

## Scanning Thermal Microscopy with the add-on from Ansys Instruments

The highly flexible JPK NanoWizard® AFM platform is compatible with the Scanning Thermal Microscopy (SThM) module from Ansys Instruments. The technique generates simultaneous nanoscale thermal images and topography images. This is achieved by a combination of electronics and a specialized probe that has integrated circuitry that allows it to be heated.

### Set-up and operating principle

The SThM module comprises a power supply, a controller and an interface box (see Fig. 1). The interface box connects both to the JPK controller and to the specialized cantilever, which is mounted onto the tip holder, designed by JPK specifically for this purpose. The tip holder is, in turn, attached to the NanoWizard AFM head. Fig. 2 shows the probe, probe holder and the electrical connection through the strain relief interconnection module, purpose-built by JPK.

The output from the interface box feeds into an auxiliary input on the JPK controller. This signal is then handled by the JPK SPM Control software in exactly the same way as it handles any other signal. It can be displayed as an imaging channel, or as a spectroscopy channel and saved together with a regular topography image, with a single force-distance curve, multiple curves in a force map (such as JPK QI™).

The SThM probe has a resistor at its apex. Owing to the fact that the probe is part of a special circuit (called a Wheatstone bridge) it is possible to monitor the resistance of the probe, which varies with temperature. As a result, the circuitry in effect becomes a thermometer, so where a sample has regions of different temperatures (such as an operating semiconductor device) the temperature differences show up in the SThM image.

Another possibility is to actively heat the tip by sending a current through the probe. In this mode the hardware will

be able to distinguish areas of different thermal conductivities, by using feedback to maintain the probe temperature. An area of low thermal conductivity will be a good insulator for the probe and so the probe will drawing only a little current. A highly conductive area of the sample, on the other hand, will act as a heat-sink to the probe, meaning that it will require more current to maintain the probe temperature.



Fig. 1 JPK NanoWizard® 3 AFM and Ansys SThM module

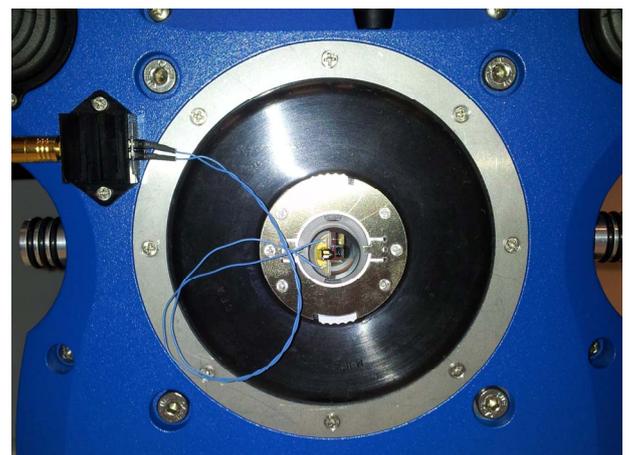
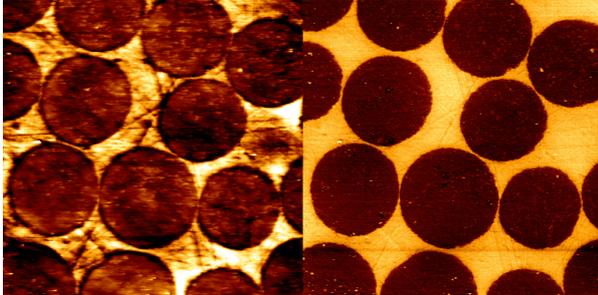


Fig. 2 A view of the bottom of the NanoWizard® 3 AFM head showing the SThM probe and JPK SThM probe holder and the electrical connection to the probe.



**Fig. 3** 30  $\mu\text{m}$  topography and SThM images of a carbon fiber-epoxy composite sample. The two components of the composite sample are clearly resolved, particularly in the thermal conductivity map (right). The Z range of the topography image is 35 nm. The thermal conductivity map is in arbitrary units.

## Application fields

SThM and the related technique of nano-thermal analysis (nanoTA) have various wide ranging applications.

One area of interest with SThM is to resolve hot-spots in integrated circuitry magnetic recording heads or laser diodes and waveguides, where it can help with understanding current flow through such devices and with defect analysis.

The field of polymer science also benefits from SThM, because it can be applied to polymer blends in order to examine phase separation where the components are difficult to distinguish by other means. An example is presented in Fig. 3 where a carbon fiber-epoxy sample is analyzed by SThM.

The SThM module is easily upgraded to nano-thermal analysis which adds the capability of performing calibrated temperature ramps for determining local phase transition temperatures such as glass transitions or melting temperatures on the nanoscale.

## Specifications\*

### Controller

Measurement Mode: Temperature contrast

Temp. Resolution:  $<0.1$  °C (dependent on probe)

Input Signal: 16 bit ADC 1.2 Msps

Input Gain: 10X, 100X or 1000X (software controlled)

AC Input: BNC connector on the CAL box allowing up to 50 kHz sine waves to be summed onto the output to the probe

### Probe

Max. Temperature: 160°C (dependent on probe)

Spring Constant:  $\sim 0.3$  N/m

Resonant Frequency:  $\sim 50$  kHz

Tip Radius:  $<100$  nm

Tip Height:  $\sim 10$  microns

Cantilever Length: 150 microns

\* taken from Anasys SThM data sheet

## Key features

- Specialized probe with integrated heating
- Tip holder purpose-built by JPK
- Input into JPK software
- Simultaneous AFM imaging and local temperature or thermal conductivity variations
- Readily upgradeable to nano-thermal analysis
- Compatible with all generations of NanoWizard® AFMs