PMC MicroMag™
VSM and AGM Systems
MicroMag™ 2900 Series AGM System

- Very high sensitivity (10 nemu standard deviation at 1 s/point), enabling measurements of weak magnetic samples
- Conduct experiments faster with signal averages as fast as 10 ms/pt
- Supports a maximum sample size of 5 mm × 5 mm × 2 mm, (≤200 mg with robust x-axis probe)
- Samples fit into parallel and perpendicular transducer probes (includes two probes)
- High-speed four-quadrant magnet power supply
- Easy-to-use Windows® based application software
- Hardware and software compatible with 3900 Series VSM

The MicroMag™ 2900 Series AGM is a powerful alternating gradient magnetometer system for measuring the magnetic properties of various materials. The system offers extremely high sensitivity (10 nemu rms, corresponding to less than 50 pg of iron) and speed of measurement (10 ms per point).

Combined with compact design and ease of use, you get a system that’s well-suited for a number of production test, quality control, and research applications. Because of its high sensitivity, the AGM system is particularly useful for research involving materials with very low magnetic moment; it can measure materials with moments too low to measure in a VSM system.

Possible applications include measurements of magnetic recording media, MRAM materials, spin-valves, GMR heads, amorphous metals, superconductors, or diamagnetic and paramagnetic materials. The 2900 Series also works very well in paleomagnetic, nanomagnetic, and other research applications requiring first-order-reversal-curve (FORC) measurements, ideal because of its sensitivity and measurement speed.

The MicroMag™ 2900 Series AGM accommodates solid and ultra thin film samples (up to 5 × 5 × 2 mm, 200 mg mass) with a sample holder embedded within transducer probes. The system includes two polyimide probes (one P3 parallel and one P3 perpendicular).

Also included are a PC with 17-inch LCD monitor and comprehensive Windows® based operating software. The MicroMag™ 2900 Series AGM is available with either a 2-inch or 4-inch laboratory electromagnet, each powered by a fast four-quadrant power supply, all under computer control.

Specifications

**Magnetic moment measurement**

- **Range**: 1 μemu to 5 emu full scale
- **Resolution**: 0.005% of full scale with 60% overrange capability
- **Accuracy**: 2% vs. calibration
- **Sensitivity**: 10 nemu standard deviation (room temperature operation, 1 s averaging time)
- **Stability**: ≤10^-4/h at constant ambient temperature; ≤5(10^-4)/°C (vs. ambient temperature)
- **Repeatability**: 1% standard deviation (sample undisturbed); 2% standard deviation (sample removed and replaced)
- **Gradient field**: x-axis coils (0.5 in air gap), 15 Oe/mm, 1.5 Oe/mm, 150 mOe/mm (typical, over three ranges)
- **Displacement amplitude**: Typically in the range from 1 nm to 10 μm

**Transducer probes**

P1: General purpose, (x-axis; samples up to 4 × 4 × 1 mm), mass ≤50 mg
P2: Intermediate, (x-axis; samples up to 5 × 5 × 1 mm), mass ≤100 mg
P3: Robust, (x-axis; samples up to 5 × 5 × 2 mm), mass ≤200 mg
MicroMag™ 3900 Series VSM System

- Very versatile — can also ordered as a dual-head VSM/AGM system or upgraded to a combination system later
- High sensitivity (0.5 μemu standard deviation at 1 s/point)
- Conduct experiments faster with signal averages as fast as 10 ms/pt
- Versatile, quick-change sample holders for measuring solid, thin-film, powder, and liquid samples
- Continuous sample rotation about z-axis under computer control
- High-speed four-quadrant magnet power supply
- Easy-to-use Windows® based application software
- Hardware and software compatible with 2900 Series AGM
- High- and low-temperature accessories available

The MicroMag™ 3900 Series VSM establishes a new standard for magnetometer performance. It not only offers fast scans, but high repeatability and maximum versatility. Order it as a world-class VSM or specify it as a dual-head version with the capabilities of the 2900 Series AGM included.

