EFFECT OF ION IMPLANTATION IN LIQUID PHASE EPITAXIALLY (LPE)-GROWTH EULA GA: YTTRIUM IRON GARNET (YIG) FILMS

Singh, S. K.

Department of Pure and Applied Physics,
Adamawa State University, Mubi, Nigeria.

ABSTRACT

The effect of ion implantation in liquid phase epitaxially grown thin films of composition $Eu_{0.6}Y_{2.4}Ga_yFe_{5+y}O_{12}$ and $Eu_{0.1}La_{0.2}Ga_{1.15}Fe_{3.85}O_{12}$ have been studied. Resonance line widths, ΔH_{11} and ΔH_1, effective g-factor, g_{eff} and uniaxial anisotropy K_u for the unimplanted and the implanted films have been investigated in the temperature range 85K to Tc (430K). the collapse field at room temperature has also been measured. It was found that there is a general tendency that ΔH_{11} increases while ΔH_1 decreases in the ion implanted film. It was also observed that uniaxial anisotropy (K_u) of the implanted film is lower than that of the unimplanted film at all temperature. It was observed, that there is smaller scatter ion the collapse with field for implanted film.

Keywords: technological, unpredictable, ion-implanted, bubble and Hard hubbies

1.0 INTRODUCTION

The rare earth gallium substituted garnet films exhibit interesting physical and magnetic properties which are of fundamental and teleological importance. In the application of magnetic bubble materials for memory device the main obstacle arises from the presence of hard bubbles. Hard hubbies have different spin structure in the domain wall compared to the normal bubbles [W.L. Tabor et.al (1972) and A. P, Molozenoff (1972)] .consequently their response to the rotating in the plane field, which is invariably required for the movement of the bubble from one location to another, is unpredictable. It has been found that ion implantation suppresses the hard bubbles[R. Wolfe et.al (1973)and R. Wolfe and J.C. North, (1972)] and thus provide a very useful technique to the bubble device engineer to improve the performance of the bubble memory device.

Several magnetic and structural studies on ion-implanted garnet films are reported in the literature[V. V. Nemoshkalenko et.al (1990) and H. A . Aigra and J. M. Robertson, (1980)]. We have studied the effect of ion-implantation of composition $Eu_{0.6}Y_{2.4}Ga_yFe_{5+y}O_{12}$ (y= 0.9,1) and $Eu_{0.1}La_{0.2}Ga_{1.15}Fe_{3.85}O_{12}$

2.0 EXPERIMENTAL DETAILS

The garnet films of composition $Eu_{0.6}Y_{2.4}Ga_yFe_{5+y}O_{12}$ (y= 0.9,1) and $Eu_{0.1}La_{0.2}Ga_{1.15}Fe_{3.85}O_{12}$
Was grown on [111]-oriented gadolinium gallium garnet(GGG) substrates using the liquid-phase epitaxy(LPE) technique from $PbO-B_2O_3$ base flux. The films have been implanted with Ar' ions at an energy of 80keV and dosage of 10^4 ions cm^{-2} at Tata Institute of Fundamental Research, Mumbai. The implanted depth was estimated to be nearly 2000Å. The thickness of the film was determined using the grooving technique[S. D. Rosenbaum(1968) and B. Uma Maheshwar et.al (1986)], the lattice mismatch, Δa, is obtained from XRD. The magnetization has been obtained using a Faraday balance (George Associates). FMR measurements have been made at 9.08GHz using a Varian E112 spectrometer. The g_{eff} has been obtained using the relation:

$$\omega = \gamma_{eff}\{[H_{11}(1.25H_{11}+H_1)]^{\frac{1}{2}} - \left(\frac{H_{11}}{2}\right)\}. \quad (1)$$

Where H11 and H1 are the resonance fields for the field parallel and perpendicular to the plane of the film and γ is the gyromagnetic ratio.

