THE FORMATION OF STRIP DOMAINS IN BUBBLE GARNET FILMS BY PROTON IRRADIATION

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In last years an interest to magnetic-optical films of bubble garnet films (BGF) with stable strip domains (SD) stimulating the working out of magnetic-optical films of BGF in the quality of deflectors and modulators in optical telecommunication was shown. Stable strip domains (SD) in memory devices on vertical Bloch lines (VBL) with the density of record till 10^{10} bit/cm^2 serve as storage registers placed in stable state [1]. Therefore the obtaining of BGF with SD is very important problem in the area of domain microelectronics.

There are many methods for the stable strip domains formation in BGF. A simple method of SD formation is current loops, marked on the film's surface of the current conducting layer by the photolithography method [2]. During the current flow of several μA on rectangular loops, bubble magnetic domain, which is situated inside is stretched into the strip domain. But this method is useful only for investigation of the dynamics of strip domains. An effective method is suggested by Conici [3], where on the BGF's surface the hollow till the half of its thickness along the SD is etched. At work [4] the stabilization of SD with the laser annealing by scanning of BGF's surface based on creation in BGF the magnetic relief is suggested.

Changing of the magnetization of saturation M_s can be observed by irradiation of the domain's surface by different nuclear particles. For example, in [5] it was established, that the irradiation of BGF by the fast neutrons decreases the saturation of magnetization. The irradiation by electrons increases the magnetization M_s. As it follows from [5], if the irradiation of domain having magnetic films by neutral particles comes to decreasing of M_s, but with the charged particles to increasing of M_s, then the possibility of formation of strip domains from the difference of ΔM_s is created by simultaneous irradiation the BGF by these particles.

Namely, on this nature the given work is based. For irradiation of the magnet garnet films we used the protons with the energy of 14 MeV and the current 0.2–0.3 μA of Cyclotron U–150 of INP of AS Uzbekistan. The samples were $(Sm\ Lu\ Y\ Ga)_3(Ge\ Fe)_5O_{12}$ the bubbles garnet films grown on (111) gallium gadolinium garnet ($Gd_3\ Ga_5\ O_{12}$) substrates. The magnetic parameters of films are the following; the width of domain is w = 4.9 μm, film thickness h = 4.5 μm, field of collapse H_c = 127 Oe, saturation magnetization M_s = 293 G.

Before the irradiation on the BGF's sample the specially made mask-absorber from aluminum foil (the thickness of the foil is more than the range of protons) was inserted. The topology of mask was presented by alternating rectangular slots and absorbers with the period of 0.4 mm.

On the fig.1 the method of irradiation of the BGF samples is presented. As it seen from the fig.1 the protons at slots insignificantly change their energy, but protons, collided with absorber, knock the fast neutrons by reactions (p,n) and (p,2n). In this case the number of secondary neutrons flying out from Al absorber is approximately 10^{10} n/c·cm^2 and with energy of neutrons till 11 MeV the current of protons being 1 μA/cm^2. After 60–70 minutes irradiation the samples were cooled 7–10 days activity decay from the short-living radionuclids, formed from the matrix elements.

On the magneto-optical setup of micron resolution [6] (here polarization microscope is equipped by a TV-camera and monitor) the observation and measurement of domain structures before and after irradiation of BGF was conducted. The thickness of the films, the width of domain and field of collapse were measured by magneto-optical methods. Magnetization of saturation was determined from correlation $M_s = H_c/4\pi g(l/h)$. Here $4\pi g(l/h) = [1-(3l/h)+3l/4h)]$, where ($l = 0.34+0.01$ μm), l – characteristic length of the films. As the observations show, on the monitor's screen, the labyrinth domain structure after relief irradiation accepts a row of strip domains. On the fig.2 a microphotograph of domain structures, appearing in the initial state after the irradiation and in the state. In this case the changes in the width of domains is of no significance, the difference in the collapse field $\Delta H_c/H_c$ being 20–25%. The investigations showed, that the simultaneous irradiation of BGF by protons and neutrons comes to the changing of magnetization of $\Delta M_s/M_s$ film till 30%. The disproportional distribution of magnetic relief on the film's surface caused the formation of the strip domains in the films.

By application of constant bias field $H_b \leq H_c$, strip domains accepted the strictly straight rows (see fig. 2c). However, after $H_b > H_c$ parallelism of SD in some areas of the film was broken. The irradiation of MGF by fast neutrons may cause the decreasing of M_s, which can be explained by formation of amorphous microareas, point defects and ionizing effects of the $Fe^{3+} \leftrightarrow Fe^{2+}$ type, and increasing of film M_s by redistribution of the cations by tetra and octa knots during proton irradiation [5].

So, the irradiation by protons of bubble garnet films through the mask absorber leads to relief changing of the saturation magnetization of magnetic films, causing strip domain's formation.

Reference

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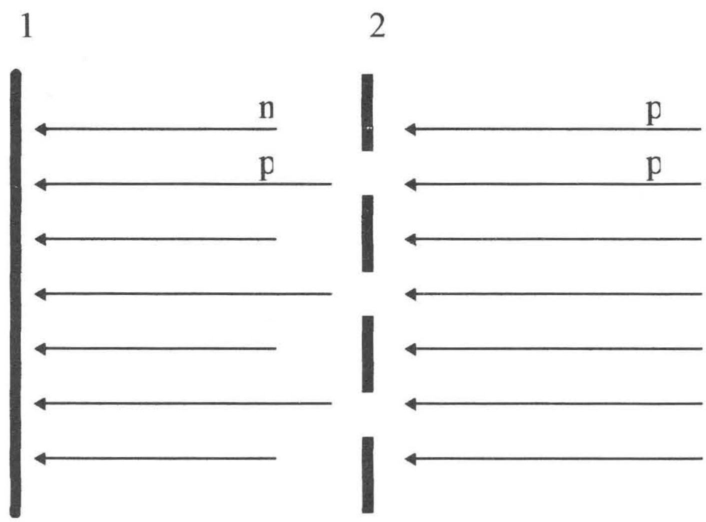

Fig. 1. The method of irradiation of BGF.
1 - bubble garnet films,
2 - mask absorber

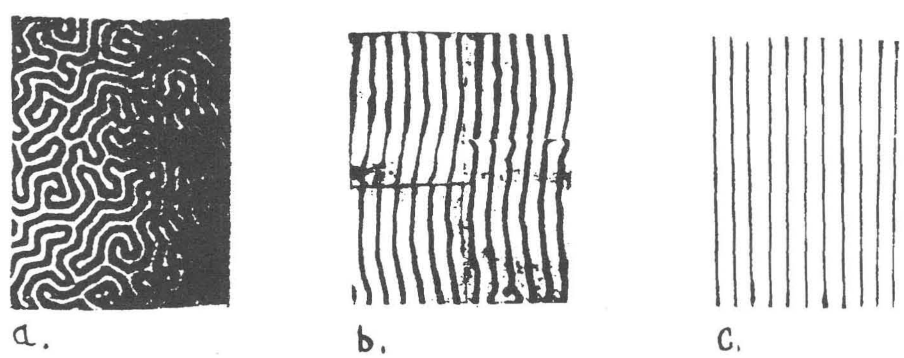

Fig. 2. Microphotograph of domain structures of BGF.
a - labyrinth domain structure of BGF,
b - image of BGF after the irradiation,
c - during application of constant bias field $H_b \leq H_c$.