ELSEVIER

Journal of Luminescence 72–74 (1997) 693–695

JOURNAL OF LUMINESCENCE

Time-resolved luminescence and induced absorption in $PbWO_4$

D. Millers[a], S. Chernov[a], L. Grigorjeva[a,*], A. Popov[a], E. Auffray[b], I. Dafinei[b], P. Lecoq[b], M. Schneegans[c]

[a] *Institute of Solid State Physics, University of Latvia, 8 Kengaraga St., Riga, Latvia*
[b] *CERN, Geneva, Switzerland*
[c] *LAAP, Annecy, France*

Abstract

Luminescence and short-lived induced absorption are studied for two undoped $PbWO_4$ crystals. Luminescence decay at LNT is delayed relative to irradiation pulse. The delay observed is either due to reabsorption of luminescence or due to creation of luminescence center excited states via energy or/and charge transfer after irradiation pulse. Short-lived absorption is observed within 1.1–3.6 eV spectral region at LNT as well as at RT. It is proposed that the short-lived absorption band peaking at ~3.5 eV is intrinsic.

Keywords: $PbWO_4$; Time-resolved luminescence; Short-lived absorption

1. Introduction

The monocrystalline $PbWO_4$ (PWO) is a promising material for scintillators [1, 2] for use in high-energy physics experiments. The luminescence of PWO [3, 4] is studied widely and under steady-state ionizing irradiation the complex luminescence band [3, 5] peaking within 2.4–3.0 eV is observed. The luminescence band position and shape vary for undoped samples [5] obtained from different sources. Photoluminescence [4, 5] showed more than one excitation as well as luminescence bands. In general, the luminescence of PWO is divided into 'blue' and 'green' and blue luminescence arises due to some recombination process [5] in bulk, whereas green luminescence centers are associated with intrinsic defects. The study of luminescence decay [5] showed a very complicated kinetics indicating that more than two types of luminescence centers were acting. Thus, the study of time-resolved luminescence and induced absorption of PWO can highlight some details of radiation stimulated processes in these crystals.

2. Experimental

Luminescence and induced absorption spectra and decay kinetics have been measured for two undoped PWO samples from different sources. Pulsed electron beams (pulse width 10 ns, electron energy 270 keV, excitation density ~15 MW/cm^2) have been used as irradiation source. Time resolution for luminescence and absorption registration was 25 ns. Spectra of steady state luminescence under X-ray irradiation (40 kV, tungsten target) have been measured at RT and LNT.

* Corresponding author. Fax: 371-711 2583; e-mail: lgrig@acad.latnet.lv.

PII S0022-2313(96)00320-1

3. Results and discussion

Luminescence band peaking at 2.9 eV is dominant in both samples at RT under pulsed electron beam irradiation; however, some distinction in band shapes is observed for different samples. This distinction shows that the defect or/and the uncontrolled impurity content are different in various samples. The kinetics of luminescence decay are different within the luminescence band and thus the luminescence spectra at room temperature show evolution in time. Luminescence band peaking at ~2.4–2.5 eV (Fig. 1) is dominant in the delayed spectrum. The distinctions in decay kinetics give evidence once more that the luminescence band is complex and this is the reason for the differences between the luminescence spectrum under pulsed electron beam irradiation and the steady-state luminescence spectrum under X-ray irradiation (Fig. 1).

At LNT, luminescence spectra under pulsed electron beam irradiation were very close to each other for both samples. Peak position of band is at ~2.8–2.9 eV and the band shape is similar to that obtained at RT. At LNT, the luminescence decay kinetics were the same within the whole luminescence band. The decay of luminescence is delayed at LNT and begins 100–200 ns after irradiation pulse.

