CNIC-01038
LIHMPH-0010

CN9601304

中国核科技报告

前剂量和退火温度对石英热释光剂量学特性的影响

THE EFFECTS OF PREDOSE AND ANNEALING TEMPERATURE ON SOME DOSIMETRIC PROPERTIES OF THERMOLUMINESCENCE OF QUARTZ

中国核情报中心
原子能出版社

China Nuclear Information Centre
Atomic Energy Press

VOL. 27 № 15

林志凯：卫生部工业卫生实验所助理研究员，1979年毕业于北京大学技术物理系核物理专业。1994～1995年作为访问学者赴日本科学技术厅放射医学综合研究所工作。

LIN Zhikai: Researcher of Laboratory of Industrial Hygiene, Ministry of Health. Graduated from Department of Technique Physics, Peking University in 1979, majoring in nuclear physics and has been National Institute of Radiological Sciences, STA, Japan as a visiting scholar in 1994～1995.

CNIC-01038
LIHMPH-0010

前剂量和退火温度对石英热释光剂量学特性的影响

林志凯

（中国卫生部工业卫生实验所）

限元芳一　野田丰

（日本政府科学技术厅放射线医学综合研究所）

摘　要

对下述石英剂量学特性进行了研究：(1)石英的剂量灵敏度在不同退火温度下随不同前剂量的变化；(2)使石英的剂量灵敏度恢复到原有水平的最佳退火温度的选择；(3) 在 500℃，8 小时退火温度时，石英的剂量灵敏度随退火时间的变化；(4)经前剂量照射的石英样品在 700℃，3 小时退火后石英的剂量灵敏度恢复到原有水平的可能性。结果表明，在 700℃，3 小时的退火条件下，可使石英的剂量灵敏度变化最小，并几乎恢复了其原有水平。用四种不同的石英样品进行的重复性实验进一步验证了这一结果。同时还发现，石英的 TL 发光峰曲线只有在 900℃，1 小时退火条件下才发生畸变，这一结果与 D. J. Huntley et al. （1988）得到的结果有所不同。*

* 本课题由日本政府科学技术厅资助提出并在日本放射线医学综合研究所完成

The Effects of predose and Annealing Temperature on Some Dosimetric Properties of Thermoluminescence of Quartz

LIN Zhikai
(Laboratory of Industrial Hygiene, Ministry of Health, China)
Yoshikazu KUMAMOTO Yutaka NODA
(National Institute of Radiological Sciences, STA, Japan)

ABSTRACT

The following aspects of dosimetric properties of quartz sample were studied. (1) The changes in dosimetric sensitivity of quartz with different predoses under different annealing temperatures; (2) The option of optimal annealing temperature which can make the dosimetric sensitivity of quartz to restore its original level; (3) The changes in dosimetric sensitivity of quartz with different annealing time at 500 ℃ for 8 h; (4) Repeated experiments were carried out in order to prove whether the sensitivity of quartz can restore its original level at annealing temperature 700 ℃ for 3 h. It has been found that at 700 ℃ for 3 h gave the least sensitivity change and the sensitivity of quartz almost restored its original level. Repeated experiments with four kinds of quartz sample confirmed this conclusion. The dramatic change of TL glow curve occurred only at the condition of annealing temperature 900 ℃ for 1 h. This result was different from that obtained by D. J. Huntley et al. (1988).

INTRODUCTION

It has been found that predose can greatly enhance the sensitivity of thermoluminescence (TL) of quartz and high temperature at 700 ℃ for 3 h can cause a dramatic spectral change (D. J. Huntley et al., 1988). The main purpose of our experiment was not only to study the effects of predose and heating treatment on the sensitivity of quartz, but also to try to find out the optimal annealing condition in order to make the irradiated quartz to restore its original sensitivity.

The aim of this study is also to demonstrate how the predose and annealing temperature play roles in changing the sensitivity and dosimetric properties respectively. So the dosimetric properties of quartz which were irradiated by different predoses and annealed by different temperatures were studied.

1 MATERIALS AND METHODS

1.1 The quartz samples with the size ranging from 105 to 210 μm were prepared by a method adopted by Takashi Maruyama et al. (1984).

1.2 The effects of annealing time on sensitivity

Irradiation was performed at room temperature with a ^{60}Co γ-source at SSD=50 cm. Dose rate was 0.41 Gy/min.

