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GENERATION OF RING DOMAINS AND FORMATION OF DYNAMIC GRATING OF THEM IN FERRITE-GARNET FILM

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A formation of a dynamic grating of ring domains as a result of a functioning of the local domain source in an alternating magnetic field has been observed in the ferrite-garnet film. Dynamic characteristics of the domain source and quantitative parameters of the ring domains grating have been determined.

It is known [1] that in the ferrite-garnet (FG) films with perpendicular anisotropy a self-organization of a system of magnetic domains takes place under the influence of an external magnetic field. Stable regular dynamic domain structures (DDS) of different configuration are formed in a region of an anger state (AS). At the same time a self-generation of the periodical processes of an appearance/disappearance of the DDS with a certain geometry takes place.

The frequencies of these processes are no less then three orders smaller then the pumping frequency f. The systems of spiral and concentric ring domains [1, 2], cylindrical magnetic domains (CMD) gratings and mixed gratings [3] are the typical ordered DDS. In [3, 4] the DDS of leading centre (LC) type in the form of the concentric ring domains, slowly expanding from centre were revealed and studied. The centre is connected with some local defect, on which the CMD of the opposite polarities arisen and expanded periodically. Thus the defect proves to be a source of dynamic domains at appropriate pumping conditions. In the present paper we are reporting about new kind of domain sources (DS) and new type of the ordered DDS.

We investigated the FG liquid-phase-epitaxy (111) film of the composition $(YBi)_3(FeGa)_5O_{12}$ with thickness 2 μm, static saturation field $H_S = 50$ Oe. The sample of 5 mm in dimension was placed into the coil with an inner diameter 6 mm. An alternating space-homogeneous field $H(t) = H_0 \sin 2\pi f t$ was oriented along the normal to the film, i.e. along the easy magnetization axis. The field is applied continuously during tests, only the frequencies f and amplitudes H_0 are changing. The temperature of the films was kept nearly 27 °C. The domain structure was observed through a microscope by using the magneto-optical Faraday effect and was photographed with the exposure $t = 1$ ms.

In the initial state the film is of irregular domain structure with arbitrary form of domains, as the temperature of the magnetic moment compensation for this sample is near to the room temperature. After demagnetization at the field with $f = 50$ Hz the structure looks like as a labyrintic one but the domain boundaries are broken. The mobile labyrintic structure with smooth boundaries is formed under the influence of the field of $f \sim 10^4$ Hz and $H_0 =$ 15–30 Oe. The width of domains $d = 50$ μm.

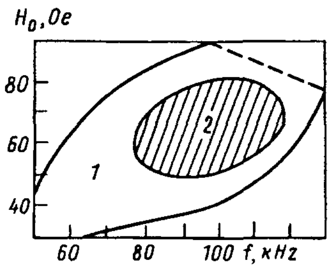

Fig.1. The gain-frequency regions of action of the ring domains source (*1*) and of existense in the film of the ringlets' stable grating (*2*)

Different domain sources (DS) are functioning in the film at region of $f =$ 20–140 kHz and $H_0 =$ 30–90 Oe. There is a LC among DS, generating concentric ring domains. The diameter of the external ring may reach 1 mm. These DS connected with local defects release various domains (concentric rings [4], CMD either singly or in whole groups [5], separate ring domains). With changing of f and H_0 the favourable conditions for intensive functioning of one among them are created. The DS generating small ring domains in sequence one after another is "working" actively at f and H_0, corresponding to the gain-frequency region *1* in fig.1. The diameters of these domains are much smaller by far than the diameters of the LC rings. Therefore we called them as ringlets. The DDS photographed on one and same of the sample at different H_0 and f are shown in fig.2. Fig.2*a* corresponds to the edge of the (H_0–f) region of ringlets existence and fig.2*b* corresponds to its middle part. The first ring domains in the chaotic DDS (fig.2*a*) are observed near the bottom border of region *1* in fig.1, where this DS starts functioning. The intensity of generation of ringlets from DS increases with growth of the H_0 at f = 80–100 kHz. The other DS are suppressed. As a result a stable grating of ringlets (fig.2*b*) is formed in film at f and H_0, corresponding to shaded region *2* in fig.1. Such dynamic grating of ring domains (GRD) has been observed for the first time[1)]. The DS exists an arbitrarily long time if the proper alternating magnetic field is applied. This DS stops its work gradually at H_0 and f corresponding to top borders of (H_0–f) region *1* in fig.1. The remaining ringlets are elongated and torn.

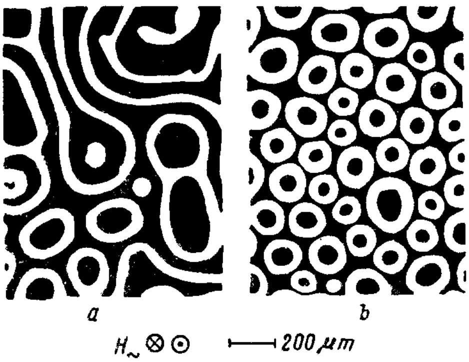

Fig.2. Photos of the domain structure in alternating field at H_0 and f, respectively: *a*) 38 Oe, 60 kHz; *b*) 60 Oe, 100 kHz

The DS have natural frequencies f_s. These frequencies are much smaller than the frequencies of the pumping f [3]. The intensity of the generation of ringlets changes depending on the H_0 and f. Fig.3*a* exhibits the nonmonotonic dependences $f_s(H_0)$ The DS stops it's action at amplitudes which smaller or higher than critical values of H_0. The most intensive generation of ringlets occurs at H_0 and f corresponding to middle of the region *2* in fig.1. One can see also the maximum of $f_s(H_0)$ curve is displaced towards greater amplitudes with increasing of f.

