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EPITAXIAL GARNET FILMS FOR MICROWAVE ELECTRONICS

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The technology of growth the substituted yttrium-iron monocrystalline garnet films (YIG) on the monocrystalline substrates of the gallium-gadolinium garnet (GGG) with the orientation (111) by the isotermal dipping method of liquid phase epitaxy was carried out. The penetration of La^{3+} ions into structure of YIG leads to decreasing of lattice mithmatch between the ferrite film and substrate .The control of growth speed of the epitaxial films on the whole process of growing and application of the compulsory mixing of melt-solution of oxides enables to receive the films with homogeneous thickness and small magnetic losses. The penetration into the YIG structure films the non-magnetic Ga^{3+} and La^{3+} ions considerably improves their thermostabillity without an essential increasing of the ferromagnetic resonance linewidth (FMR).

At the present time to the equipment of the communication and radiolocation set the next pertain requirements: the increasing of their rapid and reliability, weight and size decreasing, the stabilization of the parameters at use of integral technology. These requirements use content in apparatus, which are worked in the surface magnetostatic waves. As a working medium the monocrystalline epitaxial ferrite films with the garnet structure are used.

We have worked the technology of growth yttrium iron-monocrystalline films $Y_3Fe_5O_{12}$ with magnetization equel 1750 G and substituted by Ga^{3+} and La^{3+} YIG films with magnetization equal 1000-1200 G and diameter to 80 mm. Their thickneses are from one to hundred units μm. The obtained films are practically without deffects and have homogeneous magnetic properties over the diameter and thickness.

The monocrystalline ferrite garnet films heve been grown on the monocrystalline substrates of GGG by the liquid phase epitaxy method from the melt-solution of the ferrite mixture which are based on flux PbO - B_2O_3 .

For the receiving the YIG thick ferrite films with narrow FMR linewidth the part of ytrrium ions are replased to La^{3+}- ions, which have larger ion radius The main factor, which influence on the films quality is the operation of growth speed during the whole technological process. The dependence of films lattice parameter from growth speed is measured. It has been established that when the lattice parameter of the film (a= 13.383A^0) and substrate from GGG is coincide then the

optimal growth speed is equal 0.4-0.55 mm/s. The change of the growth speed is caused by the decrease of concentration of garnet formative components in all volume of melt-solution,the for-mation of the gradient of concentration on the front of crystallisation and the temperature vibration in growth reactor.

At studing the deposite degree of each of these factors we established:

1) the growth speed of films is proportional to the degree of overcooling ΔT of melt - solution;

2) if molar coefficient R_1 increases at one unit the point of saturation decreases at 5,6 K and with the decreasing of the coefficient R_4 at one unite the point of saturation increases at 26 K;

3) the growth speed is proportional to square root from speed rotation of substrate.

Using method of control of growth speed and restoration of the properties of melt-solution [1] we obtained the qualitative YIG films to 80μm of thickness with ΔH parameter which lies in range from 0,50 oE to 0,65 oE and lattice parameter from 12.3819A^0 to 12.3833 A^0 .

The simultaneous Ga^{3+} ions and La^{3+} ions input in garnet structure permit to keep (to compare to clear YIG) the parameter of crystalline lattice practicaly without changing. For growth the $Y_{3-y}La_yFe_{5-x}Ga_xO_{12}$ ($0,17 \le x \le 0,90$; $0,038 \le y \le 0,15$) films we selected composition of melt-solution of ferrite mixture with molar Blank-Nilsen coefficients [1]:

$$R_5 = Y_2O_3/La_2O_3 = 6 \quad \text{and} \quad R_2 = Fe_2O_3/Ga_2O_3 = 29$$

for films with $4\pi M_s$ = 1000 G and R_5 =6, R_2 =21 for films with $4\pi M_s$ = 1200 G.

