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THE INFLUENCE OF ION TREATMENT ON THE PROPERTIES OF RARE EARTH IRON-GARNET FILMS

ABSTRACT. *In present work the results of analyzes of chemical elements distribution on "film-substrate" interface of deposited ferrite-garnet films before and after thermal annealing are presented. It's shown the role of both thermal The paper presents the results of studying the features of the structural, optical and magneto-optical properties of epitaxial iron-garnet films (EIGF), which doped by rare-earth elements, after inhomogeneous ion etching through a mask. It was shown that when using a cylindrical mask, an EIGF etching profile nearly to elliptical is formed. The thickness of the EIGF in different parts of the etching profile determines the form of the transmittance and the magneto-optical Faraday effect spectra. diffusion and ionic stimulated diffusion for formation of profile of elements distribution. It has been proposed the method of reconstruction of "real" form of interface profile before the ionic beam influence.*

INTRODUCTION

For the effective use of epitaxial iron-garnet films (EIGF), their surface is often subjected to ion-plasma treatment. This is necessary both as a post-growth treatment (removal of the surface layer) and to give a certain profile (removal of edge stresses, form-factor, etc.). Also, the layer-by-layer etching technique can be used to study the internal structure of the film and the size dependences of the magnetic and magneto-optical effects. So the topical issue is to study the effect of ion treatment on the properties of such films.

It is known that the influence of high-energy ions on the surface of a solid body leads to a modification of its physical properties, which must be taken into account when designing final devices. This work is devoted to the study of the features of changes in the structural, optical, and magnetic properties of iron-garnet films after ion etching.

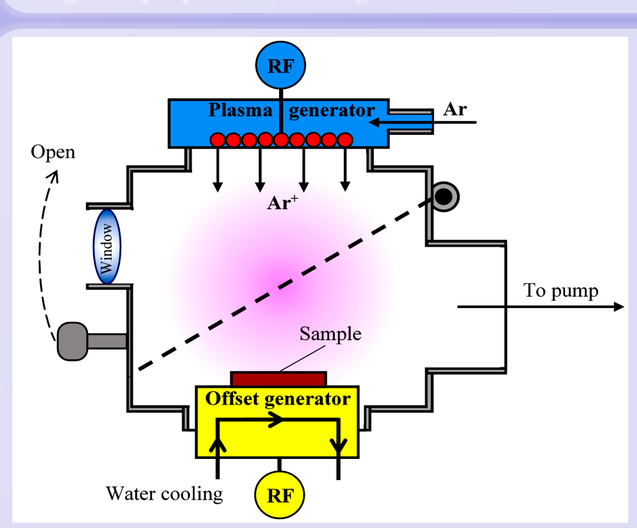


Fig. 1 – The scheme of the reactor chamber of the vacuum machine for ion-plasma etching.

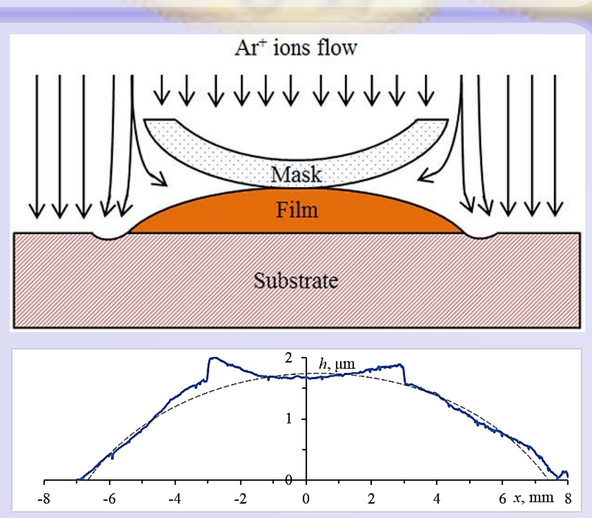


Fig. 2 – Spatially inhomogeneous etching through a cylindrical mask and EIGF profile after etching.

