Article ID: 1003－7837(2005)02,03－0348－01

Anisotropic model of ferrite films

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The dispersion relations for waves being excited play an important role in the development and analysis of physical models for spin-wave devices. The purpose of this presentation is to propose a method for obtaining an approximate dispersion equation for a surface magnetostatic wave (SMSW) in weakly anisotropic ferrite films. An appropriate analysis based on the laws of despersion discribing the general case of an arbitary crystallographic magnetic anisotropy lead to the final relation for SMSW frequency[1]

$$f^2 = f_0^2 \exp(-2kd) + f_\infty^2 [1-\exp(-2kd)] - P(kd)\sigma - R(kd)\varepsilon, \quad (1)$$

$$P(kd) = \frac{\exp(-2kd)}{2}\left[\frac{2kd}{1-\exp(-2kd)} - 1\right],\ \sigma = 4\pi(Mg)^2(N_{xx} - N_{yy}),$$

$$R(kd) = \frac{1}{\exp(2kd)-1}\left[\frac{4kd}{1-\exp(-2kd)} + \exp(-2kd) - 3\right],\ \varepsilon = (MgN_{xy})^2$$

k－wave vector, d－thickness of film, $4\pi M$－saturation magnetization, g－gyromagnetic ratio, N_{ij}－the tensor components of effective demagnetizing anisotropy factors, f_0 and f_∞－the longwave and shortwave boundary frequencies ($kd \to 0, \infty$).

After the substitution of expressions for f_0 and f_∞ into Eq.(1), the latter will explicity define the dependence of fon kdas well as on the anisotropy tensor components N_{ij}. Thus, the application of an approximate Eq. (1) instead of the exact dispersion equation allows us to substantially simplify the analysis of the effect of magnetic anisotropy of films on the spectrum of SMSWs. The approximate dispersion equation is used for studying the angular dependences of frequency in tangentially magnetized films of cubically anisotropic ferrites. It should be noted in connection with the problem being considered that the basic material used in spin-wave electronics is yttrium iron garnet (YIG, $Y_3Fe_5O_{12}$) belonging to weakly anisotropic ferrites with a cubbic symmetry of the crystal lattice. The approximate dispersion equation (1) successfully describes the "amplitude" and "phase" of angular variations of SMSW frequencies in YIG films. Thus, our results can be used for improving the characteristics of ferrite films and in development of spin-wave devices.

References

[1] V.V. Shagaev. Technical Physics, Vol. 49, № 10, 2004, p.1354－1359.

Received date: 2005－08－29