AUGER FREE LUMINESCENCE PROPERTIES OF THE CsBr AND CsBr:LiBr CRYSTALS

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CsBr crystal has the Auger-free luminescence (AFL) [1] with the fastest decay time found so far [1]. However this crystal has low AFL intensity at room temperature, which is about 100 times smaller than at liquid nitrogen temperature [2,3]. According to Davioli et al [4] this decrease at room temperature is due to the non-radiative relaxation process of the outermost-core holes due to the absorption induced by the Urbach effect.

In the present work, a new crystal composed of CsBr and LiBr with a mole mixing ratio of 1:1 was synthesised, with the purpose of increasing the AFL intensity of the crystal. Since the band-gap energy of LiBr is larger than that of CsBr [5], the resultant band-gap energy as well as the exciton energy in the CsBr:LiBr crystal could be larger than those of the CsBr crystal . Thus it is expected that the Urbach effect be suppressed in the crystal. The light output of the CsBr:LiBr crystal should, therefore, be larger than that of the CsBr crystal.

To ascertain this hypothesis, systematic studies on the AFL were made including the emission spectrum, the time dependence of luminescence, the photo-excitation spectrum and the reflectance spectrum. Measurements were made using vacuum-ultraviolet photons from synchrotron orbital radiation and high energy electron produced by gamma rays [6].

Figure 1 shows the measured reflectance spectra of the valence exciton region for the CsBr and CsBr:LiBr crystals at room temperature. The reflectance spectrum for CsBr is in good agreement with that reported by Rubloff [7]. Referring to the reflectance spectrum for the CsBr crystal, the first peak (τ) appeared at 6,70 ± 0,03 eV in the CsBr:LiBr reflectance spectrum can be attributed to the exciton creation. It should be stressed here that the peak location was shifted to the higher energy side by 0,15 eV in the CsBr:LiBr crystal with respect to that in the CsBr crystal.

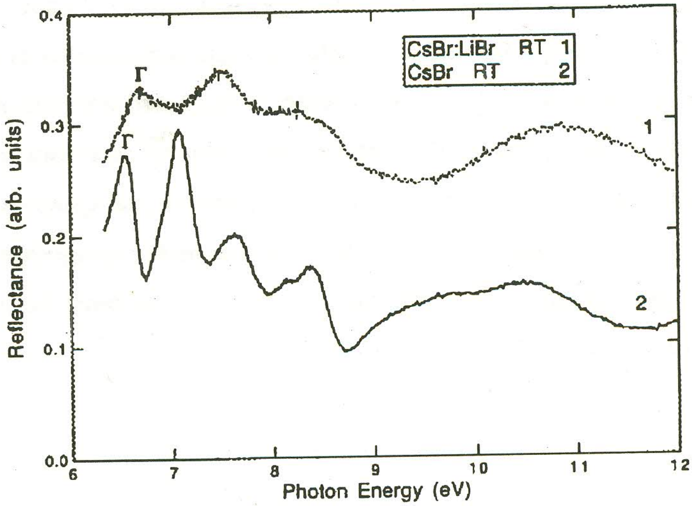

Fig. 1. Reflectance spectra in the valence exciton region for CsBr and CsBr:LiBr crystals

Figure 2 (a) and (b) show the emission spectra for the CsBr and CsBr:LiBr crystals at room temperature. The CsBr crystal has a weak AFL band peaking at 5.3 eV and a dominant luminescence band at 3.2 eV, as shown in Fig. 2 [1]. The 3.2 eV band observed under the valence band excitation has been considered to be a kind of luminescence associated with defects introduced in the crystal[3]. The emission spectrum of the CsBr:LiBr crystal under outermost-core and excitation at rom temperature consists of three luminescence bands around 5,5 eV, 4,3 eV and 3,4 eV, as it can be seen in Fig 2b. The 5,6 eV and 4,5 eV bands have the same threshold energy E_{th} of 14.1 ± 0,2 eV for the photo excitation spectrum The two bands are the Auger-free luminescence involving the $Br^{-}4p$ valence electron and the $Cs^{+}5p$ holes. The 3,4 eV band is not related to the AFL, since this can also be excited under excitation valence band exciton, as shown in Fig. 2c.

The intensities of the AFL in the CsBr and CsBr:LiBr crystals were measured at room and liquid temperature by using 14,8 eV photons. It was found that the AFL intensity of the CsBr crystal at room temperature is 40 times larger than that in the pure CsBr. This increase in the intensity can be explained in terms of the suppression of the Urbach effect due to increases in the band gap energy and in the exciton energy of the CsBr:LiBr crystal compared with those in the CsBr crystal. At liquid nitrogen, the increase of the luminescence intensity in the CsBr:LiBr crystal was less effective, being only two times larger than that of the CsBr crystal.

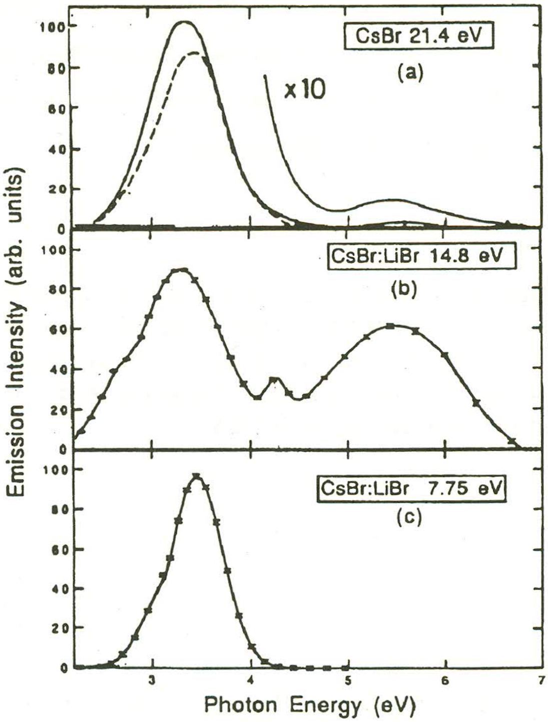

Fig. 2. Emission spectra of CsBr (Ref.4) and CsBr:LiBr crystals measured under 14,8 eV and 7,75 eV photo excitation.

Since the suppression closes one of the decay channels of the formation of the Auger process, the apparent decay time should be longer under the suppression of the Urbach effect. The decay time measured, by employing the time resolved spectroscopy using the single photon counting technique, was 0.90 ± 0.06 nsec in the CsBr:LiBr crystal , which is significantly longer than that of 0.20 ± 0.05 nsec in the CsBr crystal as expected. Therefore, this increase in the decay time of CsBr:LiBr crystal provides an evidence of suppression of the Urbach effect.

The radiative relaxation of holes which competes with the Auger process, can be more efficient in CsBr:LiBr crystal than in the CsBr crystal, as a consequence of the suppression of the Urbach effect. In this way, the increase in the intensity is obtained in the CsBr crystal.

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