plastically deformed aluminum layer, and an outer elastically stressed aluminum layer should be considered. Then the stress reduction with the film thickness can be explained by the expansion of the transition layer. With thin aluminum films, the aluminum yield point increases almost by the order and therefore the relaxation of the stresses is difficult.

IV. CONCLUSIONS

Thus, in this paper the analysis of the internal stresses in deposited aluminum layers is demonstrated and dependences of the internal stresses on the thickness of the aluminum films deposited at various substrate temperatures and evaporation rates are studied. The study may be applied to fabricate the nanoporous alumina coatings for different kinds of high-sensitive sensors.

ACKNOWLEGMENTS

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INFRARED AND VISIBLE PHOTOLUMINESCENCE FROM Er-DOPED SOL-GEL DERIVED FILMS

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I. INTRODUCTION

The formation technologies of the erbium-doped materials and film structures on their basis have received an enormous interest due to their applications in the laser physics, planar optoelectronics [1], solar energy [2, 3], biomedicine [4] etc. Most of the studies carried out nowadays are focused on the optical 4I13/2 – 4I15/2 transitions of the trivalent erbium ions with a maximum at 1.53 µm and on the upconversion processes involving the absorption of the infrared (IR) radiation and an erbium ion emission in the visible wavelength range (anti-Stokes luminescence). Due to that the erbium-doped glasses and coatings can greatly enhance efficiency of the silicon solar cells by absorbing the inefficient IR-radiation and converting it into the visible light.

Among the different film technologies the sol-gel technology is relatively low-cost for the erbium-doped materials production. In this paper we have studied the Stokes and anti-Stokes luminescence of the erbium ions in titania films and yttrium alumina composites formed by a sol-gel method on the monocrystalline silicon and the silicon/porous anodic alumina substrates. The presence of the porous anodic alumina (PAA) improves the adhesion of the phosphor layer to the substrate, which is important for the high-temperature (about 1000 °C) synthesis required for erbium optical activation in most of the materials.

II. EXPERIMENTAL PART

Titania sols were synthesized on the basis of titanium isopropoxide with the addition of ethylene glycol monomethyl ether, acetone and acetylacetone or ethanol-aqueous solution of citric acid with distilled water and nitric acid. Erbium nitrate was used as a dopant. The components ratio in the sol was Ti:Er = 2:1.

Yttrium alumina garnet (YAG) sols were prepared from the aluminum, yttrium and erbium nitrates with addition of the distilled water, ethanol and citric acid. The erbium concentration in the sol was 0.023 mol/l.

The erbium-doped films on the monocrystalline silicon and silicon/PAA substrates were fabricated by spinning followed by the drying of each layer at 200 °C. Finally all xerogel/substrate structures were heat treated at 1000 °C in air.

Visible and IR photoluminescence (PL) of the Er-doped structures was examined.

The strong infrared luminescence with the maximum at 1.53 µm was obtained from the erbium-doped garnets and titania. Figure 1 shows the typical IR PL spectra of Er-doped films under 532 nm excitation.
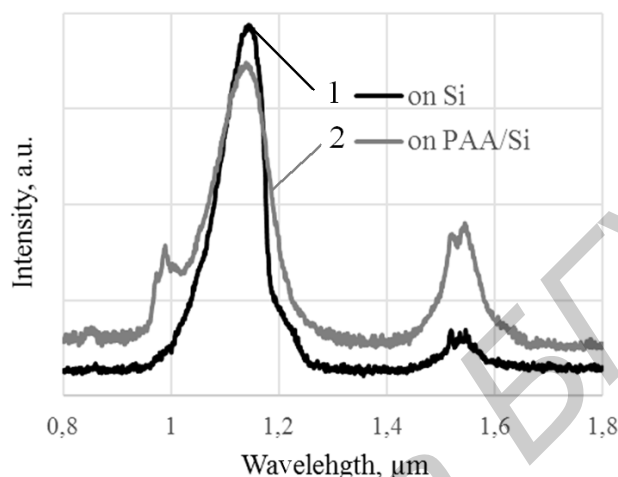

Figure 1 – PL spectra of the TiO2:Er films deposited on two substrates: 1 – on Si, 2 – on PAA/Si

There is the main PL peak at 1.53 µm related with the interatomic transitions from the excited 4I13/2 to the ground 4I15/2 state of erbium trivalent ions. PL bands with the maxima at 1.14 µm are associated with the interband recombination in the silicon substrates. The appearance of the PL band at 0.987 µm is associated with transitions $4I11/2 \rightarrow 4I15/2$ of Er ions.

