

different thicknesses. At $d > 150 \text{ \AA}$ there is observed the usual HCP structure of bulky technetium, and the lattice parameters of the thick films practically coincide with those of the bulky sample (Table 1). Technetium films with $d < 150 \text{ \AA}$ have a BCC structure with lattice parameter $a = 3.68 \pm 0.05 \text{ \AA}$.

Table 1
Lattice parameters of HCP technetium modification

| Bulky Tc [3] | Tc films ($d > \text{\AA}$) |
|-----------------------------------|--|
| $a = 2.729 \pm 0.001 \text{ \AA}$ | $a = 2.732 \pm 0.002 \text{ \AA}^{1)}$ |
| $c = 4.379 \pm 0.001 \text{ \AA}$ | $c = 4.381 \pm 0.002 \text{ \AA}^{1)}$ |

The transformation of the metal from one modification to the other is accompanied by a strong increase in the grain size a (see Table 2).

Table 2
Grain size in technetium films with different thicknesses

| d | 17 \AA | 35 \AA | 50 \AA | 75 \AA | 150 \AA | 300 \AA |
|-----|------------------|------------------|------------------|------------------|------------------|------------------|
| a | 100 \AA | 200 \AA | 500 \AA | 600 \AA | 5 μ | 5-10 μ |

We have thus observed in the films the presence of a face-centered cubic modification that is stable at room temperature at thicknesses $d < 100 \text{ \AA}$.

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1) The parameters of the technetium film lattice were determined with a TlCl standard.

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GIANT FARADAY EFFECT AND OPTICAL ABSORPTION IN EPITAXIAL FILMS OF THE SYSTEM $\text{Y}_{3-x}\text{Bi}_x\text{Fe}_{5-y}\text{Al}_y\text{O}_{12}$

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Single-crystal magneto-uniaxial films of the garnet $\text{Y}_{3-x}\text{Bi}_x\text{Fe}_{5-y}\text{Al}_y\text{O}_{12}$ were grown by a liquid epitaxy method. The Faraday rotation, the optic extinction coefficient, the magnetic characteristics of the films, and the domain-structure parameters were measured at wavelengths 0.5 - 1.0 μ . The obtained material was found to have a unprecedented large optical Q factor and a stable cylindrical magnetic domain structure.

An anomalously large level of the Faraday effect (FE) has been observed in single-crystal garnet films of the system $\text{Y}_{3-x}\text{Bi}_x\text{Fe}_{5-y}\text{Al}_y\text{O}_{12}$; it exceeds in the visible band 50,000 deg/cm, which is many times larger than the FE of all known nonmetallic magnets at room temperature. Owing to the large relatively high transparency of the films at wavelengths below 0.5 micron, their magneto-optic Q factor ψ (the ratio of the specific Faraday rotation ϕ_F to the extinction coefficient α) is also unusually large.

Films with compositions $Y_{2.35}Bi_{0.65}Fe_{4.25}Al_{0.75}O_{12}$ (1) and $Y_{2.05}Bi_{0.95}Fe_{3.9}Al_{1.1}O_{12}$ (2) were obtained by liquid-phase epitaxy from a $PbO - B_2O_3 - Bi_2O_3$ solution. The substrates were made of single-crystal Gd-Ga garnets grown by crucibleless zone melting with radiation heating [1].

The film thickness was monitored by interferometry. The optical absorption spectra were obtained with an SF-8 two-beam spectrophotometer. The dependence of the FE on the wavelength was plotted by using a set of dielectric interference filters with transmission half-width ~ 50 Å. The chemical composition of the films was determined with an MAR-2 x-ray spectrum micro-analyzer and polycrystalline standards. The static magnetic characteristics were calculated from the field dependence of the domain-structure parameters [2, 3].

Figure 1 shows the absorption spectra of the films in the visible region of the spectrum, and Fig. 2 shows their magneto-optical characteristics. We see that the FE of film 1 is larger than that of film 2, but the parameter ψ of film 2 is higher, owing to the much higher transparency of the latter. For both compositions, the value of ψ is much larger than for pure yttrium-iron garnets.

When single crystals and films of bismuth-containing garnets are grown from lead solvents, the Pb impurities decrease appreciably the transparency in the visible region. By adding bismuth oxide to the films we were able, as shown by microanalysis, to eliminate almost completely the contamination of the films by lead. Replacement of the yttrium and iron by Bi^{3+} and Al^{3+} ions exerts mutually opposing influences on the transparency of the films. Namely, the aluminum, by diluting the iron sublattices, lowers the intensity of the Fe^{3+} electronic transitions, thus increasing the transparency in the visible and in the near-IR. The bismuth, on the other hand, by shifting the fundamental absorption edge into the long-wave region, contributes to a deterioration of the transparency in the region $\lambda < 0.65 \mu$. The joint action of these mechanisms causes the transparency of film 2 in the visible to be practically the same as for pure yttrium iron garnets.

