

Effect of temperature of optical stimulation on thermoluminescence peak of synthetic quartz

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Several researchers have utilized physical treatments such as annealing temperature, annealing duration, ionizing radiation, grain size and optical bleaching as well as temperature of optical stimulation to establish the definite correlation between TL/OSL sensitivity and colour center with a view to suggest most appropriate physical treatment to be given to the specimen. The effect of temperature of optical stimulation (stimulation at room temperature (RT) (25°C) and stimulation at 160°C) on TL sensitivity, stability of TL peak and role of colour center for specimen annealed at 600°C and 1000°C followed by various beta doses has been studied in the present paper. The TL dose response curves were also plotted for each annealed sample after completion of optical stimulation. The present work reports that the 210°C TL peak is predominant for the specimens annealed at 1000°C prior to optical stimulation at room temperature. This peak remains thermally stable at 210°C and grows with dose systematically regardless of temperature of optical stimulation. The TL peak at 375°C is found to be intense, when the optical stimulation was performed at room temperature or elevated temperature of 160°C. The changes in TL glow curve pattern and sensitivity are strongly attributed to the role of E_1' center and Ge center.

Keywords: Optical stimulation, Thermoluminescence, Synthetic quartz

1 Introduction

A quartz specimen is easily available material in earth crust. However, it is highly used in the field of research particularly dating and dosimetry by several researchers. An extensive work was carried out for specific applications by using natural quartz to establish definite correlation between thermoluminescence (TL) and defect by showing well-known TL peaks¹ at 110°C (pre-dose peak), 325°C (RBP) and 375°C (SBP). But researchers were faced with some problems to establish the correlation between TL and defects due to changes in internal structure of specimens under influence of various physical conditions like annealing temperature, annealing duration, ionizing radiation and illumination intensity etc. However, they suggested a laboratory grown synthetic quartz crystal, which is of high crystalline quality and high purity material and, therefore, must present the simplest case for study. Also its irradiation and thermal histories are known-in particular it is known not to have received a natural pre-dose². Therefore, laboratory irradiated synthetic quartz gives some more details about TL peaks than natural quartz for 110, 160, 180, 210, 245, 325 and 375°C under identical physical conditions which are highly used in various applications. Researchers

applied various protocols for quartz material to understand the TL and its related phenomena like photo-transferred TL mechanism in which the properties of deep traps could be understood with the help of pre-dose or 110°C TL peaks³. Also, in case of Optically Stimulated Luminescence (OSL) technique, a selection of suitable wavelength of light from visible part of spectrum was used to stimulate high temperature traps (i.e. 325°C and 375°C) which play a vital role in dating and dosimetric applications of quartz due to its higher sensitivity and stability of TL peaks. Similarly, TL peak at 210°C is also equally active to stability and sensitivity under influence of illumination of light⁴.

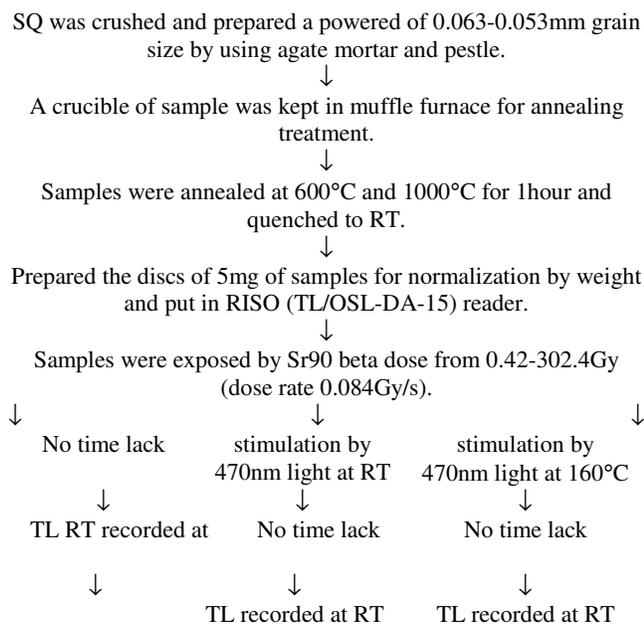
The effect of temperature of optical stimulation at RT (25°C) and at 160°C on TL nature of annealed synthetic quartz under different physical condition to the specimen has been studied. It is noted that material annealed at 600°C exhibits a single TL peak at 110°C, which is diminishing with the growth of new TL peak at 210°C under the influence of optical stimulation at RT for specimen annealed at 1000°C. It may be due to growth of Ge center with decay of E_1' center. Whereas annealed samples were stimulated at 160°C, only two significant peaks were appeared at 210°C and 375°C, it may be responsible for the