Its major components, including its software, are fully compatible with the AGM, so you can combine techniques from both systems to measure over a wider range of applications. The integrated design of the combination MicroMag™ VSM/AGM is highly attractive in terms of economy and measurement capability.

As a VSM, the 3900 Series offers high sensitivity (0.5 μemu at 1 s/point), a fast four-quadrant power supply, and very fast scanning times, enabling you to bring greater efficiency to your lab. The system is also ideal for first-order-reversal-curve (FORC) measurements, owing to its sensitivity and speed.

Anisotropy measurements are facilitated by a driver head that provides continuous rotation about the z-axis (under computer control). Precision x, y, and z translation stages enable fast and accurate sample placement. Plus, its sample holders accommodate a wide variety of thin films, solids, powders, and liquids. A quick-release collet and reduced length drive rods allow for rapid sample interchange.

With the VSM, you get either a 2- or 4-inch laboratory electromagnet, as well as a PC with 17-inch LCD monitor. Its comprehensive Windows® based operating software simplifies the process of having to analyze the properties of varying materials. The 3900 Series is a truly simple-to-operate, state-of-the-art magnetic measurement system.

Also available for both VSM and AGM system configurations: optional high- and low-temperature accessories.

Specifications

Magnetic moment measurement

<table>
<thead>
<tr>
<th>Range</th>
<th>50 μemu to 10 emu full scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>0.005% of full scale with 60% overrange capability</td>
</tr>
<tr>
<td>Accuracy</td>
<td>2% vs. calibration</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.5 μemu standard deviation (room temperature operation, 1 s averaging time)</td>
</tr>
<tr>
<td>Stability</td>
<td>≤10⁻⁴/h at constant ambient temperature; ≤5(10⁻⁴)/°C (vs. ambient temperature)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>0.5% standard deviation (sample undisturbed); 1% standard deviation (sample removed and replaced)</td>
</tr>
</tbody>
</table>

Optional variable temperature cryostat

<table>
<thead>
<tr>
<th>Type</th>
<th>Continuous flow LHe or LN₂ (must specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>LHe 10 K to 473 K; LN₂ 125 K to 473 K</td>
</tr>
<tr>
<td>Temperature accuracy</td>
<td>±1% of set temperature ±1 K</td>
</tr>
<tr>
<td>Resolution</td>
<td>100 mK</td>
</tr>
<tr>
<td>Cryostat cooldown time</td>
<td>30 min</td>
</tr>
<tr>
<td>Sample cooldown time</td>
<td>2 min (cold cryostat)</td>
</tr>
<tr>
<td>Cryostat inside diameter</td>
<td>6 mm (sample zone)</td>
</tr>
<tr>
<td>Cryostat outside diameter</td>
<td>11 mm (magnet air gap, 20 mm)</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Chromel vs. Au 0.07 atomic % Fe, located approximately 10 mm below sample</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>2 μemu standard deviation at 1 s averaging time</td>
</tr>
<tr>
<td>Temperature slew rate</td>
<td>Approximately 5 min full span</td>
</tr>
</tbody>
</table>

Optional high temperature furnace

<table>
<thead>
<tr>
<th>Type</th>
<th>Continuous flow (helium gas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>100 °C to 800 °C</td>
</tr>
<tr>
<td>Temperature accuracy</td>
<td>±0.75% of set temperature ±2.2 °C</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.1 °C</td>
</tr>
<tr>
<td>Temperature slew rate</td>
<td>Approximately 3 min full span</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Type K</td>
</tr>
<tr>
<td>Sample chamber</td>
<td>Fused silica, ID 6 mm (sample zone), OD 11 mm (magnet air gap, 20 mm)</td>
</tr>
<tr>
<td>Sample holder</td>
<td>Macor®</td>
</tr>
<tr>
<td>Gas flow</td>
<td>Approximately 5 L/min</td>
</tr>
</tbody>
</table>
Electromagnet/power supply specifications

Magnetic field measurement/control

Ranges: 30 Oe, 100 Oe, 300 Oe, 1 kOe, 3 kOe, 10 kOe, and 30 kOe full scale
Resolution: 0.005% of range in use, with 60% overrange
Accuracy: 2% of indication ±1 Oe
Noise: 5 mOe rms (100 ms averaging time)
Stability: 0.01% of full scale

