NANONICS IMAGING

USER GUIDE

# *Temperature/Thermal Conductivity Measurements with SPM MV-2000/MV-4000*

Temperature/thermal conductivity measurements with Nanonics thermo resistive probes integrated with Nanonics SPM MultiView – 2000/4000

March 2013 – Version B

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## Note on Printing

This manual is designed to be printed in color, single-sided on A4 paper

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# Introduction

Resistance thermometry uses the variation with temperature of the electrical resistance of the metals. The resistance increases with increasing the temperature because the thermal motions (vibrations) of the atoms scatter (deflect) the electrons, which are carrying the current and so impede their motion. As the temperature rises, the thermal motions increase, so the scattering increases and therefore the resistance also.

Pt thermometers traditionally were used for temperature measurements, because of their repeatability, their neutrality with other materials and the linear dependence of Resistance/Temperature.

Except at low temperatures, the Pt resistance thermometer is not far from linear in thermodynamic temperature and its behavior can usually be represented as

$$R_t = R_0 (1 + \alpha T),$$

where $R_t$ –resistance on the current temperature,
$R_o$ is the resistance at 0ºC, T is temperature interval between these two points,
$\alpha$ is the thermal coefficient and it is $0.0038C^{-1}$ for Platinum. It means that 1ºC temperature change will cause a 0.38Ohm change in the resistance.

Nanonics cantilevered Pt thermal resistive probes operate as the miniature resistance thermometer and can be used for the simultaneous collection of the topographic/temperature and topographic/thermal conductivity data.

There are two modes of the probe operation:

A. **"Passive" mode: This mode is usually used for the temperature measurements.** The probe acts as a passive thermosensing element. A low constant current (in order to make a self-heating of the probe negligible) is passed through the probe. The probe is brining in contact with the sample. During the scanning across the sample the resistance of the probe changes due to the temperature differences on the sample. The resistance variation converted in voltage is monitoring by the control system and represented as the temperature map.
B. **"Active" mode: This mode is usually used for the thermal conductivity measurements.** In this mode the lager constant current (sufficient to raise the temperature of the probe above that of the surface) is passed through the probe. When the probe is brought in the contact with the tested sample, the tip is cooled due to the heat conduction from the probe into the specimen. The resistance of the probe is changed in the results of the cooling. This resistance variation converted in voltage is monitoring with the control system and represented as the thermal resistance mapping.

# Thermoresistor Signal Amplifier Operation

*Warning: Please follow the instructions below exactly as written in order to prevent burning of the Thermal Resistive probes.*

1. High-resolution thermal resistive probes can be used for the simultaneous detection of the topographic and temperature/thermal conductivity data.
   The thermal resistance probe is mounted on special tip mount. The probe is electrically connected to the metal contact pads on the tip mount.

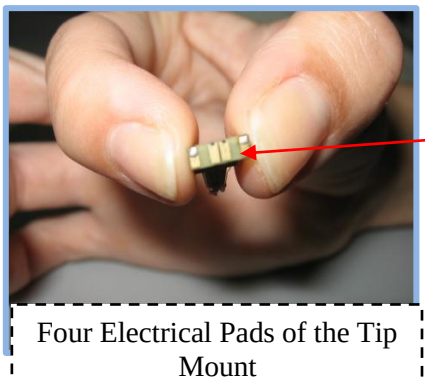

2. A specially designed Thermal resistor signal amplifier is used for the thermal conductivity measurements.
3. Switch on the thermal resistor signal amplifier (switch is on the rear).


4. Before connecting the probe to the input of the thermal resistor signal amplifier set the current to minimum. For this set the Display knob to current and using the *SET* knob put the current on the minimum.
5. The cable "To SPM_C-8B_El/P1" connects the "To Head" input on the back panel of the SPM controller with the stepper motor and the preamplifier of the scanning head. This cable includes a special BNC cable labeled as "For Electro/thermo Measurements", which is used for the electrical and thermal measurements.
6. Connect the special BNC cable to IN of Thermoresistance signal Amplifier.
7. Connect the channel "Out" on the Thermoresistor Signal Amplifier with channel "AUX 2 "or "NSOM" on the Data Translation box using additional BNC cable.

