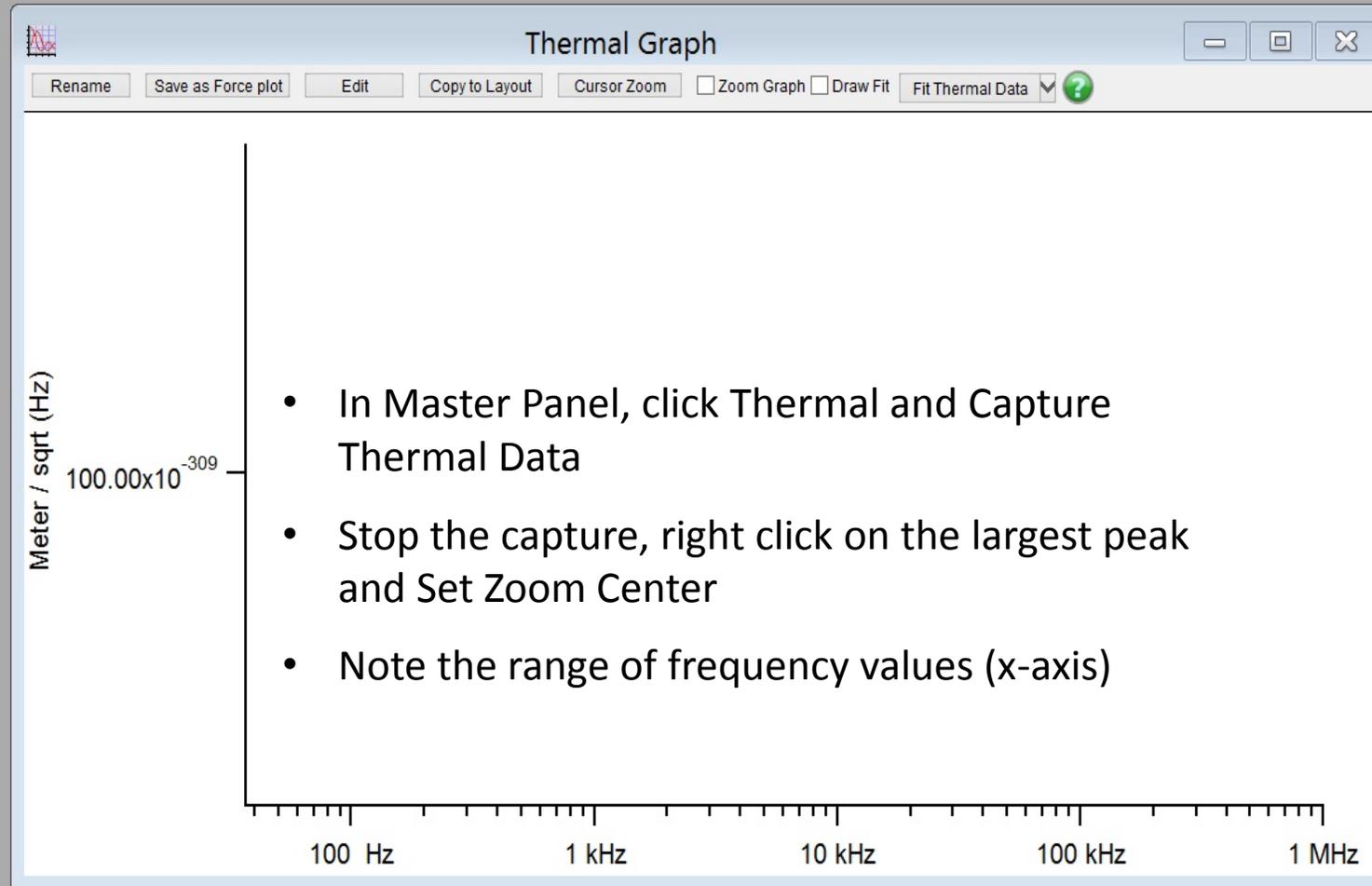
Graph Log Log/Log ?

Averaging Count 1000 ?

Current Samples 1 ?

Resolution 5, default ?

Thermal Panel Setup ?



TUNING THE CANTILEVER

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File Edit Data Analysis Macros Windows Panel Misc Help AFM Controls AFM Analysis Programming User Settings

Master Panel ...

Main Thermal Force Tune FMap

Auto Tune

Auto Tune Low 50.000 kHz ?

Auto Tune High 400.000 kHz ?

Target Amplitude 1.00 V ?

Target Percent 0.0 % ?

Auto Tune ?

Manual Tune

Drive Frequency 75.000 kHz ?

Sweep Width 5.000 kHz ?

Drive Amplitude 100.00 mV ?

Q Gain 0.0000 ?

Tune Time 0.96 S ?

