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ANGULAR DEPENDENCE OF TL AND OSL RESPONSES OF Al_2O_3:C COMMERCIAL DETECTORS IN STANDARD BETA RADIATION BEAMS

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ABSTRACT

The luminescent response of radiation detectors was evaluated by means of the thermoluminescence (TL) and optically stimulated luminescence (OSL) phenomena, for verification of its application in radiation dosimetry. An angular dependence study was performed in this work, using Al_2O_3:C commercial detectors, which were exposed to the radiation beams of a $^{90}Sr+^{90}Y$ source from a beta radiation secondary standard system. The detectors were irradiated with an angle variation from -60° to +60°, and the results obtained using the TL and OSL techniques were within the international recommendation limits.

1. INTRODUCTION

In order to evaluate the detector response and its usefulness as a radiation dosimeter, some characterization tests may be performed, as for example, the angular dependence study. By means of this work, the detector response was determined in function of the radiation incidence angle.

Different techniques of signal stimulation of the material are applied, and they can be utilized to analyze the radiation detector response, as from a solid state dosimeter: two of these techniques are the thermoluminescence (TL) and the optically stimulated luminescence (OSL). These phenomena have been used in several works, and for different purposes [1-4]. The main difference between them is the stimulation form of the luminescence process: heat for TL and light for OSL.

The objective of this work was to study the dependence of the response of Al_2O_3:C commercial detectors, Rexon [5], with the variation of the radiation incidence angle, using the TL and OSL techniques. These detectors were previously studied in relation to the TL characteristics [6], for a possible application in radiation dosimetry. For the angular dependence test, the detectors were exposed to the beta radiation secondary standard beams of a $^{90}Sr+^{90}Y$ source.

2. MATERIALS AND METHODS

Carbon doped aluminum oxide pellets (Al_2O_3:C), commercialized by the Rexon TLD Systems as TLD-500 detectors, were studied in this work; these pellets present dimensions of 5.0 mm in diameter and 1.0 mm in thickness.

The TL and OSL responses of the Al_2O_3:C detectors were evaluated after their exposure to a $^{90}Sr+^{90}Y$ source (nominal absorbed dose rate of [16.46 ± 0.220] μGy/s, 12.01.05); this source is a component of the beta radiation secondary standard system, BSS2, Isotrak, Germany, and it has a calibration certificate issued by the primary standard laboratory Physikalisch – Technische Bundesanstalt (PTB), Germany. During the experimental procedures, the irradiations were realized according to the specified conditions at the certificate: no utilization of the field flattening filter, and calibration distance (source-detector distance) of 30 cm. For the TL response, the absorbed dose of irradiation was 10 mGy, and for OSL response, it was 50 mGy.

A polymethylmethacrylate (PMMA) support was used for positioning and irradiation of the samples, which were covered with an aluminized Mylar foil (superficial density of 0.71 mg/cm^2), in order to keep the pellets at the dark to avoid the signal loss. The support with the samples was positioned in the irradiation set-up of the BSS2 system. For the angular dependence study, the goniometer of the BSS2 system was used. The radiation incidence angle varied from 0 to ±60°.

For the evaluation of the TL and OSL responses of the radiation detectors, a Risø reader system, model TL/LOE-DA-200, was used. During the TL measurements, the following parameters were adopted: heating rate of 10°C/s and final temperature of 400°C. For the OSL readings, the parameters were: blue LEDs for the signal stimulation, optical power of 90% and stimulation time of 50 s. For the blue LED stimulation, a Hoya U-340 filter was coupled to the reader system, in order to avoid the stimulation light to interfere into the emitted light (OSL signal) from the material. A collimator with a central hole of 5.0 mm of diameter was used during the measurements, avoiding the saturation of the photomultiplier.

The TL and OSL measurements were immediately taken after the irradiation of the samples, and then they were thermally treated to 400°C, during 1 hour, for reutilization.

3. RESULTS AND DISCUSSION

Initially, the TL and OSL detectors were verified in relation to the reproducibility of their response. Then, an angular dependence study was performed using a total of seven Al_2O_3:C detectors for each luminescent technique.

3.1. Reproducibility of Response

The reproducibility study results of the TL and OSL response of the Al_2O_3:C samples were obtained after four cycles of irradiation, reading and thermal treatment. The detectors were irradiated with an absorbed dose of 10 mGy ($^{90}Sr+^{90}Y$).

For the TL response, the reproducibility obtained for the samples was 4.9%, with a maximum standard deviation of 5.2%. In the case of the OSL response, the reproducibility and the maximum standard deviation were 3.9% and 4.9%, respectively.

3.2. Angular Dependence

The angular dependence study of the Al_2O_3:C detectors was performed varying the radiation incidence angles in each sample. After the evaluation of TL and OSL responses of the detectors, the values taken for each angle were normalized to the result obtained for the null angle. Table 1 shows the normalized values and the responses with the variation of the radiation incidence angles, for both TL and OSL techniques.

Table 1. Normalized values and variation of the TL and OSL responses of Al_2O_3:C (TLD-500), in function of the incidence angle of the beta radiation ($^{90}Sr+^{90}Y$).