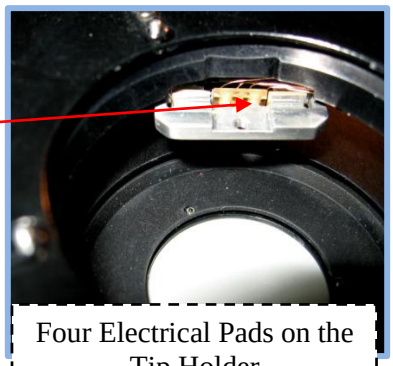
8. Accurately take out the thermal resistive probe from the package box and insert it into the tip holder by sliding. Fasten the tip mount on the tip holder with the fixation screw.


**Note: Do not press strongly on the tip holder during the mounting. It can damage the upper scanner**

**It is very important to create a good contact between the contact pads of the tip mount and the contacts pads of the tip holder.**



Four Electrical Pads of the Tip Mount



Four Electrical Pads on the Tip Holder

9. Increase the current to the desired value (usually3-5 mA). Set the "Gain "knob in the position 7-8 o`clock (slightly higher than minimum).
10. Set the Display knob to out and balance the voltage to zero using the *BALANCE* knob. Because each probe has its own resistance, each one must be balanced separately.



11. Adjust the Lock-in parameters and feedback tuning of the thermal resistive probe exactly as in the case of the standard AFM probe.
12. Approach the thermal resistive probe to the sample surface.

***Note:*** *Sometimes approaching causes the drift of the "Out" signal from the zero value. In this case continue approaching with the probe. Then retract the probe slightly out from the sample surface. Adjust the voltage on the "Out" to zero using the "Balance" knob and bring the probe in contact again*

13. Select scanning settings (Scan range, time per point and other). Select either Aux or NSOM channel in the software depends on the input channel chosen on

the Data translation box for the thermal signal detection.

14. Start the scanning.

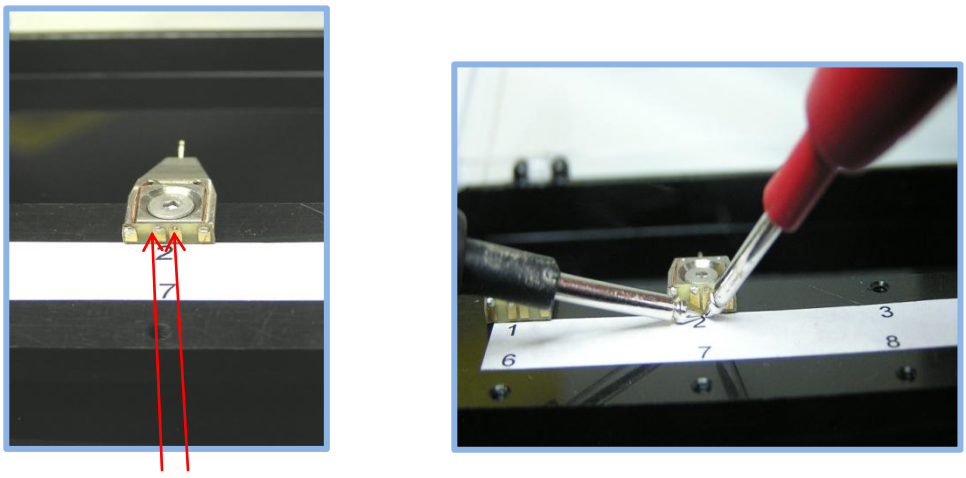
***Note:*** *In the case of the low thermal or thermal conductivity contrast on the sample, it is recommended to increase the Gain of the Thermoresistor Signal Amplifier. In order to change the gain, stop the scanning, and retract the probe slightly out from the sample surface. Increase the "Gain" (Rotate the "Gain "knob clockwise direction). Adjust the "Out" signal to zero using the "Balance" knob and approach the probe again. Increasing the gain causes more sensitive balancing of the 'Out" signal.*

