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INVESTIGATION OF COLOUR CENTRES IN $SrLaAlO_4$ AND $SrLaGaO_4$ SINGLE CRYSTALS

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Absorption spectra of $SrLaAlO_4$ and $SrLaGaO_4$ single crystals are investigated as well as their changes after irradiation by γ-quanta (^{60}Co source). Both crystals reveal a similar behaviour that is caused, as it seems, by the same nature of colour centres in them. The conclusion that oxygen defects as well as Fe impurities play a significant role in the colour centres formation in these crystals.

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1. Introduction

The $SrLaAlO_4$ (SLA) and $SrLaGaO_4$ (SLG) single crystals having a tetragonal structure of K_2NiF_4-type are considered as promising substrate materials for high-temperature superconductor (HTSC) film epitaxy and as a laser host material as well. For both applications high quality crystals are required but many investigators [1–5] note a series of difficulties in growing crystals by the Czochralski method. The process of growing is very sensitive to the purity and the technique of raw material preparation, the charge stoichiometry, the growth thermal configuration, the growth and pulling rate, the pulling direction orientation and crystal-melt interface shape, the composition of the atmosphere, etc. Deviations from the optimal growing conditions cause colouring of the crystal to light-yellow, yellow, green or brown colour and may even cause clouding and cracking of the crystal or appearance of foreign phase inclusions [5]. Colouring is more intense when the axial temperature gradient during the crystal pulling is greater. In Ref. [5] it was also noted that crystal colouring was not uniform throughout the bulk of crystal: the core was usually a bit lighter than the outer parts of the crystal.

The present work is devoted to an investigation by optical spectroscopy methods of colour centres in SLA and SLG single crystals grown under different conditions and subjected to the influence of gamma-irradiation.

2. Experimental details

The SLA single crystals were grown in (100) direction by the Czochralski method in nitrogen atmosphere (with 1% oxygen). They were cooled and then stored at room temperature. Flat plates cut out of single crystals perpendicular to the growth axis, were the subjects of the investigation. The thickness of the samples was in the range of 0.27–0.6 mm. One of the SLA samples had no markedly visible colouring [5]. All other SLA samples were yellow coloured of different tints starting from light-yellow to saturated yellow and each of them had inhomogeneity of colouring described in Ref. [5]. The SLG samples under investigation had light-yellow or green colour. The green SLG samples had well-boarded areas of red-brown colour that were disposed on the plates' edges in [001] directions.

Absorption spectra of samples were investigated as well as the additional absorption (AA) spectra induced by the influence of irradiation treatment of the samples. Optical absorption of a sample was calculated from the optical transmission spectra without taking into account the reflection. The induced AA was found by the following formula:

$$\Delta k = 1/d \ln(T_1/T_0),$$

where d is the thickness of the sample, T_0 and T_1 are the optical transmissions before and after the treatment. The optical transmission spectra were registered at room temperature in the range of 50000–11000 cm (0.2–0.9 μm) with the help of a spectrophotometer Specord-M40 attached to PC. The irradiation of the samples with gamma-quanta was executed by ^{60}Co source with an average energy of gamma-quanta of 1.25 MeV to the absorbed dose $10^3 - 10^6$ Gy. The exposition dose intensity was about 170 R/s and the temperature of the sample during irradiation did not exceed 50°C.

3. Results

The typical absorption spectra of the investigated SLA samples are shown in Fig. 1a. In all the samples, the colourless one including, the absorption band is observed in the range of 32000–36000 cm^{-1}. In the coloured samples the band is much more intense and besides it, another band is observed around 26000 cm^{-1} (which, it seems, is probably connected with yellow colouring of the crystals) and as well as darkening near the fundamental absorption edge (FAE). In the coloured samples the darkening in the range of 32000–36000 cm^{-1} has a more complex structure. Beside the quantitative difference of absorption, by comparing curves 1 and 3 in Fig. 1a, a considerable difference in the spectrum shape is displayed which is caused, it seems, by the difference in the absorption spectra's structure. This difference was found and investigated earlier in our work [6]. According to those results the coloured SLA samples may be divided into two groups by the absorption bands observed in the spectra. The majority of them had an absorption band maximum at 33500 cm^{-1} and an absorption near 38000 cm^{-1} against the background of the widened FAE. The second group of samples has absorption consisting of bands with maxima 36000 and 32000 cm^{-1}.

The SLG crystal absorption spectra are presented in Fig. 1b. The spectrum of light-yellow sample (see the curve 1 in Fig. 1b) has a likeness with the absorption

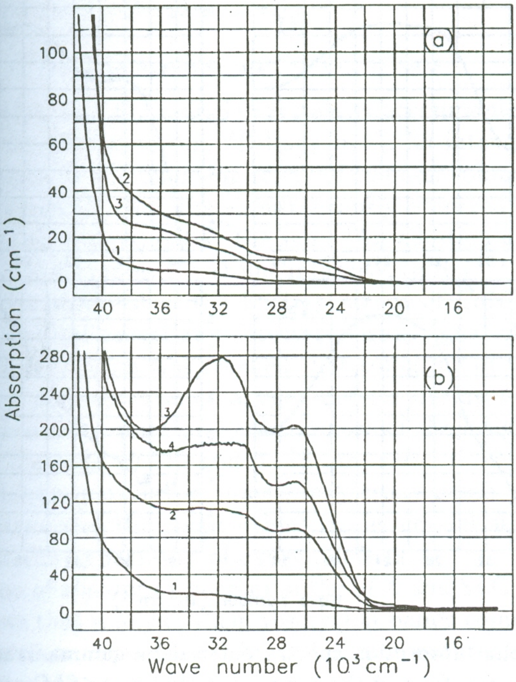

Fig. 1. Absorption spectra of the SLA (a) and SLG (b) crystals: curves in (a) correspond to absorption of the colourless sample (1) and the sample of the first group (2) and the second one (3); curves in (b) correspond to the yellow sample (1), light-green (2), intense-green (3) and red-brown (4) areas of the green sample.

spectrum of the majority of the SLA samples (see the curve 2 in Fig. 1a), i.e. it contains the absorption bands with maxima near 33500 and 26000 cm^{-1} and the shoulder near 38000 cm^{-1} against the background of the widened FAE. The spectra of green samples differ one from another by intensity of absorption only. They differ from the spectra of yellow samples by much more increased absorption in the bands near 33500 and 26500 cm^{-1}. The curves 2–4 show the absorption spectra measured locally in light-green (curve 2), intense-green (curve 3) and red-brown (curve 4) regions of the same green sample. One can see from the comparison of these curves that the red-brown colouring is accompanied by a superposition of the own bands of green sample with another features. Using the differential spectrum technique [6] we have found that the main feature of the last spectrum is a presence of absorption near 20000–22000 cm^{-1}.

The spectra of the AA induced in the investigated samples by the gamma-irradiation are shown in Fig. 2. The irradiation causes clearing near the FAE in the SLA crystals and in the adjacent bands and also leads to darkening in the region of 20000–30000 cm^{-1}. In the clearing region the bands being characteristic of each group manifest themselves in the samples of the first group (33500 and 38000 cm^{-1}