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# Stimulation Energy of the X-Ray Storage Material KBr: In

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The KBr: In crystal was proposed as X-ray storage material in [1, 2]. The application is based on the phenomenon of photostimulated luminescence (PSL) the stimulation being fulfilled by red light in the peak of the F absorption band of the KBr crystal (630 nm at RT). The PSL spectrum is centered round 440 nm. Choosing the optimal material for X-ray storage recording attention should be paid to such parameters as the stimulation energy $E_s$ [3 to 5].

The stimulation energy is expressed as

$$E_s = \tau I_F \, (\mu J/mm^2),$$

where $\tau$ (s) is the time during which the PSL intensity decreases $e$ times under continuous stimulation with light from the F absorption band peak; $I_F$ ($\mu J/mm^2$) is the absolute value of the stimulating red light. The physical meaning of one unit of $E_s$ is the amount of stimulating light energy that causes the PSL with intensity to decrease $e$ times during 1 s. Therefore, the lower the $E_s$ parameter, the better is the characteristic of the storage material.

If the stimulating light does not coincide with the peak of the F absorption band, then the stimulation with the same intensity $I_F$ will cause PSL with larger $\tau$ and, consequently, with larger $E_s$ value. That is why speaking about the value $E_s$ of the material the spectral characteristics of the stimulation light should be mentioned for the sake of clarity.

In this note we have found the value $E_s$ (630 nm) for KBr: In (crystalline and powdered) with the purpose to use it as possible material for energy storage. The crystalline and powdered samples were produced from a Stockbarger-grown KBr: In crystal with activator concentration of $3 \times 10^{17}$ $cm^{-3}$.

After X-irradiation the KBr: In sample was placed into the chamber of the experimental set-up (Fig. 1, position II) and irradiated with red light (630 nm) from an incandescent lamp with appropriate glass filters. The response pulse of PSL was recorded with photomultiplier and $X-Y$ recorder. Special attention was paid to the uniform distribution of red light across the sample surface, since otherwise the PSL pulse would be a superposition of pulses with various $\tau$.

Contrary to the simplicity of $\tau$ measurements the measurement of the absolute value of stimulating light intensity is a rather complicated task. To solve this problem we have applied a special method using a test specimen with a known value of stimulation energy $E_{s,t}$.

Particularly, it was another KBr: In crystal with previously estimated parameter $E_s$ which was used as a test specimen. Investigation of the test specimen [6, 7] showed that the

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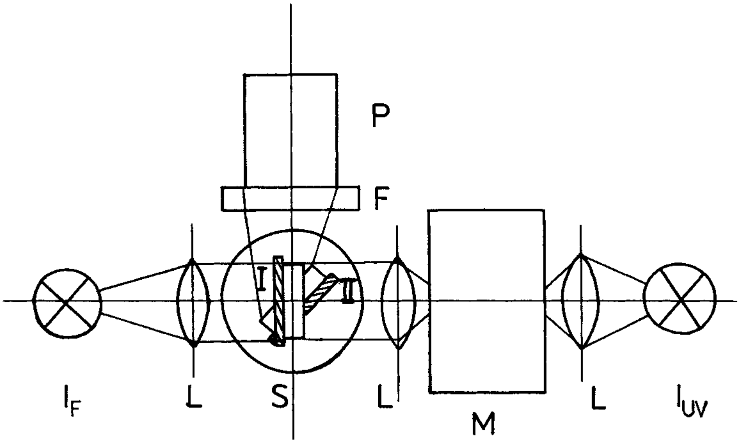


Fig. 1. Scheme of the optical set-up for the detection of stimulation energy. S sample, F $X-Y$ recorder, P photomultiplier, L lenses, $I_{UV}$, $I_F$ sources of ultraviolet and red light, M monochromator

absorption cross-section in the F band peak is

$$\sigma_t = \frac{1}{E_{s,t}} = 2.0 \times 10^{-16} .$$

This gives the value of the stimulation energy for the test specimen, $E_{s,t} = 15.7\ \mu J/mm^2$, which was used by us to determine the stimulation energy $E_{s,x}$ values of the samples under investigation.