We have chosen the mean value (with respect to 20–100 domains) of the external diameter d_m of ringlets and their number per unit (1 mm^2) of sample area N as quantitative parameters of the GRD. The dependences $d_m(H_0)$ for f = const and $d_m(f)$ for H_0 = const are shown in fig.3*b* and 3*c*, respectively. One can see the average diameter of ring domains decreases monotonely with growth H_0 and f, i.e. the dynamic grinding of the DDS takes place. Such effect was observed earlier for another DDS [2]. The number of ringlets per unit of sample area depends on H_0 nonmonotonically (curves *3,4* in fig.3*b*). At first N increases with growth of H_0, when the ringlets grating is forming and condensed. Then N decreases with futher growth of H_0 and the destruction of the grating takes place. Apparently, a delay of the arising and growthing of remagnetization nuclei and dependence of their form on defect configuration cause the effects described above.

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[1)]The statical gratings of ring domains were first observed for garnet crystals in [6] and recently for FG films in [3].

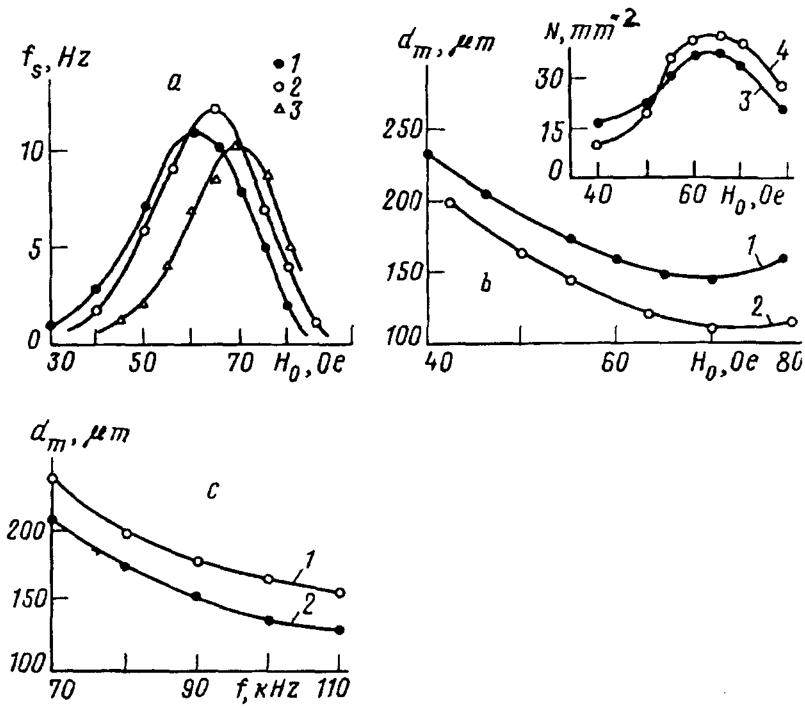

Fig.3. The parametres of the domain source and grating of ringlets: *a*) natural frequency f_s of generation of ringlets as a function of the amplitudes H_0 at the different fixed pumping frequencies $f = 90$ (•), 100 (o) and 110 kHz (Δ); *b*) the average diameter d_m of ringlets vs amplitudes H_0 at the different pumping frequencies f: 80 (*1*) and 100 kHz (*2*) and their number N per 1 mm^2 as a function of external field amplitudes H_0 at $f = 90$ (*3*) and 100 kHz (*4*); *c*) the average diameter d_m of ringlets vs pumping frequencies f for different fixed amplitudes $H_0 = 50$ (*1*) and 60 Oe (*2*)

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1. G.S.Kandaurova and A.E.Sviderskiy, Zh. Eksper. Teor. Fiz. (Sov. JETP) **97**, 1218 (1990).
2. G.S.Kandaurova and Yu.V.Ivanov, Fiz. Met. Metalloved. (Sov. Phys. Met. Metallogr.) **76**, 49 (1993).
3. F.V.Lisovskiy and E.G.Mansvetova, Zh. Eksper. Teor. Fiz. (Sov.JETP) **58**, 836 (1993).
4. G.S.Kandaurova and A.E.Sviderskiy, Physica B **176**, 213 (1992).
5. G.S.Kandaurova, Dokl. Acad. Nauk, Fizika (Sov. Physics-Doklady) **31**, 428 (1993).
6. G.S.Kandaurova, L.A.Pamyatnikh, and V.E.Ivanov, Izvestiya Vuzov Fizika, **3**, 57 (1982).