stability of new Ge center and optically released charged were distributed to high temperature TL peaks, which are slowly bleachable in nature.

2 Experimental Details

Laboratory grown synthetic quartz (SQ) crystals was collected from. G C R I Kolkatta, India. The production and growth detail was explained elsewhere⁵.

The following protocol was followed to the specimens prior to TL measurements:



3 Results and Discussion

The effect of temperature of optically stimulated luminescence at room temperature (25°C) and elevated temperature (160°C) on TL nature of synthetic quartz was performed and results were explained systematically. Prior to these studies, it is necessary to know the TL peaks' position and a contribution of colour centers, which are responsible for the production of TL peaks. However, Fig. 1 shows the TL glow curves were recorded at RT for 600°C and 1000°C annealed specimens at 1hr duration followed by 5.04 Gy beta dose. It was observed that the material annealed from 600°C to 1000°C, the significant rise in intensity of 110°C TL peak was noticed with the shifting of high temperature TL peak (352°C) towards lower temperature side at 210°C with enhancement in TL intensity from 7568au to 19213au. Researchers suggested that the natural quartz and its family give first TL peak at 110°C for any test dose and it varies

between 89°C to 150°C under the influence of various physical conditions of the specimens⁶. However, in the present investigations, the laboratory grown synthetic quartz specimen also gives an identical pattern of TL glow curve after irradiation. The present paper reports the production of TL peak at 210°C which was observed for the material annealed at high temperature, it may be due to the decay of E_1' center with the growth of new Ge centers. Also the sudden enhancement in TL intensity for both peaks (110°C and 210°C) is attributed to well-known phenomenon of phase-transformation in synthetic quartz. These sensitivity changes have been associated with alterations in the concentration of recombination centers^{7,8}.

The changes in TL glow curve pattern at high temperature, stability and sensitivity were recorded at room temperature under influence of different optical stimulation at different temperatures (RT and 160°C) and compared with the results of TL glow curves which were recorded at room temperature prior to optical stimulation for identical physical conditions (Figs 2 and 3). It is noticed that the material was annealed at 600°C prior to 5.04 Gy beta dose exhibited a single TL peak at 110°C with reducing in TL intensity from 1.93335×10^6 to 35256 au after the stimulation at RT. Such peak was disappeared with growing of two peaks at 210°C and 375°C during the stimulation at 160°C. These peaks were remained stable with more intense for the specimen annealed at 1000°C under identical stimulation temperature. The

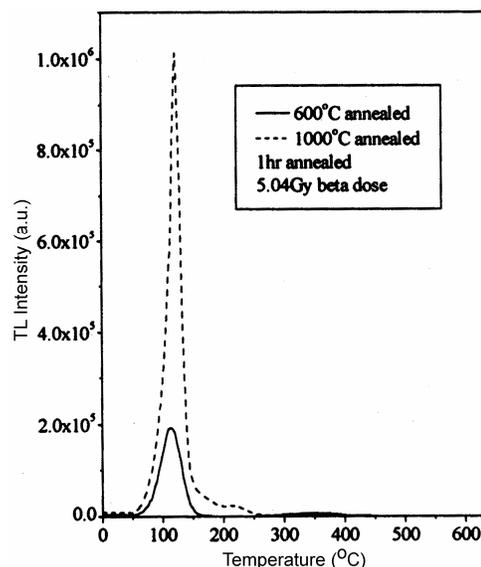


Fig.1 — TL recorded at RT for different annealed sample followed by 5.04Gy beta dose