FERRO-MAGNETIC RESONANCE

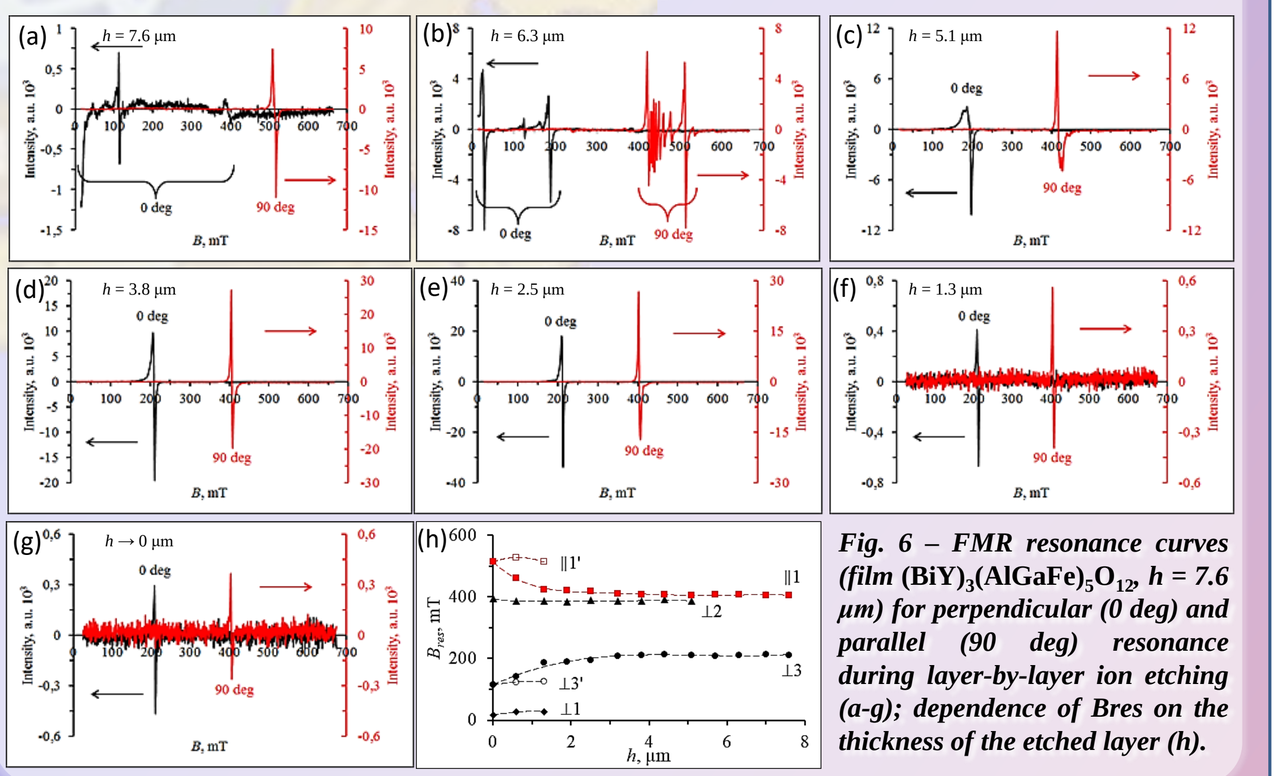


Fig. 6 – FMR resonance curves (film $(BiY)_3(AlGaFe)_5O_{12}$, h = 7.6 μm) for perpendicular (0 deg) and parallel (90 deg) resonance during layer-by-layer ion etching (a-g); dependence of Bres on the thickness of the etched layer (h).