The uniaxial Hu was obtained using :

$$H_u = 4\pi M_s + \{[H_{11}(1.25H_{11} + H_1)]^{\frac{1}{2}} - \left(\frac{H_{11}}{2}\right) - H_1\} \quad (2)$$

The uniaxial anisotropy constant K_u was also obtained using

$$K_u = \frac{H_u M_s}{2}. \quad (3)$$

Bubble collapse field has been obtained by observing the bubble domain diameter as a function of applied magnetic field and noting the field at which the bubble domain collapses. Bubble domain have been observed in Reicert Jung Polyvar-Met polarizing microscope. The measured values of the various parameters EuYGaIG and EuLaYGaIG films at room temperature are given in table 1,2,3 &4.

3.0 RESULTS AND DISCUSSION

3.1 Uniaxial anisoiropy (K_u) and g_{eff}

The uniaxial anisotropy obtain using eqn. (2) &(3) for unimplanted & implanted films at 300K is listed in table 2.

Table 1 Thickness, lattice mismatch and magnetization measured at 300K for some EuYGaIG and EuLaYGaIG films.

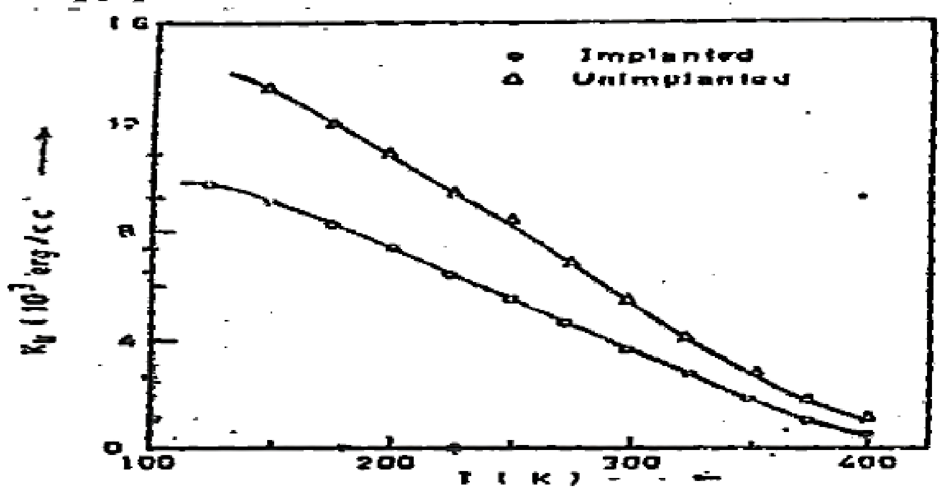
Composition	Thickness h(μm)	Lattice mismatch Δa(Å)	$4\pi M_s$ (G)
$Eu_{0.6}Y_{2.4}Ga_{0.9}Fe_{4.1}O_{12}$	4.93	0.034	215
$Eu_{0.6}Y_{2.4}Ga_1Fe_4O_{12}$	7.79	0.034	205
$Eu_{0.1}La_{0.2}Y_{2.7}Ga_{1.15}Fe_{3.85}O_{12}$,	3.60	0.020	194

Table2 Uniaxial anisotropy (K_u) and g_{eff} of unimplanted and implanted EuYGaIG and EuLaYGaIG films measured at 300K.

Composition	Unimplanted film $K_u(10^3 erg/cc)$	g_{eff}	Implanted film $K_u(10^3 erg/cc)$	g_{eff}
$Eu_{0.6}Y_{2.4}Ga_{0.9}Fe_{4.1}O_{12}$	6.9	1.47	5.6	1.48
$Eu_{0.6}Y_{2.4}Ga_1Fe_4O_{12}$	8.9	1.38	7.2	1.37
$Eu_{0.1}La_{0.2}Y_{2.7}Ga_{1.15}Fe_{3.85}O_{12}$,	5.4	1.96	3.7	1.96

Since the implanted layer is only about 2000Å thick, the observed anisotropy through ESR is dominated by the growth induce uniaxial anisotropy of the film. . It has been observed that the uniaxial anisotropy of the implanted film is always smaller than that of the unimplanted film. It was also observed that the uniaxial anisotropy of implanted film is lower than that of the unimplanted film at all temperatures as shown in figures.1 to 2. Thus ion implantation suppresses the growth - induced uniaxial anisotropy perpendicular to the film by introducing a stress - induced anisotropy parallel to the film.

sotropy parallel to the film.



