Synthesis and Photoluminescence of Strontium Titanate Xerogels Doped with Terbium, Ytterbium and Europium

M. V. Rudenko, T. F. Raichenok, N. V. Mukhin, and N. V. Gaponenko

Abstract Terbium, ytterbium and europium doped strontium titanate thin films and undoped strontium titanate powder were synthesized using sol-gel method. Xerogel was deposited by spin-on technic on monocrystalline silicon and porous anodic alumina substrates formed on monocrystalline silicon. Structure and photoluminescence of obtained films were investigated. Doped strontium titanate xerogel films show photoluminescence spectra with emission bands caused by electron transitions of relevant rare earth dopant. The broad photoluminescence band of the undoped $SrTiO_3$ powder at 300–400 nm is detected.

The doping of materials having perovskite structure with rare earth elements (REE) is prospective for the creation of effective phosphors. Strontium titanate, $SrTiO_3$ with a perovskite structure has found wide application in the manufacture of electronic components. The introduction of various rare-earth elements into strontium titanate makes it possible to observe strong luminescence in the blue, green or red spectral ranges [1]. In this connection, the study of luminescence in a wide band gap material such as strontium titanate doped with REE receive interest in the development of new functional materials for optoelectronics and lighting engineering [2]. In addition, the high radiation stability of strontium titanate is of considerable interest for the creation of X-ray converters [1]. Strontium titanate properties depend not only on its chemical composition, but also on its structure, shape and grain size [3]. Sol-gel synthesis of strontium titanate films is of particular interest, since this technology is low cost and allows tailoring the

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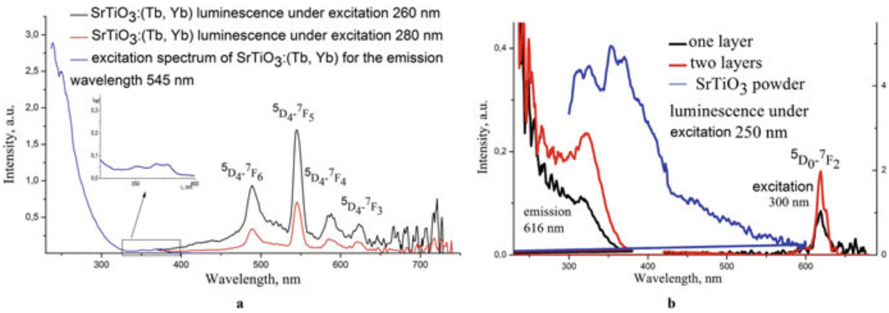

Fig. 1 The excitation and luminescence spectra of the structures of $SrTiO_3$:(Tb, Yb)/PAA/silicon and $SrTiO_3$:Eu/silicon and $SrTiO_3$ powder

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The xerogels doped with REE (Tb, Yb, Eu) were synthesized on monocrystalline silicon and in porous anodic alumina (PAA) formed on silicon by sol-gel route from sols based on titanium isopropoxide, nitric acid salts of strontium and REE and ethylene glycol monomethyl ether. The use of highly ordered PAA as a carrier matrix for nanoclusters makes it possible to achieve anisotropy of the propagation of light within such a structure and provides an increase in the luminescence intensity due to anisotropic density of photonic states for the emission modes and multiply scattering of exciting light [4, 5]. The PL and PL excitation spectra of the obtained structures were detected by the spectrofluorometer CM2203. A high pressure xenon arc lamp 150 Watt was used as an excitation source. The PL spectra in Fig. 1a, contain the main peaks belonging to the trivalent terbium, corresponding to the transitions $^5D_4 \rightarrow {}^7F_6$, $^5D_4 \rightarrow {}^7F_5$, $^5D_4 \rightarrow {}^7F_4$, $^5D_4 \rightarrow {}^7F_3$ with the most intensive band at 545 nm. The ratios of the components were Sr:(Tb + Yb) = 2.5 and Tb:Yb = 2:1. With a decrease in the excitation wavelength the luminescence intensity increases.

The excitation and PL spectra of $SrTiO_3$:Eu xerogel formed on monocrystalline silicon after annealing at 750 °C contain intensive PL peak at 618 nm corresponding to the transition $^5D_0 \rightarrow {}^7F_2$ of the trivalent europium (Fig. 1b). Sequential deposition of the second layer promotes an increase in the luminescence intensity. The broad PL band of the undoped $SrTiO_3$ powder at 300–400 nm associated probably with oxygen vacancies [6] matches the $SrTiO_3$:Eu excitation band (Fig.1b). One and two layered $SrTiO_3$:Eu xerogel films with high porosity and about 350 and 510 nm thick respectively are shown in Fig. 2. The films are characterized with high porosity contrary to previously fabricated undoped $SrTiO_3$ xerogels synthesized using another solvents [7].

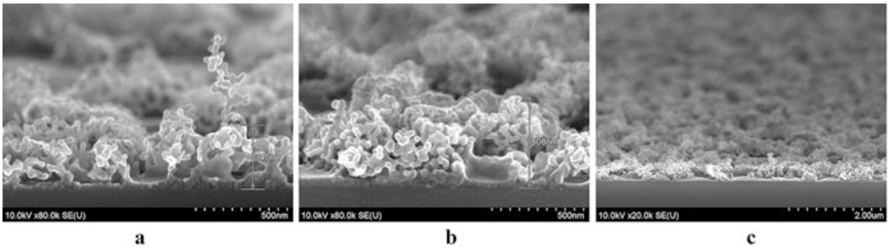

Fig. 2 The SEM images of one (**a**) and two layered (**b** and **c**) $SrTiO_3$:Eu xerogel films

The described porous $SrTiO_3$:Eu xerogel films of structures are prospective for optoelectronic devices through multiple scattering in a porous structure, which contributes to obtaining the optimum luminescent properties.

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