The test specimen with known $E_s$ was situated in the chamber of the set-up, irradiated with UV light (200 nm) in position I (Fig. 1), and then turned into position II for the red light stimulation. From the PSL curve the decay time for the test sample $\tau_t$ was recorded. Knowing $E_{s,t}$ and $\tau_t$ one can estimate the intensity of the stimulating light from the equation

$$I_F = \frac{E_{s,t}}{\tau_t} .$$

The red light stimulation of any previously X-rayed crystal under investigation situated in position II causes a PSL pulse with decay time $\tau_x$. The value of stimulation energy of the sample under investigation $E_{s,x}$ can be derived from

$$E_{s,x} = \tau_x I_F = E_{s,t} \frac{\tau_x}{\tau_t} = 15.7\ \mu J/mm^2 .$$

This means that the estimation of $E_{s,x}$ by means of our method needs only measurements of the pulse decay time for the test crystal $\tau_t$ and the crystal under investigation $\tau_x$, eliminating the complicated measurements of the absolute intensity of the stimulating red light.

Fig. 2 shows the PSL pulses of different samples under the same conditions and the corresponding $E_s$ values, calculated by the mentioned method. All the pulses except (a) are shown in the same scale, so that not only the decay times, but also the released PSL light sums of the pulses can be compared. The pulse a) is that of the test specimen, used for the calculation of $E_x$ of other samples.

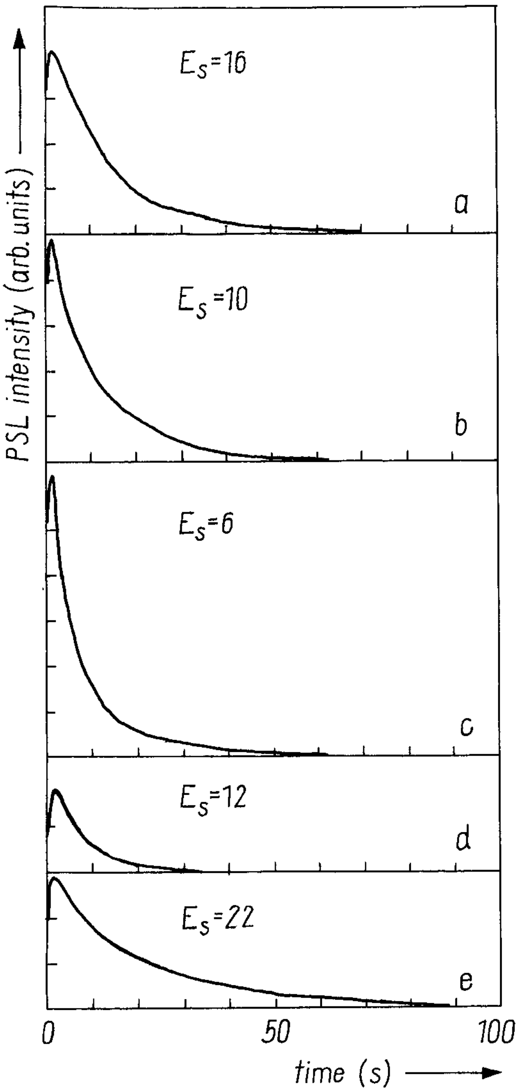


Fig. 2. Pulses of PSL; $T = 295$ K; stimulation light wavelength $\lambda = 630$ nm, the $E_s$ values are given in units of $\mu J/mm^2$; a) crystalline KBr : In after irradiation with UV light, $\lambda = 200$ nm; b) crystalline KBr : In after X-irradiation; c) powdered KBr : In (grain size < 0.2 mm) after X-irradiation; d) powdered KBr : In (grain size < 0.06 mm) after X-irradiation; e) powdered BaFBr : $Eu^{2+}$ after X-irradiation

