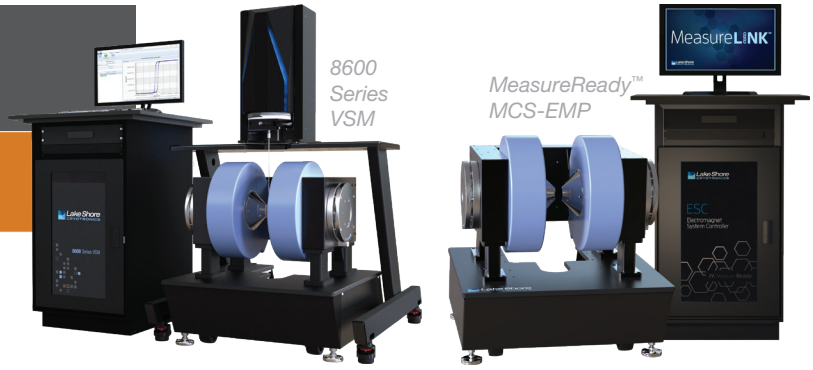

Ferromagnetic resonance measurements for the 8600 Series VSM and MCS-EMP

Lake Shore Cryotronics

FMR explained

Ferromagnetic resonance (FMR) measurements allow the magnetodynamic properties of thin-film magnetic materials in the 10s of GHz range to be determined. The most widely used electrical FMR instruments are those based on a vector network analyzer (VNA). A thin-film sample is placed on a co-planar waveguide (CPW), which is connected to the VNA, and a mutually perpendicular static (DC) applied field and a microwave (AC) field are oriented either in-plane (IP) or out-of-plane (OOP) with respect to the film plane. The reflection and transmission coefficients are then determined by the VNA at either fixed frequency where the magnetic field is swept or at fixed field while the frequency is swept. FMR measurements are used to obtain values for the effective magnetization M_{eff}, anisotropy constant K, Gilbert damping parameter α, and the gyromagnetic ratio γ.

FMR spectrometry in an EM platform or VSM using broadband FMR spectrometers

The NanOsc Instruments AB line of FMR spectrometers provide a simple solution to magnetodynamics research for frequencies ranging from 2 to 40 GHz (for more information, visit nanosc.se). When combined with a Lake Shore Cryotronics MeasureReady™ MCS-EMP or an 8600 Series VSM using the CPW holder (FMR-CPW-U-KIT), broadband FMR measurements to variable DC magnetic fields >2.3 T for IP and >2.9 T for OOP orientations are possible.

Key features

- Both static and dynamic magnetic properties can be measured when used as an option to the 8600 Series VSM
- Variable magnetic fields to >2.3 T for IP orientation or >2.9 T for OOP orientation for perpendicular magnetic anisotropy (PMA) thin films
- Low-noise 4-quadrant electromagnet power supply
- Integrated teslameter for closed-loop field control
- MeasureLINK™-MCS control software license for magnet control integration with NanOsc data collection software[1]
- FMR-CPW-U-KIT includes bracket for mounting NanOsc standard U-type CPW on MCS-EMP and 8600 Series VSM magnet platforms. Does not include NanOsc-supplied CPW, Helmholtz coils, cables, and FMR instruments[2]

[1] *Will also require NanOsc software with Lake Shore MeasureLINK interface module for use with MCS-EMP and for use with 8600 VSM (which requires MeasureLINK software for FMR application modes, not available using standard 8600 VSM software)*

[2] *The NanOsc instrument, cabling, reaction coils, and U-type CPW must be purchased from NanOsc*

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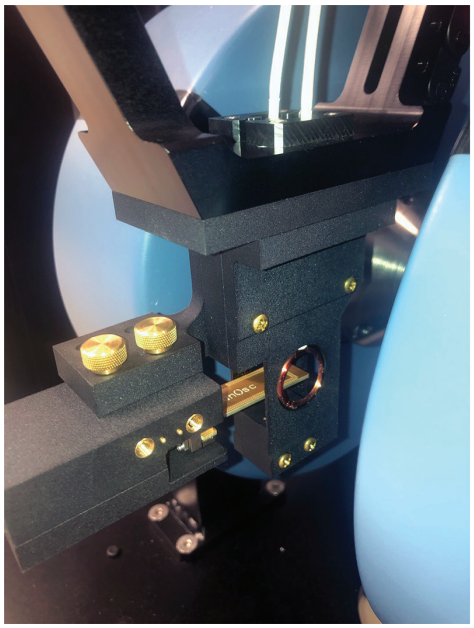
Specifications

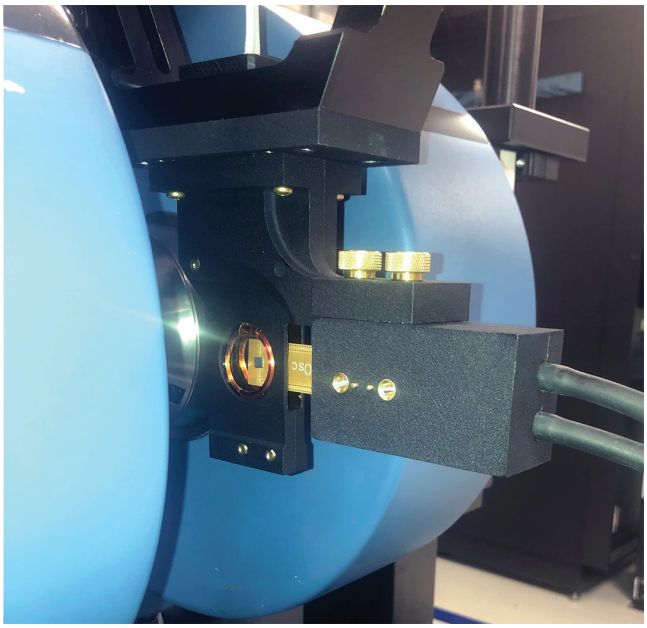
NanOsc FMR bandwidth

Instrument	Bandwidth
PhaseFMR	2 to 18 GHz
PhaseFMR-40	2 to 40 GHz

MCS-EMP and 8600 Series maximum fields when configured with the NanOsc FMR option

Model	IP maximum field	OOP maximum field
MCS-EMP-4	1.69 T	2.41 T
MCS-EMP-7	2.34 T	2.91 T
8604 VSM	1.54 T	1.96 T
8607 VSM	2.23 T	2.55 T





FMR-CPW-U-KIT sample mount shown with an integrated IP (left) and OOP (right) co-planar waveguide

Typical results

Measured and fitted data for $Ni_{80}Fe_{20}$ (10 nm)/Ta (5 nm) thin film as a function of IP field to 0.12 T at frequencies of 2, 4, 6, 8, and 10 GHz (figure 1), and as a function of IP field to 0.94 T at frequencies of 30, 32, 34, and 36 GHz (figure 2).