The quartz was irradiated with a predose of 8.3 Gy, followed annealing in an electric furnace for 1～6 h at 500 ℃ by. Then the annealed quartz was irradiated with a dose of 2.96 Gy again. The TL glow curves were measured in two days after irradiation.

1.3 The effects of predose on sensitivity

The quartz samples were divided into 6 groups. Group 1 was used as standard sample; group 2, which was unirradiated by predose but annealed, was used for comparison with group 3-group 6 which were irradiated with doses of 0.9 Gy, 5.0 Gy and 8.3 Gy again respectively. Group 1 was also divided into three aliquots which were irradiated by the three same dose points.

The relative TL sensitivity was plotted with the ratio of tan α (i) /tan α (s). Here tan α(i) is the slopes of linear dose response curves for quartz group 2-group 6, tan α (s) is the slope of dose-response curve for quartz group 1.

1.4 The conditions of annealing

The quartz was annealed in the electric furnace for 8, 3, 1 h at 500, 700, and 900 ℃ respectively. The annealing method was as follows: the quartz was put into the furnace after the annealing temperature reached the required temperature; the annealed quartz was taken out of the furnace as soon as the annealing time was over and then the annealed quartz was cooled to the room temperature quickly.

1.5 TL measurement

The TL measurement was performed with a HARSHAW 2000 A and 2000 B thermoluminescence dosimeter using a heating rate of 10 ℃/min. and nitrogen gas of 1 L/min. Aliquots of about 5 milligrams were used for the measurement of TL glow curves which were recorded by a WX 451 WATANABE X-Y Recorder. The final results were obtained from the average values of 3 aliquots for every dose point.

2 RESULTS

2.1 The effects of annealing time on sensitivity

The experimental results is shown in Fig. 1.

It can be clearly seen from Fig. 1 that the sensitivity changes very slowly with annealing time. The sensitivity in different aliquots agreed with each other with a variation of 10%. The deviation from average value was ±7.6%. In other words, the changes of sensitivity depended only on annealing temperature rather than on annealing time.

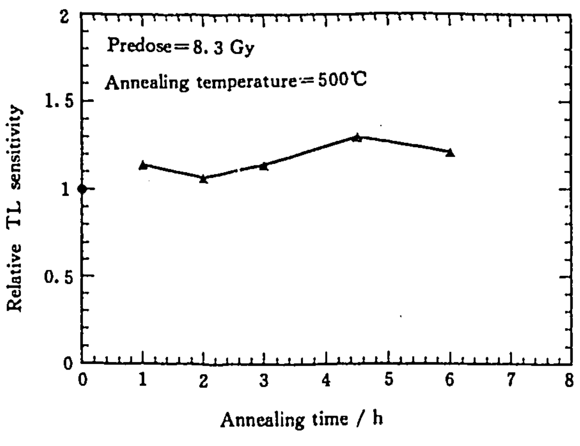

Fig. 1 The relations between the sensitivity quartz and annealing time at 500 ℃

• The sensitivity of standard quartz sample.

In this experiment, only obvious increase in sensityivity was observed. Comparison of the average value of sensitivity with that of standard aliquot, the sensitivity was enhanced by 17.5% after irradiation and annealing at 500 ℃.

2.2 The effects of predose on sensitivity

The typical TL dose-response curves were illustrated in Fig. 2. The behaviors of TL dose-response curves of other aliquots were same as those in Fig. 2. These results are shown in Fig. 3.

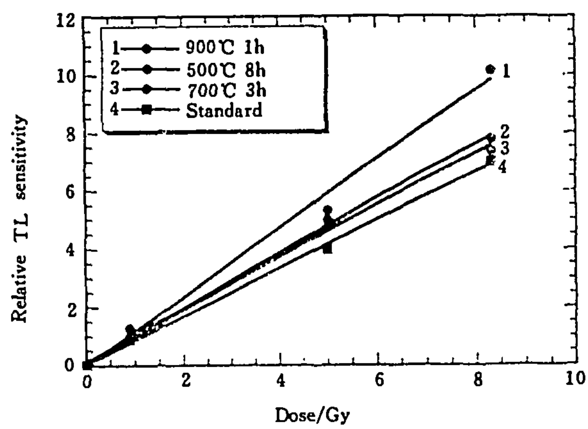

Fig. 2 The dose-response of quartz exposed to different predoses of ^{60}Co gamma-rays
The linear correlation coefficients are 0.9959、0.9992、0.9974 and 0.9991 respectively.