2 in electromagnet

Weight: 50 kg (110 lb)
Width: 610 mm (24 in), including bell cranks used to adjust magnet gap
Depth: 410 mm (16 in)
Height: 530 mm (21 in), including probe translation stages
Resistance: 4.0 Ω (cold)
Maximum current: 15 A
Water cooling: 2 L (0.5 gal)/min at full power
Air gap: Adjustable, 10 to 76 mm (0.4 in to 3.0 in)
Poles: 51 mm (2 in) diameter
Pole caps: Tapered to 38 mm (1.5 in) diameter
Maximum field: 14 kOe at 12 mm (0.5 in) air gap, without cryostat; 10 kOe at 20 mm (0.75 in) air gap, with cryostat

4 in electromagnet

Weight: 261 kg (575 lb)
Width: 940 mm (37 in), including bell cranks used to adjust magnet gap
Depth: 610 mm (24 in)
Height: 1.65 m (65 in), including probe translation stages and console
Resistance: 2.4 Ω (cold)
Maximum current: 30 A
Water cooling: 8 L (2.0 gal)/min at full power
Air gap: Adjustable, 10 mm to 89 mm (0.4 to 3.5 in)
Poles: 102 mm (4 in) diameter
Pole caps: Tapered to 51 mm (2.0 in) diameter
Maximum field: 22 kOe at 12 mm (0.5 in) air gap, without cryostat; 18 kOe at 20 mm (0.75 in) air gap, with cryostat

Power supply (for 2 in electromagnet)

Enclosure: Rackmount chassis, 140 mm (5.5 in) height, 480 mm (19 in) width, 480 mm (19 in) depth
Weight: 11.4 kg (25 lb)
Input electrical power: 208/380 V (specify) three-phase, 50/60 Hz, 3 kVA
Output: ±125 V DC at ±18 A
Type: Bipolar, wideband switching-mode power amplifier
Regulation: Feedback control of magnetic field
Cooling: Forced air
Protection: Magnet coolant flow overtemperature PS overcurrent, and overtemperature

Power supply (for 4 in electromagnet)

Enclosure: Rackmount chassis, 140 mm (5.5 in) height, 480 mm (19 in) width, 530 mm (19 in) depth
Transformer enclosure: (Remote on casters), 400 mm (16 in) height, 560 mm (22 in) width, 510 mm (20 in) depth
Weight: Rackmount chassis 11.4 kg (25 lb); remote transformer enclosure 90 kg (200 lb)
Input electrical power: 208/380 V (specify) three-phase, 50/60 Hz, 6 kVA
Output: ±140 V DC at ±32 A
Type: Bipolar, wideband switching-mode power amplifier
Regulation: Feedback control of magnetic field
Cooling: Forced air
Protection: Magnet coolant flow overtemperature PS overcurrent, and overtemperature

Contact Lake Shore for the most current selection of recirculating chillers to go with your system.
2900 Series AGM sample data

File: agm-2.5.png

File: m(uemu) sample data

File: m(uemu) sample data

File: m(uemu) sample data

File: m(uemu) sample data

File: m(uemu) sample data

File: m(uemu) sample data

File: m(uemu) sample data
3900 Series VSM sample data

Description: [Not assigned]
File: #1 Fe3O4 irradiated M(t): 20 ms 22 sec

Description: [Not assigned]
File: #3 Fe3O4 irradiated FORC 50 ms 19 min

Description: [Not assigned]
File:

Description: [Not assigned]
File:

Description: [Not assigned]
File:
System comparison

<table>
<thead>
<tr>
<th></th>
<th>2900 Series AGM</th>
<th>3900 Series VSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic moment measurement range</td>
<td>1 μemu to 5 emu full scale</td>
<td>50 μemu to 10 emu full scale</td>
</tr>
<tr>
<td>Magnetic moment measurement resolution</td>
<td>0.005% of full scale with 60% over range</td>
<td></td>
</tr>
<tr>
<td>Magnetic measurement accuracy</td>
<td>2% vs. calibration</td>
<td></td>
</tr>
<tr>
<td>Magnetic measurement repeatability</td>
<td>1% standard deviation at sample undisturbed; 2% standard deviation at sample removed and replaced</td>
<td></td>
</tr>
<tr>
<td>Magnetic moment measurement stability</td>
<td>≤10⁻⁴/h at constant ambient temperature; ≤5(10⁻⁴)/°C (vs. ambient temperature)</td>
<td></td>
</tr>
<tr>
<td>Maximum sample size</td>
<td>5 × 5 × 2 mm (200 mg mass)</td>
<td>Approximately 6 mm³</td>
</tr>
<tr>
<td>Measurement temperature range (with optional cryostat)</td>
<td>N/A</td>
<td>10 K to 473 K</td>
</tr>
<tr>
<td>Maximum temperature (with optional furnace)</td>
<td>N/A</td>
<td>800 °C (1073 K)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>10 nemu (1 s/pt)</td>
<td>0.5 μemu (1 s/pt)</td>
</tr>
</tbody>
</table>

Send us your samples for evaluative measurements
We can demonstrate how well the MicroMag™ systems perform. For details, contact Lake Shore today.

FORC measurements
The magnetic characterization of materials is usually made by measuring a hysteresis loop. However it is not possible to obtain information of interactions or coercivity distributions from the hysteresis loop and thus, first-order-reversal-curves (FORC) provide insight into the relative proportions of reversible and irreversible components of the magnetization of a material.

Two technical considerations for FORC measurements are the sensitivity of the measurement technique and measurement speed. Because of this, the Lake Shore PMC MicroMag™ VSM and AGM systems are arguably the standard for FORC measurements.

FORC measurement applications include:
- Geomagnetic and geological materials
- Exchange-coupled nanocomposite permanent magnet materials
- Exchange-biased spin-valves
- Arrays of magnetic nanowires, nanodots or nanoparticles

Request a copy or download our FORC-related application notes from www.lakeshore.com
- “First-Order-Reversal-Curve (FORC) Measurements of Magnetic Materials”
- “Rock Magnetism and First-Order-Reversal-Curve (FORC) Measurements”

Request a quote

2900 Series systems
Part number Description
2902 2900-02 AGM system (±14 kOe at room temperature)
2904 Model 2900-04 AGM system (±22 kOe at room temperature)
Each system includes one P3 parallel probe and one P3 perpendicular probe

2900 Series options
Options include: P1, P2, and P3 AGM transducer probes in 2 in and 4 in lengths (all available as perpendicular versions, and P2 and P3 probes available as parallel versions); sample-handling fixture; gradient coil assemblies, and more.
For a complete list, visit www.lakeshore.com.

3900 Series systems
Part number Description
3902 Model 3900-02 VSM system (±14 kOe at room temperature)
3902C Model 3900-02C VSM system (±14 kOe at room temperature, ±10 kOe with cryostat)
3904 Model 3900-04 VSM system (±22 kOe at room temperature)
3904C Model 3900-04C VSM system (±22 kOe at room temperature, ±18 kOe with cryostat)
Each system includes two drive rods and five each of the 3900-SH-SM, 3900-SH-BM, and 3900-SH-PB sample holders

3900 Series options
Options include: variable temperature cryostat field retrofit kits with a temperature controller and transfer line (LHe or LN₂); high-temperature furnace; carbon fiber drive rods for room temperature and low temperature; fused silica drive rods for furnace; side-mount sample holder; powder or bulk sample holder; sample holder for furnace; and more.
For a complete list, visit www.lakeshore.com.

Combination 2900/3900 Series systems
Part number Description
2902-3902 Model 2900/3900-02 AGM/VSM system (room temperature, ±14 kOe)
2904-3904 Model 2900/3900-04 AGM/VSM system (room temperature, ±22 kOe)
Each system includes two drive rods and five each of the 3900-SH-SM, 3900-SH-BM, and 3900-SH-PB sample holders, plus one P3 parallel probe and one P3 perpendicular probe