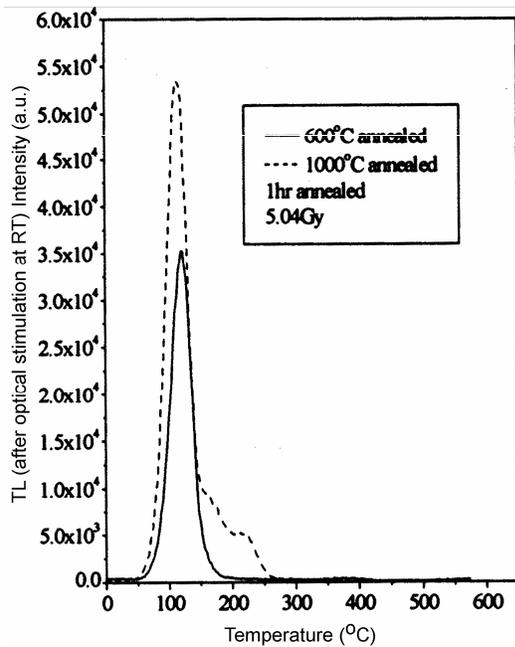


Fig. 2 — TL recorded at RT (after optical stimulation at RT) for different annealed sample followed by 5.04 Gy beta dose

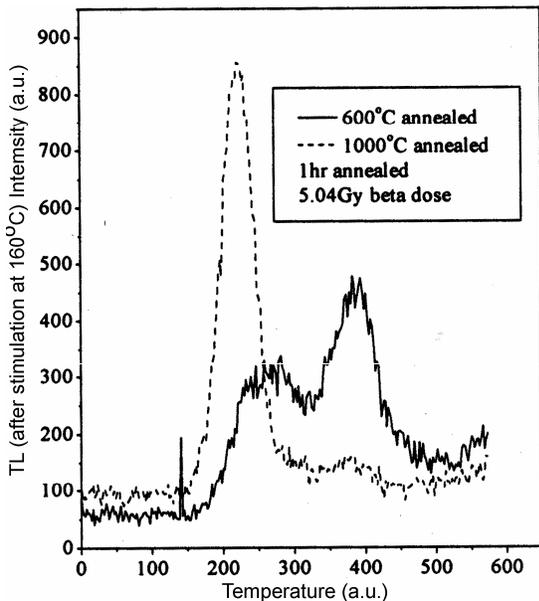


Fig. 3 — TL recorded at RT (after optical stimulation at 160°C) for different annealed sample followed by 5.04 Gy beta dose

high temperature annealed treatment also produced a significant TL peak at 210°C during optical stimulation at RT by reducing the TL intensity of 110°C peak from 1.013×10^6 to 5354 au. The dose response curves were also plotted for 210°C and 375°C TL peaks at different optical stimulation temperatures for identical physical condition (Figs 4-6).

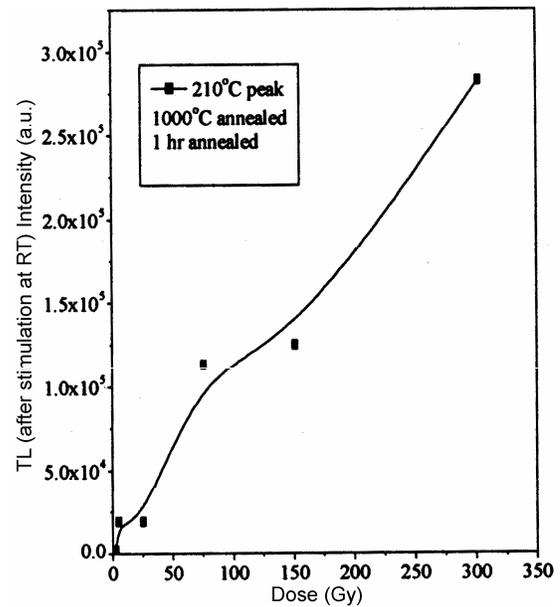


Fig. 4 — TL dose response curve (after optical stimulation at RT) for 210°C TL peak at 1000°C annealed synthetic quartz

