International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-10, Issue-2, March 2022
https://doi.org/10.55524/ijircst.2022.10.2.109
Article ID IRPV1048, Pages 568-580
www.ijircst.org

Study of Thermal and Optical Sensitivity of Higher Thermo luminescence Glow Peaks in Synthetic Quartz Material

T. B. Akhani[1], Y. D. Kale[2], and Y. H. Gandhi[3]

[1]Parul Institute of Applied Sciences, Parul University, P O Limda, Vadodara, India
[2]Applied Sciences and Humanities Department, Parul Institute of Technology, Parul University, P O Limda, Vadodara, India
[3]Applied Physics Department, Faculty of Engineering & Technology, the M. S. University of Baroda, Vadodara, India

Correspondence should be addressed to T. B. Akhani; trilokkumar.akhani@paruluniversity.ac.in

Abstract- In the present scenario, 600 oC and 1000 oC annealed synthetic quartz material were irradiated by beta doses. The thermoluminescence glow curves are recorded for treated sample under influence of optical bleaching temperature and cutoff duration of 290 oC preheat temperature. The thermal and optical sensitivity of higher temperature TL glow peaks are to be examined including their dose response. Under the influence of optical bleaching either at room temperature or 160 oC, the growth of 375 oC TL glow peak is observed at 600 oC annealed sample by complete bleaching of 350 oC glow peak. However, the thermal stability and optical sensitivity of this peak is increased when the temperature is increased to1000 oC annealed sample accordance with new 220 oC TL glow peak by complete optical bleaching of 300 oC glow peak. The cutoff durations of 290 oC preheat temperature followed optical bleaching at 160 oC show unique contribution of 375 oC and 220 oC glow peaks in 600 oC and 1000 oC annealed sample respectively. This Study focussed on the Thermal and Optical Sensitivity of Higher Thermo luminescence Glow Peaks in Synthetic Quartz Material. The changes in TL outcomes are elaborated by thermal and optical sensitization properties of TL traps under annealing treatment, pre-heat temperature and optical bleaching temperature.
Keywords: Annealing Treatment, Beta Dose, Optical Bleaching, Pre-Heat Duration, Synthetic Quartz, Thermo luminescence.

I. INTRODUCTION

Quartz is known to have a broad range of thermo luminescence (TL) light peaks that change with temperature. The majority of glow curves for various types of quartz show a cluster of peaks at 60 oC, 100-110 oC, 80 oC 180 oC, 130 oC 230 oC 200-210 oC, 310 oC, and 350 oC. TL peaks at 100-110 oC, 200-210 oC, and 350 oC were explored in particular, despite the fact that there have been several examinations of quartz TL characteristics. Aside from these peaks, two other TL glow peaks for sand size grains were found at 325 oC and 375 oC. The peak at 375 degrees Celsius was selected for dating, whereas the peak at 325 degrees Celsius did not seem to provide a consistent dosage response. However, when quartz is optically stimulated by 514 nm light, the charge is ejected from the crystal lattice's traps, is associated with 325 oC TL emission, and recombines with luminescence centers to create optically stimulated luminescence (OSL). In reality, TL measures are utilized to identify between charge-holding traps. These are divided into shallow traps and deeper traps (those with TL emission around 280-400 oC) that are thermally stable at room temperature but lose charge when activated by light.

Researchers [1] have reported that higher temperature TL glow peaks (220.00 oC as well as 370 oC) are more steady after irradiation as well as these peaks can also be used to estimate dose. The sensitization of a 220 oC TL glow peak in quartz separated from sand as a function of pre-gamma dosage and post-irradiation annealing treatment at a test dose has also been observed. P G Benny et al [2] has The influence of annealing temperature, pre-dose irradiation, and annealing duration on the sensitization factor was investigated. Several workers [3] The influence of heating and irradiation on the parameters of TL glow curves for synthetic quartz has also been investigated.