IG.1 –DEPENDENCE OF K_u ON TEMPERATURE FOR IMPLANTED AND UNIMPLANTED FILMS OF COMPOSITION $Eu_{0.1}La_{0.2}Y_{2.7}Fe_{3.85}Ga_{1.15}O_{12}$

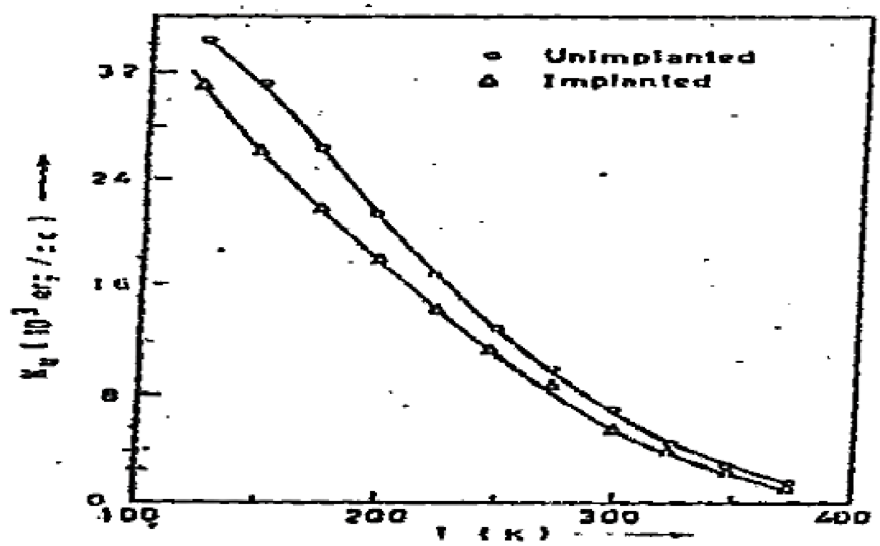


FIG.2 – DEPNDENCE OF K_u ON TEMPERATURE FOR IMPLANTED AND UNIMPLANTED FILMS OF COMPOSITION $Eu_{0.6}Y_{2.4}Fe_{4.1}Ga_{0.9}O_{12}$

The values of g_{eff} of implanted film do not differ much from those of unimplanted film. Since there is no compositional modification due to the implantation process, g values do not change, as observed in table 2.

3.2 FMR line width

We have measured the ΔH_{11} and ΔH_1 of the implanted and unimplanted films. The values of ΔH_{11} and ΔH_1 at room temperatures are listed in table 3.

Table 3 FMR line width, H11 and H1 for unimplanted and implanted EuYGaIG and EuLaYGaIG films measured at 300K.

Composition	Unimplanted film ΔH_{11}(Oe)	Unimplanted film ΔH_1(Oe)	Implanted film ΔH_{11}(Oe)	Implanted film ΔH_1(Oe)
$Eu_{0.6}Y_{2.4}Ga_{0.9}Fe_{4.1}O_{12}$	130	380	140	200
$Eu_{0.6}Y_{2.4}Ga_1Fe_4O_{12}$	200	260	220	320
$Eu_{0.1}La_{0.2}Y_{2.7}Ga_{1.15}Fe_{3.85}O_{12}$,	35	90	50	30

It was observed that there is a general tendency that ΔH_{11} increases while ΔH_1 decreases in the ion implanted film.

