

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 μ emu 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: $\leq 10^{-4}$ /h at constant ambient temperature; $\leq 5(10^{-4})/^{\circ}\text{C}$ (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 μ m

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 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

Range: 50 μemu to 10 emu full scale

Resolution: 0.005% of full scale with 60% overrange capability

Accuracy: 2% vs. calibration

Sensitivity: 0.5 μemu standard deviation (room temperature operation, 1 s averaging time)

Stability: $\leq 10^{-4}$ /h at constant ambient temperature; $\leq 5(10^{-4})/^{\circ}\text{C}$ (vs. ambient temperature)

Repeatability: 0.5% standard deviation (sample undisturbed); 1% standard deviation (sample removed and replaced)

Optional variable temperature cryostat

Type: Continuous flow LHe or LN₂ (must specify)

Temperature range: LHe 10 K to 473 K; LN₂ 125 K to 473 K

Temperature accuracy: $\pm 1\%$ of set temperature ± 1 K

Resolution: 100 mK

Cryostat cooldown time: 30 min

Sample cooldown time: 2 min (cold cryostat)

Cryostat inside diameter: 6 mm (sample zone)

Cryostat outside diameter: 11 mm (magnet air gap, 20 mm)

Temperature sensor: Chromel vs. Au 0.07 atomic % Fe, located approximately 10 mm below sample

Sensitivity: 2 μemu standard deviation at 1 s averaging time

Temperature slew rate: Approximately 5 min full span

Optional high temperature furnace

Type: Continuous flow (helium gas)

Temperature range: 100 $^{\circ}\text{C}$ to 800 $^{\circ}\text{C}$

Temperature accuracy: $\pm 0.75\%$ of set temperature ± 2.2 $^{\circ}\text{C}$

Resolution: 0.1 $^{\circ}\text{C}$

Temperature slew rate: Approximately 3 min full span

Temperature sensor: Type K

Sample chamber: Fused silica, ID 6 mm (sample zone), OD 11 mm (magnet air gap, 20 mm)

Sample holder: Macor®

Gas flow: Approximately 5 L/min

Applications

- Magnetic recording media development
- Superconductivity research
- Particulate and continuous magnetic films
- Diamagnetic and paramagnetic material study
- Rare earth materials analysis
- Geomagnetic and geological studies
- Nanomagnetic materials development
- Magnetic multi-layers (GMR, TMR)
- Amorphous metals research
- MRAM applications
- Ferrofluid measurement (VSM only)

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

Software features

- Menu-driven with color graphics
- Efficient demagnetization routines
- Multiple segments
- Choice of cgs or SI units

Data processing capabilities

- Expand and offset
- Background subtraction
- Demagnetization factor correction
- ΔM (remanence)
- Slope correction (e.g., for dia/paramagnetic substrate)
- Normalization for sample mass or volume

Parameters measured

- Magnetization curves
- Magnetization vs. time
- First-order-reversal curves (FORCs)
- Magnetization vs. temperature
- Saturation magnetization
- Isothermal remanent magnetization
- DC demagnetization remanence
- Coercivity
- Minor loops
- Squareness ratio
- Hysteresis loops vs. temperature
- Coercivity of remanence

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: $\pm 125 V_{DC}$ 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: $\pm 140 V_{DC}$ at ± 32 A