Phase Offset 0.00 ° ?

Input Range Auto [±10V] ?

Continuous ?

One Tune ?

Center Phase ?

F & P from Thermal ? Phase from Thermal ?

Other Things

Dual AC Mode ?

iDrive Check Holder ?

Backwards Both ?

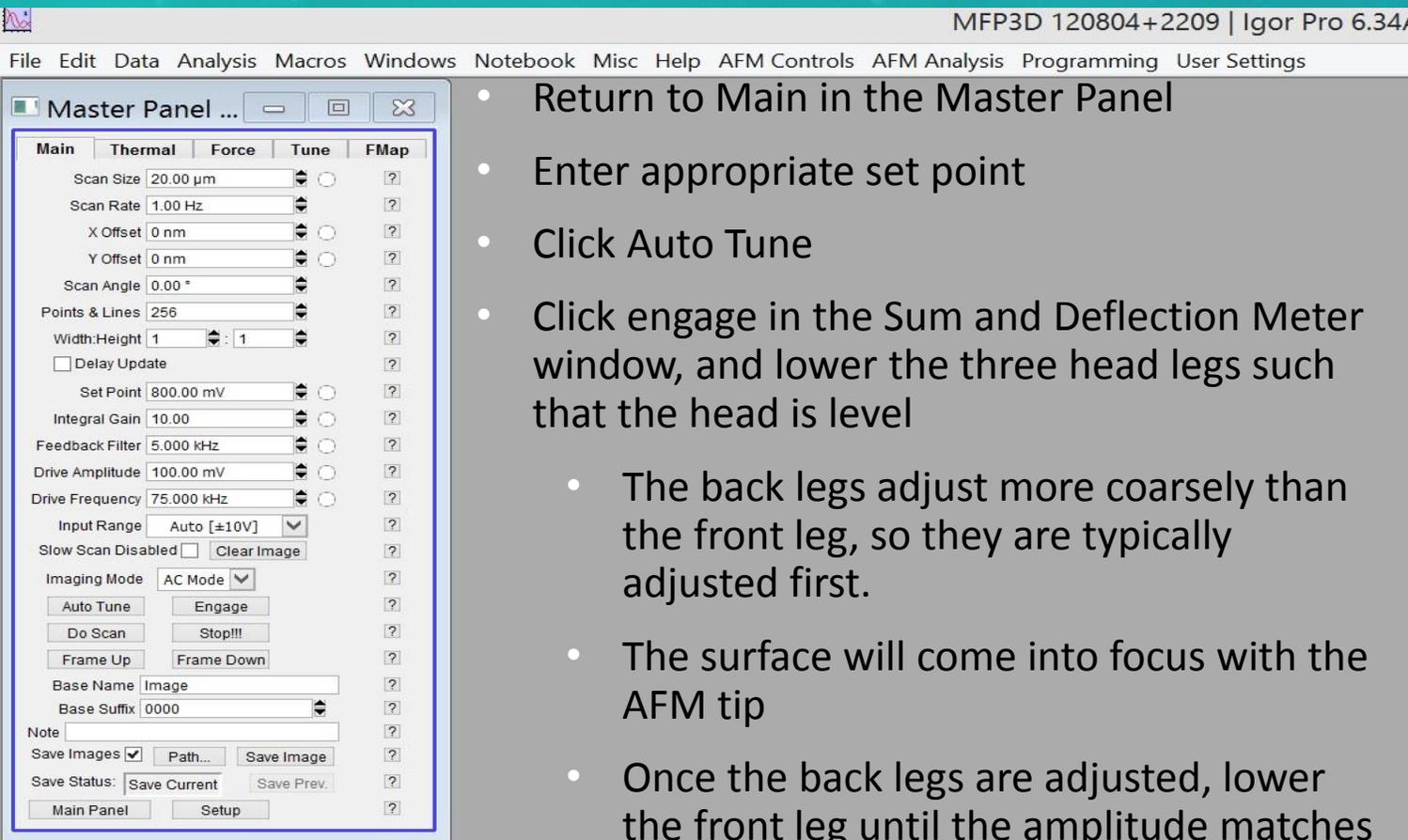
Append Thermal SHO Fit ?

Append Phase SHO Phase ?