The growth of the Faraday rotation in iron garnets following introduction of Bi^{3+} ions is customarily attributed to the ensuing additional electronic transitions between the Fe^{3+} ions with tetrahedral environment and the oxygen [4, 5]. Such transitions, with approximate energy 2.6 eV, become possible because of mixing of the orbitals of the bismuth with the orbitals of the oxygen, which leads to a sharp increase of the spin-orbit interaction of the electrons on

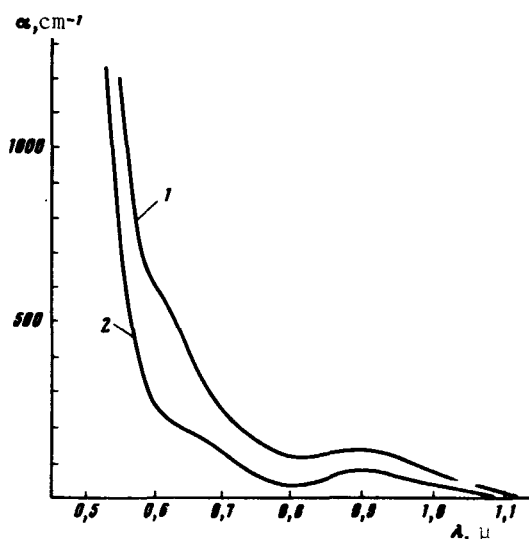


Fig. 1. Absorption spectra in the visible and near IR regions: 1 — $Y_{2.35}Bi_{0.65}Fe_{4.25}Al_{0.75}O_{12}$, 2 — $Y_{2.05}Bi_{0.95}Fe_{3.9}Al_{1.1}O_{12}$.

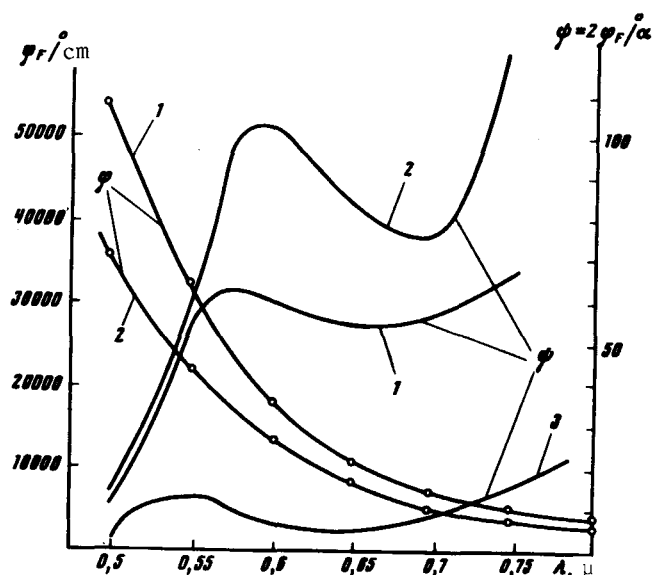


Fig. 2. Per-unit Faraday rotation (ϕ_F) and magneto-optical quality (ψ) in the visible region: 1 — $Y_{2.35}Bi_{0.65}Fe_{4.25}Al_{0.75}O_{12}$, 2 — $Y_{2.05}Bi_{0.95}Fe_{3.9}Al_{1.1}O_{12}$, 3 — $Y_3Fe_5O_{12}$.

the 2p oxygen orbital [4]. The anomalously high level of the FE observed by us in films containing appreciable amounts of aluminum casts doubt on the correctness of the indicated mechanism, since the Al^{3+} ions replace the Fe^{3+} ions predominantly in the tetrahedral positions, and this should hinder the growth of the FE in accord with [3, 4].

Magnetic properties and parameters of the domain structure of films of the system $\text{Y}_{3-x}\text{Bi}_x\text{Fe}_{5-y}\text{Al}_y\text{O}_{12}$

| Film comp. | Thickness μ | Average CMD diam. μ | Coercivity H_c , Oe | Uniaxial anisotr. field H_k Oe | Saturation mag. $4\pi M_s$, G |
|------------|-----------------|-------------------------|-----------------------|----------------------------------|--------------------------------|
| 1 | 6.9 | 2.0 | 1.0 | 1300 | 700 |
| 2 | 1.05 | 1.3 | 0.5 | 1500 | 350 |

The table lists the main magnetic characteristics of the films and the domain-structure parameters. We see that the ratio of the uniaxial-anisotropy field H_k to the saturation magnetization $4\pi M_s$ exceeds unity for both compositions, so that stable existence of cylindrical magnetic domains (CMD) is possible in the films. When observed in a polarization microscope, the strip and cylindrical domains exhibited a rather high optical contrast, attributed to the large values of the parameter ψ .

In view of the unprecedentedly large values of the magneto-optical quality and the existence of strip and CMD domain structure with low coercivity, the films with the investigated compositions are of practical interest for the development of magneto-optical devices using CMD and strip domains, and especially optical transparencies for holographic memory devices of large capacity.

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TEMPERATURE DEPENDENCE OF THE INTENSITY OF THE CHARACTERISTIC ENERGY LOSSES OF 2p ELECTRONS OF IRON IN CEMENTITE

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A sharp decrease in the intensity of the characteristic losses was observed in an experimental electron-spectroscopy study of the spectra of the $2p_{3/2}$ level of iron in cementite at temperatures below and above the Curie point. This decrease is attributed to a decrease in the number of uncompensated 3d electrons of the iron on going from the ferromagnetic to the paramagnetic state.

One of the applications of the electron-spectroscopy method [1] is its use for the study of magnetic materials. In transition-metal compounds, the presence of uncompensated 3d electrons, which are responsible for the magnetic properties, leads to multiplet splitting of the internal levels [2, 3] and to effects of multielectron excitation (shake effects) [4, 5], as a result of which an intensive extended structure (in the binding-energy scale) is produced on the high-energy side of the fundamental line. This structure is superimposed on the region of the characteristic electron energy losses inherent in the electronic spectra of solids, and are