Type: Bipolar, wideband switching-mode power amplifier

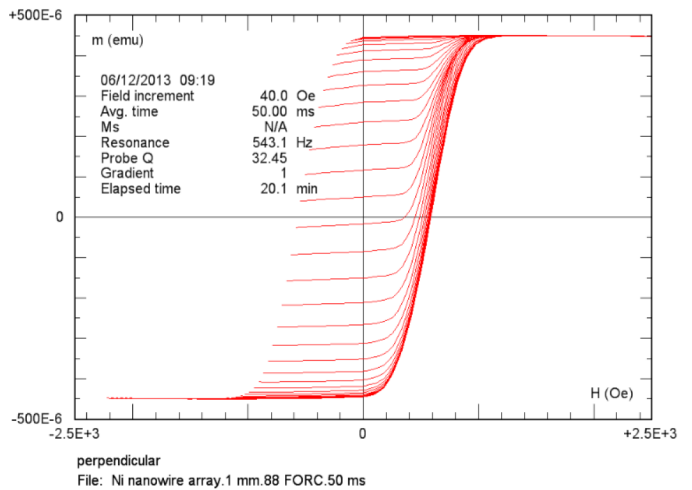
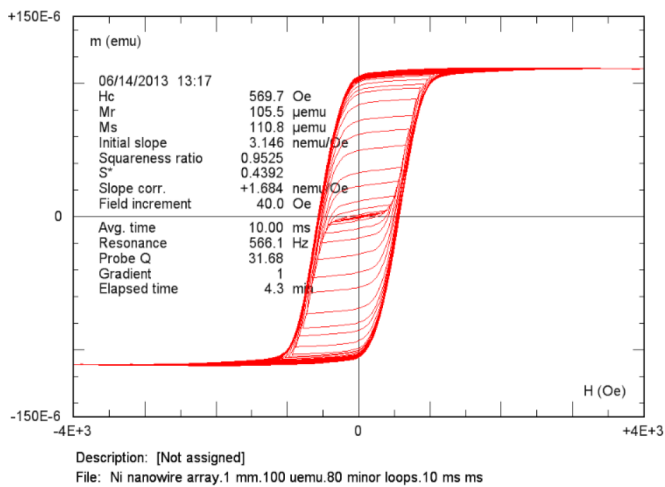
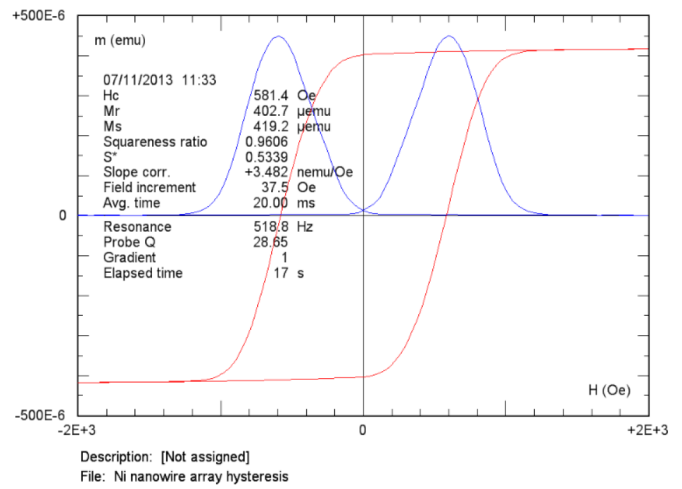
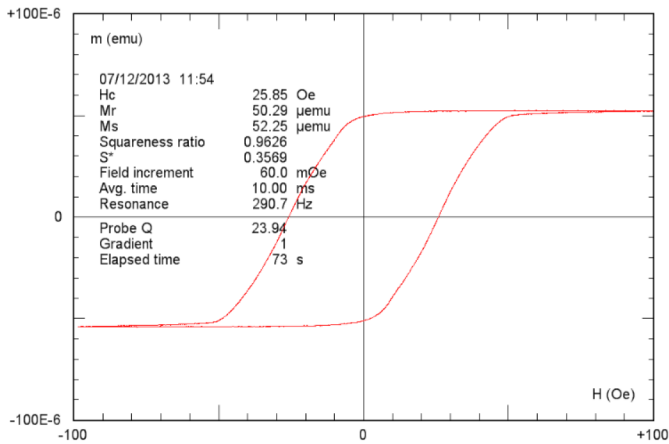
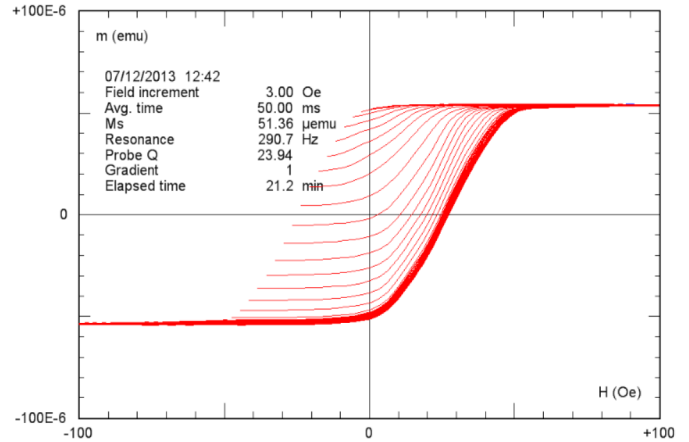
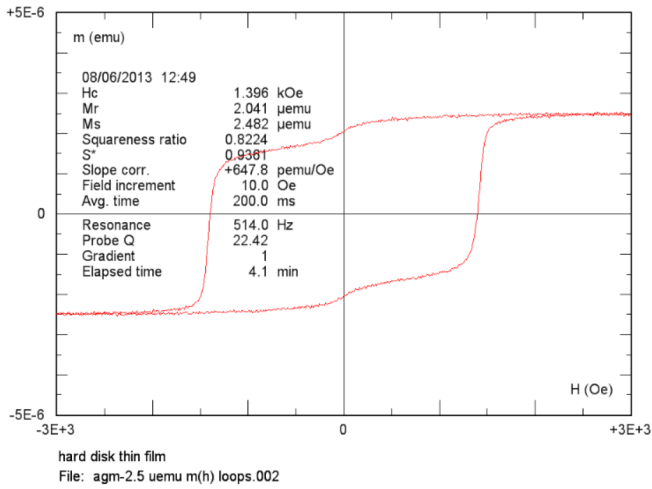
Regulation: Feedback control of magnetic field

