Ultrafast luminescence of CsI

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An ultrafast luminescence of CsI, with $\tau \leqslant 10$ ps, has been detected. This luminescence apparently is associated with the radiative transitions in the split valence band.

Three types of fast, fundamental (defect-independent) luminescence of ionic crystals have now been detected: a fundamental plasma luminescence which is associated with the radiative transitions in an electron-hole plasma produced as a result of strong excitation,[1] a luminescence of unrelaxed excitons,[2,3] and an interband (cross) luminescence which is associated with the radiative transitions between various valence bands (the $2p$ band of fluorine and the $5p$ band of barium in BaF_2).[4] The decay time of the interband luminescence in BaF_2 is ~ 600 ps (Ref. 5). Although the decay times of the fundamental plasma luminescence and of the unrelaxed exciton luminescence have not been measured experimentally, they should be much shorter, based on the estimates of Refs. 1 and 2, than the decay time of the interband luminescence.

We have detected an ultrafast luminescence of CsI ($\tau \leqslant 10$ ps) which is not associated with the defects and which differs in nature from the types of fundamental luminescence of ionic crystals listed above.

The luminescence was excited by high energy electron pulses (the energy was 450 keV, the pulse length at half-maximum was 50 ps, and the current density of the sample was 100 A/cm^2). The spectral composition of the emission was analyzed by an SPM-2 monochromator and AGAT-SF-1 image converter was used to detect the luminescence signal (the time resolution was ~ 10 ps under experimental conditions). The maximum of the detected luminescence is situated at 1.9 eV (Fig. 1) and the shape of the luminescence pulse correlates, within experimental error, with the shape of the exciting pulse, making it possible to set a bound, $\tau \leqslant 10$ ps, for the decay time of this luminescence (Fig. 2).

The spectral composition, the yield, and the kinetics ($\tau \leqslant 10$ ps) of the detected luminescence do not depend on the temperature in the temperature range 80–400 K and are unaffected by the introduction of radiation-induced defects and impurities (sample irradiation, Na and Tl activation).

These facts and the extremely short decay time are evidence of the fundamental nature of the luminescence with a maximum at 1.9 eV. The spectral composition of this luminescence differs sharply from the known types of fundamental luminescence (narrow bands at ~ 6 eV in the case of unrelaxed-exciton luminescence[2] and structureless luminescence, which encompasses the entire visible and near-ultraviolet regions of the spectrum in the case of the fundamental plasma luminescence[1]) and from the

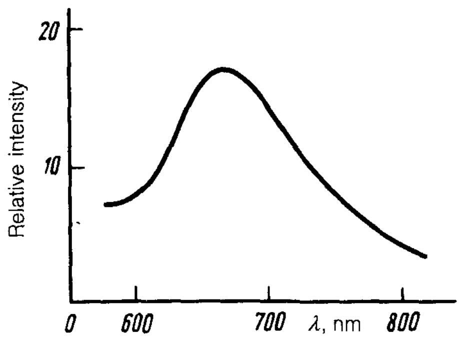

FIG. 1. Spectrum of ultrafast luminescence of CsI.

interband luminescence which should lie in the region of 6 eV (Ref. 6). These results allow us to conclude that we are dealing with a new type of fundamental luminescence.

We assume that the detected luminescence is associated with the radiative transitions between the subbands of the valence band of CsI which is split as a result of spin-orbit coupling ($j = 3/2$ and $j = 1/2$). The fact that the luminescence region coincides with the data on the splitting of this band[6] and with the absorption band assigned to the hole transitions between the indicated subbands[7] and the fact that the decay time of this luminescence is very short ($\lesssim 10$ ps) are arguments in favor of this assumption.

The correctness of this interpretation will be checked by measuring the excitation spectra of the detected luminescence.

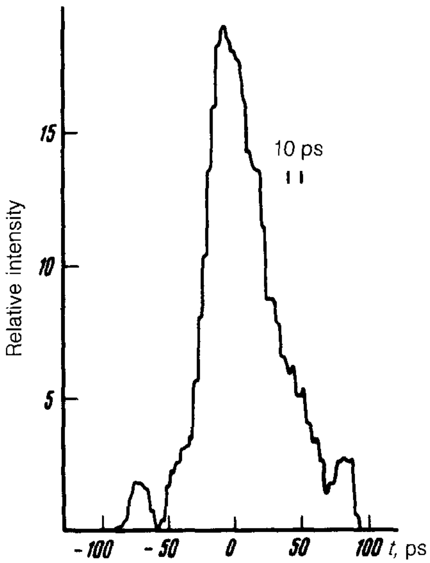

FIG. 2. Shape of the ultrafast-luminescence pulse of CsI at 1.9 eV.

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