7-7 Applications of Selective Ion Implantation to Magnetic Bubble Devies

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Recently, it was reported that the uniform proton bombardment over an epitaxial garnet film could suppress hard bubbles and the the selective proton bombardment to an epitaxial garnet film could also provide a propagation circuit for bubbles[1-2]. We also observed that magnetic bubbles tend to exist along the boundary between the implanted and un-implanted areas and they can stretch along the boundary[3]. In this paper, various aspets of selective implantation of proton and inert ions such as He, Ne, Ar, Xe, etc. onto various garnet films are described from a device point of view.

In a 10μm thick magnetic garnet ($Gd_{0.5}\ Y_{2.5}\ Ga\ Fe_4\ O_{12}$) selectively implanted with 200 keV protons of 10^{16} cm^{-2}, the following phenomena are observed: (I) A strip domain adheres to the edge of the implanted area. (II) As the bias magnetic field increases, each strip domain turns to a bubble which is localized at a specific position along the edge of the implanted area. (III) Bubbles can earily be moved along the edge of the implanted area by applying an in-plane rotating magnetic field. (IV) Bubbles can be stretched more than several tens times at once along the edge of the implanted area at a very high speed, if the bias field is decreased slightly below the run-out field, and appropriate in-plane magnetic field is applied (Fig. 1 (a),(b)). In all above phenomena, magnetic domains can be present inside or outside the implanted area according to the magnetic bias and driving conditions.

Films of the garnet implanted with 240 keV He ions of 10^{16} cm^{-2} exhibit other interesting features as follows: (I) Domains in the implanted area tend to be squashed or enlarged in comparison with those in the un-implanted area . (II) Bias magnetic fields required for producing and collapsing bubbles decrease by the implantation. (III) Presence and absence of domains in the implanted area exhibits hysteresis effect for the change of the bias field, suggesting the existence of a kind of barrier at the boundary between the implanted and un-implanted areas (Fig. 2 (a),(b),(c)).

Another remarkable effect of helium ion implantation on magnetic characteristics of the garnet films is that a magnetic domain which moves along the edge of the implanted area can rearrange the whole distribution of the adjacent domains so as to line up along the boundary between the implanted and un-implanted areas (Fig. 3 (a),(b),(c)).

Implantation of heavy ions such as Ne, Ar, and Xe of 200-250 keV gives less effect on the magnetic characteristics of the above garnet film, because the penetration depth in garnet is less than 0.1μm. These heavy ions may show noticeable effects on the smaller bubbles in thinner garnets.

An efficient bubble stretcher for the detection of small bubble domains can be made by the use of these effects and various kinds of novel logic device may also be realized by controlling the above mentioned effects by magnetic or electric means. Great advantage of the application of ion implantation to bubble devices over the permalloy technique are (I) flatness of the surface (II) good electrical insulation and (III) transparency which are quite important in providing a conductor circuit for control, driving or detection of bubbles.

Referrences

(1) R.Wolfe et al.: The Bell System Technical Journal (July-August 1972)

(2) R. Wolfe et al.: 18th MMM Conference (Nov.-Dec. 1972)

(3) T. Tsurushima et al.: 20th Annual Meeting of the Japan Society of Appl. Phys. (March, 1973)

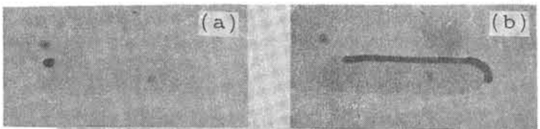
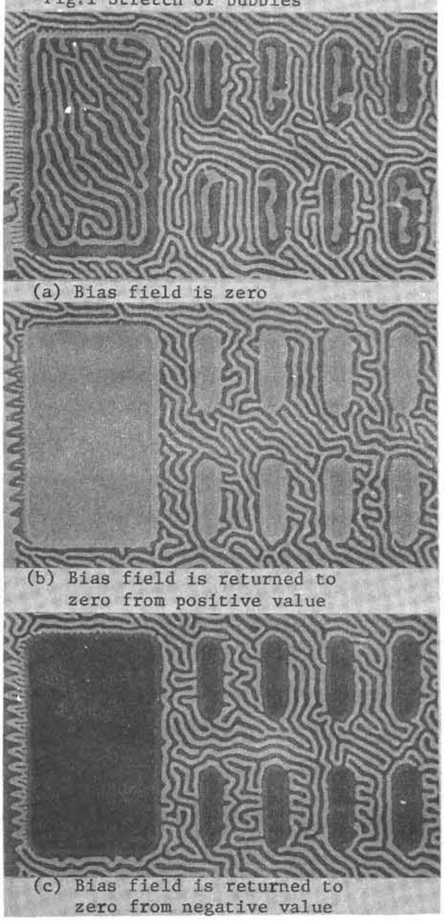


Fig.1 Stretch of bubbles

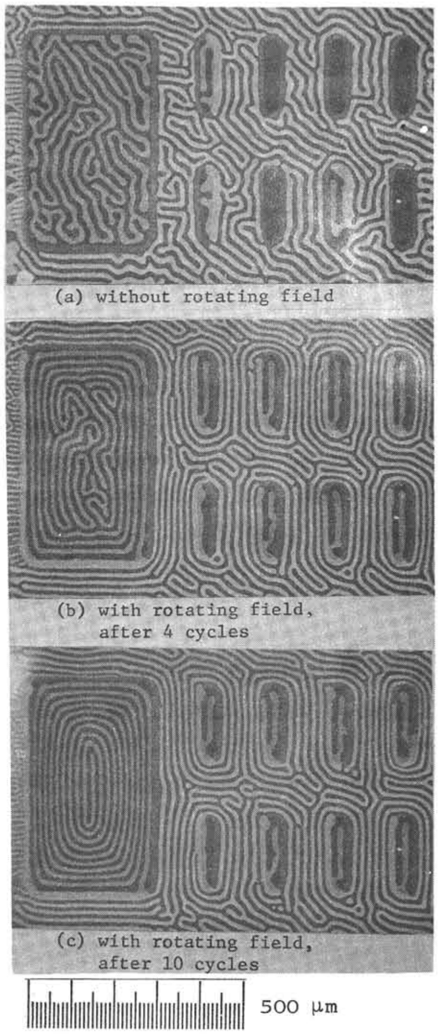


(a) Bias field is zero

(b) Bias field is returned to zero from positive value

(c) Bias field is returned to zero from negative value

Fig.2 Hysteresis of domains



(a) without rotating field

(b) with rotating field, after 4 cycles

(c) with rotating field, after 10 cycles

Fig.3 Alignment of maze patterns