TL IN LiF(TLD-100) AND $\text{CaSO}_4:\text{Dy}$

Progress Report

M. R. Mayhugh

University of Wisconsin
Madison, Wisconsin

July 15, 1973 to July 15, 1974

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

PREPARED FOR THE U. S. ATOMIC ENERGY COMMISSION
UNDER CONTRACT NO. AT(11-1)-1105

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

fy

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

C00-1105-214

TL IN LiF(TLD-100) AND $\text{CaSO}_4:\text{Dy}$

M. R. Mayhugh

A) Pre-existing radiation damage (after 2 MR) does not alter the supralinearity and saturation of LiF(TLD-100). B) High temperature TL in LiF(TLD-100) can be eliminated by optical bleaching at 280°C without appreciably altering increased sensitivity in peak 5 (~200° C). This result is a counter-example to the suggestion that the high temperature TL peaks accompany sensitization. C) Photostimulated TL in Dy activated calcium sulfate appears to depend on the energy of the enabling (previous) exposure in the way that the direct TL does, while in LiF(TLD-100) these energy dependences for direct and photostimulated TL are different from one another.

This report was prepared as an account of Government-sponsored work. Neither the United States, nor the Atomic Energy Commission nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

THERMOLUMINESCENCE IN LiF(TLD-100) AND $\text{CaSO}_4:\text{Dy}$

M.R. Mayhugh

A. Effect of Radiation Damage on Supralinearity and Saturation in LiF(TLD-100)

High exposures are known to damage TLD-100 in the sense that the response to subsequent low exposures is decreased.¹ We wish to consider whether or not this radiation damage might cause the saturation observed near 10^5R . (A lack of traps apparently does not explain saturation since trap filling^{2,3} continues beyond 10^5R .) To check the effects of damage on the radiation response, TLD-100 powder was given $2.3 \times 10^6\text{R}$ followed by an hour's anneal at 400°C ("Damaged") or at 275°C ("Sensitized"). Subsequently the response of these damaged and sensitized samples was compared with that of TLD-100 which was only annealed an hour at 400°C . The relative response to 300R is similar to other's results¹, to wit: Damaged = 0.31, Normal = 1.0, Sensitized = 1.67. (All irradiations were with ^{137}Cs .)

Figure 1 shows the response vs. exposure for the three samples. To facilitate comparison of the shapes, the curves are normalized at 300R. The normal powder and the damaged material show supralinearity and saturation in a nearly identical fashion, although the damaged phosphor may be slightly less supralinear (20%). Apparently, supralinearity and saturation are little affected by pre-existing damage. If saturation were due to damage, the simplest interpretation would predict that saturation should set in sooner in the pre-damaged sample than in a normal one.

The sensitized material shows the linear response and saturation typical of TLD-100 sensitized by lower pre-exposures. In the saturation region, the signal from this powder is about the same as that from the damaged phosphor. (Recall that the data in Fig. 1 are normalized.)

At $2 \times 10^5\text{R}$ the relative responses are Damaged = 0.26, Normal = 1.0, Sensitized = 0.28. The high pre-exposure appears to limit the maximum light output for either intervening anneal.

B. Optical Bleaching of High Temperature TL in LiF(TLD-100)

Lithium Fluoride (TLD-100) displays several glow peaks at temperatures above the major peak (No. 5 at $\sim 200^\circ\text{C}$). Several authors have suggested that these may be related to sensitization of peak 5. In C00-1105-209 we point out that LiF is sensitized by high exposure followed by simultaneous annealing and u.v. illumination just as it is when the annealing is performed in the dark. Here we look at the effect of the u.v.-anneal on the high temperature TL.

Samples of TLD-100 exposed to $4 \times 10^5\text{R}$ (^{137}Cs) display glow curve a shown in Fig. 2. The glow peaks up to number 5 are easily identified. Peak 6 is not usually seen on peak 5's shoulder, but can be resolved⁴ after post-irradiation annealing in the $100\text{--}150^\circ\text{C}$ range. The remaining peaks, 7 to 10, are numbered in the order of their appearance. Their positions for our heating rate ($1^\circ\text{C}/\text{sec}$) indicate that the labels correspond to those assigned by Sunta⁵ et al.

Curve b of Fig. 2 shows the TL remaining when the $4 \times 10^5\text{R}$ exposure is followed by a 40 min anneal at 280°C . Peaks 1-8 are obliterated, peaks 9 and 10 remain. Continued annealing at this temperature removes⁶ peak 9 after several hours. The remaining peak, No. 10, has been suggested to be related to sensitization because the high exposure and 280°C anneal are the procedure used to sensitize the phosphor. A counter-example to this suggestion is provided when the high exposure is followed by a 30 min u.v.-anneal at 280°C . (See C00-1105-209 for details of the u.v.-anneal.) Curve c shows that the TL in peak 10 is reduced at least a factor of 100 by the u.v.-anneal, yet the sensitivity (peak 5) remains

virtually unchanged.

