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ABSTRACT

$CaSO_4$:Dy exposed to $10^3 - 10^8$ R then annealed in the range 280 – 400°C displays little TL in the major dosimetry peak near 200°C. Subsequent illumination with 250 mm light reinduces the 200°C TL. This radiation-enabled photo-TL is roughly proportional to the square root of the enabling exposure at least to 10^8 R.

INTRODUCTION

High exposures ($> 10^5$ R) can be measured through the color centers produced in ionic crystals, for example, by measuring optical absorption in single crystals, or photoluminescence, reflectivity, or thermoluminescence (TL) in either single crystals or powders[9,8,2,4,3]. In TL, high temperature glow peaks are read because the more commonly used low temperature ones saturate near 10^5 R. We demonstrate that high exposures can be measured by detecting color centers through photo-stimulated TL (photo-TL) rather than absorption reflectivity or high-temperature TL. The procedure is similar to one suggested for rereading LiF dosimeters[5]; only germicidal lamps and a conventional TL reader are needed, and powder can be used. In addition to conventional applications, high exposure dosimetry with this method could be useful in geological dating where saturation is one limitation.

Virgin TL phosphers are usually insensitive to ultraviolet light (< 6.5 eV) because their band gaps are large (> 7 eV). Exposure to ionizing radiation fills deep and shallow traps in the gap; the shallow traps can be emptied by annealing at a temperature selected to leave some deep centers intact. In this situation illumination may empty deep traps to refill shallow ones, then heating results in photo-TL from these repopulated shallow centers. The combination of exposure and annealing renders the TL material sensitive to ultraviolet light. This type of photo-TL is also referred to as optical re-population or transfer-TL. If the illumination is not too long and the sample is not too dense optically, then the photo-TL is a measure of the deep centers' population. Note that the deep centers' population is sampled without reading to high temperature; thermal quenching of luminescence and the reader's incandescence are not problems. Also, under proper conditions the photo-TL can be induced and read many times after a single high-exposure.

In particular we have investigated photo-TL in $CaSO_4$:Dy (Harshaw). The main dosimetry peak near 200°C saturates with increasing exposure at about 10^3 R. Figure 1 shows that photo-TL does not saturate to at least 10^8 R. The figure actually reports the results of separate experiments, as follows. The circles represent TL obtained after the indicated exposures to 50 kV peak x-rays, followed by annealing 15 min. at 280°C, after which the powder was illuminated with 250 mm light from a Bausch & Lomb SP-200 lamp passed through a monochromator. The crosses show the results of exposure to ^{60}Co at Brookhaven National Lab followed by annealing for 30 min. at 400°C after which the powder was exposed to unfiltered germicidal lamps. Both experiments show that the photo-TL grows as $R^{0.55}$ up to at least 10^8 rads. (The two experiments used different lamps and readers, and the samples were purchased two years apart; the magnitude of the response in one experiment cannot be compared to the other. In both experiments the ultraviolet illumination was short enough to fall the region where the photo-TL is linear with illumination time.)

(*) Based in part on L.V.E. Caldas' Master's Thesis, University of Sao Paulo (1973) (Unpublished)