SURFACE MORPHOLOGY

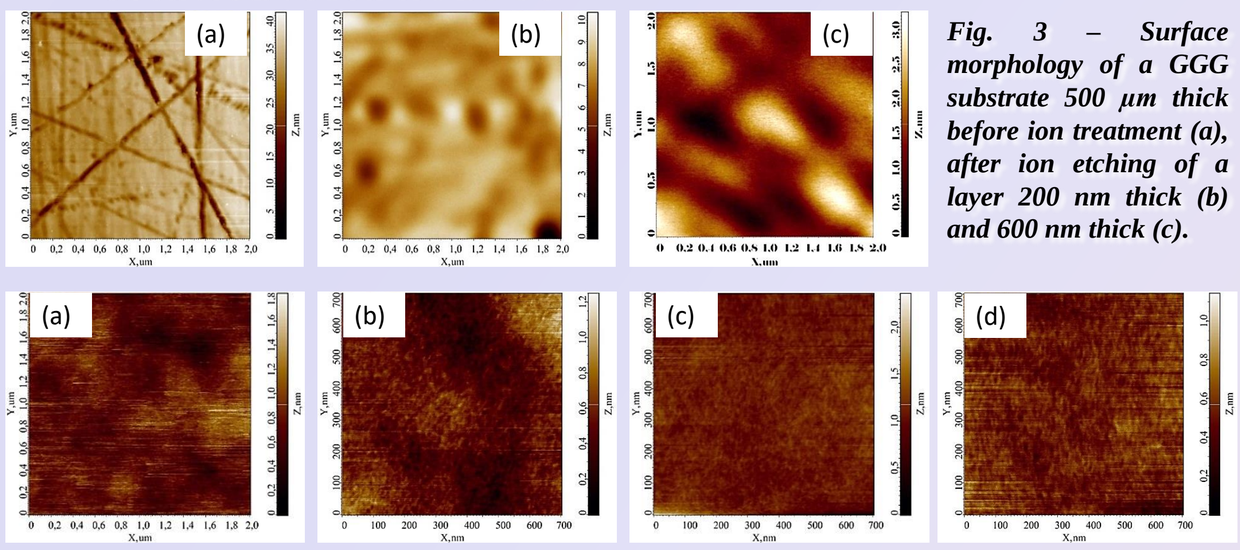


Fig. 3 – Surface morphology of a GGG substrate 500 μm thick before ion treatment (a), after ion etching of a layer 200 nm thick (b) and 600 nm thick (c).

Fig. 4 – Morphology of the EIGF surface after ion etching (film $(BiY)_3(AlGaFe)_5O_{12}$, h = 2 μm): a–d – different sections of the profile from the center to the edge, step of 2.5 mm.

MAGNETO-OPTICAL HYSTERESIS LOOPS

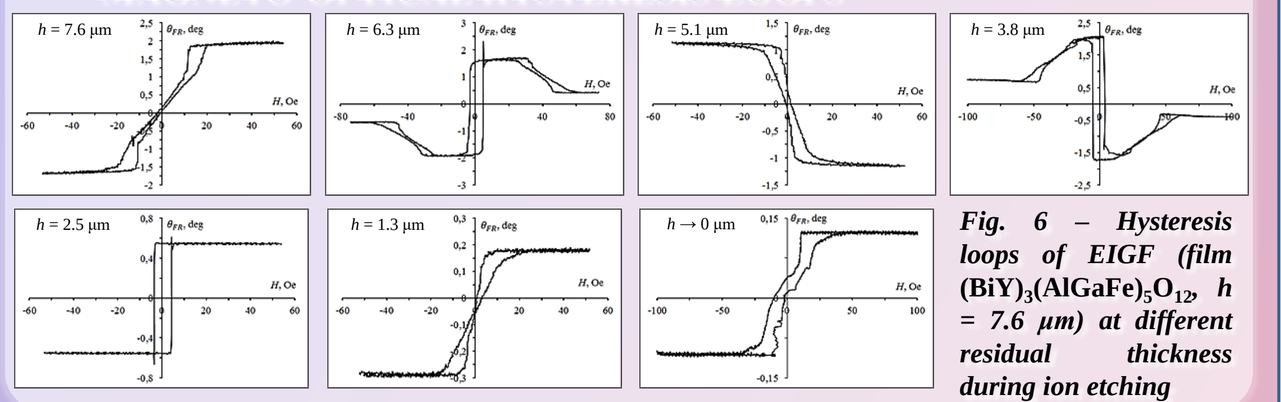
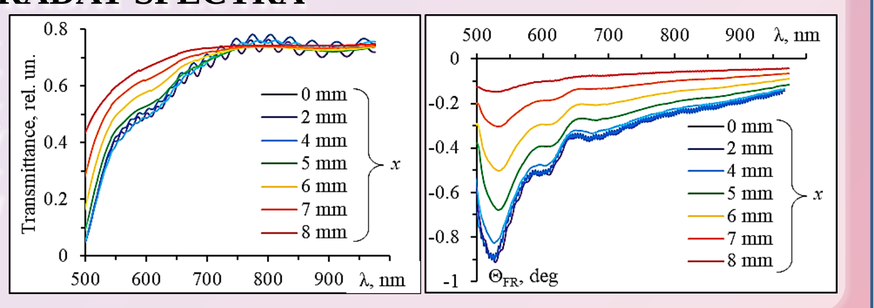


Fig. 6 – Hysteresis loops of EIGF (film $(BiY)_3(AlGaFe)_5O_{12}$, h = 7.6 μm) at different residual thickness during ion etching

OPTICAL AND FARADAY SPECTRA

Fig. 6 – Optical (a) and magneto-optical (b) characteristics of the EIGF in different areas of the etch profile (the coordinates of the areas in millimeters are indicated in the legend and correspond to Fig. 2)



