Luminescent Properties of LGBO:Ce Fibers at Soft X-ray Excitation

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The Ce-doped lithium lanthanide borates present a class of new scintillators. The Li₆Gd(BO₃)₃:Ce (LGBO:Ce) incorporate three of the popular neutron absorbing nuclei with high cross-sections (B, Li and Gd) and, consequently, is considered as a potential material for low-energy neutron detection. The investigation of luminescent and scintillation characteristics of LGBO:Ce materials in bulk or powder forms was carried out early [1-3]. The present work is devoted to studying the properties of firstly produced LGBO:Ce fibers.

LGBO:Ce fibers (samples kv, tv1, tv2 and tv3) were produced using Micro Pulling Down method at Université Lyon 1 (France). LGBO:Ce_kv sample with 0.5% Ce concentration was synthesized at argon atmosphere, while other fibers (tv1, tv2 and tv3 ones with 0.1%, 0.5% and 1.0% Ce concentration respectively) were produced in air. After producing fibers with 0.1%Ce (i.e. kv and tv1 samples) were exposed to heat treatment at 600°C for 15 hours at argon atmosphere. X-ray luminescence spectra (LS) (2.5 – 5 eV), luminescence excitation spectra (LES) (45-250 eV) and luminescence kinetics at T=10 K and 300 K were measured on BW3 channel of DORIS synchrotron (HASYLAB, DESY, Hamburg). The luminescence was excited using Zeiss SX700 monochromator (average spectral resolution is 0.04 eV for energy range of 45-250 eV). The LES were corrected for the equal number of the exciting photons. LS at 2.5-5 eV was registered by means of 0.4 m vacuum Seya-Namioka monochromator coupled to MCP 1645 (Hamamatsu).

LS and LES measured at 300 K are presented in Fig. 1-3. X-ray luminescence spectra are not elementary ones. We tried to decompose them on Gaussian components and satisfactory approximation was carried out only in case of four fitting curves (the example of such decomposition for LGBO:Ce_kv and LGBO:Ce_tv1 samples is shown in Fig. 3). Taking into account that cerium luminescence derived from emitting transitions from 5d-excited state to 4f-ground state split by spin-orbital interaction, we should conclude the existence of at least two non-equivalent cerium Ce⁴⁺ positions. This fact is confirmed by discrepancy between luminescence kinetics measured in different points of spectrum (Fig. 4).

LES profile (Fig. 2) gives a possibility to discuss the plausible mechanisms of energy transfer in studied materials. So, for LES of LGBO:Ce fibers the typical structure at N-edge of absorption of gadolinium ions (energy range of 140-175 eV) and K-edge of absorption of boron ions (resonance at 193 eV) is well-outlined. At the same time we have not observed any spectral features at the area of expected K-edge of absorption of lithium ions (near 55 eV). The mechanism of Gd→Ce energy transfer in Gd-contained materials is well-known [4]. But the presence of well-outlined resonance at 193 eV indicates the boron ions participation in the process of energy transfer too. In last case we are likely to deal with excitonic mechanism of energy migration with intermediate creation of relaxed electronic excitation on boron-oxygen planes, probably near impurity center, and following energy transfer to this center.

The profile of X-ray luminescence spectra (Fig. 1) allows to conclude that among LGBO:Ce fiber samples the most effective energy transfer by Gd→Ce channel take place for LGBO:Ce_kv sample since in this case we have not observed intrinsic gadolinium luminescence. Luminescence excitation spectra (Fig. 3) confirm this statement as it is LGBO:Ce_kv sample that has the deepest gap in LES at the area of N-edge of absorption of gadolinium ions. One more argument in favour of our statement is profile of luminescence kinetics for different LGBO:Ce fiber samples. Only for
LGBO:Ce_kv sample we have not observed the rise stage leading to increasing of decay time (and consequently, degradation of scintillation properties) in case of other fiber samples.

**Figure 1:** X-ray luminescence spectra of LGBO:Ce at \( E_{\text{ex}} = 130 \) eV, \( T = 300 \) K.

**Figure 2:** Luminescence excitation spectra of LGBO:Ce for \( E_{\text{em}} = 3.2 \) eV, \( T = 300 \) K.

**Figure 3:** X-ray luminescence spectra of LGBO-Ce_kv and LGBO-Ce_tv1 (inset) fibers at \( E_{\text{ex}} = 130 \) eV.

**Figure 4:** Luminescence kinetics of LGBO:Ce_kv fiber at \( E_{\text{ex}} = 130 \) eV and \( E_{\text{ex}} = 450 \) eV for \( E_{\text{em}} = 2.8 \) eV and \( E_{\text{em}} = 3.2 \) eV, \( T = 300 \) K.

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**References**