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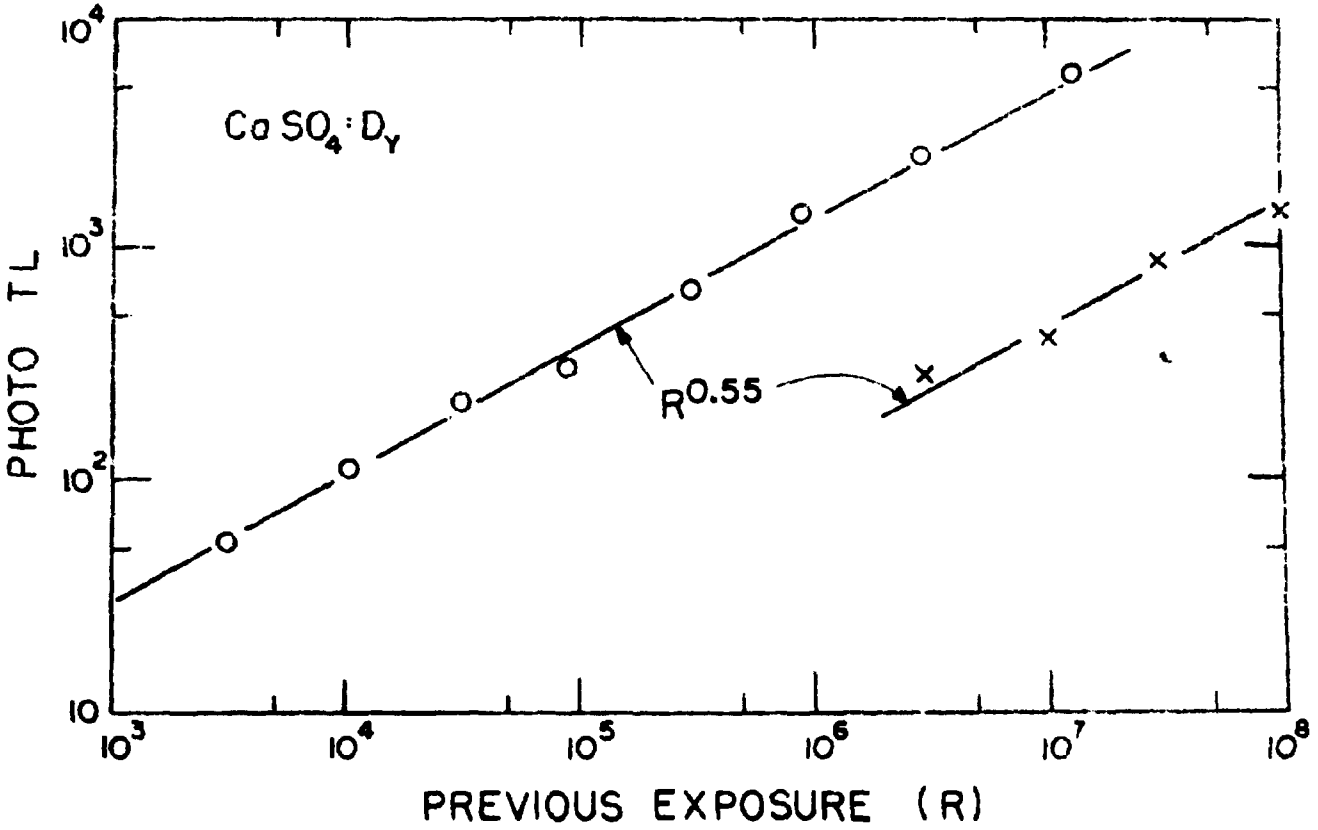

Figure 1 – Photo-stimulated TL as a function of previous exposure The circles and crosses show results of completely independent experiments; the units of response are arbitrary in each case.

While these results do not demonstrate a precise dosimetry system, they do demonstrate the principle. Other workers[7] have reported similar experiments with $CaSO_4$, but found the photo-TL to be more nearly independent of the enabling exposure. Preliminary experiments with 100 R at various effective energies indicate that the photo-TL follows the dose delivered by the enabling exposure[6]. The photo-TL actually exhibits two glow peaks, the usual one near 200°C, and another around 275°C; details are available elsewhere[1].

As an aside we note that a growing deep population of optically active centers does not guarantee success of the technique. In LiF (TLD-100) deep centers give TL above 200°C and cause photo-TL in the main dosimetry peak near 200°C (peak 5). Even though the deep traps population grows beyond 10^5 R, the photo-TL in peak 5 saturates near 10^5 R just as the direct response does. (The samples were determined not to be opaque to the illumination used to induce the photo-TL).

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RESUMO

As amostras de $CaSO_4$: Dy expostas a 10^3 a 10^8 R e aquecidas no intervalo de 280 a 400°C exibem pouca TL no pico dosimétrico principal de ~ 200°C. Uma iluminação subsequente ($\lambda = 250$ nm) reinduz a TL de 200°C. Esta TL fotoestimulada induzida pela radiação é aproximadamente proporcional à raiz quadrada da exposição pelo menos até 10^8 R.

RÉSUMÉ

Les échantillons des $CaSO_4$: Dy exposés entre 10^3 et 10^8 R et chauffés dans les intervales entre 280 e 400°C montrent peu TL dans le pic dosimetrique principal de ~ 200°C. Une illumination subséquente ($\lambda = 250$ nm) reinduit le pic de 200° C. Cette TL photostimulée due à la radiation est approximativement proportionnel à la racine carrée de l'exposition détectable au moins jusqu'à 10^8 R.

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