EFFECT OF PRE-HEAT TEMPERATURE ON THE TL GLOW CURVE OF FUSED QUARTZ

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Abstract

Fused quartz obtained from SPI laboratories in West Chester USA was studied extensively for the possibility of its application as a TL detector using Victorreen TL reader model 2800M at the Center for Energy Research and Development, O.A.U., Ile- Ife.

Results have shown that the maximum of the peak 1 of the glow curve was shifting towards the higher temperatures as the pre-heat temperature increases, indicating that the presence of overlapping peaks in this composite one. Anomalous fading was observed between the two glow peaks, with the deeper trap represented by peak 2 growing at the expense of the shallower peak 1. The dose response curve of the glass was somehow linear within the dose range considered. It can be concluded from this study, that with a judicious choice of pre-heat temperature and annealing regime, this material may be a good candidate for retrospective dose reconstruction in the study of a nuclear accident site.

1. Introduction

Quartz is abundant in nature and can be found in archaeological artifacts as well as geological materials (Sawakuchi and Okuno, 2004). The choice of fused quartz for dating and retrospective dosimetry applications (Chen and Mckeever, 1997; Pagonis et al, 2002) has led many studies on its Thermoluminescence (TL) characteristics (Adamic, 2005.)

Other studies on the influence of excitation dose and thermal treatment on the TL properties of glow peaks in quartz have been reported for examples, de Lima et al (2002) and Yang and Mckeever (1990) have shown that pre-irradiation annealing produces profound changes in the sensitivities of the peaks. Kitis et al (2003) on an Arkanansas quartz has also shown that positions of the glow peaks in quartz either remains constant or shift to lower temperature as excitation dose given to the sample is increased.

In this study the effect of pre heat temperature on the shape of the glow curve and other TL properties of fused quartz are reported. To estimate the linearity of the dose response, the linearity index F (D) proposed by Chen and Mckeever (1994) was used:

$$F(D)=\left[\frac{S(D)-S_o}{D}\right]\left[\frac{S(D_1)-S_o}{D_1}\right]^{-1} \quad (1)$$

where in the graph of TL versus dose, S_o represents the intercept on the TL intensity axis extrapolated from the linear region of the graph. S(D) is the sample TL response corresponding to dose D and D_1 is a dose in the linear region, (SD1) is the sample TL response corresponding to dose D1. By this definition, F(D)≥1, F(D)=1, and F(D)≤1 implying supralinearity, linearity and sub linearity respectively.

2. Materials and Methods

(a) Sample Preparation

Samples used in this work consisted of fused quartz from SPI laboratories, West Chester USA. Before use, the samples were annealed at 400 °C for 1 hour (gallenkamp furnace) and cooled rapidly in air.

TL measurements were carried out at the Center for Energy Research and Development, Obafemi Awolowo university Ile-Ife, Nigeria using a Victoreen TL reader at various heating rate between 50 and 200 °C.The signal was detected by a photo multiplier tube through 232 USB PORT.

All the measurements were made in a nitrogen atmosphere; this was done to ensure a uniform cooling of the sample with the TL reader. During this cooling region, the equipment is automatically shut off such that the sample cannot be re-read until it has sufficiently cooled done. For each sample, two measurements were made one after the other and each from the set pre heat temperature.

In each case, the second measurement is subtracted from the first in order to correct for the effect of blackbody radiation from the sample holder. For each of the measurement reported, about 12 mg of the sample was placed at the center of the planchet .in order to investigate the dose response of the fused

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quartz. Sets of the glass samples were irradiated to doses in range of 1 Gy-4 kGy .The irradiation at 6.05 Gy/min, was done using ^{60}Co gamma cell irradiator.

