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Effects of predose treatment on the thermoluminescence in synthetic quartz

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Abstract

The effects of thermal annealing and of exposure to high β doses as well as of the pre-dose treatment on the TL sensitivity were studied separately for the main 370 and 460 nm emission bands. These bands were differently influenced by the treatments. The thermal activation energies of the main TL peaks were the same for the two emission bands, indicating that the carriers are thermally released from the same traps. The observed changes in the TL intensities are attributed to phase transitions of the crystal.

Keywords: Thermoluminescence; Pre-dose treatment; Quartz

1. Introduction

The effect of exposure to heavy radiation doses and of subsequent heating to high temperatures on the thermoluminescence (TL) sensitivity (pre-dose effect) has been studied previously in various materials. The observed increase of the TL efficiency by the pre-dose effect has been explained by different models [1–2].

In the present work, the effects of thermal annealing by gradually increasing temperatures and of the predose treatment on the TL sensitivity were studied for the various spectral bands emitted at the main glow peaks.

2. Experimental techniques

Synthetic quartz crystals (Premium grade) and polycrystalline powders were used. In order to investigate the effects of irradiation and of thermal treatment on the TL sensitivity, the samples were annealed for 1 h to gradually increasing temperatures up to 900°C. The β irradiations were performed at RT with a Sr^{90} beta source. The influence of the thermal annealing and of the pre-dose treatment on the TL sensitivity was measured for small test doses of 5–10 Gy. Further experimental details have been given elsewhere [3].

3. Results and discussion

The emission spectra recorded at the main TL peaks showed two bands at 370 and 460 nm. The same bands have previously also been recorded in the photoluminescence (PL) and attributed to different processes [4–6]. These bands were differently influenced by the thermal treatments (Fig. 1). The intensity of 460 nm band, emitted at the main 110°C TL peak, increased after heating to 450°C by a factor of 1.8 and after a pre-dose treatment by a factor of 5. The main peak for the 370 nm emission appeared at about 90°C and

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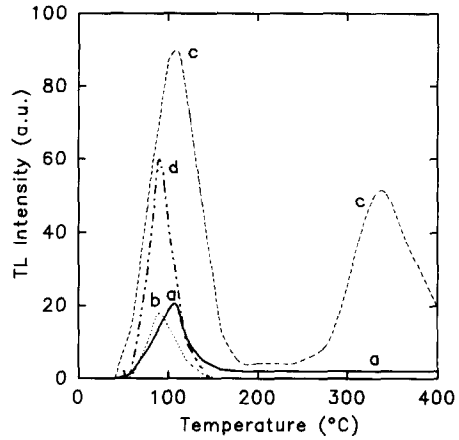

Fig. 1. Glow curves of untreated samples induced at RT by a β dose of 10 Gy and recorded at 460 nm (a) and at 370 nm (b) Curves (c) and (d) – after pre-dose treatment (300 Gy β dose and annealing to 450°C) for 460 and 370 nm emission, respectively.

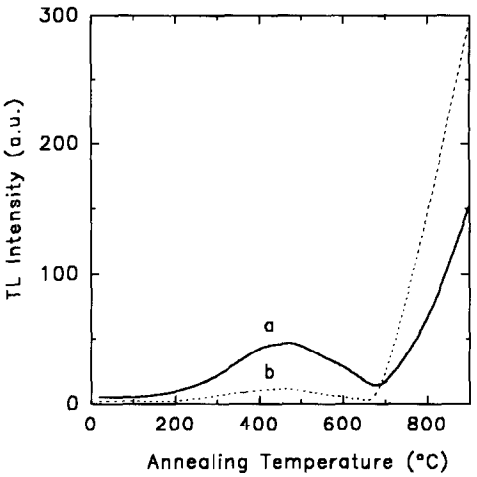

Fig. 2. The dependence of the TL sensitivity on the temperature of the treatment for: (a) the 460 nm and (b) the 370 nm emission bands. (The TL was induced at RT by β test doses of 5 Gy and was measured at the main glow peaks at 110°C and 90°C).

increased as a result of the same treatments by factors of 1.4 and 3 only. Annealing to 900°C caused an increase of the 460 and 370 nm bands by factors of 60 and 300, respectively, and the 370 nm band became dominant. This strong increase of the 370 nm emission explains the observed shift of the total TL peak after heating to about 900°C from 110°C to a slightly lower temperature. The intensity of the 460 nm emission at the TL peak near 320°C increased by a factor of 150 as a result of the pre-dose treatment. No 370 nm component was recorded at this peak. The dependence of the TL sensitivity on the temperature of the thermal treatment for the 460 and 370 nm emission bands is shown by curves a and b of Fig. 2. Up to 500°C the TL sensitivity increased mainly for the 460 nm band. Between 500°C and 650°C, a decrease was observed which was followed by a strong increase above 700°C; this was more pronounced for the 370 nm emission. A similar behavior has been recorded for the dependence of the PL efficiency on the treatment temperature and is attributed to phase transitions of the crystal. The thermal activation energies of the main TL peak near 100°C were 0.9 eV for both the 460 and 370 nm band and were not affected by the thermal treatment, indicating that the carriers are thermally released from the same traps. The present results also indicate that the pre-dose treatment causes a change in the filling of the existing trapping states, probably of the recombination centers, rather than forming new defects.

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