PicoLE CSAFM (Current Sensing AFM) User's Manual

v1.0

Molecular Imaging

Table of Contents

CSAFM Overview

Current Sensing AFM (CSAFM™) utilizes a conducting AFM cantilever and operates in contact AFM mode. It simultaneously probes the conductivity and topography of a sample surface. By applying a voltage (bias) between the sample and the conductive cantilever, a current flow is generated. This current is used to construct a spatially resolved conductivity image.

Typical operational range of the current depends strongly on the sample conductivity and its surface conditions. It varies from sample to sample. The default sensitivity of CSAFM is set to 1nA/V. Its operational range is from a few pA to 10 nA. Other ranges can be obtained by changing the preamp module with one that has a different sensitivity.

Surface contamination (especially a moisture layer on the sample surface) has been a major obstacle in preventing CSAFM from getting good and clear images. We strongly recommend the operation of CSAFM in a controlled environment, such as with an environmental chamber.

A block schematic for CSAFM is shown in Figure 1 below.

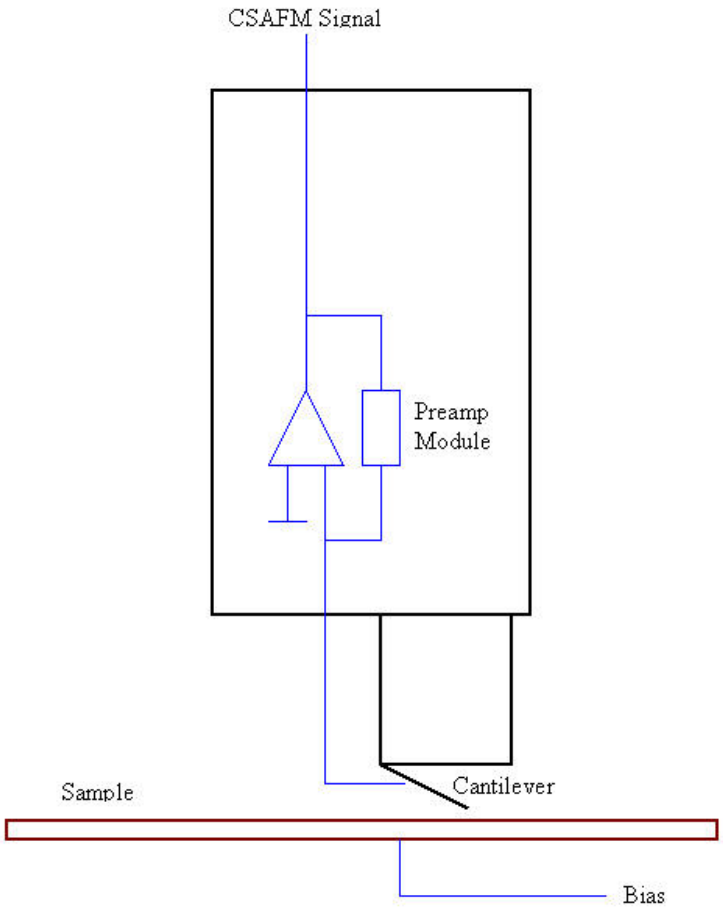

Figure 1 (CSAFM schematic)

The bias voltage for CSAFM is applied through the working electrode (WE) to the sample. The conducting cantilever is kept at virtual ground.

Setting Up the Sample for CSAFM Measurement

1. Affix the sample to the stage using appropriate hardware.
2. Using a conductive wire, connect the sample to the WE (center electrode). To secure the wire, push up on the pogo underneath the sample plate and slip the wire between the electrode and electrode assembly.

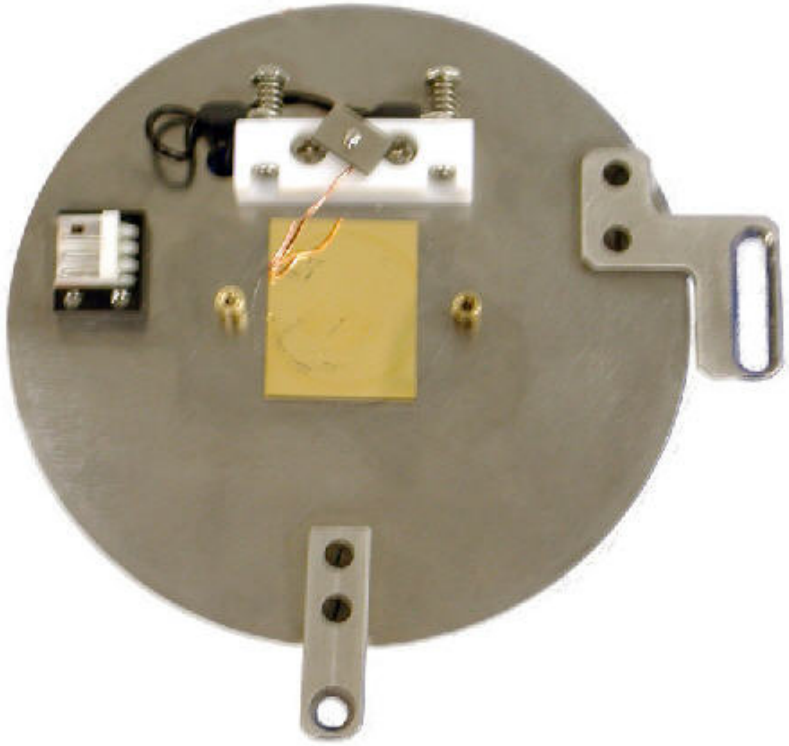

Figure 2 (Sample connected to the working electrode, WE)

3. Check the continuity between the WE contact and sample to make sure a proper connection is achieved.
4. Connect the sample stage to the microscope by using the 3-pin EC cable.
5. Check the potential between the WE contact and ground (use the exposed metal part of the DB25 connector that is connected to the microscope) with a voltmeter. It should be the same as the bias voltage set in the software. If it is not, adjust the controller calibration in PicoScan.