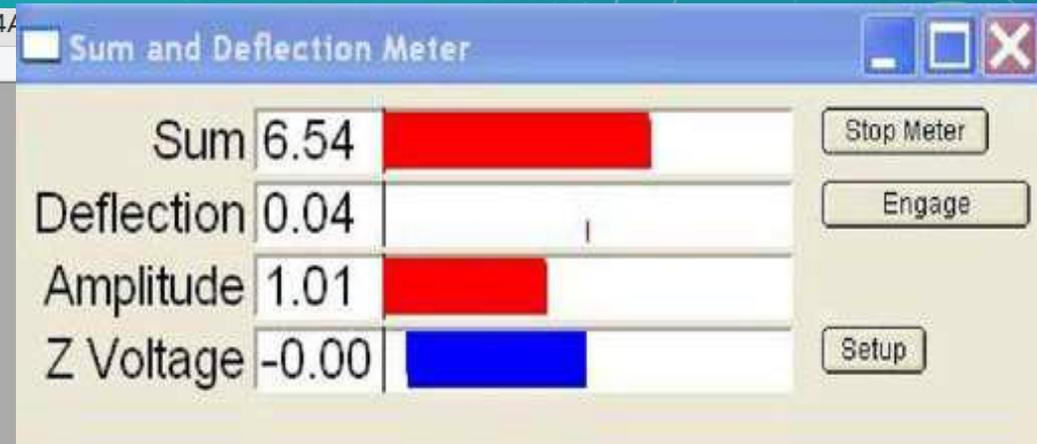
Tune Panel Setup ?

- Click Tune in the Master Panel
- Enter the range of frequency values in the low and high auto tune fields
- Target Amplitude: 1.00 or 1.50 V
- Target Percent: -5.0% (giving a set point of 800 mV or 1.15 V)

APPROACHING THE SURFACE



- Return to Main in the Master Panel
- Enter appropriate set point
- Click Auto Tune
- Click engage in the Sum and Deflection Meter window, and lower the three head legs such that the head is level
 - The back legs adjust more coarsely than the front leg, so they are typically adjusted first.
 - The surface will come into focus with the AFM tip
 - Once the back legs are adjusted, lower the front leg until the amplitude matches the set point and the Z Voltage is 70.00
- Click Withdraw, then repeat (auto tune, engage, adjust, withdraw)

