Growth of Pure YIG Epitaxial Films from Pb-Free Flux

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The yttrium iron garnets $Y_3Fe_5O_{12}$ (YIG) films have been shown to be a prospective material for microwave devices, magneto-optic (MO) applications as well as spintronics [1-2]. For growth garnet films by liquid phase epitaxy (LPE) method the most commonly used flux is PbO–B$_2$O$_3$ (PB) of Bi$_2$O$_3$-based. However, the uses of such fluxes are contaminated films of Pb$^{2+}$, Pb$^{4+}$ and Pt$^{4+}$ ions, which have negative effect on properties of garnet films. To avoid this problem, the use of Li$_2$MoO$_4$-based flux has been proposed in [3].

This work is focused on growth process by LPE method of pure $Y_3Fe_5O_{12}$ films from PbO-free flux, investigation of surface morphology and magnetic properties of grown films.

The YIG films were grown by LPE method on (111)-oriented gadolinium gallium garnet (GGG) substrate from a melts based on the Li$_2$MoO$_4$–MoO$_3$ (LM) flux. Melt compositions and molar ratios was choose to ensure garnet primary phase crystallization and remain to the binary join of Li$_2$MoO$_4$–$Y_2$(MoO$_4$)$_3$ on phase diagram (Fig. 1a). The technological experiments were carried out in a temperature range 950…1050 °C. Growth rate of YIG films was changed from 0,1 to 0,3 $\mu$m/min. Films thickness till to 9 $\mu$m.

In the YIG films grown from LM flux, uncontrolled impurity of Pt or Pb were not detected. The composition of the grown films corresponds to pure stoichiometric yttrium iron garnet. All grown films demonstrate a mirror surface, however, with an increase of film thickness the surface roughness was observed.

The YIG films grown from LM flux demonstrate FMR linewidth $\Delta H$ around 5...6 Oe, which 6 times more than for YIG grown from PB flux ($\Delta H < 1$ Oe).

In-plane anisotropy field for YIG films grown form LM and PB fluxes equal to 2,7 and 2,6 Oe (fig1.b). Saturation magnetisation of films grown from both fluxes close to theoretical value equal to 1750 G, but difference in magnetisation curves has been observed (fig1.c).

Such differences in the magnetic properties, apparently, connected with the peculiarities of growth mechanisms of YIG films from LM flux and require further investigation.