3. Results and Discussion

(a) Shape Of The Glow Curve With Changes In Pre-heat Temperature

Figures 1 to 5 show the TL glow curve of fused quartz irradiated to a test dose of 2.5 kGy and readout at the heating rate of 8 °C/s. The glow curves aside Fig. 1 show 2 prominent peaks, which henceforth are referred to as peaks I and II, respectively. This shows that there are at least 2 different charge traps in this phosphor was not evident with 50 °C preheat temperature. This was not the case when the pre heat temperature of the measuring system was adjusted from 50 °C to15°, 175,200,300 °C, respectively. We can infer that the shape of the glow curve is dependent on the choice of pre heat temperature.

(b) Dose Response

Fig.6 shows the variation of maximum TL intensity with dose for peaks II and I. It could be seen from the figure that the dose dependence of the maximum TL intensity of all the peaks is assumed to obey the relation

$$S(D) = \alpha D^{\delta} \quad (2)$$

as given in Chen and Mckeever (1997), where S(D) stands for maximum intensity, D is the excitation dose, α and δ are the fitting parameters. The linear region of this dose response curve can be located by Eqn. 2 to the curve shown in this Figure. The linear region was taken to be one where δ is closest to 1. In this way, the linear region of the peak was determined to be from 500 to 2000 Gy .It could also be suggested from this plot that there is a high supralinearity of dose response in fused quartz. The linearity within 500 – 2000 Gy range makes this fused quartz a very good candidate for Dosimetry in this dose range monitoring (personal and environmental)as well as in high dose applications such as in food irradiaton,medical equipment sterilization and nuclear accident monitoring.

4. Conclusion

The effect of the preheat temperature on the TL glow curve of fused quartz have been investigated. Difference in the glow curve shape with change in pre heat temperature was observed. Linnearity index analysis showed that the response of the integral peak is linear at medium dose glow, supralinear as dose is increased.