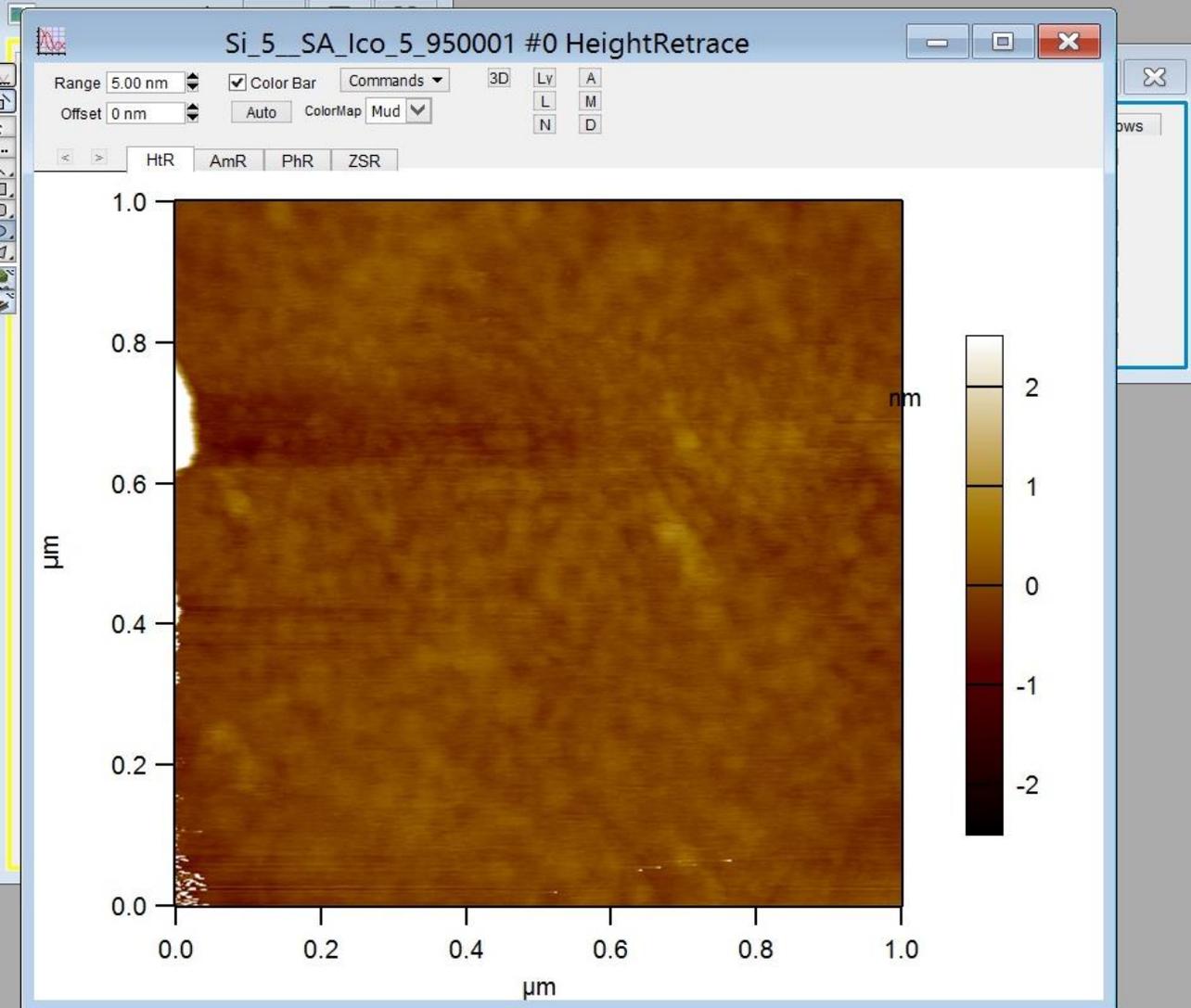


Note: It may be necessary to adjust the deflection (PD Knob) back to 0

IMAGING THE SURFACE

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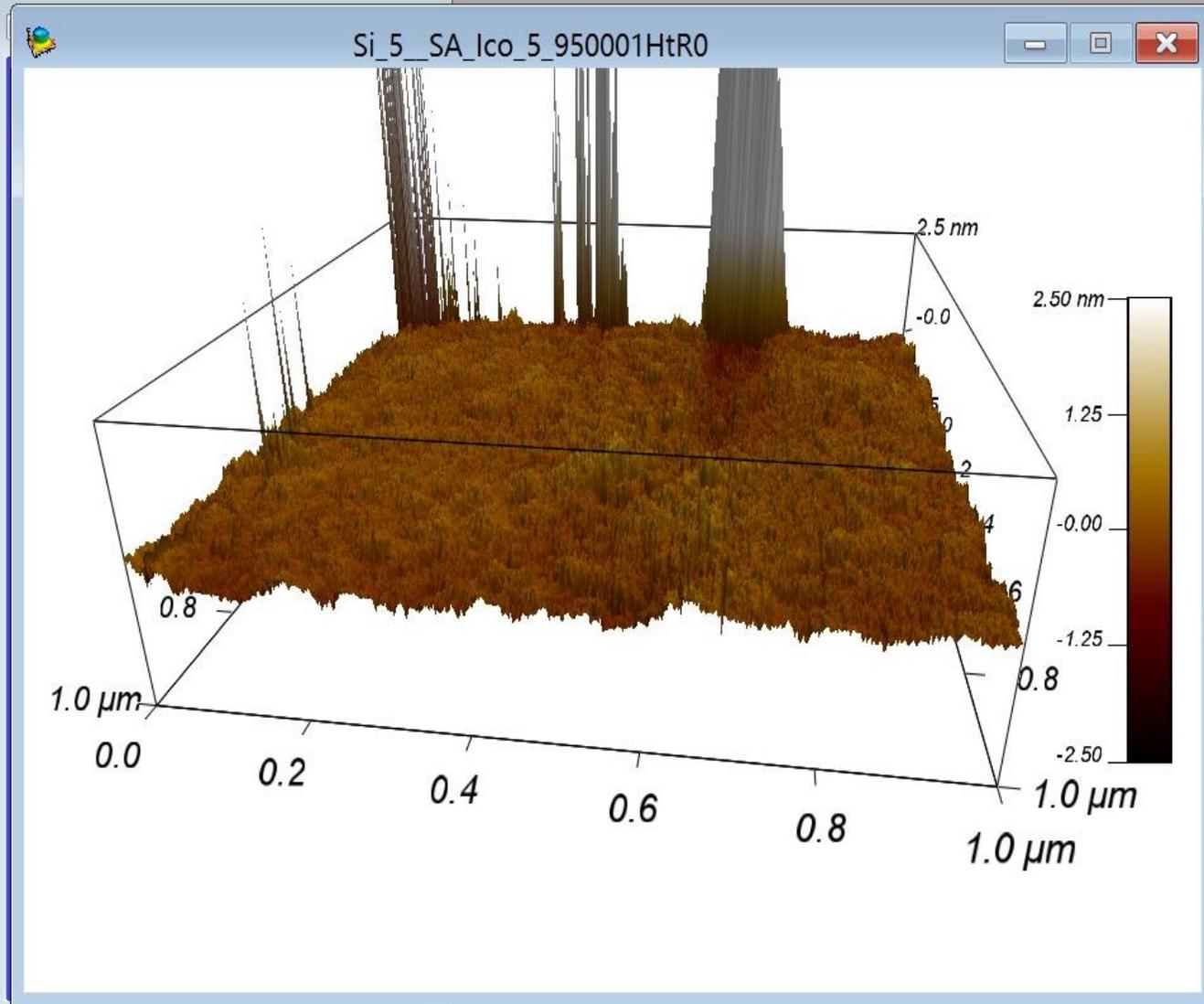
File Edit Data Analysis Macros Windows Graph Misc Help AFM Controls AFM Analysis Programming User Settings