Cooling: Forced air

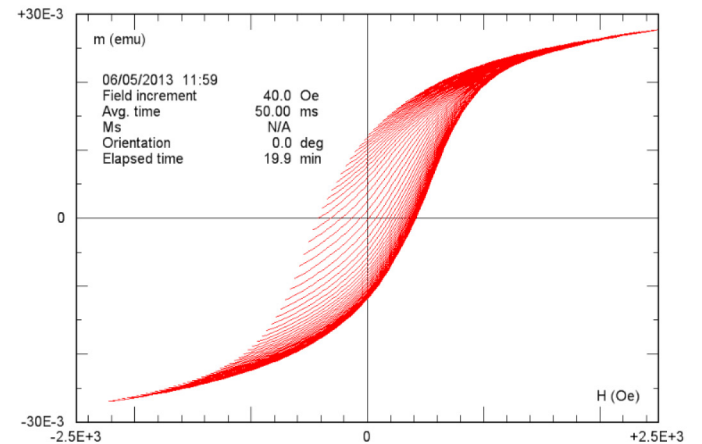
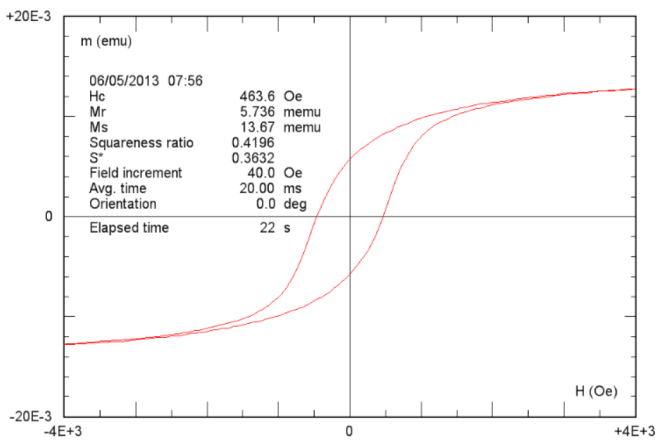
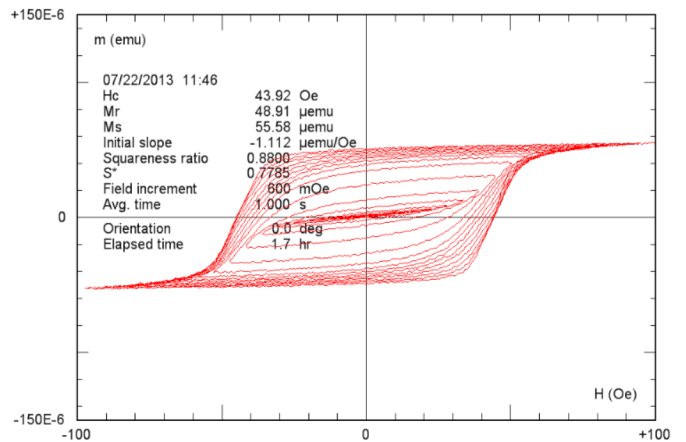
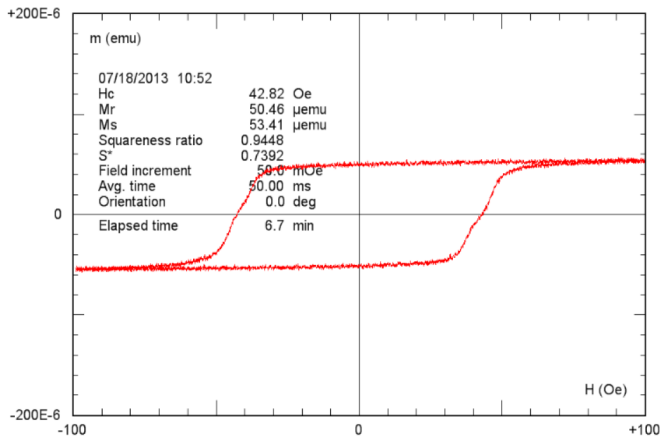
Protection: Magnet coolant flow overtemperature PS overcurrent, and overtemperature

Contact Lake Shore for the most current selection of recirculating chillers to go with your system.

