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A. A. Rusinov; E. A. Rusinova

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Evolution and Parameters of Dynamic Domain Structures of the "Leading Center" Type

A A Rusinov[1] and E A Rusinova[2, a)]

[1]*Ural State Transport University,Yekaterinburg, Russia*
[2]*Ural Federal University, Yekaterinburg, Russia*

[a)] *Corresponding author: earusinova@mail.ru*

Abstract. A detailed study of the behavior of ordered, stable dynamic domain structures (DDS) of the "leading center" (CC) type, determination of the quantitative characteristics of these DDSs were carried out [1, 5] on several samples of garnet-ferrite films, for which, according to dynamic domain phase diagrams (PD) , there were large amplitude-frequency regions (H0-f) of the existence of this type of DDS. In this work, the dependence of the geometric dimensions of the BVTs (the number of rings and the outer diameter) on the conditions of energy pumping is investigated. The dependence of the number of annular domains (CD) N, “black” and “white”, was also established with a change in the amplitude H0 and fixed frequencies f.

EXPERIMENTAL TECHNIQUE

In this work, we studied thin single-crystal epitaxially grown films of garnet-ferrites with the (111) orientation [6-7]. In [8-11], DDS in films of ferrite-garnets are considered in detail, the regions of existence of various domain structures are studied. Let us consider how the parameters of the DDS of the VC type change for sample No. 1.1. The initial DS for this sample can be seen in Fig. 1a. Sample No. 1.1 was obtained from the same ferrite-garnet film as sample No. 1. The difference between the sample and sample No. 1 is that it contains, in addition to natural defects and artificially applied diamond indenters. When determining the parameters of the leading center (the number and width of the rings, the period of the structure in them, the outer diameter of the leading center, the frequency of ring production, etc.), the method of micro-video filming was used.

EXPERIMENTAL RESULTS

At certain values of the frequency f and the amplitude H0 of the alternating field, the defects become centers-sources of concentric annular domains. The leading center on an artificial defect (Fig. 1b) will be called a large VC (BVC), since it can grow up to 1.5 mm in diameter and have up to 40 rings, and a VC on a natural defect (Fig. 1b) will be called a small VC (MVC), its maximum number of rings in our experiments did not exceed 12.

The geometrical dimensions of the BVTs (the number of rings and the outer diameter) are strongly dependent on the conditions of energy pumping. The dependence of the number of annular domains (CD) N, “black” and “white”, with a change in the amplitude H0 and fixed frequencies f is not monotonic (Fig. 1a). However, when H0 is fixed and f increases, the number of CDs as a whole monotonically increases (Figs 1b, c.). The maximum number N in our experiment at the BVTs (N = 40) is achieved at a frequency f = 140 kHz at amplitudes H0 = 61-65 Oe. The limited capabilities of the experimental setup did not allow us to find out whether N will continue to increase with increasing f or begin to decrease.

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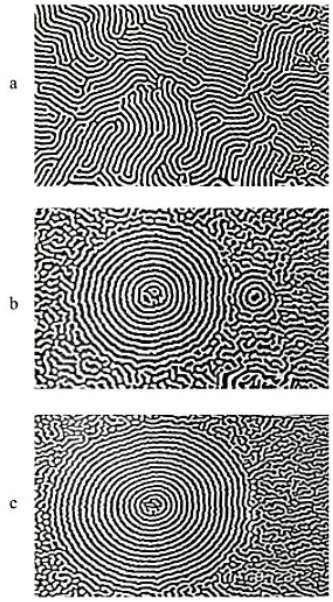

FIGURE 1. Initial domain structure of the film in the demagnetized state (a) and DDS of the VC type in an alternating field.