DOMAIN STRUCTURE

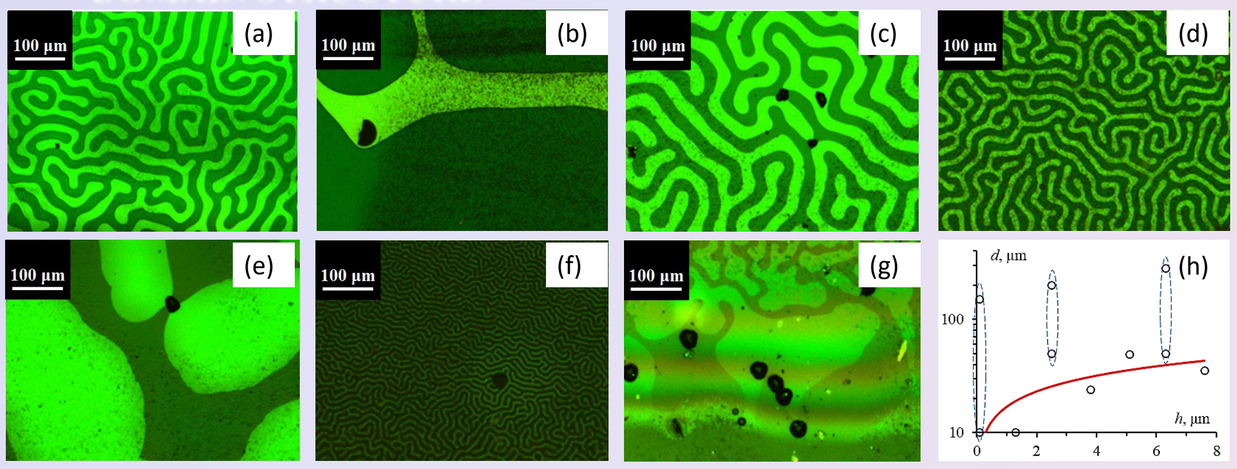
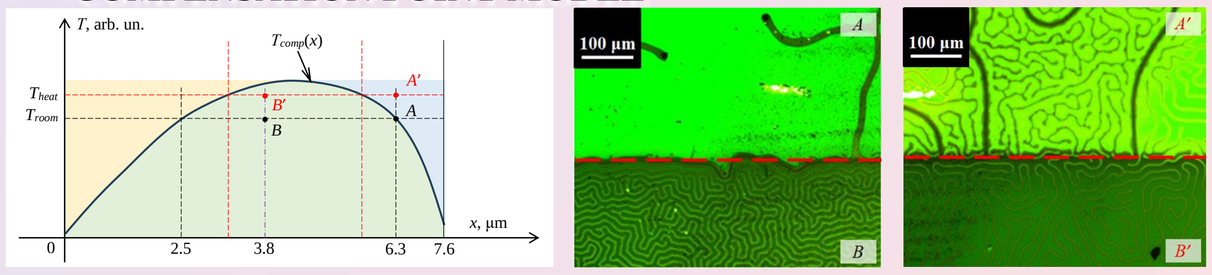


Fig. 5 – Domain structure of EIGF $(BiY)_3(AlGaFe)_5O_{12}$ at different values of the residual thickness: a) h = 7.6 μm (without etching); b) h = 6.3 μm; c) h = 5.1 μm; d) h = 3.8 μm; e) h = 2.5 μm; f) h = 1.3 μm; g) h → 0 μm; h) dependence of the period of the domain structure d on the film thickness h (points – experimental data, line – approximation)

COMPENSATION POINT MODEL



CONCLUSIONS

The influence of ion etching of epitaxial iron-garnet films on their structural, magnetic, optical, and magneto-optical properties has been investigated. It is shown that ion etching of the surface of single-crystal gadolinium-gallium garnet (substrate) leads to a decrease in roughness by more than 6 times down to 0.4 nm, which is less than the lattice parameter of garnet. During ion etching of an epitaxial iron-garnet film the surface morphology is preserved in all areas of the etching profile. The investigation of the domain structure, FMR and magneto-optical analysis show the presents of three layers in the film structure. The properties of these layers are determined by the different state relative to the point of the magnetic sublattices compensation in the garnet. The interfaces between the layers correspond to the transition through the compensation point. It was shown that the position of the layers interfaces can be moved by changing the sample temperature.

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