In this experiment, no supralinearity was observed. Even though supralinearity existed, it might be small enough to be neglected. Significant enhancement in sensitivity can be observed in aliquots annealed at temperature 900 ℃ for 1 h (see Fig. 2). But for the aliquots which were annealed for 3 h at 700 ℃, the sensitivity approximated that of standard aliquot with a difference within 5.3%. This result indicated that quartz irradiated previously can restore its original sensitivity at the annealing temperature of 700 ℃ for 3 h. By comparing the dose-response curves of aliquots annealed at 500 ℃ with that of standard aliquot, the sensitivity was enhanced by 11.4%.

The results in Fig. 3 exhibit the same behavior as that in Fig. 2, i.e. the sensitivity of quartz were increased obviously after predose irradiation and annealing at 500 ℃ and 900 ℃. For all aliquots annealed at 700 ℃for 3 h, it can be seen that their sensitivity was close to that of standard aliquot. In comparing the results of the aliquots annealed at 900 ℃、500 ℃ and 700 ℃ with that of standard aliquot, the sensitivity was enhanced by 39.1%、13.3% and 7.8% on average respectively. However, the increase in sensitivity exhibited random distribution and was not proportional to predose.

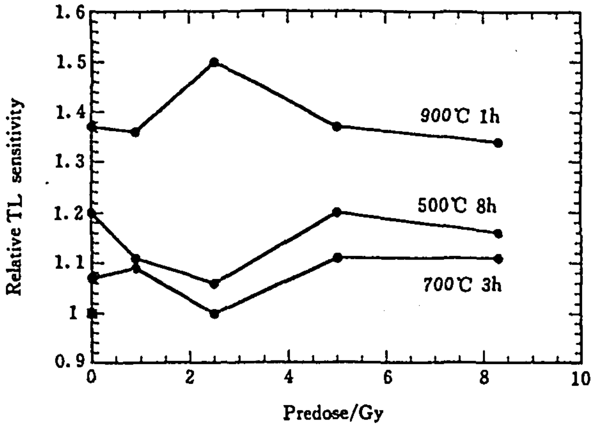

Fig. 3 The TL sensitivity of quartz as a function of gamma predose

2.3 The results of repeated experiments

Four kinds of quartz samples were used for repeated experiments in order to verify whether the different irradiated quartz samples can restore their original sensitivity under the annealing condtions at 700 ℃ for 3 h. The results were shown in Table 1. All four kinds of quartz were irradiated with a predose of 8.3 Gy and then annealed at 700 ℃ for 3 h. After this procedure, the quartz were irradiated with 5.85 Gy.

Table 1 The comparison of sensitivity in four kinds of quartz

Experimental condition	Relative TL sensitivity of four quartz samples			
	1	2	3	4
Predose=0 Unannealed	7.6±0.1	0.5±0.1	3.9±0.5	3.3±0.1
Predose=8.3 Gy Annealed	6.5±0.4	0.5±0.1	4.1±0.2	3.5±0.1

Two evident characteristics can be noticed from Table 1. One is that the sensitivity of all these quartz almost restored the original sensitivity as stated before. The other is that the sensitivity of different quartz samples to gamma-dose is quite different.

Besides two characteristics mentioned above, no other dramatic TL glow curve change was found like that described by D. J. Huntley et al. (1988).

2.4 The behavior of TL glow curves

It is always expected to remove the effect of lower temparature peak on the TL dose measurement. This purpose can be achieved by using preheating method described by Klaus Becker et al. (1978).

The comparison of TL glow curves is as the following.

In this experiment, the aliquots were preheated by keeping them in an electric furnace at 80 ℃ overnight (15h). Then the TL glow curves were measured. The normallized typical TL glow curves plotted with the average values of 3 aliquots were shown in Fig. 4.

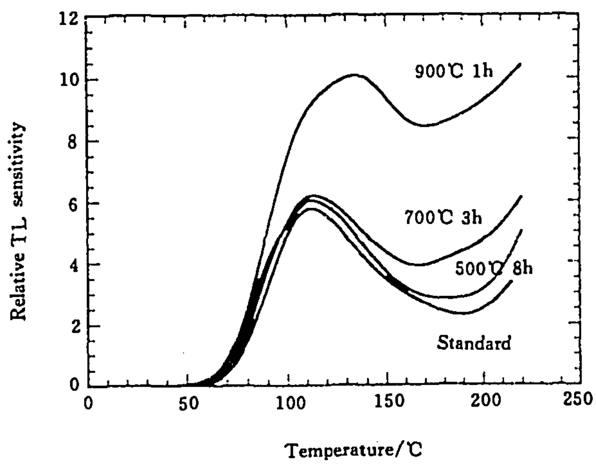

Fig. 4 The normalized TL glow curves of quartz annealed at 900 ℃、700 ℃ and 500 ℃ respectively. Irradiation dose is 8.3 Gy