- Click Do Scan, then Last Scan and a 2D image will appear as it is generated
- Once the scan is complete, the 2D image can be opened as shown here
- Clicking 3D will open a prompt for a 3D image

3D IMAGE

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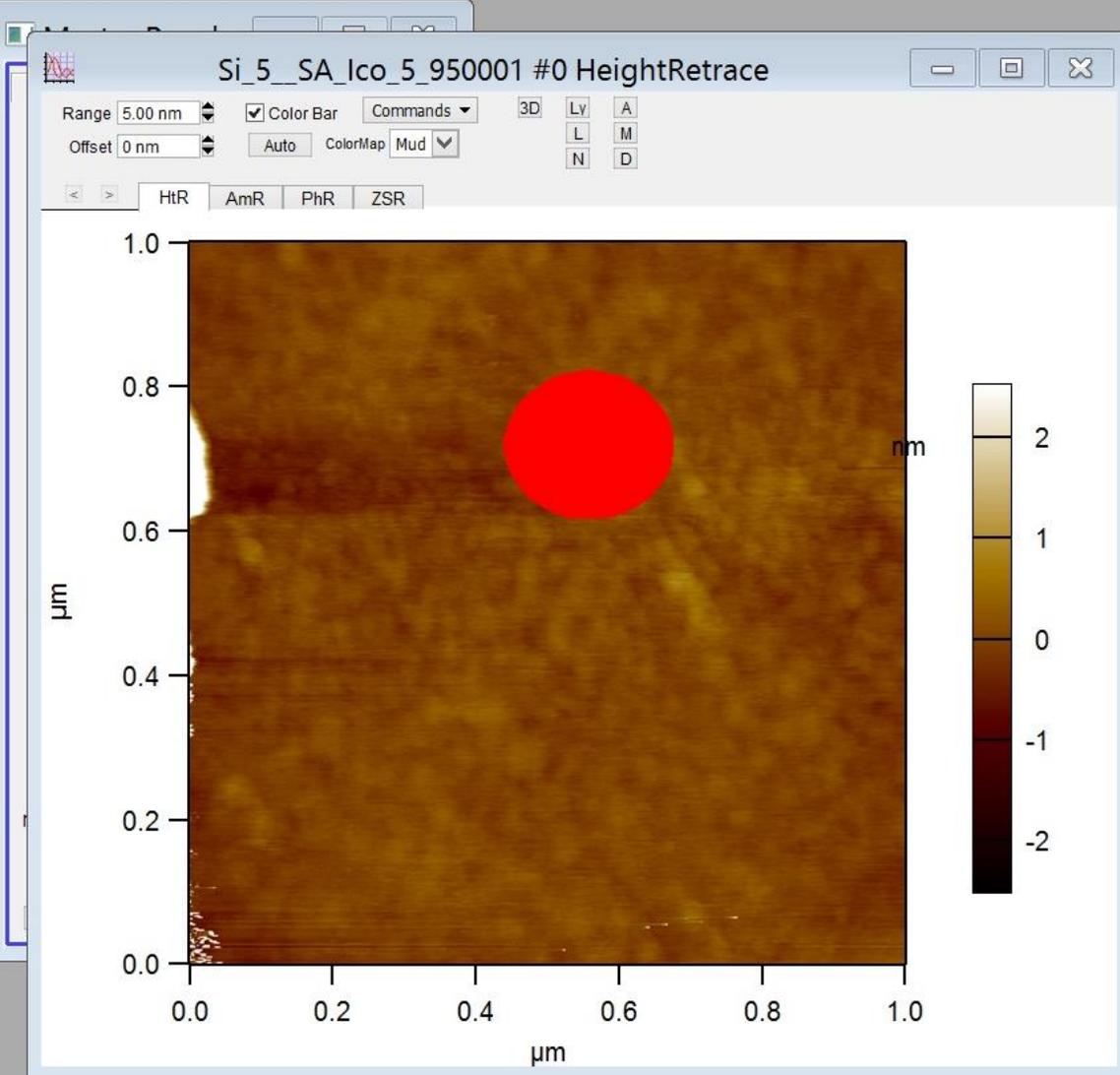


The Master ArGL Panel is a control interface for the 3D image. It contains several tabs: New, Display, Axes, View, Lights, Prefs, and Windows. The View tab is currently selected. The panel displays the file name "Si_5_SA_Ico_5_950001HtR0" and a color bar. Below the color bar, there are several controls: a checkbox for "All", a "Clip" dropdown menu set to "None", a "View Mode" dropdown menu set to "Data Scale", a "Data Scale" input field set to "5.00 nm", and a "Data Offset" input field set to "-222.04 nm". There are also several sliders and buttons, including "Fix", "Make ArGL View Panel", and "Setup".