Radiation Incidence Angle (°)	TL		OSL	
	Normalized Value for 0°	Variation (%)	Normalized Value for 0°	Variation (%)
-60	0.502 ± 0.020	49.8	0.391 ± 0.012	60.9
-45	0.625 ± 0.020	37.5	0.628 ± 0.033	37.2
-30	0.780 ± 0.020	22.0	0.728 ± 0.010	27.2
-15	0.889 ± 0.014	11.1	0.847 ± 0.022	15.3
-10	0.940 ± 0.027	6.01	0.963 ± 0.014	3.73
-5	1.018 ± 0.017	-1.79	1.019 ± 0.049	-1.92
0	1.000 ± 0.021	0.00	1.000 ± 0.044	0.00
5	1.020 ± 0.034	-2.01	1.014 ± 0.040	-1.37
10	0.942 ± 0.037	5.83	0.962 ± 0.026	3.82
15	0.888 ± 0.019	11.1	0.827 ± 0.021	17.3
30	0.770 ± 0.022	23.0	0.755 ± 0.024	24.5
45	0.637 ± 0.017	36.3	0.615 ± 0.012	38.4
60	0.511 ± 0.020	48.9	0.454 ± 0.014	54.6

The behavior for the TL and OSL signals can be observed in Fig. 1a-b in function of the radiation incidence angle. The graphs show, for both TL and OSL techniques, an increasing behavior of the signal in the case of the angle of ±5°, when the response at 0° is taken as reference. From the TL/OSL response obtained for the angle of -60°, an increase until the angle of -5° can be seen. Then, the TL/OSL response in the angle interval from 5° to 60° in the TL/OSL responses decreases.

The results obtained in this study agree with those already presented by Pinto [7], for Al_2O_3:C commercial detectors, Landauer, exposed to beta radiation beams, in relation to the decrease of the OSL signal. Furthermore, the percentage variation observed in this work is within the recommended limits of the European Standard Norme, which recommends a maximum variation of ±40% in the interval of 0° to ±45° [8]. The maximum variation in this work was 37.5% for the TL technique (at the angle of -45°), and 38.4% for the OSL technique (at the angle of 45°).

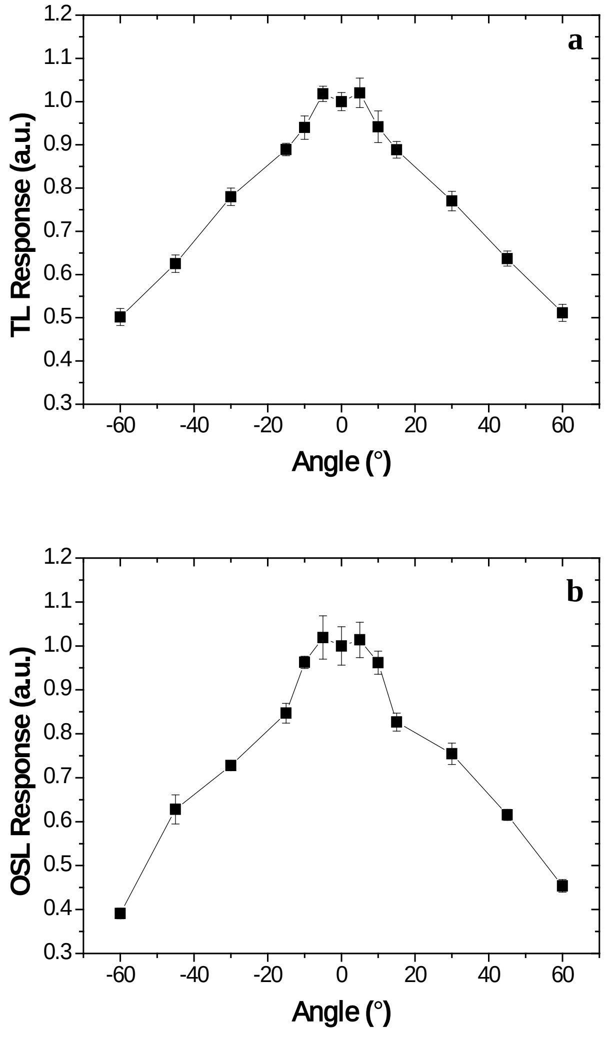

Figure 1. Angular dependence study of the Al_2O_3:C detectors: (a) TL response, and (b) OSL response in beta radiation beams of $^{90}Sr+^{90}Y$.

4. CONCLUSIONS

The two characterization tests performed in this work showed the good behavior of the Al_2O_3:C commercial detectors, when exposed to the beta radiation secondary standard system beams ($^{90}Sr+^{90}Y$ source), because for both tests the TL and OSL responses were adequate. In the reproducibility test, a stability of response of the samples was verified, with a maximum value of 4.9%, for the case of TL. The angular dependence test presented compatible results with those recommended by the European Standard Norme, for both luminescent techniques. Therefore, the detectors may be used with efficiency in beta radiation dosimetry.

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