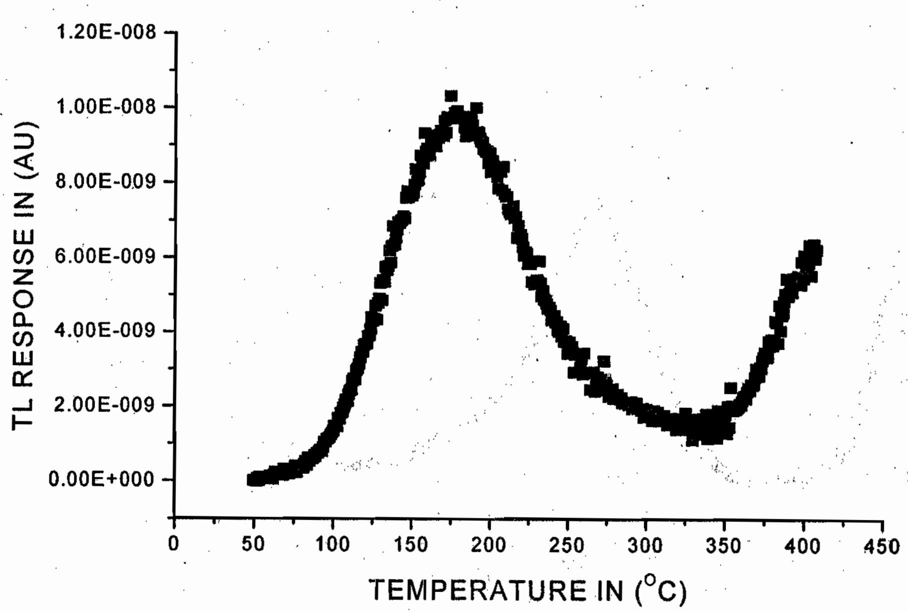

Fig. 1: Glow curve of Fused quartz with 50 °C pre heat

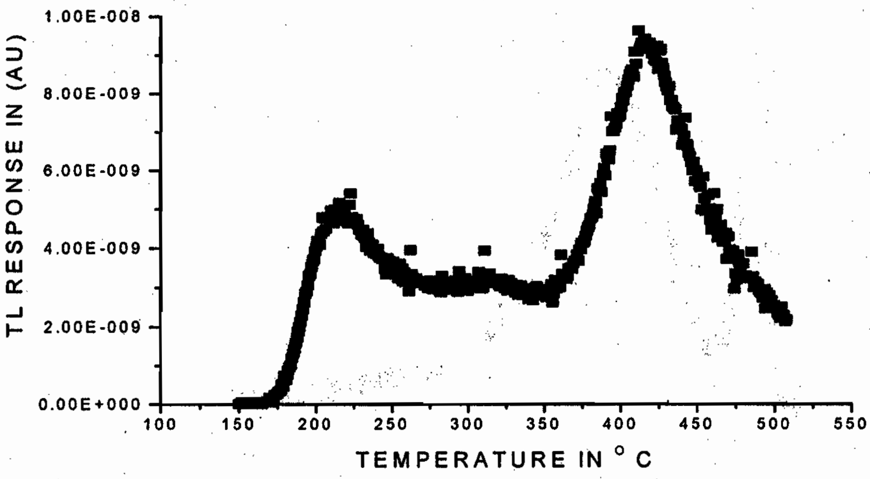

Fig. 2: Glow curve of Fused quartz with 150 °C pre heat

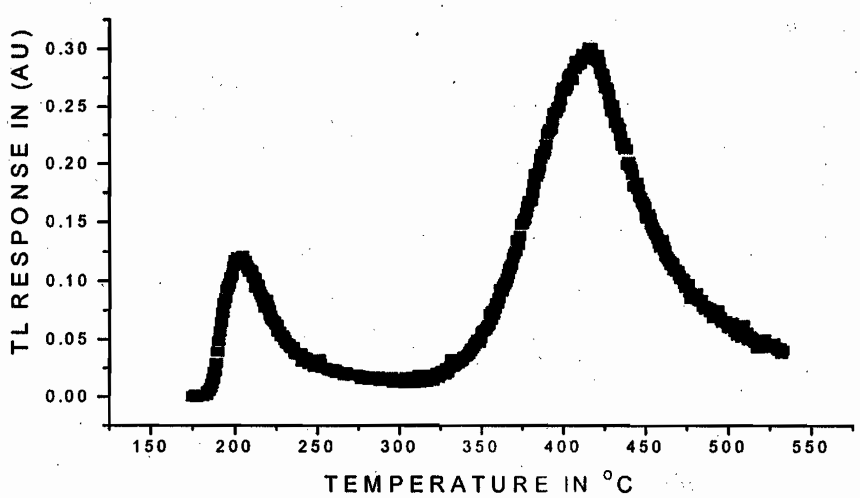

Fig. 3: Glow curve of Fused quartz with 175 °C pre heat