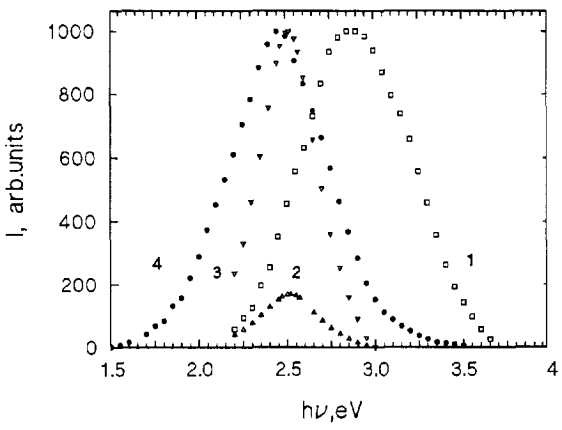

Fig. 1. Luminescence spectra of PWO at RT: (1) under irradiation pulse; (2) delayed (Δt = 100 ns); (3) delayed and normalized; (4) excited by X-rays.

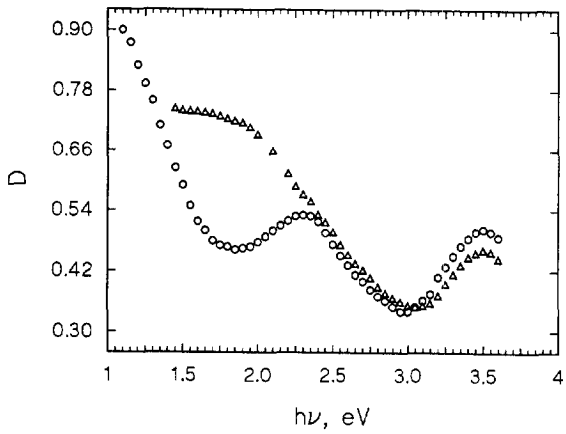

Fig. 2. Short-lived absorption spectra at the end of irradiation pulse at LNT for the two samples.

Decay kinetics in the microseconds region can be represented as nearly exponential having $\tau \approx 4.5$ μs; however, in general it is nonexponential. Under pulsed electron beam irradiation short-lived induced absorption is observed in both samples at LNT as well as at RT. Induced absorption spectra at LNT (Fig. 2) in the spectral region 2.8–3.6 eV are nearly the same for both samples and show absorption band peaking at ~3.5 eV. In the region 1.1–2.8 eV the induced absorption spectra are different for various samples; however, absorption band peaking at ~2.3 eV may be similar for both samples. Since samples under study are undoped, induced absorption band peaking at 3.5 eV can be either due to the excited state of intrinsic luminescence center or due to some intrinsic radiation defect.

Decay kinetics of short-lived absorption at LNT within 1.4–3.5 eV are nearly the same and show fast initial decay during 100–200 ns followed by a slower one having time constant ≈4.6 μs. It is important that the delay of luminescence decay after irradiation pulse is nearly the same as the time of short-lived absorption with faster initial decay. Thus, the delay for luminescence decay can be either due to luminescence reabsorption or due to creation of excited luminescence centers via some energy or/and charge transfer after irradiation pulse.

References

[1] P. Lecoq, I. Dafinei, E. Auffray, M. Schneegans, M.V. Korzhik, O.V. Missevitch, U.B. Pavlenko, A.A. Fedorov, A.N. Annenkov, V.L. Kostylev and V.D. Ligun, Nucl. Instr. and Meth. A 365 (1995) 291.
(2) M. Kobayashi, M. Ishii, Y. Usuki and H. Yahagi, Nucl. Instr. and Meth. A 333 (1993) 429.
(3) J.-P. Peigneux, Nucl. Instr. and Meth. A 351 (1994) 197.
(4) W. van Loo, Phys. Stat. Sol. A 27 (1975) 565.
(5) M. Nikl, K. Nitsch, K. Polak, E. Mihokova, I. Dafinei, E. Auffray, P. Lecoq, P. Reiche, R. Uecker and G.P. Pazzi, Phys. Stat. Sol. B 195 (1996) 311.