CLASSIFICATION OF LiF-DOSIMETERS USING THE RATIO OF PEAK HEIGHTS

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INTRODUCTION

During the past decade thermoluminescence (TL) has received wide application in radiation protection and health physics. Because of its tissue equivalent response LiF has become a preferred substance as a detector material (1). The most widely used and best studied LiF dosimeter materials are the commercial products TLD-100 and TLD-700. When TLD-700 is irradiated at room temperature and subsequently heated to 220 °C five glow peaks are observed which are conventionally labelled 1 - 5, as shown in Fig.1.

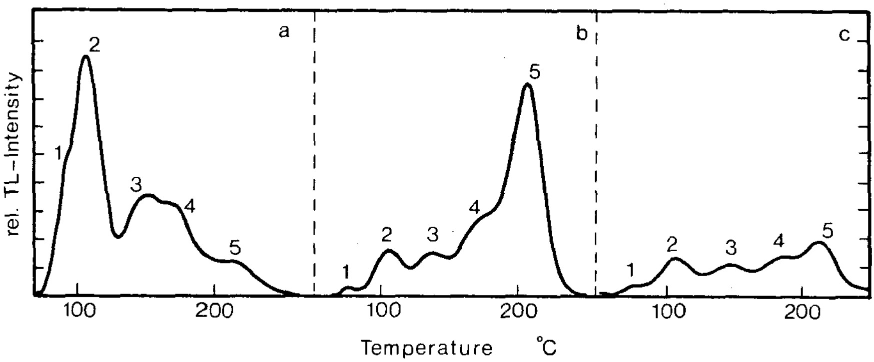

Figure 1. Glow curves of LiF:Mg, Ti specimen doped with various amounts of Mg and Ti.

Glow peak 4 and 5 near 200 °C are suitable for dosimetry in the dose range between 10^{-5} Gy (1 mrad) and 10 Gy (10^3 rad) because of their prominence and their stability at room temperature. For re-use LiF (TLD-100) must be standardized by a pre-irradiation heat treatment (1 h at 400 °C followed by a fast cool to room temperature).

Additional to the influence of heat treatments on the shape of the glow curve (2) there is a marked dependence of the glow curve's shape on the concentration of the activator impurities Mg and Ti. In a study of TL in samples from molten LiF and single crystals doped with Mg and Ti, we obtain different structured glow curves due to various concentrations of Mg and Ti. To describe the glow curve structure, which determines the quality of LiF for dosimetric application, we used the ratio of peak 5 height to peak 4 height and the ratio of peak 5 height to peak 3 height.

EXPERIMENTAL

For the preparation of samples from the melt the following procedure was used: Various amounts of MgF_2 and TiF_3 were added to LiF powder (suprapur, Merck) in a graphite crucible, which was heated up to 950 °C in an argon atmosphere. Then the furnace was switched off and the melt cooled within 30 minutes to room temperature. Afterwards the melt was crushed to powder and sieved. From this powder pellets were pressed. Additional single crystals were prepared using the Czochralski technique. For irradiation gamma rays from a ^{60}Co source and 30 kV-rays from a molybdenium tube were used. All samples were annealed at 400 °C for 1 h and afterwards cooled rapidly to room temperature by placing them on a copper block. After irradiation the glow curves were recorded (heating rate 2 °C/s) with an EG & G reader.

RESULTS

A careful study of glow curves from several specimen from the melt and from single crystals revealed strong differences in the glow curve structure. If the Mg-concentration (ppm by weight) was low (Mg/Ti = 1 ... Mg/Ti = 15) compared with the Ti-concentration glow curves similar to that shown in Fig.1a could be observed. This glow curve is typical for a material with "poor" dosimetric properties, because the contribution of glow peak 2 and 3 is greater than that from the main dosimetric glow peaks 4 and 5. If the ratio of concentrations Mg/Ti was about 30 we found dosimetric glow curves structured like that known from TLD-100 (Fig.1b). With increasing Mg-concentration the glow peaks broadened and peak 4 and 5 decreased to about the same height as peak 2 and 3 (Fig.1c). By using the ratio of peak 5 height to peak 4 height (or height ratio of peak 5 to peak 3) to describe the glow curve structure, we found a relation as shown in Fig.2. A classification in 3 categories (I, II, III) seems advantageous. Dosimeters in category II are of interest for dosimetric application.

