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TWICE ORIENTATED YIG POWDER [1)]

ДВАЖДЫ ОРИЕНТИРОВАННЫЙ YIG ПОРОШОК

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This contribution deals with the double orientation of powder particles of the yttrium iron garnet. Possibilities of the evaluation of material quantities from an FMR measurement (g-factor, magnetization M, first order anisotropy constant K_1) are illustrated by numeral results. YIG is taken as a testing material.

Single crystal particles of YIG were dispersed with the volume concentration 2 % in a diamagnetic viscous and gradually solidifying medium. Epoxide resin was used for this purpose. To orientate the powder particles two (mutually) perpendicular magnetic fields H_a and H_b were applied. Fig. 1 shows both time dependences of these fields with the same starting point. The values $\mu_0 H_a = \mu_0 H_b = 0.5\,\mathrm{T}$ are sufficiently high to saturate the particles of YIG.

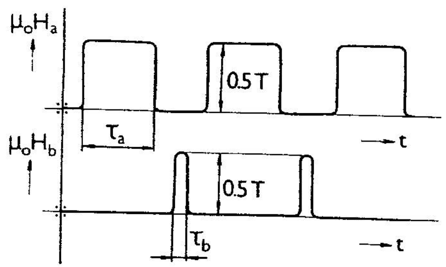

Fig. 1.

Both time intervals $\tau_a \sim 100\,\mathrm{s}$ and $\tau_b \sim 10\,\mathrm{s}$ were chosen from experience. The choice of these intervals was based on the initial viscosity of the resin and the behaviour of the dispersed particles. The relaxation time τ of the rotational motion of the particles in the resin must satisfy the inequalities

$$\tau_a > \tau > \tau_b . \qquad (1)$$

No chains of particles were created under these conditions.

The field H_a must be applied first. By this field the particles were aligned so that their length (a) became approximately parallel to the direction of H_a.

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The field H_b was applied as the second one. Owing to the condition $\tau_b < \tau$ the field H_b caused only a small rotation around the directions (a) of the particles (i.e. approximately around the direction H_a).

Multiple repetition of these two steps is necessary to reach this final result:

1. The lengths (a) of all particles became nearly parallel to H_a.
2. The thicknesses (c) of all particles became nearly perpendicular to both H_a and H_b.

The result of this procedure is showed in Fig. 2.

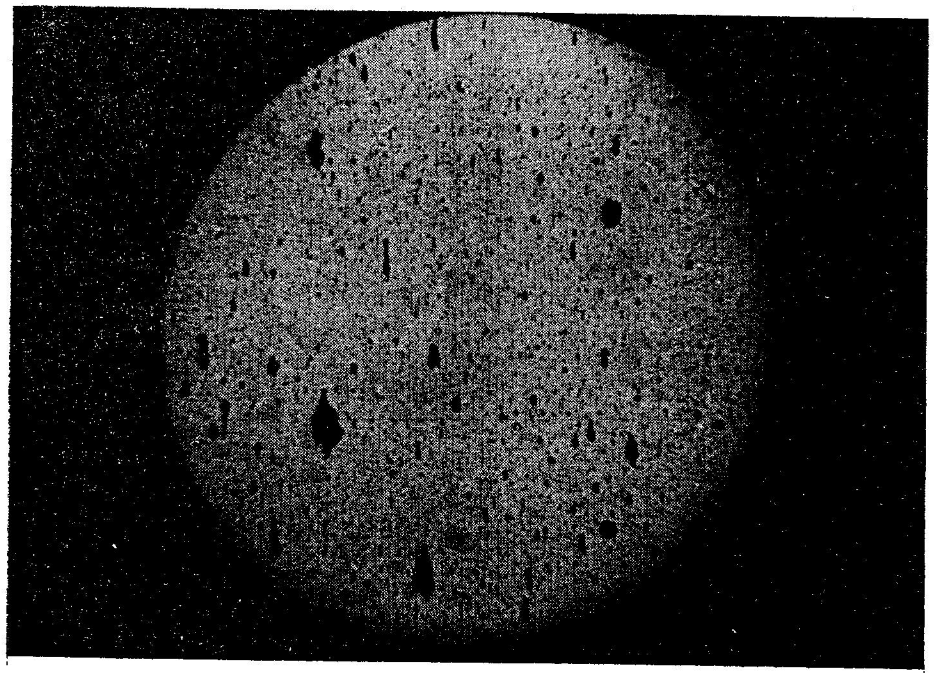

Fig. 2.

The YIG particles in this section will be regarded as a system of ellipsoids with parallel axes a, b and c, respectively. All assumptions of the model of independent particles used in this contribution were already introduced in the preceding paper [1]. First the mean geometrical form of the greatest particles was determined by optical microscopy. From these measurements the following demagnetizing factors were evaluated:

$$N_a = 0.185 \quad N_b = 0.312 \quad N_c = 0.503. \qquad (2)$$

As an example of the magnitude of particles let us introduce the average length 40 μm, which represents about 90 % of the mass of the power sample.

In the FMR measurements the first derivatives of the absorption signals were observed and their zero points were determined. At room temperature and the frequency of 10.925 GHz three different values of the resonance field were measured:

$$H_{arez} = 2.563 \times 10^5\,\mathrm{Am^{-1}}, \quad H_{brez} = 2.834 \times 10^5\,\mathrm{Am^{-1}}, \quad H_{crez} = 3.228 \times 10^5\,\mathrm{Am^{-1}}. \qquad (3)$$

The indices a, b, c indicate the orientation of the sample with respect to the external magnetic field.

For these three orientations the distribution functions were calculated. To simplify the computational procedure only Kittel's resonance condition contaning first order anisotropy terms was taken into account (see, e.g., [2]). The magnetization is assumed to be parallel with the external magnetic field under an arbitrary orientation of the anisotropy axes of YIG. The problem of minimization of the total energy mentioned in [1] was not solved. The shapes of all calculated distribution functions were the same as those of Schlömann [3] for very small negative anisotropies. By means of these theoretical results and of the experimental values of the demagnetizing factors and resonance fields the following quantities were evaluated:

$$g = 2.16 \quad M = 1.4 \times 10^5\,\mathrm{Am^{-1}} \quad 2K_1/\mu_0 M = -(5 \pm 2) \times 10^3\,\mathrm{Am^{-1}} \qquad (4, 5, 6)$$

Measurement on a single crystal prepared from the identical material of YIG gives

$$g_{SC} = 2.01 \quad (2K_1/\mu_0 M)_{SC} = -(6.84 \pm 0.1) \times 10^3\,\mathrm{Am^{-1}} \qquad (7, 8)$$

The difference $g - g_{SC} = 0.15$ cannot be explained within the approach used in this paper. The value M corresponds well to that of YIG. The sign and the order of $2K_1/\mu_0 M$ agree with the known values for YIG but the accuracy of this quantity is very low. K_1 evaluated by means of (5) and (8) gives $K_1 \sim 6 \times 10^2\,\mathrm{Jm^{-3}}$.

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