To examine the degree of sensitization, we exposed normal TLD-100, and the above samples, to 100R and measured their response. Figure 3 shows the resulting glow curves. Peak 5 is sensitized to about the same extent for both normal and u.v.-anneals, as expected from the results of COO-1105-209. To reiterate: Peak 5's sensitivity does not depend on the presence of glow peak 10. Peak 7, on the other hand, has a much higher response to 100R in the sample sensitized with the dark anneal.

C. Photostimulated TL in LiF(TLD-100) and $\text{CaSO}_4:\text{Dy}$ as a Function of the Energy of the Previous X-ray Exposure

Virgin TL materials are usually insensitive to ultraviolet light ($<6.5\text{eV}$) because their band gaps are large ($>7\text{eV}$). After exposure to ionizing radiation some states in the gap may remain filled, even after an intermediate anneal. Subsequent illumination may cause these charges to be transferred into the usual TL centers, and give rise to photostimulated TL (PSTL). Usually, then, PSTL depends on an enabling exposure to ionizing radiation, an intermediate anneal, and a subsequent illumination with light. Hence, a single exposure to ionizing radiation can be detected by a direct TL response and then again by a PSTL one.

Our object is to discover whether or not the PSTL depends on the energy of the enabling radiation in the same way that the direct TL does. Work in LiF indicates that energy dependences do not follow dose (COO-1105-209) and PSTL might show additional variations.

TLD-100 high sensitivity ribbons (400°C 1h, 80°C 24 h) were exposed to 100R at various effective energies (see COO-1105-209 for calibration details), then their direct TL was read up to 280°C. Their relative response, shown as solid circles in Fig. 4, is typical of LiF(TLD-100).

(Error bars are the total deviation in the two readings whose average constitutes the point.) After the direct reading, these same ribbons were annealed together for 15 min at 280°C, then for 24h at 80°C, after which they were exposed together at room temperature to germicidal lamps (principal line 254 nm). In other words, the original 100R exposures have now become the enabling ones for PSTL. The relative response of the PSTL signal is not the same as the primary TL, as illustrated by the crosses in Fig. 4. Experimental scatter is sufficient to preclude quantitative analysis except to say that the relative response to low energy x-rays is higher for the indirect PSTL than for normal TL.

PSTL in $\text{CaSO}_4:\text{Dy}$ has been suggested⁶ as a method for high exposure dosimetry. Essentially, PSTL provides a means to detect deep (thermally stable) centers without reading to high temperatures where incandescence and thermal quenching are problems. Because of this potential application, energy dependence of this PSTL is also of interest. Powdered $\text{CaSO}_4:\text{Dy}$ (Harshaw) was exposed to 100R at various effective energies (see COO-1105-209 for calibration details) and read. The energy dependence of the direct response is shown by the solid circles in Fig. 5, and is typical of that expected for CaSO_4 . Powder X-rayed at the same time was annealed at 400°C for 15 min, then exposed to germicidal lamps. The lamps induce PSTL as shown by the crosses in Fig. 5. It appears that PSTL and the direct TL both follow the original dose. Scatter is worse in this PSTL than for LiF, presumably because of different reflectivities in the Ag pans used during illumination and read-out of the powder. The error bars are derived from averages on three separate annealings, illuminations and PSTL readings.

REFERENCES

1. K.P. Doppke and J.R. Cameron, USAEC Report C00-1105-119. Also in Cameron *et al.*, Thermoluminescent Dosimetry, (Univ. of Wisc. Press, Madison, 1968).
2. E.W. Claffy, C.C. Klick, and F.H. Attix, Proc. 2nd Int. Conf. Luminescence Dosimetry, Gatlinburg, Tenn., (1968).
3. D.W. Zimmerman and J.R. Cameron, Thermoluminescence of Geological Materials, ed. D.J. McDougall (London: Academic Press), pp. 485-91.
4. D.W. Zimmerman, C.R. Rhyner and J.R. Cameron, Health Physics 12, 525 (1966).
5. C.M. Sunta, V.N. Bapat and S.P. Kathuria, Proc. 3rd Int. Conf. Luminescence Dosimetry, Riso, Denmark (1971).
6. L.V.E. Caldas, Masters Thesis, Universidade de São Paulo, 1973, (unpublished).

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5