DISCUSSION

Glow curve shape and TL-sensitivity determine the quality of LiF for the application in dosimetry. The glow curve of a material with high quality consists of low peaks 2, 3 and prominent peaks 4, 5 (high peak height ratio). So the peak height ratio allows,as a simple measure for dosimeter quality,classification of different commercial available LiF dosimeters. In different batches of the same material various dosimetric properties can be measured. We observed for example an outstanding quality improvement in charges of TLD-100 hot extruded chips (6.3 x 6.3 x 0.9 mm) produced between 1978 (peak 5 height/peak 4 height = 1.75) and 1979 (peak 5 height/peak 4 height = 2.1).

LiF of high dosimetric quality is obtained if the optimal Mg-concentration (which is determined by the peak of the curve in Fig.2) is added to the material with optimal Ti-content. The optimal Ti-content determines the TL-sensitivity of LiF (3) and the optimal Mg-concentration is necessary for a suitable dosimetric glow curve shape.

In each LiF:Mg, Ti material one can find in principle a relation between glow curve structure and activator concentration like that shown in Fig.2 but the position of the optimum is between Mg/Ti = 20 to Mg/Ti = 40. The actual position depends on the concentration of hydroxyl ions (OH^-) in LiF (4).

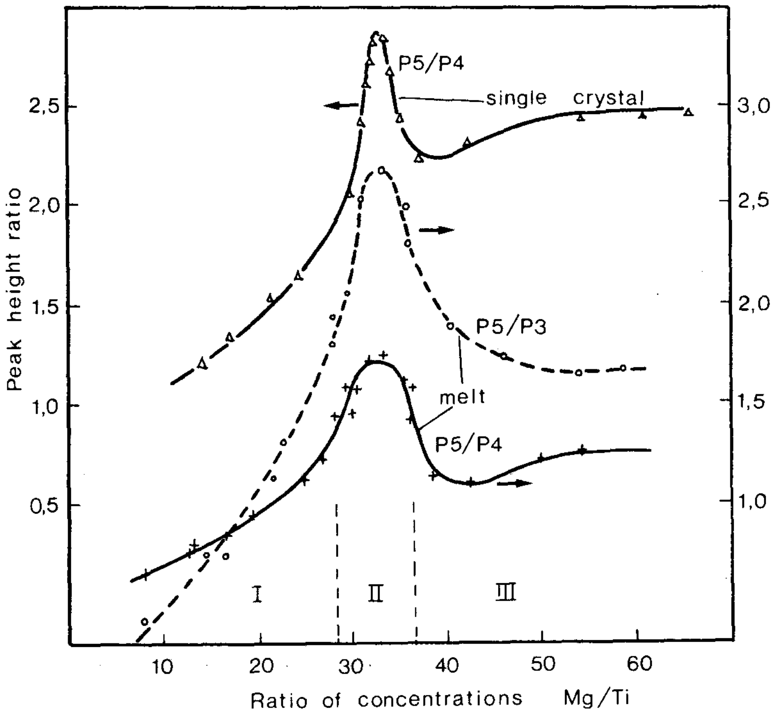

Figure 2. Peak height ratio depending on the concentrations (ppm) of Mg, Ti.
(P5/P4 ... ratio of peak 5 height to peak 4 height,
P5/P3 ... ràtio of peak 5 height to peak 3 height)

REFERENCES

1. Becker K. (1973): Solid State Dosimetry, Cleveland Ohio: CRP Press.
2. Stoebe T.G. and Watanabe S. (1975): Phys. stat. sol. (a) 29, 11.
3. Rossiter M.J., Rees-Evans D.B., Ellis S.C. and Griffiths J.M. (1971): J. Phys. D: Appl. Phys. 4, 1245.
4. Wachter W., Vana N.J. and Aiginger H. (to be published): The influence of hydroxyl ions on the TL-properties of LiF:Mg, Ti.