It is established for both compositions that the growth speed of film V_f with inclination equal 0.0042 μm/sK linearly increases when the degree of overcooling ΔT of the melt-solution changing from 0 to 30 K.The dependence of the magnetisation $4\pi M_s$ from growth speed also has linear character that is explained by the dependence input coefficient of gallium in composition of the ferrite film upon on degree overcooling. The value scattering of saturation of magnetization lies in range from 3 % to 10 % over the disk square and depends on rotation speed of substrate in melt-solution. It has been established that with V_f increasing the disordering Δa lattice parameters of substrate and ferrite films decreases and we conect it with increasing the degree of input of La^{3+} ions in ferrite film. The measurement of ferromagnetic resonance linewidth ΔH has been carried out by "magnetic hole" method which permit to do undestructive control of ferrite films. We obtained ferrite films with ΔH parameter which lies in the range from 0,40 to 0,70 oE. The value scattering of ΔH is 10 % - 15 % over the disk square and depends on the diameter of substrate. For every film the difference of thicknesses over the disk square was estimated by interferention metod and it was less than 6% - 7%. The dependence of ΔH for $Y_{3-y}La_yFe_{5-x}Ga_xO_{12}$ films is shown on Fig.1.

The angle dependence of resonance field at 295 K for $Y_{3-y}La_yFe_{5-x}Ga_xO_{12}$ films was investigated.The dependence of resonance field H_r on the angle α, which is formed by the direction of external magnetic field, changes according to the Acos2α law (Fig 2).

The single crystalline ferrite garnet films of composition $Y_{3-x}Gd_xFe_5O_5$ (x=1.77, 1.80, 1.83, 1.89) have been grown by liquid phase epitaxy on nonmagnetic (111) $Sm_3Ga_5O_{12}$ substrates. The films thicknesses were near 5-15 μm. The ferromagnetic resonance on garnet films at 9.2 GHz frequency in temperature range 77-550 K was investigated. The peak on temperature dependence of FMR linewidth ΔH with the gap in compensation point of ferrite was discovered. The anomaly of ΔH near T_c is caused by the change of the films magnetic structure which is connected with the origin noncollinear magnetic structure in iron and gadolinium sublattice. We have discovered that saturation magnetization value of $Y_{3-x}Gd_x Fe_5O_{12}$ ferrite films is constant practically in the wide

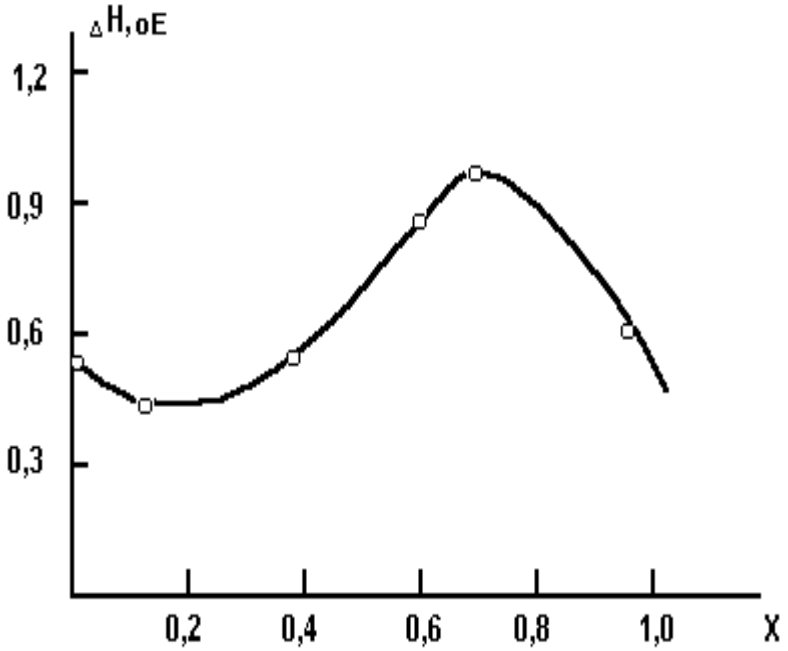

Fig. 1. The dependence of FMR linewidth from x for $Y_{3-y}La_yFe_{5-x}Ga_xO_{12}$ films at T=295 K