3.3 Collapse field.
We have measured collapse field for implanted and unimplanted films, the value of which are given in table 4

Table 4 Values of collapse field of unimplanted and implanted EuYGaIG and EuLaYGaIG films measured at 300K.

Composition	Unimplanted film Collapse field(Oe)	Implanted film Collapse field(Oe)
$Eu_{0.6}Y_{2.4}Ga_{0.9}Fe_{4.1}O_{12}$	45-60	45±5
$Eu_{0.6}Y_{2.4}Ga_1Fe_4O_{12}$	62-82	65±5
$Eu_{0.1}La_{0.2}Y_{2.7}Ga_{1.15}Fe_{3.85}O_{12}$,	75-100	75±5

It is observed that there is a smaller scatter in the collapse field which indicates that the hard bubbles have been suppressed by ion implantation

4.0 CONCLUSION

The effect of ion implantation on LPE - grown thin films of composition $Eu_{0.6}Y_{2.4}Ga_yFe_{5-y}O_{12}$.
(y = 0.9, 1) and $Eu_{0.1}La_{0.2}Ga_{1.15}Fe_{3.85}O_{12}$,have been studied. We have measured the resonance line widths ΔH_{11} , ΔH_1, g_{eff} and K_u for the unimplanted and implanted films in the temperature range 85 K to Tc (430 K). We have also measured the collapse field for the unimplanted and implanted films at 3 00K. It was found that ion implantation suppresses the K perpendicular to the film by introducing a stress — induced anisotropy parallel to the film. It has been observed that uniaxial anisotropy of the implanted film is always smaller than that of the unimplanted film. It also observed that uniaxial anisotropy of the implanted film is lower than that of the unimplanted film at all temperature. It is observed that the smaller scatter in the collapse field for implanted film, which indicates that the hard bubbles have been suppressed by ion implantation.

REFERENCES

A. P, Molozenoff (1972) Interacting Bloch lines: a new mechanism for wall energy in bubble domain materials Appl. Phys. Lett. 21, 149.

B. Uma Maheshwar Rao, P. Mukhopadhyay and C. M. Srivastava(1986) Ferromagnetic relaxation in LPE-grown Eu-Ga substituted yttrium iron garnet films J. Appl. Phys. 60,3656.

H. A . Aigra amd J. M. Robertson, (1980) The effects of ion implantation on La, Ga:YIG films as observed by spin wave resonance , J. Magn. Magn. Mat. 15-18,1107

Osamu Okada and Hiroko Honda, (1986) Magnetization and Uniaxial Anisotropy Measurements for He^+ and H_2^+ Implanted Garnet Filmus, Japan J. of Appl. Phys. 25, 1203.

R. Wolfe, J.C. North and Y. P. Lai, (1973) Crystalline and magnetic properties of an ion-implanted layer in bubble garnet films, Appl. Phys. Lett.22,15.

R. Wolfe and J.C. North, (1972) R. Wolfe, J.C. North and Y. P. Lai, (1973) Suppression of hard bubbles in magnetic garnet films by ion implantation: Dependence on ion species, dose, energy, and annealing, Bell Syst. Tech.J.51,1436.

S. D. Rosenbaurn(1968), Cytokine gene expression and gene therapy in experimental corneal ...
soild state. Eletron. 11, 711,

V. V. Nemoshkalenko, B.K. Ostafiichuk, V. A, deiriik, V. D. Fedoriv, A. Yu Grinchenko and N. A. Skakun, Soy(1990) Ion channeling investigations of the oxygen displacements in $La_{2-x}Sr_xCuO_{4-\delta}$ and $Nd_2CuO_{4-\delta}$. Phys.Solid State 32,418.

W.L. Tabor, A. H. Boback, G.P. vella (1972) Magnetic characterization of bubble garnet films in an LPE growth facility, Coleiro and A. Rosencwaig, Bell Syst. Tech. J. 51, 1427.