Erbium upconversion with the visible light emission bands at 550 and 670 nm was observed for the film structures comprising $Al_5Y_{2,71}Er_{0,29}O_{12}$ xerogels deposited onto porous anodic alumina/silicon (Figure 2). The signal was observed under excitation with the 3W laser operating at 1.53 µm.
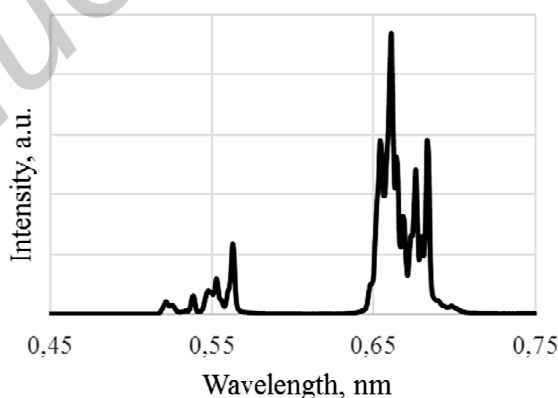

Figure 2 – PL spectrum of the YAG:Er films deposited on Si/PAA substrates under 1.53 µm excitation

III. CONCLUSIONS

Er-doped film structures were fabricated using the sol-gel technology. The fabricated coatings demonstrate room-temperature erbium Stokes PL at 1.53 µm and the anti-Stokes (upconversion) PL at 550 and 670 nm. Thus, the erbium-doped coatings produced by the sol-gel method on silicon and Si/PAA structures receive interest for the silicon solar cells applications.

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LATTICE VIBRATIONS IN FeIn$_2$S$_4$ SINGLE CRYSTALS

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I. INTRODUCTION

The spinel structure compounds are one of the most important and most comprehensive studies of all structure types. The spinel structure compounds are used in photo-electronic and optical applications [1] due to the wide band gap observed in these structures. The studies of spinel structure compounds also have numerous applications in geophysics and magnetism [2–4]. The ferromagnetic properties of some spinels are also of great importance in solid state chemistry.

Lattice dynamical calculations is a valuable tool for the detailed analysis of the vibrational spectra, information on bonding, structure and the dynamics of the spinel structure compounds.

II. EXPERIMENTAL

The single crystals of FeIn$_2$S$_4$ were grown by the method of directional crystallization of an almost stoichiometric melt of this compound. The synthesis of FeIn$_2$S$_4$ crystals was carried out by the two temperature method from the parent elements of purity no less than 99.999 wt. %. To suppress the dissociation of the compound and obtain a composition of necessary stoichiometry, we created a pressure of sulfur vapors of ~1.5 atm. over the melt and conducted cooling of the FeIn$_2$S$_4$ melt in the regime of the switched off furnace. The ingot synthesized was ground and placed into a double quartz ampoule; the internal ampoule had a cylindrical capillary at its end, which ensured the formation of the single crystals seeding. After the evacuation of the ampoule to a residual pressure of ~10^{-3} Pa, it was placed into a vertical one zone furnace. The temperature in the furnace was increased at a rate of ~100 K/h to 1400 K and, for the homogenization of the melt, was maintained at this temperature for 2 h, after which the directional crystallization of the melt was conducted by reducing the temperature at a rate of ~2 K/s until complete solidification of the melt. For the homogenization of the ingots obtained, they were annealed at ~1020 K for 150 h. This regime made it possible to reproducibly grow single crystals ingots with a diameter of ~14 mm and a length of ~40 mm.

Raman and IR spectra of the FeIn$_2$S$_4$ compound were obtained on the Fourier spectrometer FIR–30 in the frequency range 50–500 cm^{-1} at room temperature with a resolution of 2–4 cm^{-1}.

III. VIBRATIONAL ANALYSIS

The crystal structure of spinel AB$_2$S$_4$, classified as the HI1 space group O_h^7 (Fd3m), is cubic and consists of a slightly distorted cubic close-packed arrangement of S–ions with the A and B–ions occupying 1/8 of the tetrahedral and 1/2 of the octahedral interstices, respectively (normal spinel) [5]. An inverse spinel has one half of the B–ions occupying the tetrahedral sites and the other half of the B–ions and the A–ions occupy the octahedral sites. In the present paper only normal spinel structure compounds are considered. In normal spinels, the deviation from the cubic close–packed structure consists of a displacement of the S–ions by an amount $\sqrt{3}\delta$ away from the occupied tetrahedral sites. For an ideal spinel $\delta = 0$.