APPLICATION NOTE

Test for Line Width and Gyromagnetic Ratio

Introduction

At a constant microwave frequency ($\omega = 2\pi f$), ferrimagnets exhibit electromagnetic energy absorption that is a function of the internal static magnetic field (H_i). Maximum absorption occurs when the precession frequency and direction of the elementary magnetic dipoles equals that of the incident microwave magnetic field. The magnitude of H_i (H_r) required to obtain maximum absorption (i.e., the ferromagnetic resonance condition) can be computed from the following equation:

$$\omega = \gamma_{eff} H_r \quad \textbf{(1)}$$

Where:

$\omega = 2\pi \times$ the resonant frequency
γ_{eff} = Effective gyromagnetic ratio
H_r = Magnitude of H_i

For a spherical test specimen, H_i is independent of the material magnetization and may be taken as equal to the applied Direct Current (DC) magnetic field.

The ferrimagnetic resonance line width (ΔH) is defined as the separation of the two H_i values at which the power absorbed by the ferrimagnet is equal to half the maximum absorption, as shown in Figure 1.

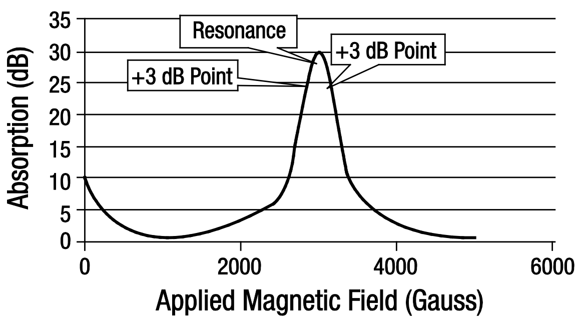

Figure 1. Ferrimagnetic Resonance for a Sphere at 9300 MHz

Cavity Method

The A TE_{10n} (n even) cavity resonant in the X-band region is used, or alternatively is the H-field maximum in the coupling iris of a cross-guide coupler. The Loaded Q (Q_L) of the empty cavity should be 2000 or greater. The test sample is a sphere that is a diameter of approximately
0.040 inches. The cavity technique requires that the sample be small compared to one-quarter of the wave-length (λ) of the microwave radiation within it:

$$\lambda = 3 \text{ x } 10^4/f(\varepsilon')^{1/2} \text{ [cm]} \quad \textbf{(1)}$$

Where:

λ = Wavelength (cm)
f = Frequency in megacycles
ε' = Dielectric constant
cm = Centimeters (dimension which the wavelength is measured)

The sample, mounted on a fused silica or equivalent rod, is positioned away from the cavity wall at a point of minimum microwave electric and maximum microwave magnetic field. A power meter can be used to read off the half-power points by adjusting the DC magnetic field and measuring the difference in field directly.

Measurement

Measurement is carried out at a fixed frequency, and the DC field from an electromagnet of suitable homogeneity is adjusted until the specimen is at ferromagnetic resonance (peak absorption). Using Equation (1) the gyromagnetic ratio can be initially determined from the measurement frequency and the resonance field. This characteristic may also be given in terms of $\gamma_{eff} = \gamma_{eff}$ x 2mc/e, (MKS units).

The width of the ferromagnetic resonance is found by sweeping the magnetic field through resonance, and measuring the DC field at the half-power (+3 dB) point using an accurate Gaussmeter. Trans-Tech, Inc. (TTI) uses a Noise Margin Reading (NMR) based instrument. The exact peak is then found by differentiating the DC field/power plot digitally and the +3 dB points determined precisely using a polynomial curve fitting, which eliminates operator error in setting and reading the peak and +3 dB points.

Because the +3 dB line width is sensitive to temperature, the measurement must be carried out in a temperature-controlled room, and the magnet pole pieces are water-cooled to prevent heating. A thermocouple is used to measure the temperature at the specimen, which should ideally be controlled to within 1 °C to obtain an accuracy of 0.2 Oersted.

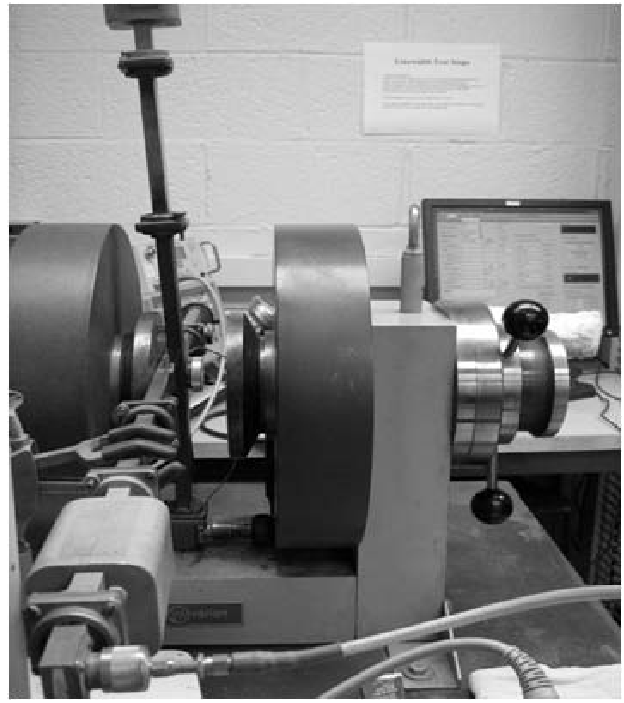

Figure 2. Typical Equipment Setup