Thus $E_{s,x}$ values were measured for crystalline and powdered samples of KBr : In (activator concentration $3 \times 10^{-17}$ $cm^{-3}$), and the following conclusions can be drawn:

1. The $E_s$ value of KBr:In is lower for the case of X-ray irradiation than after UV irradiation.

2. The powdered sample of KBr:In has a lower value of $E_s$ than the crystalline one, provided that the dimensions of grains are not too small. The diminution of size down to 0.06 mm causes an increase of stimulation energy and a decrease of the storage efficiency.

3. The comparison of PSL pulses of powdered KBr:In and the well-known storage material BaFBr:$Eu^{2+}$ shows the superiority of the former due to the considerably lower value of its stimulation energy.

Table 1
Stimulation energies for several PSL materials (stimulation wavelength $\lambda$ = 630 nm)

| materials | $E_s$ (μJ/mm$^2$) | ref. |
|---|---|---|
| BaFBr : $Eu^{2+}$ | 17 | [3, 4] |
| BaFBr : $Eu^{2+}$ | 20 | [5] |
| $Ba_5SiO_4Br_6 : Eu^{2+}$ | 70 | [3, 4] |
| $Ba_5GeO_4Br_6 : Eu^{2+}$ | <70 | [4] |
| $Sr_{3.96}Eu_{0.04}OBr_6$ | 276 | [5] |
| $Ba_{3.96}Eu_{0.04}OBr_6$ | 300 | [6] |
| $Ba_{3.96}Eu_{0.04}OCl_6$ | 460 | [6] |
| BaFBr : $Eu^{2+}$ | 22 | this work |
| KBr : In (after UV irradiation) | 16 | |
| KBr : In (crystalline, after X-irradiation) | 10 | |
| KBr : In (powdered, after X-irradiation) | 6 | |

Not discussing the physical reasons of the results here, it should be concluded, however, that the powdered KBr : In is worth considering as a good photostimulable X-ray storage material. This is seen from Table 1, where KBr : In is presented along with other well-known storage materials.

From the view point of KBr : In as a possible X-ray storage material the given work may be regarded as a supplement to another paper [8] showing that it has another important good parameter — a high storage efficiency.

### *References*

[1] P. Bratslavets, A. Kalniņš, I. Pļaviņa, A. Popov, B. Rapoport, A. Tāle, and Zeigurs, in: The Advancement of Imaging Science and Technology, Proc. Internat. Conf. Photographic Science 1990, China's Internat. Academic Publ., A Pergamon —CNPIEC Joint Venture, 1990 (p. 474 to 476).
[2] P. Bratslavets, A. Kalniņš, I. K. Pļaviņa, A. I. Popov, B. I. Rapoport, and A. K. Tāle, Russia Patent from 11. 12. 1991.
[3] A. Meijerink, G. Blasse, and L. Struye, Mater. Chem. Phys. **21**, 261 (1989).
[4] A. Meijerink, PhD Thesis, Utrecht 1990.
[5] W. I. Schipper, Z. A. E. P. Vroon, G. Blasse, Th. Schleid, and G. Meyer, Mater. Chem. Phys. **30**, 43 (1991).
[6] A. Kalniņš, I. Pļaviņa, A. I. Popov, and A. Tāle, phys. stat. sol. (b) **161**, 85 (1990); J. Phys.: Condensed Matter **3**, 1265 (1991).
[7] P. F. Bratslavets, A. Kalniņš, I. Pļaviņa, A. I. Popov, B. I. Rapoport, and A. Tāle, phys. stat. sol. (b) **170**, 395 (1992).
[8] A. Kalniņš, I. Pļaviņa, and A. I. Popov, phys. stat. sol. (b), submitted for publication.

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