- The Master ArGL Panel will appear and allow for manipulation of the display colors and axes of the 3D image

IMAGE ANALYSIS

File Edit Data Analysis Macros Windows Panel Misc Help AFM Controls AFM Analysis Programming User Settings



Modify Panel

Flatten PlaneFit Erase Mask Filter FFT History Prefs

Si_5_SA_Ico_5_950001 #0 HeightRetrace

Global Flatten

Flatten

Flatten Order 0

Offset Uses: Mask All

Exclude Points

Include Points

Reset Mask

Undo Flatten

Restore Layer

Ultra Restore Layer

Make Flatten Panel

Setup

Detailed description: This panel contains various processing options for the AFM image. It includes buttons for Flatten, Exclude Points, Include Points, Reset Mask, Undo Flatten, Restore Layer, Ultra Restore Layer, and Make Flatten Panel. There are also input fields for Flatten Order (set to 0) and Offset Uses (set to All).

Analyze Panel

Roughness Section Histogram Particle Analysis

Calculate Roughness

Mask Make Reset

Box Size 1.00 μm

X:Y 1:1

Y Offset 500.00 nm

X Offset 500.00 nm

Stats Full Image Masked Image

Sdev [Rq]	378.570 μm	384.618 μm
Adev [Ra]	150.482 μm	151.878 μm
Max	15.874 nm	15.874 nm
Min	-1.331 nm	-1.331 nm
Avg	-0.000 m	1.368 μm
Skew	13.5	13.4
Kurt	263	256
Percent	100%	96.3%
Area	1.0 μm^2	967123.2 nm^2
Area %	0.4547%	0.4677%
Volume	-0 m^3	1.3e+03 nm^3

Export Roughness

Make Roughness Panel

Setup

Detailed description: This panel displays statistical data for the AFM image. It includes a table with columns for 'Full Image' and 'Masked Image'. The table contains values for Sdev [Rq], Adev [Ra], Max, Min, Avg, Skew, Kurt, Percent, Area, Area %, and Volume. There are also buttons for Export Roughness, Make Roughness Panel, and Setup.

