WHAT IS THE BEST ANNEALING TREATMENT FOR LiF DOSEMETERS? SOME EXPERIMENTAL RESULTS

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1. INTRODUCTION

Many references in the Literature, when dealing with the problem of TLD annealing, have recommended various solutions, according to the material to be treated. For lithium fluoride, one of the most widely recommended pre-irradiation annealing procedures consists of a two-phase cycle: 1 hour at 400°C (higher termperature phase) and 2 hours at 100°C (lower temperature phase).

The aim of this work is to assess whether this method is really the optimum or some variations in termperature or time should be introduced. The paramenters considered to evaluate the effectiveness of the annealing were sensitivity (as signal-to-dose ratio) and reproducibility.

2. MATERIALS AND METHODS

The dosemeters used for the present study were sintered LiF:Mg,Ti (TLD-100) chips, individually calibrated. The experimental procedure can be summarised as follows:
1 - Pre-irradiation annealing
2 - Irradiation
3 - Post-irradiation annealing
4 - Readout
5 - Data processing

As regards the pre-irradiation annealing, the lower temperature treatment has been kept constant at 100°C for 2 hours, whereas the higher temperature treatment was varied in the range between 300 and 500°C. Great care was exercised to keep constant both annealing time (+/- 10 seconds) and location of dosemeters (+/- 2 mm) into the furnaces. During this annealing, a series of five Chromel-Alumel thermocouples inserted into the furnaces were used to measure the actual temperature of the TLDs; gradients and time-dependent fluctuations of these temperatures were also checked.

The irradiations were carried out by a 60-Co Gammabeam 150-C facility.

The post-irradiation annealing was performed at 100°C for 15 minutes.

The TLDs were read out on a semi-authomatical TL analyser, Harshaw 2000-D, with a capacity of 50 dosemeters. A 300°C nitrogen flux was used in this reader. In order to allow for the long-term instability of the TL analyser, all the readouts of each reading session were normalised to the mean response of 25 additional TLD-100 chips annealed and irradiated according to a standard procedure and read during the same session.

3. EXPERIMENTAL TECHNIQUE

The parameters considered as variable in the present experiment were:
1 - Temperature of the first phase of pre-irradiation annealing;
2 - Irradiation level.

The temperature was varied in the range between 300 and 500°C, in 50°C steps. Two levels of dose were selected: 50 and 500 mGy.

Fifty dosemeters were randomly selected from the same batch and used throughout the experiment. Each temperature level was investigated by carrying out 4 annealing-irradiation-readout cycles.

4. RESULTS

A decrease in sensitivity was systematically obse ved in t e TLDs after the 500 C cycles. In order to allow for this phenomenon, the evaluation of

sensitivity at the reference temperature (400°C) was repeated before each variation of the annealing temperature.

Fig. 1 shows the reproducibility, in terms of variation coefficients, of the sensitivity obtained in the 4 cycles performed at each temperature. The experimental points are scattered in the range from 0.7 to 3.7%; the statistical analysis (F-test) of the data does not reveal any significant trend.

Figs. 2 and 3 show the mean relative sensitivity of LiF as a function of annealing temperature. The agreement of the experimental points with the decreasing exponential functions reported in the inserts is within 2%. The deviations are still lower for the 5 mGy dose level.

These figures also compare the present results with the ones published by Regulla (1981).

5. DISCUSSION

The experimental results point out that the relative sensitivity monotonically decreases in the range 300 to 500°C, with a slight negative slope below 400°C and a steeper one for higher temperatures. This behaviour is somewhat different from that found by Regulla (see Figs. 2 and 3) who observed a positive slope below 400°C, with a maximum around this temperature. However, the comparison of these two sets of data is difficult as some basic experimental parameters (e.g. dose level, lower temperature pre-irradiation annealing, etc.) cannot be found in Regulla's paper.

The decrease of sensitivity with annealing temperature can be connected with the existence of trapping levels at different energies below the conduction band. A Phenomenon of thermal destruction of centres corresponding to shallow levels is likely to occur for very high temperatures. On the contrary, for temperatures lower than 400°C, the trap concentration does not undergo a remarkable reduction, so that the slight increase in sensitivitiy for decreasing temperatures might be explained in terms of charge and centre kinetics between levels situated at different energy depths

Temperatures higher than 400°C should therefore be avoided for LiF annealing treatments because the TLDs may be permanently damaged. On the contrary, when carried out at a temperature level less than 400°C, the annealing does not lead to a relevant increase of sensitivity and, moreover, the trap emptying may be incomplete.