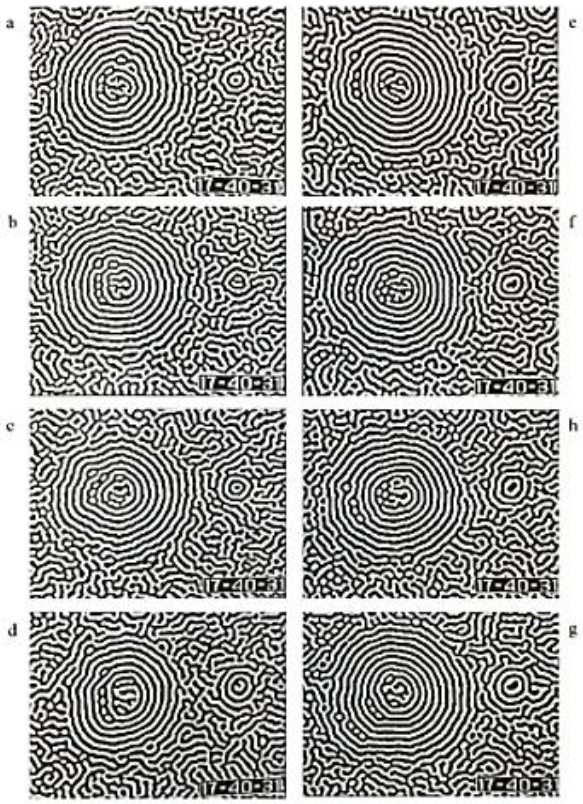

FIGURE 2. Sequential frames of the BVC evolution in the sample.

Figure 2 shows sequential frames of a microvideo film. The first frame in Fig. 2a clearly shows how white CMDs are formed in the defect area. In the second frame in Fig. 2b, they have shifted from the center by 2 rings (black and white). In the next frames, they practically did not move from the place of Fig. 2c, d, e. new CDs were

not formed. Further, it can be observed (Fig. 2e) that the CMD group under consideration has shifted by two rings at once, and in Fig. 2 (f, g, h), the "work" of the leading center is visible. It can be seen that the BVTs works with impulses with some delays, then giving birth to several rings, then dying. Thus, the dynamics of the BVC can be characterized by the frequency of CD production fs, i.e. the number of rings formed per second.

The results of experiments to determine the natural frequency of the "work" of the VC fs, carried out in the above described way for various frequencies f and amplitudes H0 of the external alternating field were averaged. The obtained dependences are shown in Fig. 3a, b. Figure 3a shows the dependences of fs for three frequencies of the external field f on the amplitude H0; it can be seen that the frequency fs first sharply increases to a maximum value at a given frequency f, and then slowly decreases to almost zero. As the pump field frequency changes, fs decreases monotonically with increasing f. With a change in the frequency of the pumping field, Fig. 3. fs decreases monotonically with increasing f. The three-dimensional dependence of fs on f and H0 is shown in Fig. 3.c.

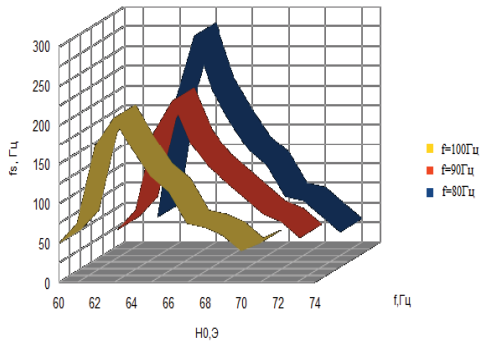

FIGURE 3A. Dependence of the ring production frequency in the BVTs on the frequency f and the amplitude H0 of the alternating magnetic field.

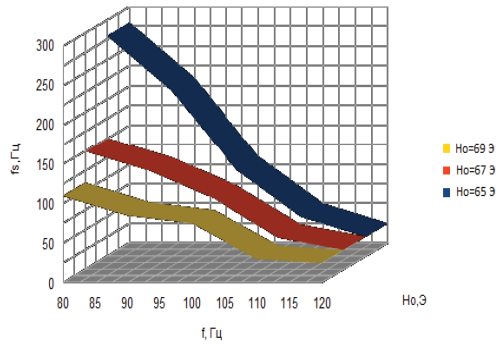

FIGURE 3B. Dependence of the ring production frequency in the BVTs on the frequency f and the amplitude H0 of the alternating magnetic field.