# Troubleshooting

The current in Thermoresistance amplifier can't go more than 1mA.
There are 2 reasons:

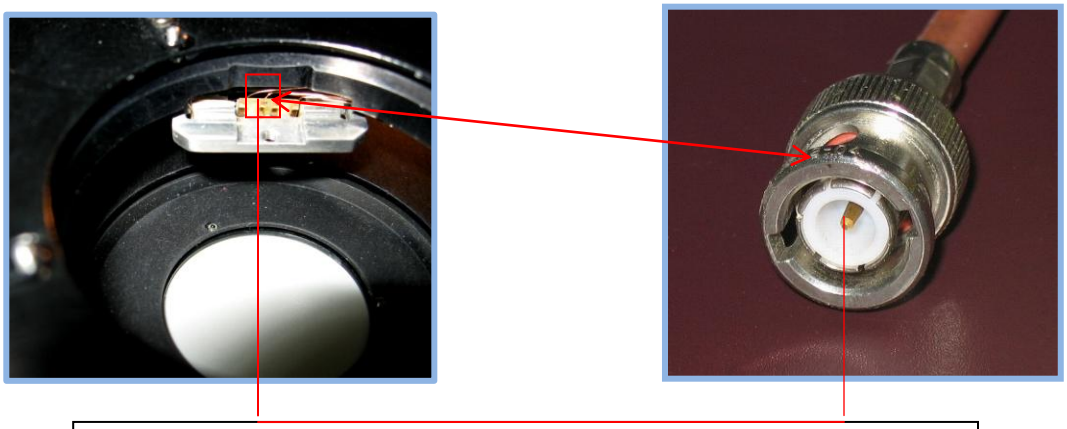
1. There is no contact between the wires
2. There is no connection between tip and BNC cable.

a. In order to check resistance between the electrical pads use the following procedure: Remove the tip mount from the scanning head. Accurately insert the tip mount back into the package box. Measure the resistance between to central electrical pads of the tip mount using the multimeter.




If the resistance is > than 200Hz change tip
If the resistance is correct, perform the following procedure:

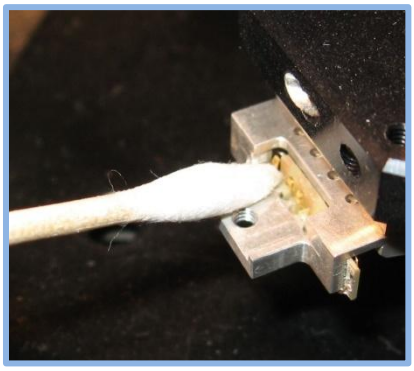
b. Check the electrical connection between two central contact pads of the tip holder (located on the upper scanner of the scanning head) and the coaxial connector of the BNC cable "For electro/thermo Measurements" using multimeter. One of the contact pads should be electrically connected to the central core of the BNC connector while the second contact pad is connected to the ground shield.



Test the electrical connection between the one of the contact pads and central core of the BNC cable and the second contact pad and outer BNC ground shield.

If the problem with the electrical connections was found out please contact to Nanonics support (support@nanonics.co.il).

If there is no problem with the electrical connections between the contact pads and BNC cable, perform the cleaning procedure:
Use a cotton stick with some ethanol on it and gently clean the connectors on the probe mount.



After the cleaning put the probe on the tip mount again. Upon mounting the probe, make sure that the contacts on the probe mount are not bended by mounting the probe. You can avoid bending the connectors by sliding the probe inside the holder and not bringing it from above. Measure the probe resistance between the central and ground channels of the "For electro/thermo Measurements" BNC cable with the multimeter again. If the measured resistance value is correct continue the thermal measurements.