SKPM

Scanning Kelvin Probe Microscopy

Scanning kelvin probe microscopy is used for measuring potential maps of samples in an atomic force microscope.

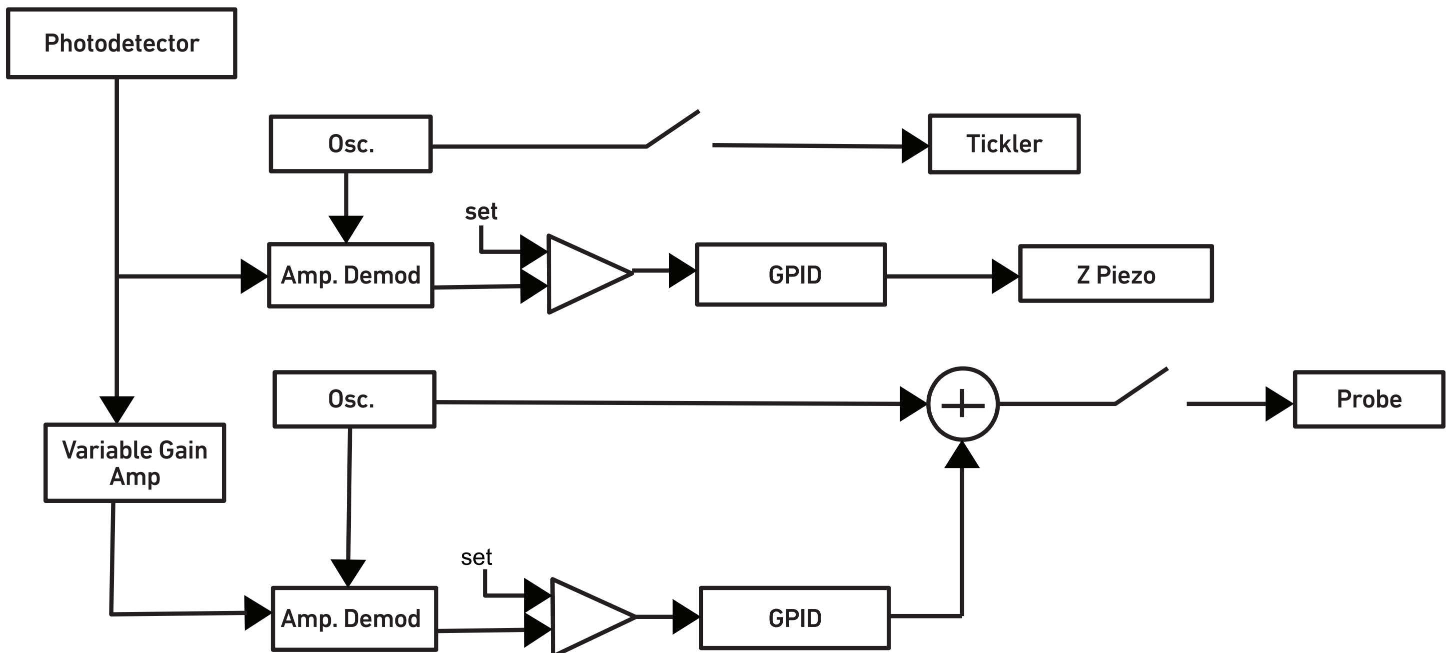
This modular mode can be used with all AFMWorkshop products.

Two Pass Imaging
First scan topography, second scan potential

Potential Feedback - Amplitude Detection
Sensitive bucking potential method

Dual Frequency
Two phase/amplitude circuits

Universal Probe Holder
Use probes from all manufacturers



Block diagram of the circuit used for the SKPM mode. On the first pass the photodetector ouput is used to control the Z piezolectric scanner. On the second pass the photodetector ouput is used to control the potential between the probe and surface.