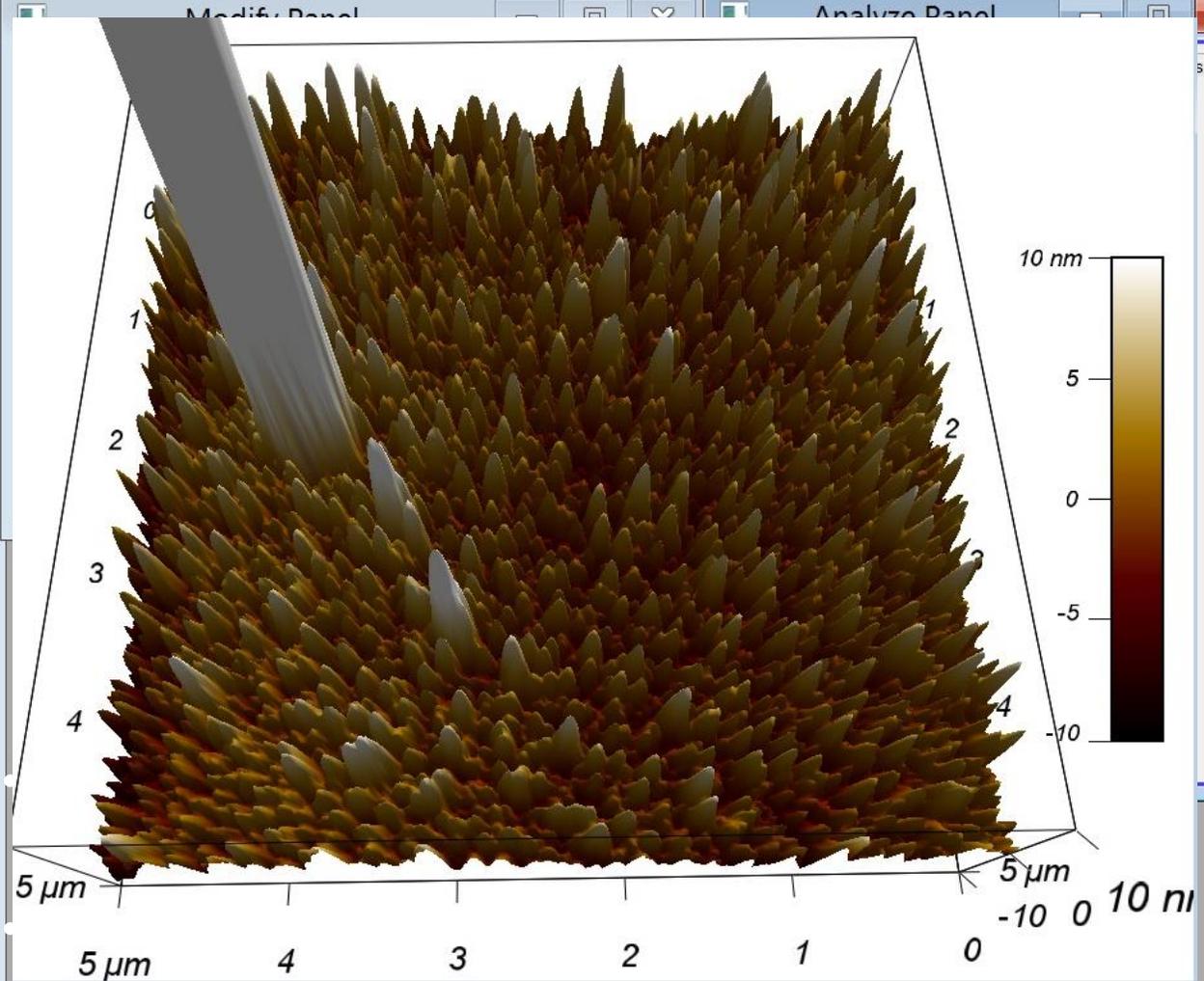
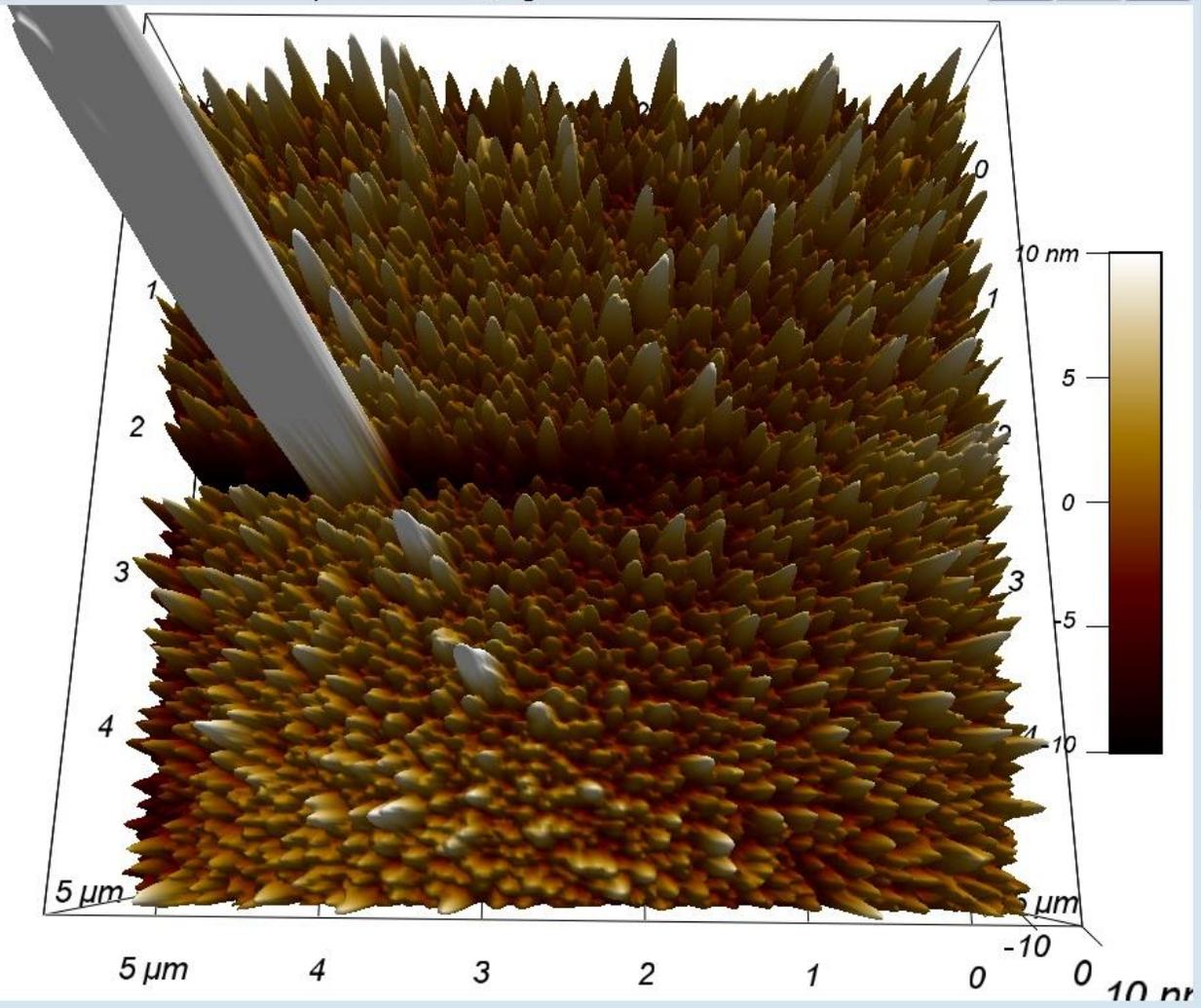
- AFM Analysis > Modify/Analyze Panels will allow for excluding artifacts and provide a calculated rms roughness