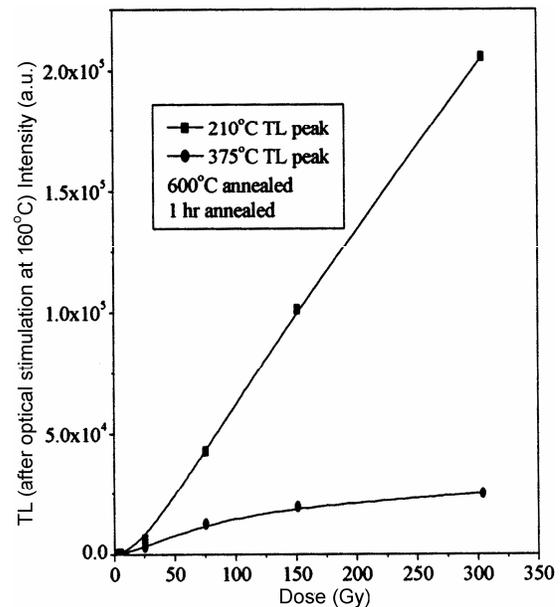


Fig. 5 — TL dose response curve (after optical stimulation at 160°C) for 210°C and 375°C TL peaks at 600°C annealed synthetic quartz

The interpretation of the present results pointed out that the material annealed at low temperature (600°C) prior to ionizing radiation gives contribution of TL peak at 110°C during optical stimulation at RT. It may be due to the role of E_1' centers. Such centers were completely disappeared and charge may be distributed to high temperature TL peak (375°C) during optical stimulation performed at 160°C. It may

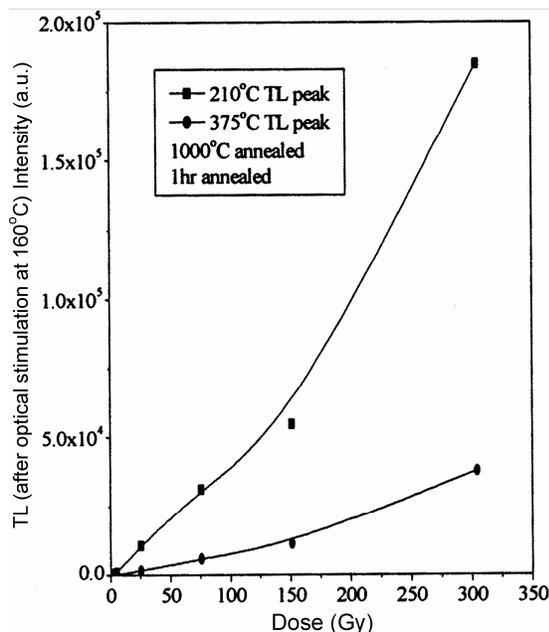


Fig. 6 — TL dose response curve (after optical stimulation at 160°C for 210°C and 375°C TL at 1000°C annealed synthetic quartz

also be suggested that for higher temperature of annealed specimens give the growth of new Ge centers with diminishing of E_1' centers⁹ (performed by ESR results). Thus, the effect of optical stimulation temperatures under identical physical conditions give significant advantage to study of the high temperature stable peaks which are high applicable in dating and dosimetry application of synthetic quartz.

4 Conclusions

The changes in TL glow curve patterns were observed under influence of different optical stimulation temperatures (RT and 160°C) are due to

the changes in the role of E_1' centers and Ge centers. It is also suggested that the optical stimulation was performed at RT the contribution of E_1' centers were noticed. Such centers were disappeared with highly charge distributions were occurred during optical stimulation was measured at 160°C. A significant changes in optical stimulation temperatures for high temperature (1000°C) annealed specimens give the growth of new Ge centers with diminishing of E_1' centers. Also it gives stability, sensitivity and liner growth of high temperature glow peaks is responsible for the concentration of Ge. Thus a physical parameter of optical stimulation temperature is useful to give an significant advantage of 210°C and 375°C TL peaks for suitable dating and dosimetric application of synthetic quartz.

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