Setting Up the CSAFM Scanner

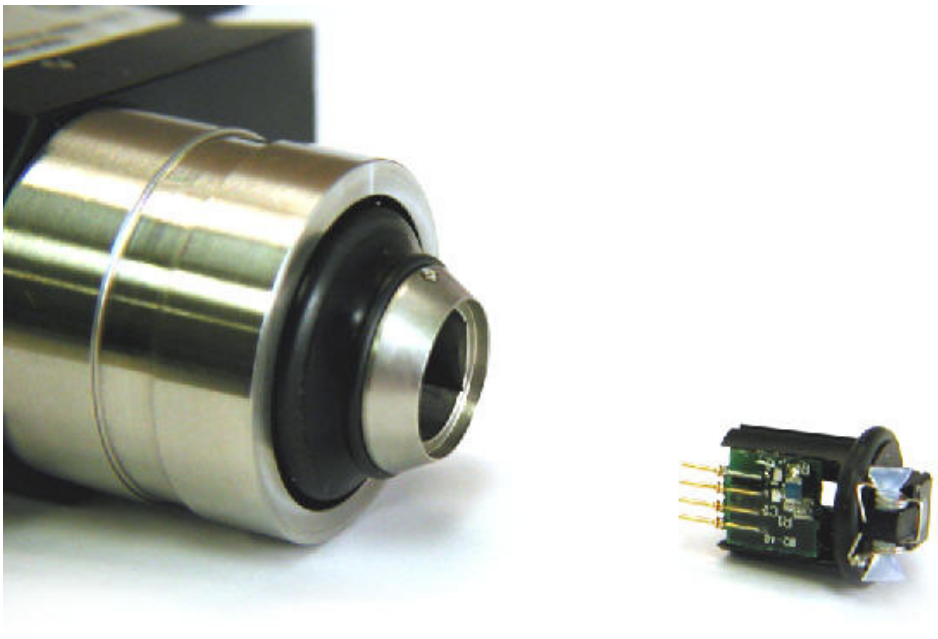

Figure 3 (Scanner and CSAFM nose)

After inserting the CSAFM nose assembly, follow the laser alignment procedure outlined in the **Aligning the Laser Beam** section in Chapter 3 of the **PicoLE System module**.

Imaging with CSAFM

1. Select CSAFM on the selector switch on the front of the PicoLE Head Electronics Box.
2. Connect the CSAFM BNC on the back of the PicoLE Head Electronics Box to the Aux In BNC connector on the front of the PicoScan controller.
3. Activate Topography, Deflection, and AuxIn BNC (CSAFM Signal) into 3 buffers.
4. Open the AFM IV spectroscopy window. The bias for CSAFM is applied using the voltage (V) slider control. Depending on the conductivity of a sample, the optimized bias may vary. It is a good practice to run an AFM IV spectroscopy first and use the IV plot as a guide in selecting a good voltage. Start with a small voltage value and gradually increase it to optimize the CSAFM image contrast. For a typical Cu film, start with a bias voltage of 0.1V. A good check is to reverse the bias (e.g. change 0.1V to –0.1V to see if the image contrast reverses).

The cantilever tip is kept at virtual ground at all times and bias is applied to the sample. The current signal is shown as positive when sample surface is biased negatively. The CSAFM image shows highly conductive regions as high features. The amplitude of the current signal obtained from CSAFM is strongly dependent on the condition of the cantilever tip and sample surface as well as the force applied to the surface.

Troubleshooting and Things to Avoid with CSAFM

1. CSAFM images become unstable when the surface of the sample is not clean. Most of the time, by allowing CSAFM to scan the surface for a while, it will clean up the image.
2. For some conductive samples the CSAFM image will show no contrast because the current may have reached saturation. Thus it is better to start with a very small Voltage and gradually increase it until a desired image is obtained. For highly conductive metallic samples even zero voltage in the software may give reasonable current image due to some small voltage offset because of possible voltage drops throughout the system.
3. Use lowest possible force during imaging to reduce the wear of the metal coating at the very end of the conductive tip.
4. Be sure to insert the cantilever onto the holder carefully to avoid damage of the conducting film coated on it.
5. It is normal for the CSAFM signal channel to have a large noise level without a sample plate placed onto the microscope. This noise will be significantly reduced when the sample plate is in place. This shields the CSAFM probe.
6. Try attaching an environmental chamber to the microscope and passing an inert gas through it. This will reduce the amount of water adsorbed on the sample, therefore increasing image quality.