FLATTENING

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File Edit Data Analysis Macros Windows Panel Misc Help AFM Controls AFM Analysis Programming User Settings

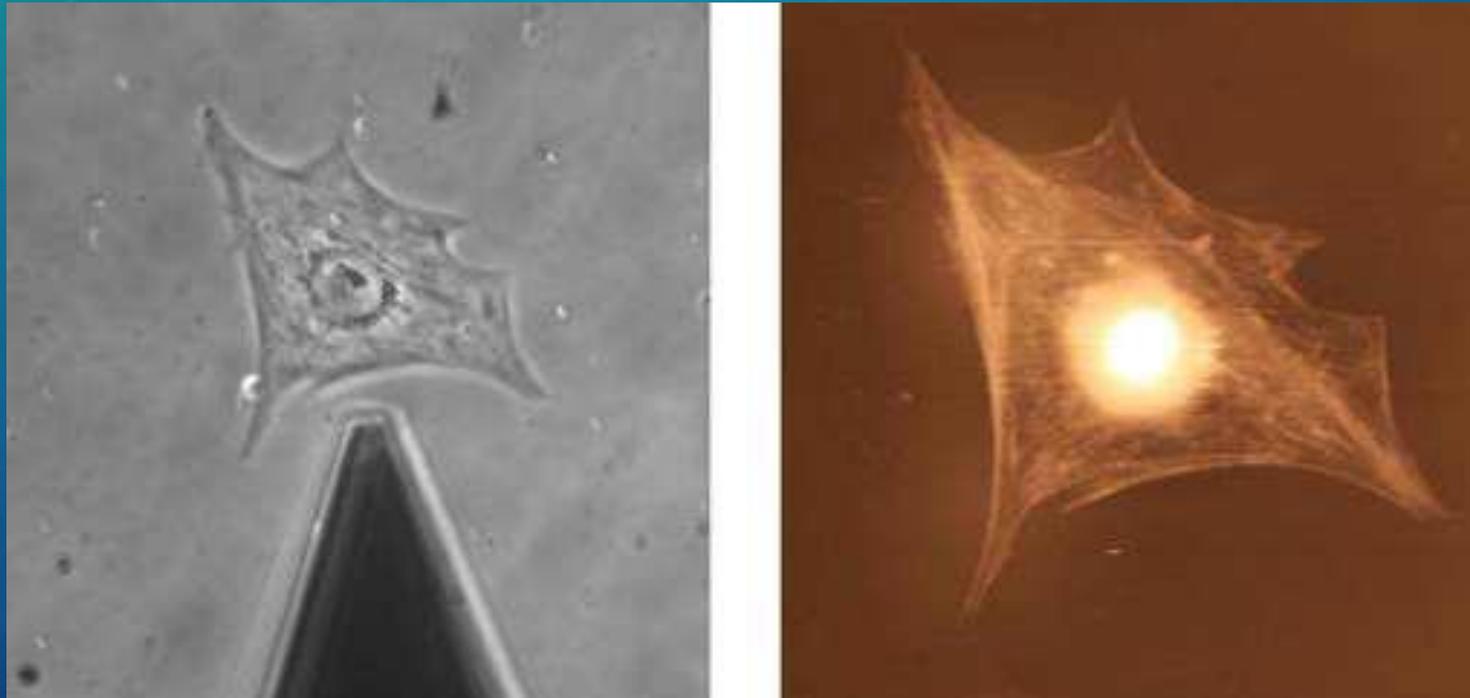
Sputtercoated_Ag10000HtR



RMS roughness 4.867 nm to 2.476 nm

REFERENCES

- Asylum MFP-3D Manual
 - <http://mmrc.caltech.edu/Asylum/Asylum%20MRP-3D%20manual.pdf>
- Asylum MFP-3D Manualette
 - <http://nano.indiana.edu/Files/MFP3D/MFP3D%20Manual2.pdf>
- Sam and Radhika



Simultaneous optical phase and contact mode topography of a living cardiac myocyte