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Abstract

Full Text

PHYSICS

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TEMPERATURE DEPENDENCE OF THE g-FACTOR AND RELAXATION TIME IN FERROMAGNETIC RESONANCE FOR CERTAIN FERRITES

It is known that the study of ferromagnetic resonance makes it possible to investigate the behavior of electron spins in a lattice under various conditions. The experimental study of this question reduces to determining the spectroscopic splitting factor g and the relaxation time T from the absorption curves of electromagnetic oscillations with frequency $\omega \sim 10^{10}$ cps and from the dispersion curves of the effective magnetic permeability in alternating magnetic fields in the presence of a constant magnetizing field.

On the basis of the general theory of L. D. Landau and E. M. Lifshitz ([1]), concerning the behavior of ferromagnets in alternating magnetic fields, various authors ([2]) proposed "resonance" formulas relating g, ω, H, I, and T, where I is the saturation magnetization. According to A. I. Pil' shchikov ([3]), the most important resonance parameters g and T can be determined with sufficient accuracy from the positions of the extrema of absorption and dispersion. The relaxation time can also be estimated from the half-width of the absorption curves.

For calculating g and T we used the known formulas, adapted to our experimental conditions:

$$\omega^2 = g^2 \left(\frac{e}{2mc}\right)^2 H \left[H(N_y - N_z)I\right] + \frac{1}{T^2}, \quad (1)$$

$$\frac{1}{T} = g^2 \left(\frac{e}{2mc}\right)^2 \frac{[H_2 - H_1][H_2 - H_1(N_y - N_z)I]}{4\omega}. \quad (2)$$

We determined the quantities g and T for two groups of technical ferrites of compositions $NiO \cdot ZnO \cdot Fe_2O_3$ and $Li_2O \cdot ZnO \cdot Fe_2O_3$. The ferrites were obtained

Table 1

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Ferrite composition	I, gauss\cm^3	I, gauss\cm^3	N_x	N_x	Diameter thickness
	290° K	4.2° K	measured	calculated	
18% Li_2O, 2% ZnO, 80% Fe_2O_3	265	361	1.67	1.79	5.52
18% Li_2O, 2% ZnO, 80% Fe_2O_3	265	361	1.20	1.19	8.27
20% Li_2O, 80% Fe_2O_3	264	357	1.63	1.93	5.12
20% Li_2O, 10% ZnO, 70% Fe_2O_3	289	367	1.88	2.09	4.77
16.7% NiO, 37.3% ZnO, 46% Fe_2O_3	282	544	1.63	2.17	4.55
18% NiO, 42% ZnO, 40% Fe_2O_3	277	525	1.76	2.18	4.52

by the sintering method and, along the grain boundaries, had residues of oxides. Measurements were carried out at temperatures of 290 and 4.2°K at a frequency of $9.4 \cdot 10^9$ cps.

For all the ferrites investigated, magnetization curves were obtained and the saturation magnetization was determined. The latter was reached in comparatively weak fields ($H < 1400$ oersted). Ferromagnetic resonance was studied with the aid of two types of waveguides: rectangular and coaxial. Ferrite washers were

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Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

placed in the waveguides so that the plane of the washer

was normal to the axis of the waveguide. The strength of the constant magnetic field was perpendicular to the strength of the alternating magnetic field. The diameter of the ferrite washer was 8 mm, while the thickness of the washer varied from 0.2 to

Fig. 1

1.15 mm. The washer had a circular hole 2 mm in diameter. Calculation and measurements showed that, for small thicknesses, the presence of the hole in the washer did not substantially affect the magnitude of the demagnetizing coefficients N_x and N_y. We could vary the strength of the constant magnetizing field from 0 to 26000 oersteds. For the generation and measurement of the electromagnetic field, standard apparatus for the frequency range 8600–9600 MHz was used. A gold-plated measuring line with adjustable immersion of the

Fig. 2

Fig. 3

probe was supplemented by two minimeters, making it possible to measure the position of the probe with an accuracy up to 0.005 mm. The signal from the silicon detector entered a galvanometer with a sensitivity of $9 \cdot 10^{-11}$ A/mm · m or the 28I amplifier. The inner surface of the rectangular and coaxial wave-

the waveguides was silver-plated. The outer cylinder of the coaxial waveguide was made of quartz. A block diagram of the apparatus is shown in Fig. 1.

Characteristic absorption curves (in relative units) and dispersion curves (in units of the scale of the measuring line) are shown in Figs. 2 and 3.

The data given in Table 2 show that, for some of the ferrites studied, the *g*-factor decreases with decreasing temperature by an amount lying outside the limits of the random experimental error, which was estimated at 4%. No general tendency is observed in the change of the relaxation time.

Table 2

Fig. 3

Figure 3: Fig. 3

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Composition of ferrites	g, 290° K	g, 4.2° K	$T \cdot 10^{10}$, sec, 290° K	$T \cdot 10^{10}$, sec, 4.2° K
18% Li_2O, 2% ZnO, 80% Fe_2O_3	2.07	2.04	4.8	4.5
20% Li_2O, 80% Fe_2O_3	2.03	1.84	5.1	3.8
20% Li_2O, 10% ZnO, 70% Fe_2O_3	2.05	2.03	4.8	5.6
16.7% NiO, 37.3% ZnO, 46% Fe_2O_3	2.23	1.86	11.0	4.0
18% NiO, 42% ZnO, 40% Fe_2O_3	2.06	1.73	4.3	4.8

The change in the g-factor with decreasing temperature cannot be explained on the basis of the existing microscopic theories.

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