THERMOSTIMULATED LUMINESCENCE IN Tb-DOPED LITHIUM TETRABORATE POLYCRYSTALS

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Thermoluminescent properties of lithium tetraborate polycrystals doped with terbium in various concentrations. The increase of the dopant content within the studied range is shown to result in the increase of thermostimulated luminescence, accompanied by the maximum shift towards higher temperatures.

Lithium tetraborate (LTB) is one of the promising matrices for thermoluminescent dosimeters [1]. The results of the studies on the thermostimulated luminescence (TSL) in polycrystals doped with Mn, Cu, Ag and their combinations are discussed in a series of papers [1-6]. It has been found that the TSL curve intensity and shape vary considerably with the dopant type and concentration. In addition, an information on the lanthanide-doped $Li_2B_4O_7$ luminescent properties is extremely scanty. It is known that these elements reveal the distinct luminescence properties and often serve as the activators of numerous nonluminescent mineral [7]. The present work concerns the TSL studies of Tb-doped $Li_2B_4O_7$ polycrystals.

The experimental studies of the TSL curves were carried out by using an automated setup, its hardware and software being described in detail in [8]. Application of the computer enabled linear heating of the sample up to 450 °C at a rate 2.8 K/s, high reproducibility of the temperature modes and broad dynamic range of the intensity registration. Luminescence was excited by an X-ray tube with copper anticathode with the current of 10 mA at 20 kV voltage, the irradiation time was equal to 100 s. TSL was measured immediately after irradiation.

The investigated samples were LTB polycrystals, doped with terbium from the melt. The initial mixture was obtained by melting the required amounts of highly purified Li_2CO_3, B_2O_3 and TbO_2 in platinum crucibles at ambient air. The products were synthesized as glass at cooling, the oven being turned off. The glass was annealed for recrystallization at the temperature of 650 – 700 °C during 2 hours. Tb concentration in the samples was controlled by atomic adsorption analysis. The size of polycrystalline samples was 5×5×1 mm.

The results of integrated TSL studies of $Li_2B_4O_7$:Tb polycrystals are given in Fig. 1. As follows from the obtained plots, the TSL curves for $Li_2B_4O_7$:Tb polycrystals have three maxima, i.e. the low-temperature (50-150°C), the intermediate-temperature (160-250°C) and the high-temperature (310-420°C) maxima denoted by A, B and C, respectively. At the minimal activator concentration, the maximum A is the less intense one. With the Tb concentration increase up to 5 mol%, its intensity rises, while the maximum itself is shifted towards the higher temperatures. At all Tb concentrations, the largest TSL intensity was observed for the maximum C, characterized by a considerable increase of the luminescence intensity with the dopant concentration (Fig. 2). For this maximum the temperature position shift is greater (17 °C between the curves corresponding to minimal and maximal Tb concentration).

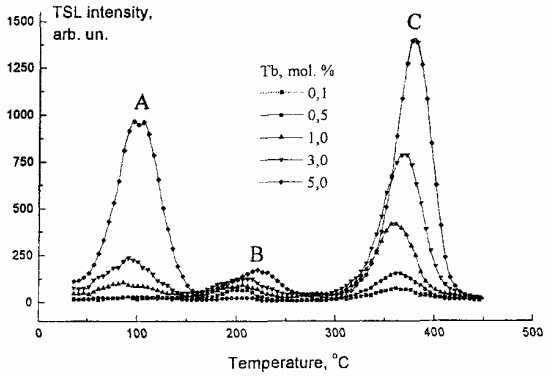

Fig. 1. TSL curves of $Li_2B_4O_7$ polycrystals doped with various concentrations of terbium.

Large half-width of the TSL maxima, a considerable concentration dependence and some peculiarities in the TSL curves testify the complicated structure of the maxima, i.e., they are due to the presence of several local charge carrier trapping levels or their quasi-continuous distribution.

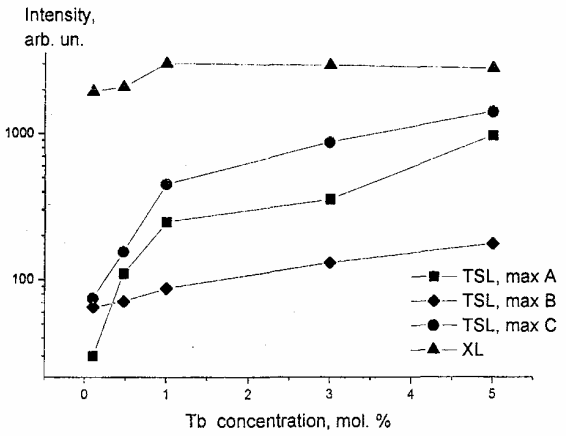

Fig. 2. Dependence of thermostimulated luminescence and X-ray luminescence (XL) maxima intensities upon the content of terbium in $Li_2B_4O_7$ polycrystals.

The low-temperature maximum intensity considerably decreases during several hours of storage at room temperature, therefore for thermoluminescent dosimetry B and C peaks are the most interesting. B maximum is located in the temperature range which is considered to be optimal [2, 4]. The fact that the release of the carriers from the local trapping levels for this maximum occurs above 300°C allows one to suggest $Li_2B_4O_7$:Tb for the use in the thermoluminescence dosimeters that may accumulate the dose at high temperatures.

Contrary to TSL, the intensity of integrated X-ray luminescence (XL) of terbium-doped lithium tetraborate polycrystals is much less dependent of the dopant concentration (Fig. 2). From the analysis of the concentrational dependence of the TSL maxima one can conclude that the increase of terbium concentration in lithium tetraborate does not result in concentrational quenching of luminescence, observed at the similar studies of $Li_2B_4O_7$:Cu polycrystals (with copper content within 0.01 to 2 mol. %) and copper-doped single crystals [9]. Hence, the optimal content of terbium, providing the best luminescent characteristics of this material, has not been determined yet, this being the ground for the future experimental studies.

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ТЕРМОСТИМУЛЬОВАНА ЛЮМІНЕСЦЕНЦІЯ ЛЕГОВАНИХ ТЕРБІЄМ ПОЛІКРИСТАЛІВ ТЕТРАБОРАТУ ЛІТІЮ

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Проведено дослідження термолюмінесцентних властивостей полікристалів тетраборату літію, легованого тербієм у концентраціях від 0,1 до 5 мол. %. Встановлено, що зі збільшенням вмісту домішки в межах даного інтервалу інтенсивність термостимульованої люмінесценції зростає, при цьому також спостерігається зміщення максимумів в область вищих температур.