ANGLE AND THICKNESS DEPENDENCE OF THE FMR LINEWIDTH IN HIGH QUALITY Ni-Fe THIN FILMS

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ABSTRACT

Measurements of linewidth versus angle between the static field and the film plane have been made at 9 GHz for high quality Ni_3Fe films 300-2700 Å thick. Both the parallel and perpendicular frequency linewidths increase with thickness, and the increase is more rapid for parallel FMR. The data for 300 Å films can be fitted with a constant Landau-Lifshitz damping. The difference between the parallel and perpendicular linewidths $[\Delta(\omega/\gamma)_{\parallel} - \Delta(\omega/\gamma)_{\perp}]$ shows a striking thickness dependence indicative of two-magnon relaxation.

Recent high quality Ni_3Fe thin films exhibit half-power linewidths of 30-40 Oe from 1 GHz up to 36 GHz.[1] Detailed measurements of the linewidth variation with angle between the static field and the film plane at 9 GHz have been made for these C.N.R.S. films with thickness 300-2700 Å. The results are in significant contrast with older data on lower quality films.[2]

Both the parallel and perpendicular frequency linewidths $\Delta(\omega/\gamma)$ increase with thickness. This result is shown in Fig. 1. The increase is more rapid for parallel than for perpendicular FMR, but it is steeper than linear in both cases. This is quite different from the older data for which $\Delta(\omega/\gamma)_{\perp}$ was constant independent of thickness and $\Delta(\omega/\gamma)_{\parallel}$ showed a linear increase. These older data were, however, for films with larger linewidths measured at lower frequencies.

A computer analysis by Bailey and Vittoria[3] indicates that the perpendicular data are well explained by a constant Landau-Lifshitz damping combined with eddy current losses. In addition, the angular variation of the linewidth for the 300 Å film is also consistent with a constant value of the damping. Damping versus angle (actually the sine of angle between the magnetization and the film plane) is shown in Fig. 2. The variation is not significantly larger than the experimental scatter. Again, this result differs greatly from the older results for poorer films, in which a large variation in damping (at lower frequencies) was required to explain the data.

It is revealing to plot the linewidth difference $[\Delta(\omega/\gamma)_{\parallel} - \Delta(\omega/\gamma)_{\perp}]$ versus thickness for these films. This is shown in Fig. 3. Up to about 700 A film thickness, the difference is constant at 32 Oe. Above 700 Å, the difference increases rapidly at first, and then appears to level off at about 80 Oe or so above 3000 Å film thickness. The abrupt increase at 700 Å is in accord with the onset of a two-magnon contribution reported some years ago.[4] The variation in the difference above 700 Å is in qualitative agreement with the thickness dependence expected for two-magnon relaxation.

Two related questions are raised by these results. (1) Insofar as the perpendicular data thickness variation is the same as expected for eddy-current losses, it is possible that the parallel linewidth is also related to eddy-currents. It is likely that at least some of the increase in Fig. 1 is due to eddy current damping. Such calculations are in progress at this time. (2) It is unclear how such losses will affect the two-magnon interpretation of the data in Fig. 3. Depending on whether the eddy-current losses are larger or smaller for parallel or perpendicular FMR, the difference attributed to two-magnon effects may be reduced or enhanced.

REFERENCES

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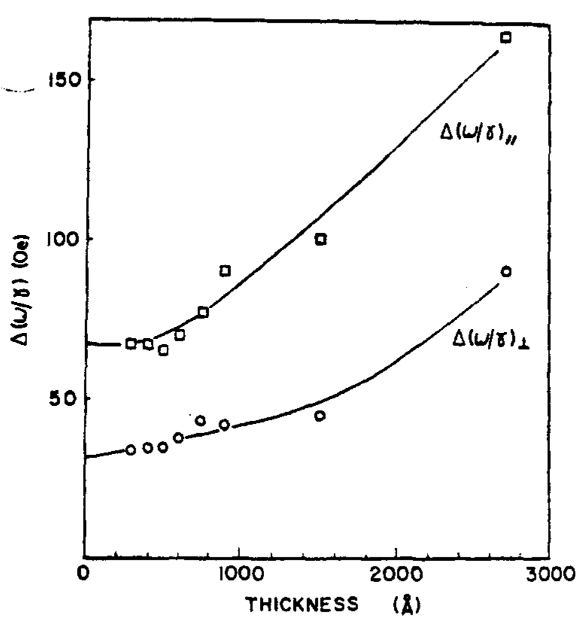

Fig.1. Frequency linewidth versus thickness for parallel and perpendicular resonance.

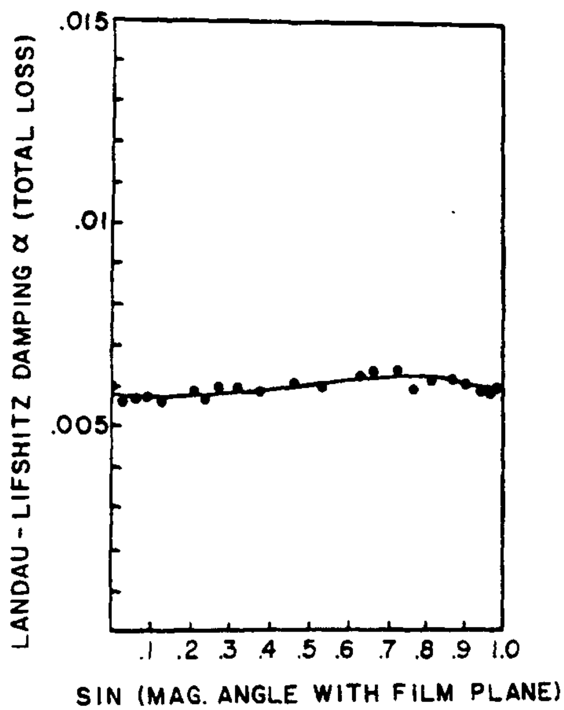

Fig. 2. Angle dependence of the Landau-Lifshitz damping parameter α.

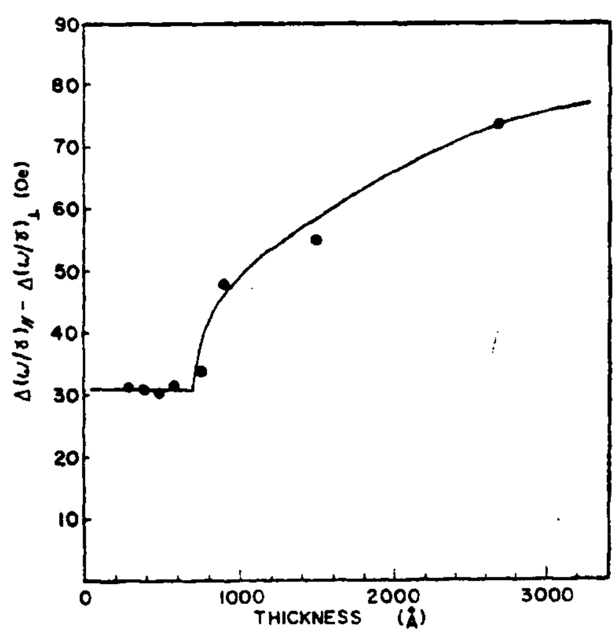

Fig. 3. Thickness dependence of the perpendicular-parallel frequency linewidth difference.