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SKPM THEORY

The force between two conducting materials is given by the following equation:

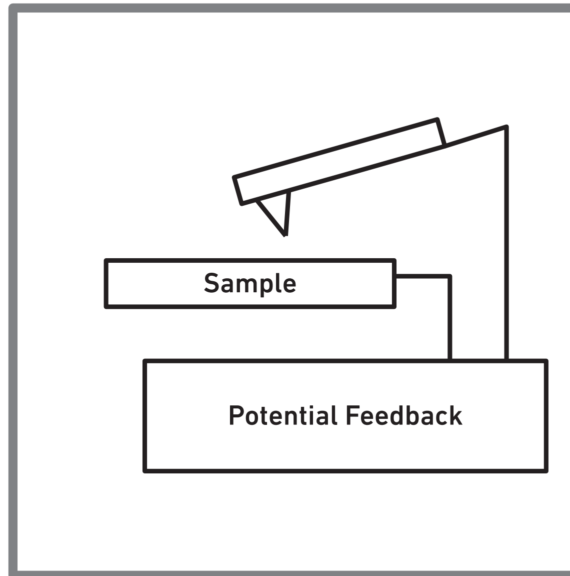
$$F = \frac{1}{2}\frac{dC}{dz}V^2$$

F = Force
C= Capacitance
z = Probe to sample distance
V= Probe-sample potential difference

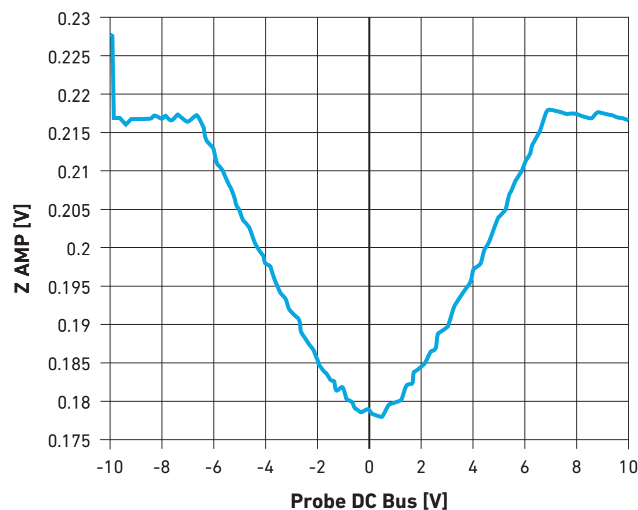
Assuming the change in capacitance with distance is negligible for small changes in distance, the force between the cantilever and surface is proportional to the voltage difference squared.

If a cantilever is held at a fixed distance from a surface, and a potential is placed between the probe and sample, electrostatic forces between the cantilever and surface will bend the cantilever at all voltages except when the probe and sample voltages are the same.

In the **SKPM**, an oscillating voltage between a probe that is near a surface causes the cantilever to oscillate when the probe and surface are at different potentials. A feedback circuit varies the potential so that the cantilever oscillation is minimized. As a scan is made, the output of the feedback electronics creates a potential map of a surface.



In SKPM, a feedback loop controls the potential between the probe and surface. The feedback loop controls the voltage so that the oscillations of the cantilever from electrostatic forces are minimized.



Sample Bias = 0 VDC

This graph shows the amplitude of vibration of a cantilever as a function of voltage applied to the cantilever. The sample is held at 0 Volts. As expected the vibration amplitude is parabolic.

TWO PASS IMAGING

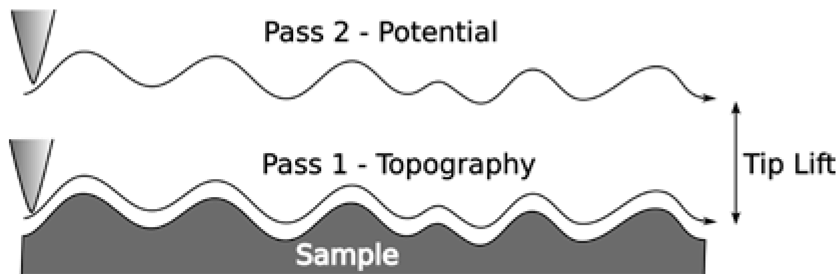
In the **SKPM**, two pass imaging is used to obtain potential and topography images.

First Pass: The first pass of the probe over the surface is used to measure surface topography. Typically, this topography measurement is made in vibrating mode (tapping) by mechanically oscillating the probe as it is scanned across the surface. In this first pass, a feedback loop is utilized to assure that the vibration amplitude (or phase) is held constant as the probe is scanned across the surface. The motion of the probe in the Z axis is stored in the electronics.