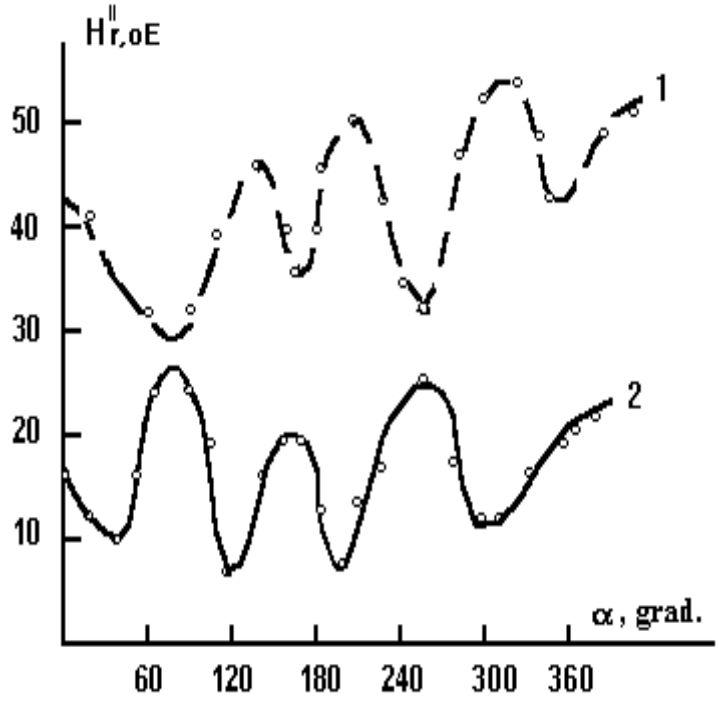

Fig. 2. The angle dependences resonance field of $Y_{3-y}La_yFe_{5-x}Ga_xO_{12}$ films at T=295 K: 1-x=0,16 and y=0,038; 2- x=0,4 and y=0,058

temperature range. When temperature is increased from 270 to 400 K the saturation magnetization value is decreased only by 5 %.

For the improvement of the parameters of ferrite films and their time stability the method of the temperature treatment of the ferrite films in the stream of dry oxygen has been worked out.

We worked out and made the diminutive variable filter on the monocrystalline $Y_3Fe_5O_{12}$ film with 20 μm of thickness. The filter is designed for narrow-band filtration of law power radio signal frequencies of decimetre range. Signal is carried out at resonance frequencies of magnetostatic waves excited in magnetised epitaxial film of yttrium iron garnet. Filtration frequency varies upon changing the value of the applied magnetic field. The magnetic field is formed by a portable screened magnetic system, which has a mechanical and electrical adjustment of field value and, hence, filter frequence. Mechanical variation range of filter frequency is (0.4-4) GHz, electronic variation range of filter frequency is 1 GHz, signal attenuation at central filtration frequency not exeeding 4 dB, filtration bandwidth at 3 dB level not exeeding 8 MHz. The filter can be used in metering instruments, systems of analog processing of microwave signals as well as in input microwave sections of radio and television tuners.

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ASPECTS OF EMC- EVALUATION OF LIN TRANSCEIVERS

With this paper a proposal for EMC- Evaluation of LIN (Line Integrated Network)-Transceiver is presented. It is based on EMC- standards for semiconductors and automotive applications and can be applied to Stand Alone LIN Transceiver and Embedded Systems with an on chip LIN Transceiver (Automotive System Basis Chips). At this time there are positive experiences by using this evaluation proposal on LIN Transceivers from different manufactures and samples in the last two years. It can be shown, that the results of the measurements have a very good reproducibility.

The proposal for EMC- Evaluation of LIN- Transceivers is based on the same procedure as EMC- Evaluation of CAN – Transceivers, witch is successful implemented in Transceiver evaluation for automotive applications and has a correlation to vehicle measurements.

1. GENERAL EMC- REQUIREMENTS ON SEMICONDUCTORS IN VEHICLES

To guarantee the EMC of semiconductors in automotive applications different tests on vehicle and component level were done up to now. On account of short development cycles it isn't valid to solve the EMC- problems of a semiconductor device in the last period of development of