FERROMAGNETIC RESONANCE FOLDOVER AND SPIN WAVE INSTABILITY IN SINGLE CRYSTAL YIG FILMS

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Introduction

Foldover in ferromagnetic resonance (FMR) has been a continuing subject of study since the early work of Anderson and Suhl,[1] Weiss,[2] and Schloemann.[3] The basic high power effect is the appearance of an extended resonance when sweeping the static magnetic field in one direction and a sharp cusp when sweeping in the other direction, as shown schematically in Fig.1. Quantitative data on foldover were recently obtained by Zhang, et al.[4] using low duty cycle pulsed microwave power and signal averaging techniques. The foldover was clearest for FMR with the dc field perpendicular to the film plane. The objective of this work was to (1) calculate field shifts for the FMR shoulder associated with foldover, following the analysis of [3], and (2) make a detailed comparison with the perpendicular FMR data of [4].

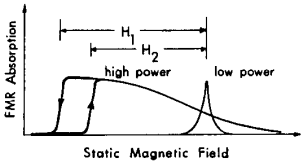

Fig.1. Schematic illustration of the FMR foldover response.

Theory

According to Schloemann's analysis of the nonlinear FMR response,[3] the field shifts H_1 and H_2 associated with foldover (Fig.1) are given by

$$H_1 = \beta \, \Delta H / 2 \qquad \text{(for downsweep static field)}$$

and

$$H_2 = 1.89 \, \beta^{1/3} \Delta H / 2 \qquad \text{(for upsweep static field),}$$

where β is proportional to the square of the microwave field amplitude h_{rf} and ΔH is the FMR linewidth. For perpendicular FMR in (111) YIG films, the β-parameter is given by

$$\beta = h_{rf}^2 \, [\, B_s + 3 \, H_A \,] \, / \, (\, \Delta H \,)^3$$

where B_s is the saturation induction, and H_A is the anisotropy field.

Results and Discussion

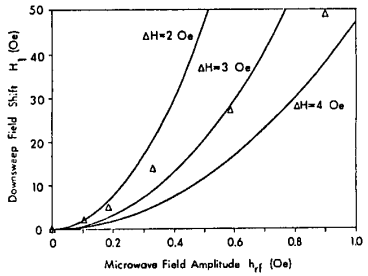

Fig.2. Foldover static field shift H_1 vs. microwave field amplitude h_{rf}.

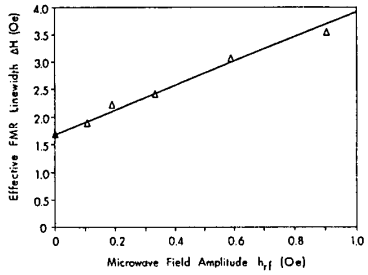

Fig.3. Effective FMR linewidth vs. microwave field amplitude h_{rf}.

Figure 2 shows data (triangles) and theory (solid lines) for the downsweep static field shift H_1 vs. h_{rf}. The theory cannot be fitted to the data for any single value of ΔH. Rather, it appears that there is an effective FMR linewidth which tends to increase as h_{rf} is increased. Such an increase in linewidth is consistent with the increase in loss that occurs at high power levels. Effective FMR linewidth values vs. h_{rf} were obtained by fitting the theory to the data. The results are shown in Fig.3. The solid point at $h_{rf} = 0$ is the actual low power FMR linewidth, 1.7 Oe. The increase is approximately linear, and follows the equation

$$\Delta H = (\, 1.7 + 2.2 \, h_{rf} \,) \text{ [Oe].}$$

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