Second Pass: In the second pass, the probe is raised a fixed distance above the surface, and the topography stored in the first scan is utilized to scan the probe at that distance above the surface. During this scan, the mechanical oscillation is disabled. The potential is measured with a feedback loop that adjusts the voltage between the probe and surface to minimize the vibrations of the cantilever at a fixed frequency.

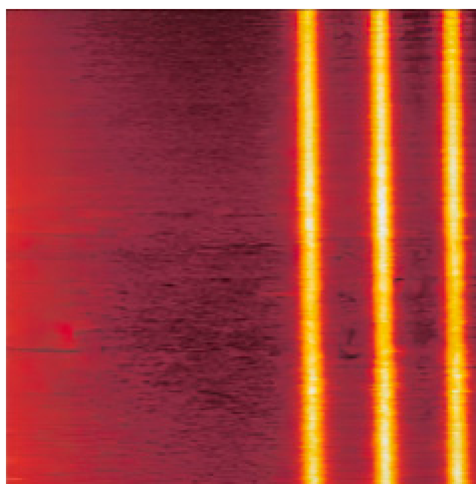
Two pass imaging generates two images, a topography image, and a potential image.

At the right is an example of **SKPM** on a test sample: metal traces are held at a higher potential than the substrate.



In two pass imaging the probe is scanned twice across the same region of a sample. In the first scan the topography is measured, in the second pass the potential map is created.

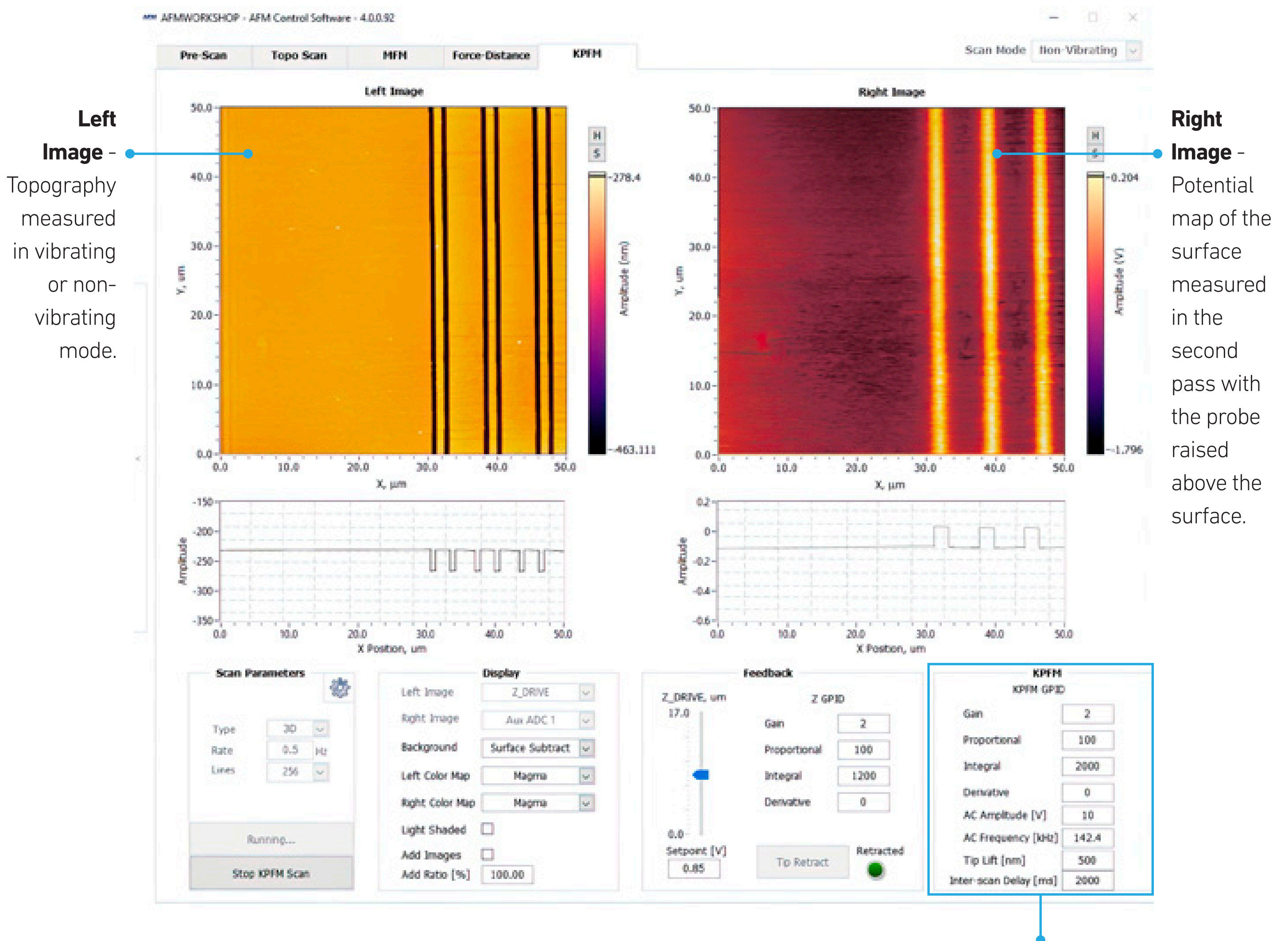
Topography image of a test pattern used for calibrating SKPM images. At the right of the image are three traces that are at a higher potential than the substrate.