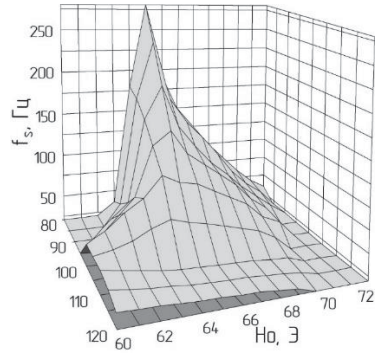

FIGURE 3C. Three-dimensional dependence of the frequency of ring production in the BVC on the frequency f and the amplitude H0 of the alternating magnetic field.

The dependence of the number of rings N in the BVTs on f and H0 is shown in Fig. 4. Curves N (H0) have maxima (Fig. 4a), which, with increasing frequency, shift somewhat towards lower amplitudes. So, for example, at f = 70 kHz, the maximum number of CDs is achieved at H0 = 73 Oe (N = 10), at f = 110 kHz - H0 = 62 Oe (N = 24), and at f = 130 kHz - H0 Oe (N = 32). The three-dimensional general picture of the change in the number of ring domains of the BVC by the change in both control parameters f and H0 is shown in Fig. 4c.

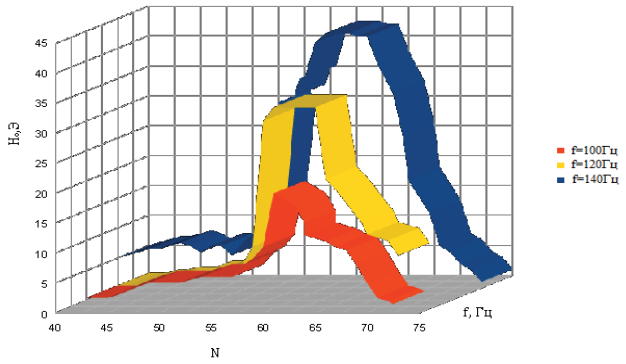

FIGURE 4A. Dependence of the number of rings N BVTs on the frequency f and amplitude H0 of the alternating magnetic field.

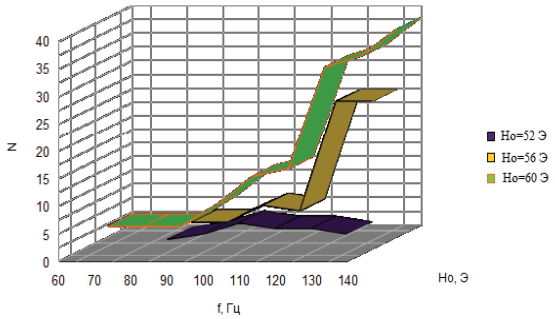

FIGURE 4B. Dependence of the number of rings N BVTs on the frequency f and amplitude H0 of the alternating magnetic field.

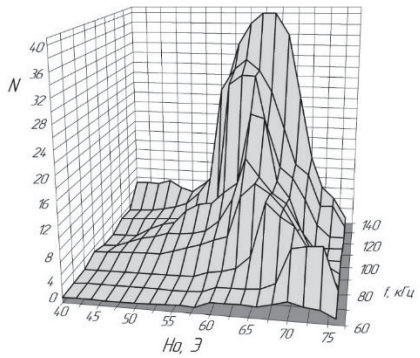

FIGURE 4C. Three-dimensional dependence of the number of rings N BVTs on the frequency f and amplitude H0 of the alternating magnetic field.

FINDINGS

In this work, the main attention is paid to the evolution and dynamic parameters of the DDS of the "eading center" type, such as the number of VD rings and the frequency of ring production. With the help of microvideo recording and frame-by-frame viewing, data on the dependence of the number of ring domains on the frequency and amplitude of the alternating magnetic field were obtained. The graphs of the dependences of the ring production frequency fs and the number of rings N on the frequency f and amplitude H0 of the alternating magnetic field are plotted. It has been shown experimentally that the maximum number of BVC rings is observed at the aximum frequency and minimum amplitude of the magnetic field for the obtained graphs. The frequency of production of BVC rings has a maximum with an increase in the field amplitude and a further decrease, and with an increase in the frequency of the magnetic field, it decreases monotonically.

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