Malaysian Journal of Science **21A**: 23-25 (2002)

Dosimetric characterisation of Er-doped optical fibre as thermoluminescent material

Y.A. Abdulla[1], Y.M. Amin[1] and D.A. Bradley[2]

[1]*Physics Department, University of Malaya, 50603 Kuala Lumpur Malaysia.*
[2]*School of Physics, University of Exeter EX4 4QL. U.K.*

ABSTRACT A radiation dosimeter based on Er-doped optical fibre is described. The thermoluminescence characteristics induced by ^{60}Co irradiation are investigated.These characteristics including reproducibility, photon dose response, minimum detectable dose, fading and annealing procedure.

(Er-doped optical fibre, Thermoluminescence)

INTRODUCTION

Optical fibres are now widely used in long distance communications, providing high performance for progressively decreasing bandwidth loss. In recent years, the photon irradiation response of optical fibres has been investigated by, among others [1-3]. It has been established that the TL (thermoluminescence) performance of an irradiated fibre is not only influenced by radiation parameters such as energy, dose rate and the total dose but also the type of fibre. The aim of the present work is to present the main dosimetric characteristics of Er-doped optical fibre.

EXPERIMENTAL PROCEDURE

In this work we use a commercially available Er-doped optical fibre. The samples were prepared as follows: The Er-doped fibre was cut into one centimeter in length and a mass of ~0.3 mg. The plastic layer, which covered the fibre, was removed before the annealing process took place. TL readout was carried out using Harshaw 3500 reader at heating rate of 15 ^{0}C/sec. The Er-doped fibre was exposed to ^{60} Co gamma radiation in dose ranging from 2.72 Gy to 400 Gy.

RESULTS AND DISCUSSION

The glow curve

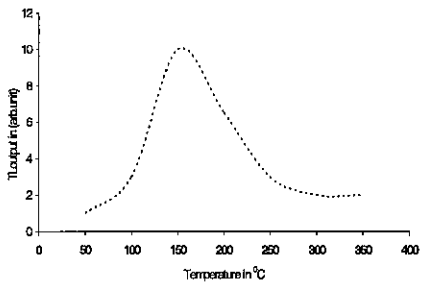

Figure 1. Er-doped optical fibre glow curve.

It is found that Er-doped fibre has a very simple glow curve, consisting of a single, well-defined TL peak having a maximum TL output at around 150 ^{0}C. Figure 1 shows the typical shape of the glow curve of Er-doped fibre. The shape and position of peak temperature seems to remain constant for all the doses delivered.

Annealing procedure of Er-doped optical fibre

The annealing procedure and the effect of annealing are also studied. The experiment was carried out using different annealing temperatures of 100, 200, 300, 400, and 500 ^{0}C

but the same annealing time of 1 hour for each temperature.

Figure 2 shows the TL response after various annealing temperatures from 100 ^{0}C to 500 ^{0}C. Each point was obtained using 7 samples submitted to the same annealing procedure and same dose. It can be seen that the highest TL (peak area) response is obtained for 400 ^{0}C annealing temperature. However, the lowest standard deviation in percentage is achieved for annealing temperature of 400 ^{0}C and 500 ^{0}C. The TL response for unirradiated sample for all the temperatures is very close to the TLD-reader background, and the variation of the response for unirradiated fibre is not significant. After setting the annealing temperature at 400 ^{0}C in air, we also studied the effect of annealing time on the TL response. The TL response to a fixed dose of 16.3 Gy, decreases with annealing time reaching the minimum after 90 min annealing time as shown in Figure 3.

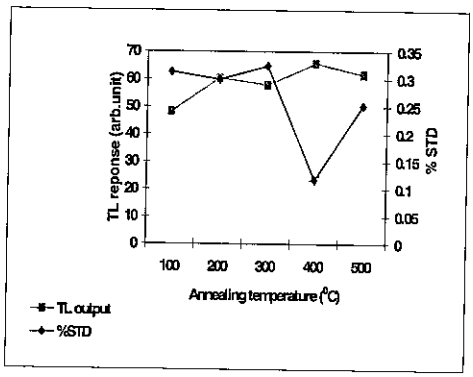

Figure 2. The behavior of the TL response as a function of the annealing temperature. The annealing time was kept constant at 1 hour.

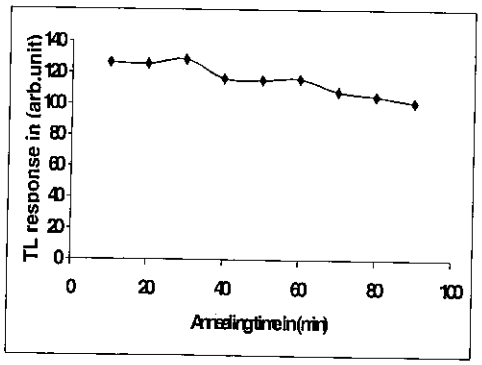

Figure 3. The TL response versus the annealing time (the annealing temperature was kept constant 400^{0}C).

