Functional Materials 10, No.2 (2003)

Magnetization processes of epitaxial ferrite-garnet films

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Received February 26, 2003

The magnetization processes in the films grown on (112) oriented substrates have been studied in experiment and theoretically. Methods to determine the easy magnetization axis orientation have been proposed. The areas where the unhomogeneous magnetic phase exists in the tilted magnetic fields have been determined.

Проведены экспериментальные и теоретические исследования процессов намагничивания в пленках, выращенных на подложках с ориентацией (112), и предложены способы определения ориентации оси легкого намагничивания. Определены области существования неоднородной магнитной фазы в наклонных магнитных полях.

The analysis of domain structures (DS) and the magnetization processes in ferromagnetics is among the most traditional tasks in the magnetism field [1]. A wide practical application of epitaxial ferrite-garnet films (EFGF) stimulates the constant interest in such tasks today [2]. The EFGF are used as magneto-optic converters [3]. In this connection, of interest are the EFGF with inclined easy magnetization axis (EMA). The films with inclined EMA were studied in numerous works. Thus, in [4, 5], small deviations of EMA from the normal due to weak misorientation of the films out of the (111) crystallographic surface. The experimental procedures used in these works, however, did not allow to reveal and study considerable EMA deviations. In [6], it has been shown theoretically within the frame of two-parameter model of induced magnetic anisotropy that the inclined EMA arrangement may be realized in the (210) films. In [7], it has been shown that the optimum photomagnetic recording sensitivity can be attained in (112) oriented EFGF.

This work is aimed at the experimental and theoretical study of magnetization processes in the EFGF grown on (112) oriented substrates and determination of the domain structure existence regions using thermodynamic theory [2].

To describe the induced magnetic anisotropy, let the two-parameter model [8] be used that is the only available working model to date. The energy density of the induced magnetic anisotropy for (112) films let be reduced to the form

$$W = K_u\sin^2\theta + K_0(\sin^2\theta\sin^2\varphi + \sqrt{2}\sin2\theta\sin\varphi), \quad (1)$$

where θ and φ are spherical coordinates of the magnetization vector **M** and the crystallographic directions $[\bar{1}10]$, $[\bar{1}\bar{1}1]$, and [112] are selected as Cartesian axes X, Y, and Z, respectively, the 0Z axis being perpendicular to the EFGF plane; K_u and K_0, the uniaxial and rhombic magnetic anisotropy constants, respectively.

Minimizing the expression (1) with respect to θ and φ, we obtain three solutions for the equilibrium arrangement of the vector **M**:

1. $\theta_0 = 0$, $\mathbf{M}\|[112]$ for $K_0 > 0$, $K_u > 0$.
2. $\theta_0 = \pi/2, \varphi_0 = 0, \mathbf{M}\|[\bar{1}10]$ for $K_0 > 0, K_u < 0$.
3. $\mathrm{tg}2\theta_0 = -2\sqrt{2}K_0/(K_0 + K_u)$, $\varphi_0 = \pi/2$ for $K_0 < 0$, $K_u - \forall$.