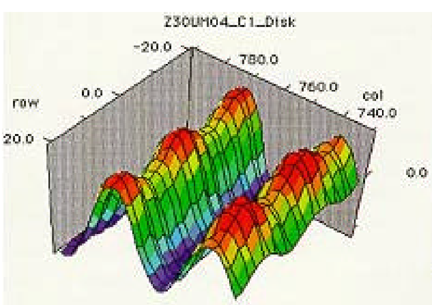
Ultra-high Resolution Scanning Magnetic Microscope

The Tristan model SMM-1000 Scanning Magnetic Microscope performs micron level non-destructive analysis of surface and sub-surface material properties using an array of small SQUID magnetometers. It can be used to image diverse objects such as:

- ♦ micro-current distributions
- ♦ vortex motion in superconductors
- ♦ traces on a circuit board or multi-chip module
- ♦ weak electric currents in semiconductors
- ♦ integrated circuits
- ♦ magnetic domains



Magnetic image of data on a hard disk. Measurements were made at a vertical standoff of 30 microns. The bit spacing is 10 microns and the inter-track spacing is 15 microns (courtesy UCSD)

Besides measuring magnetic fields, the SMM-1000 can also be configured to detect:

- ♦ transient magnetic properties
- ♦ magnetic susceptibility
- ♦ magnetic hysteresis

Model SMM-1000 Scanning SQUID Microscope

- The SMM-1000 uses a proprietary integrated circuit that incorporates an array of Superconducting Quantum Interference Devices (SQUIDs) to map the magnetic field from small samples. The use of liquid helium SQUIDs provides a 100 fold improvement in sensitivity over other magnetic detectors and allows high-resolution mapping of electric currents and magnetic sources located beneath the surface of the sample.
- It is a fully featured measurement system that allows the user to extract a magnetic image of the object being measured over the entire dc – 10 kHz frequency range. Its flat phase response allows both in-phase and quadrature information to be obtained without distortion. Additional detection channels can be supplied to speed data acquisition rates.
- It allows computer controlled scans of objects over a large (5 x 5 mm) area with 0.17 µm stepping capability. The user has the ability to preprogram the scan coordinates.
- Automated setup and computer control makes measurements rapid and repeatable. System software provides the ability to control the critical system components, acquire data from the SQUID sensor, and analyze the data to determine the magnetic properties of the sample being measured. The use of open architecture software allows the user to modify and customize nearly all aspects of operating including image processing.

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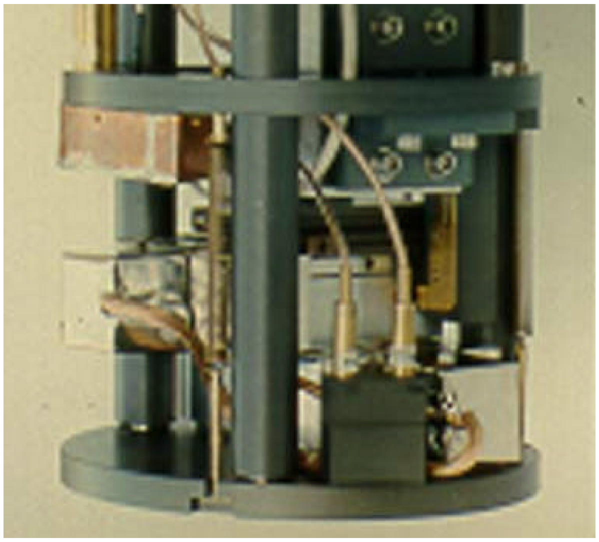
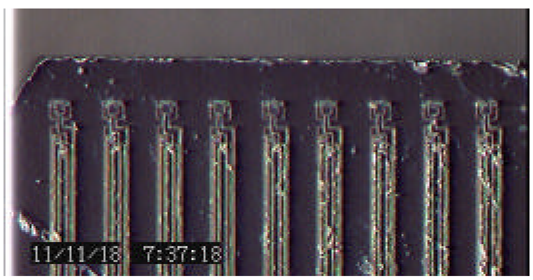


SMM-1000 sample stage

System Operation

The SMM-1000 achieves micron resolution by the use of small (14 µm) detection coils and narrow gap between the coils and the object(s) being scanned.