In conclusion, the results of the present experiment show that the optimum temperature for the first phase of the annealing cycle of LiF is not far from the universally accepted value of 400°C. Further measurements are now in progress in order to improve the resolution of the experiment, taking into account not only sensitivity and reproducibility of dosemeters but also possible 'memory' effects due to previous irradiations.

REFERENCES

D.F. Regulla - Operational aspects. In Applied Thermoluminescence Dosimetry, Eds. M. Oberhofer and A. Scharmann, Adam Hilger, 1981

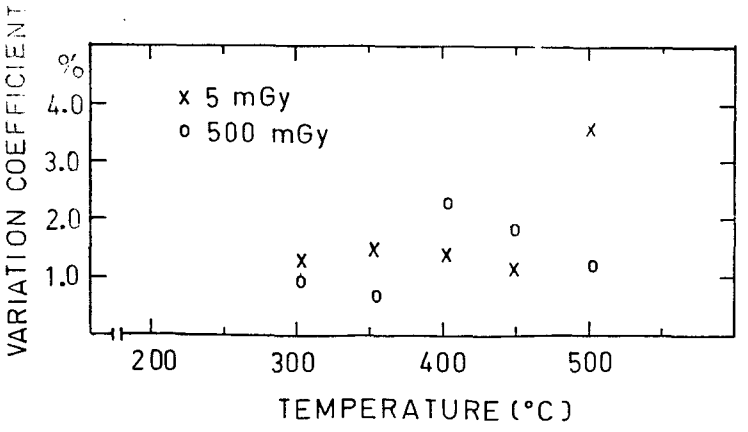

Fig. 1: Reproducibility of LiF as a function of the temperature of the pre-irradiation annealing

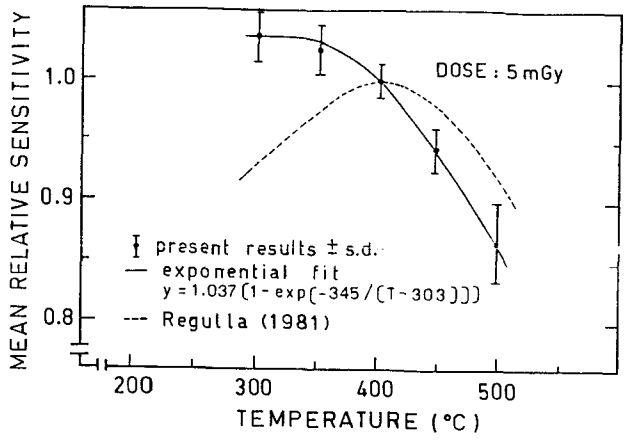

Fig. 2: Mean relative sensitivity of LiF as a function of the temperature of the pre-irradiation annealing.
Dose level : 5 mGy

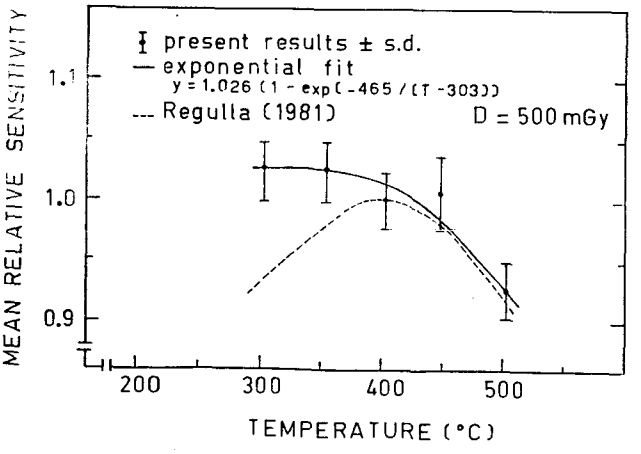

Fig. 3: Mean relative sensitivity of LiF as a function of the temperature of the pre-irradiation annealing.
Dose level : 500 mGy