Reproducibility

In order to assess the reproducibility of the dose measurements using this material, a large set of repeated readouts were carried out. Figure 4 shows the results obtained after 8 repeated cycles using five samples (annealing - irradiation-readout). The irradiation dose was 16.3 Gy. The results showed that the Er-doped fibre reproduce the dose of 16.3 Gy with about 4 % variation based on standard deviation for 8 sequential measurements.

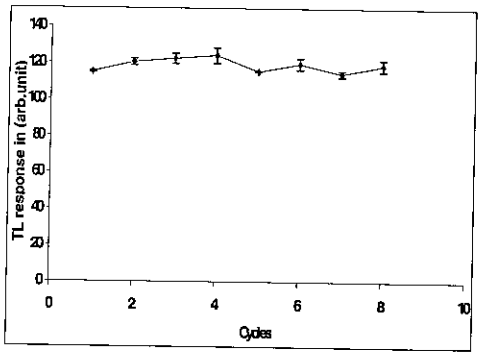

Figure 4. The reproducibility of Er-doped fibre samples through 8 repeated cycles of annealing- irradiation- readout.

Radiation dose response

The TL response to gamma radiation from ^{60}Co as function of dose is shown in Figure 5. For each dose five samples were irradiated simultaneously to obtain the mean and standard deviation. The response is linear over the range of doses used from about ~1 Gy to about 250 Gy with a regression factor equal to 0.998. A good check of the linear property of the material can be done using the so-called linearity index f(D) [4] defined as :

$$f(D) = \left(\frac{TL(D)/D}{TL(D_1)/D_1} \right)$$

Where D_1, is the normalization dose in the linear region. The f (D) value was calculated for each experimental point The threshold dose has been determined according to the following expression [4].

$$D_0 = \left(\overline{B} + 2\sigma_B\right) XF$$

Where B and σ_B are the mean TL background signal obtained from the samples annealed but not irradiated and the standard deviation of the mean background respectively and F is the TL system calibration factor, expressed in Gy/TL. The value obtained was found to be about 0.86 Gy. However, in practice the minimum detectable dose is defined as three times the standard deviation of the zero dose reading of the dosimeters. Using this definition, the detectable dose is found to be 0.37 Gy for Harshaw 3500 TL-reader used.

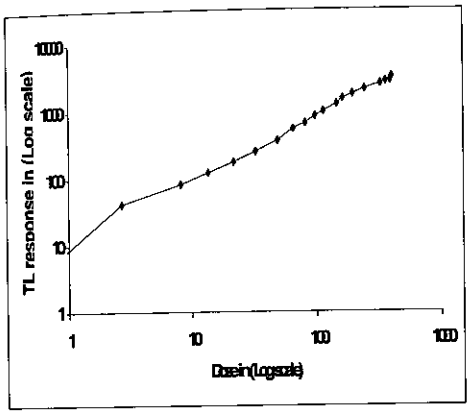

Figure 5. The dose response for Er-doped fibre.

Fading

The Er-doped optical fibre with the mean peak at about 150 ^{0}C, showed high fading, of about 30% for the first 24 hours. After 20 days storage at room temperature the fading was about 58.6% as shown in Figure 6.

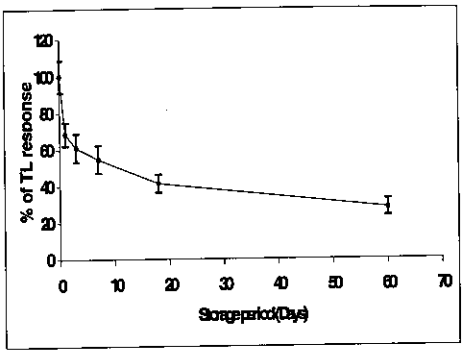

Figure 6. The fading characteristic of Er-doped fibre (at ambient temperature).

CONCLUSION

The Er-doped optical fibre shows a good linear range of the TL response as a function of the absorbed dose and has a very simple annealing procedure. The Er-doped optical fibre has a simple glow curve with well-defined peak around 150 ^{0}C. However, it has a high fading rate where 30% of the signal is lost during the first 24 hours after the exposure.

REFERENCES

1. Friebele, E.J., (1979). *Opt.Eng.* **18**,552-561.
2. Friebele,E.J., Schattz,P.C. and Gingerich, M.E., (1980). *Appl.Opt.* **19**, 2910-2916.
3. Friebele, E.J., Gingerich,M.E. and Long, K.J, (1982). *Appl.Opt.* **21**,547-443.
4. Furetta. C., Kitis. G., Weng, P.S., (1989), Operational Thermoluminescence Dosimetry. World Scientific. Singapore.