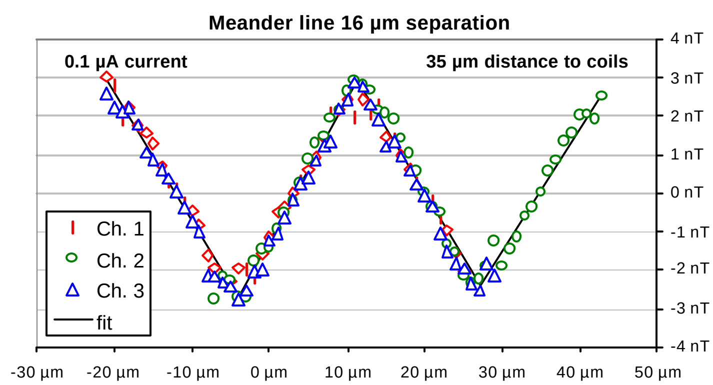
The sample is mounted inside an exchange gas can at the lower end of a cryogenic probe. This houses all of the cryogenic portions of the SMM and, during a measurement, is filled with a small amount of helium gas. The sample is placed on the sample stage and the probe can attached. Then the SMM Probe is lowered into the liquid helium dewar. After the sample stage has cooled to 4.2 Kelvin, measurements can begin. When finished, it is possible to warm up the microscope, mount a sample, and cool it back to helium temperature in as little as two hours.



Detail of SMM sensor tip showing nine 14 µm detection coils

System Components

The standard model SMM-1000 includes a single channel SMM probe (Magnetic Detection Subsystem) and iMAG® SQUID Electronics, sample position measurement and control Subsystem, liquid helium dewar with vibration Isolation stand, probe warm-up and gas-handling station, computer control console, and complete software package for system control, data acquisition and data analysis. The model SMM-1000 can be supplied with additional capabilities to extend its measurement capabilities.



OPTIONS AND ACCESSORIES

Additional Detection Channels: The model SMM-1000's measurement capabilities can be extended to multi-channel capabilities. Additional vertical (B_z) measurement sites can be installed to reduce measurement time. The standard distance between the coils is 50 µm. Coils may be located 100 µm, 150 µm, or 200 µm apart at no extra charge. Other coil diameters and configurations are available as options.

Applied Field Capability: This option generates a vertical (B_z) dc magnetic field on the sample. This allows magnetic susceptibility measurements on insulators, conductors and ferrous materials to be performed.

Variable Sample Temperature: The standard measurement temperature is 4.2 K. The variable temperature option allows sample temperature to be varied between 2 K and 100 K.

SPECIFICATIONS

SENSOR: Low temperature superconducting quantum interference device (SQUID) operating at 4.2 K

SPATIAL RESOLUTION: 1 µm for single dipole sources

SENSITIVITY: 1×10^{-10} tesla/√Hz (100 pT/√Hz)

OPERATING BANDWIDTH: dc - 10 kHz. Measurements can be made at any frequency. Bandwidths above 10 kHz are available.

CRYOGENIC COOLING: To avoid low frequency noise below 200 Hz, the system uses liquid helium to cool the sensor.

CRYOGENIC HOLD TIME: Time between refills of liquid helium is typically 3 days. Longer hold times available upon request.

SAMPLE SCANNING RANGE: 5 mm x 5 mm in x-y directions.

SAMPLE LIFTOFF: Optical readout, adjustable with minimum approach of 0.1 µm.

SCAN STEP SIZE: Adjustable with minimum step size of 0.17 µm.

SCANNING TECHNIQUE: Computer controlled raster scan, up to 10 mm/min scan rate

POWER REQUIREMENTS: 100, 115 or 220 VAC, 50 or 60 Hz

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