2900 Series AGM sample data

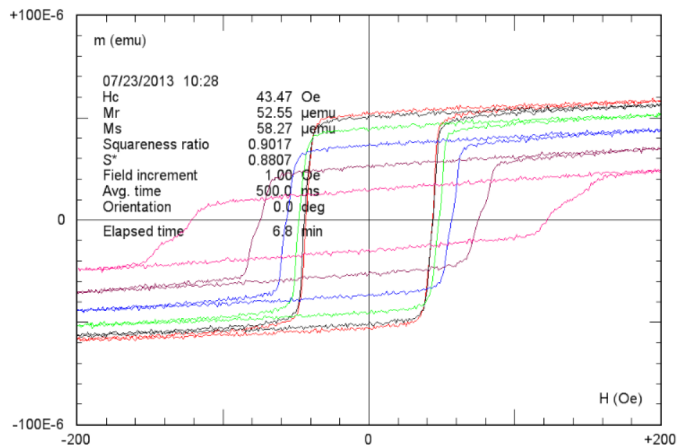
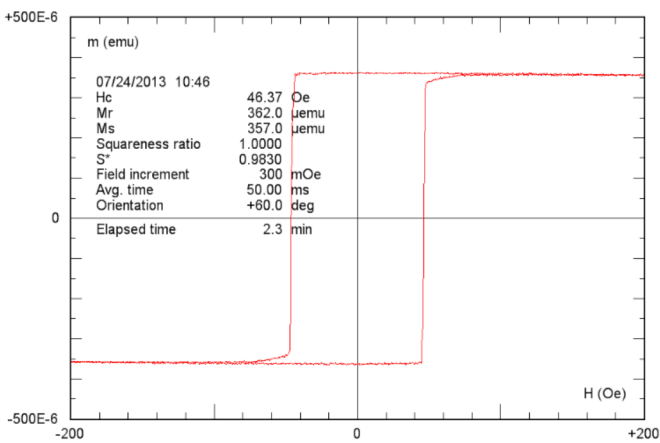


3900 Series VSM sample data



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

parallel
 File: #3 Fe3O4 irradiated.FORC.50 ms.19 min



Description: [Not assigned]
 File:

M(H) vs out-of-plane angle for thin film

System comparison

	2900 Series AGM	3900 Series VSM
Magnetic moment measurement range	1 μ emu to 5 emu full scale	50 μ emu to 10 emu full scale
Magnetic moment measurement resolution	0.005% of full scale with 60% over range	
Magnetic measurement accuracy	2% vs. calibration	
Magnetic measurement repeatability	1% standard deviation at sample undisturbed; 2% standard deviation at sample removed and replaced	
Magnetic moment measurement stability	$\leq 10^{-4}$ /h at constant ambient temperature; $\leq 5(10^{-4})/^{\circ}\text{C}$ (vs. ambient temperature)	
Maximum sample size	5 × 5 × 2 mm (200 mg mass)	Approximately 6 mm ³
Measurement temperature range (with optional cryostat)	N/A	10 K to 473 K
Maximum temperature (with optional furnace)	N/A	800 °C (1073 K)
Sensitivity	10 nemu (1 s/pt)	0.5 μ emu (1 s/pt)

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.

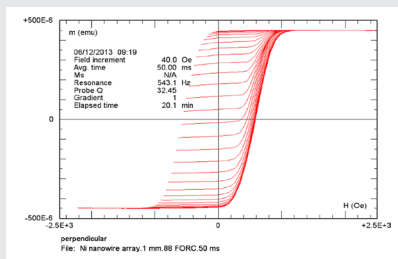
Two technical considerations for FORC measurements are the sensitivity of the measurement technique and measurement speed. Because of this, the Lake Shore PMC MicroMag™ VSM and AGM systems are arguably the standard for FORC measurements.

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

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