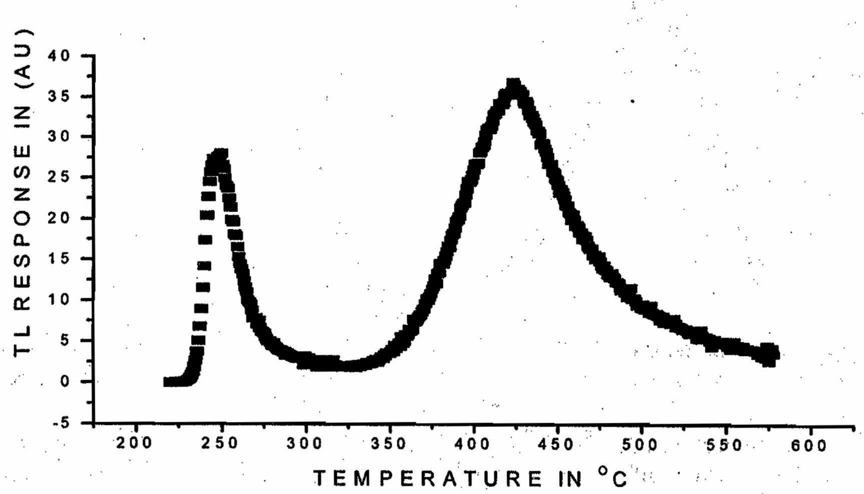

Fig. 4: Glow curve of Fused quartz with 225 °C pre heat

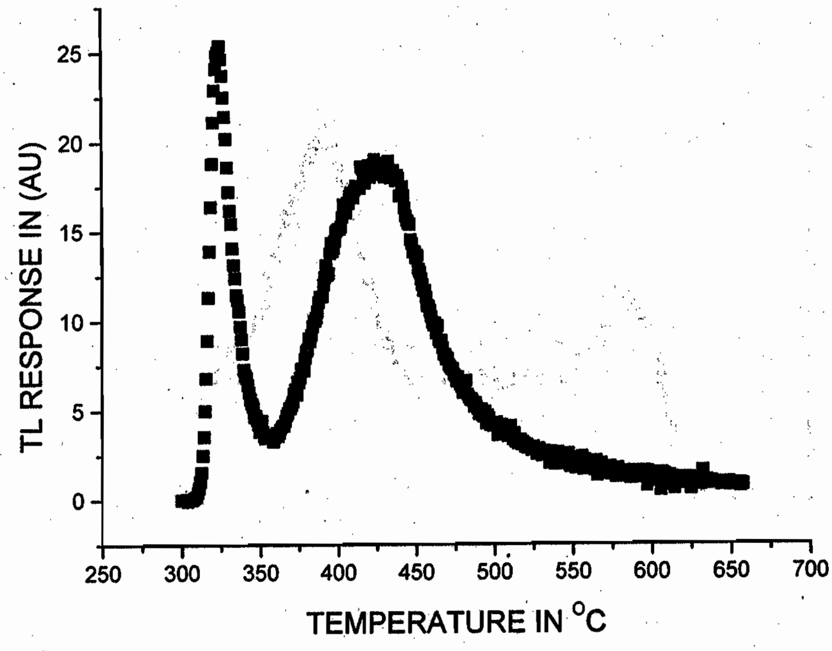

Fig.5: Glow curve of Fused quartz with 300 °C pre heat

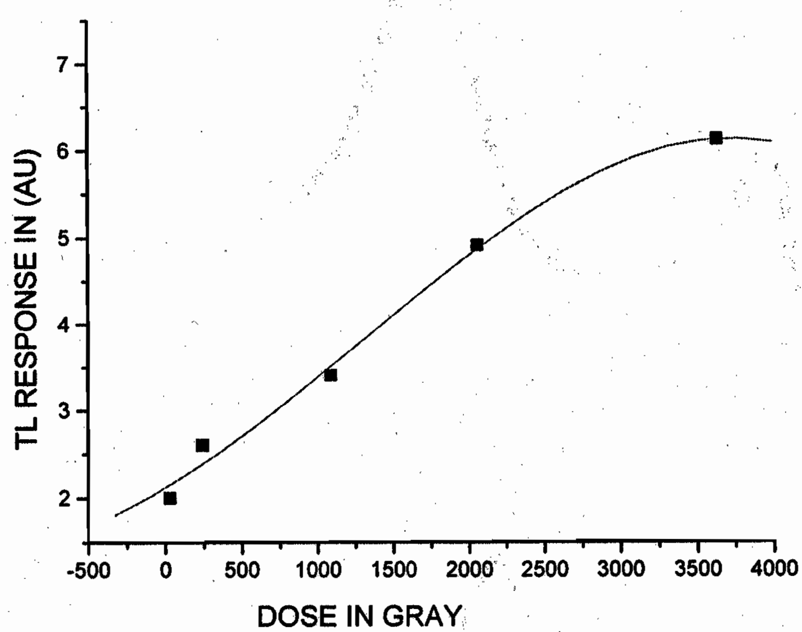

Fig.6: Dose Response curve of Fused quartz

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