The SKPM image is a potential map of the surface and shows the three traces at the right of the image are at a higher potential than the substrate.

SKPM SOFTWARE

Left Image - Topography measured in vibrating or non-vibrating mode.



Right Image - Potential map of the surface measured in the second pass with the probe raised above the surface.

The **SKPM software** is integrated with the AFMWorkshop AFMControl software.

Once installed on the host computer, the SKPM software is accessed with a modes tab at the top of the window.

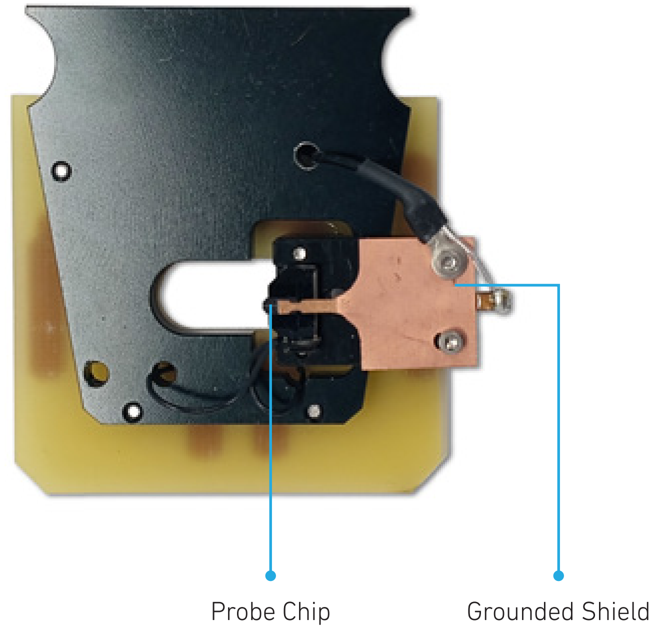
AFMControl software is written in the industry standard National Instruments LabVIEW instrument control environment.

Screenshot showing control parameters for the second pass scan which measures the surface potential. Parameters such as the oscillating frequency and amplitude voltage are set here. Also, the distance above the surface for the second scan is selected.

PROBE HOLDER

The probe holder for **SKPM** includes a special probe clip designed specifically for making electrical measurements with AFMWorkshop microscopes. To assure the greatest sensitivity, the probe clip has is comprised of a conducting spring that is electrically shielded.

Our universal probe holders accommodate probes from all major probe manufacturers, giving maximum flexibility. The probe holder is easily removed from the AFM light lever and changing probes takes only a few minutes.



PRODUCT CONTENTS

The **SKPM** mode option is compatible with all AFMWorkshop atomic force microscopes and includes all of the parts and software necessary for making SKPM images.

- SKPM Feedback Control Electronic Module
- Probe Holder
- Insulating Sample Stage
- 60 Pin Interface Cable
- 2 Pin Interface Cable
- Reference Sample
- Probes
- Power cord
- Manual
- SKPM Mode Software