It can be seen from Fig. 4 that the shapes of TL glow curves of aliquots treated by annealing at 500 ℃ and 700 ℃ were almost same as that of standard aliquot. The sensitivity was enhanced slightly. But for the aliquots treated by 900 ℃, the shape of the glow curve was dramatically changed and the sensitivity was enhanced greatly due to the higher temperature and predose effects. The locations of peaks for aliquots treated by 500 ℃, 700 ℃ and standard aliquot were at 110 ℃. But for aliquots treated by 900 ℃, its peak was moved towards to 130 ℃ because of higher temperatype effects.

Three functions of preheating can be found from this experiment. One is that a lower temperature peak of TL was completely removed and the higher temperature peak, which was the main signal, was not affected considerably. The another is that the location of TL glow peak was moved towards that of higher temperature. The last is that preheating can simplify the shape of TL glow peak because disturbance from lower temperature peak can be eliminated.

3 CONCLUSIONS AND DISCUSSIONS

According to the experimental results obtained, some conclusions can be made as follows:

(1) The predose really plays a very important role in the enhancement of TL sensitivity even though it is small. (2) Quartz can restore the original sensitivity under the annealing conditions at 700 ℃ for 3 hours according to the annealing method described in this paper. This conclusion is quite different from that reported by D. J. Huntley et al. (1988). No dramatic TL glow curve changes were found under this annealing conditions. The quartz used in this experiment was extracted from natural bricks, but the quartz used by D. J. Huntley et al. was a commercial one. Another reason may be that there are some differences between two annealing methods and befween natural quartz and commercial quartz. This problem should be studied further in the future. (3) The sensitivity of quartz can be greatly enhanced at the annealing temperature of 900 ℃ for 1 h. Dramatic TL glow curve change occurred under this annealing conditions. (4) Preheating can simplify TL glow curve and improve the accuracy of TL measurement. (5) The increase in sensitivity is not proportional to predose. (6) Different sensitivity exists in different quartz. (7) No supralinearity was observed in this study.

Acknowledgements

This work was supported by the STA Exchange Program and done at the National Institute of Radiological Sciences (NIRS), STA, Japan. We wish to thank Dr. T. Muruyama for his suggestions in the course of experiments. Z. Lin would like to express his thanks to Mrs. H. Imaseki、Y. Kokuzawa and H. Boyama of the Planning Section of NIRS for their help during his stay in Japan.

REFERENCES

1 Huntley D J, Godferey D I, Thewalt M L. Some quartz thermoluminescence spectra

relevant to thermoluminescence dating. Nucl. Tracks Radiat. Meas, 1988, 14 (1/2): 27~33

2 Takashi Maruyama, Yoshikazu Kumamoto, Yutaka Noda (1984). Thermoluminescence dosimetric techniques and their application to evaluation of A-bomb dose in Hiroshima and Nagasaki. Hiroshima/Nagasaki dose reassessment: Thermoluminescence Workshop, Coo-119-260, 3~18

3 Klaus Becker, Christian Goedicke. A quick method for authentication of ceramic art objects. Nucl. Instr. and Meth, 1978, 151: 313~316

（京）新登字 077 号

图书在版编目（CIP）数据

中国核科技报告 CNIC-01038 LIHMPH-0010 前剂量和退火温度对石英热释光剂量学特性的影响：英文/林志凯等. —北京：原子能出版社，1996. 2

Ⅰ. 中… Ⅱ. 林… Ⅲ. ①核技术-研究报告-连续性出版物-中国②反应堆-核工程-热力工程-热力计算-研究 Ⅳ. ①TL-55②TL3

中国版本图书馆 CIP 数据核字（96）第 01205 号

原子能出版社出版发行
责任编辑：武 洁
社址：北京市海淀区阜成路 43 号 邮政编码：100037
中国核科技报告编辑部排版
核科学技术情报研究所印刷
开本 787×1092 1/16・印张 1/2・字数 10 千字
1996 年 2 月北京第一版・1996 年 2 月北京第一次印刷

CHINA NUCLEAR SCIENCE & TECHNOLOGY REPORT