A. Experimental Details

In the present study, the synthetic quartz crystal was collected from Center for Glass and Ceramic Research Institute Jadhavpur, Kolkata, India. The details about crystal growth technique and experimental conditions of this this crystal was grown by using hydrothermal technique.[4] Using agate mortar and pestle, the fine powder of crystal was prepared with a grain size of 63-53 μm through standard sieves[5]–[7]. The fine powder samples were then collected in three different crucibles. Among them, one crucible of sample was kept at room temperature; it was known as “unannealed” sample. Another crucible of sample was then prepared for annealing quenched treatment through muffle furnace (temperature range up to 1200 oC with ± 1oC accuracy).

For 1 hour, the sample was maintained in a muffle furnace at 600°C. The sample was transported to room temperature for quenching after completing the annealing time at the appropriate temperature, and so this sample was classified as a 600 oC "annealed-quenched" (AQ) sample. This process was repeated at 1000 oC annealing treatment. 5 mg of sample was collected and sprayed in the form of layer over the sample disc. By this method, one disc was prepared as an unannealed sample, ~20 discs were prepared for 600 oC and ~22 discs were prepared for 1000 annealed sample. The sample discs were arranged in RISO (TL/OSL-DA-15) systems which has inbuilt facilities of Sr-90 beta irradiation source, stimulation source from visible part of spectrum and three detection filters [Hoya U-340 (Quartz OSL is often detected using the Hoya U-340 filter), Schott BG 39 as well as Corning 7-59 or BG3(Corning 7-59 (CN7-59) filter has been replaced by BG3).[8] The TL glow curves were recorded over 25 oC-573 oC measurement temperature and TL outcomes were normalized by weight.

Table 1: Prior to the TL measurement, the 600 oC and 1000 oC annealed samples underwent different physical conditions which are described in the flow chart

synthetic quartz (63-53 μm)			
↓			
600 oC and 1000 oC AQ; 1hr			
↓			
Beta Doses (2.52 Gy, 5.04 Gy, 25.2 Gy, 75.6 Gy, 151.2 Gy, 302.4 Gy) @0.084 Gy/second			
↓	↓	↓	↓
TL record 25 oC to 573 oC @ heating rate 5 oC/seconds	Optical Bleaching (OB) at RT by 470 nm for 100 seconds	Optical Bleaching (OB) at 160 oC by 470 nm for 100 seconds	Preheat at 290oC for 0 seconds, 5 seconds, 10 seconds, 30 seconds cutoff durations
	↓	↓	↓
	TL record 25 oC to 573 oC @ heating rate 5 oC/seconds	TL record 25 oC to 573 oC @ heating rate 5 oC/seconds	Optical Bleaching (OB) at 160 oC by 470 nm for 100 seconds
			↓
			TL record 25 oC to 573 oC @ heating rate 5 oC/seconds

II. DISCUSSION

Higher temperature deep TL traps, which are thermally stable at ambient temperature, may lose their charge when triggered by light, as reported in previous investigations. In view of these, in present investigations, the TL properties of high temperature glow peaks were examined for physically treated synthetic quartz under influence of optical bleaching temperature and post irradiation heat treatment at 290 oC and its cutoff durations. These studies report the thermal and optical sensitization properties of higher temperature of TL glow peak which may use for definite application of TL[9], [10].

Effect of beta dose and annealing temperature on TL glow peak:

The TL glow curve were recorded from 25 oC-573 oC for unannealed sample irradiated by 5.04Gy beta dose. It exhibits three separate TL glow peaks at ~110 oC, 220 oC and 332 oC with TL intensities of 1297 counts, 61 counts and 101 counts respectively. The influence of 600 oC and 1000 oC annealing temperature at a duration of 1 hour followed by identical beta dose on these glow peaks and TL sensitivity were studied. As the increase occurs in annealing temperature, the position of 110 oC TL shifts to 122 oC by significant enhancement in TL sensitivity. The 600 oC annealed sample exhibits 38667 counts and 1000 oC annealed sample exhibits 202620 counts which is about 95 % more sensitive than unannealed sample. Additionally, the 600 oC annealed sample exhibits 350 oC TL glow peak by 1252 counts and the1000 oC annealed sample exhibits 218 oC, 300 oC and 370 oC TL glow peaks by 4468 counts, 618 counts and 772 counts respectively (Figure 1).

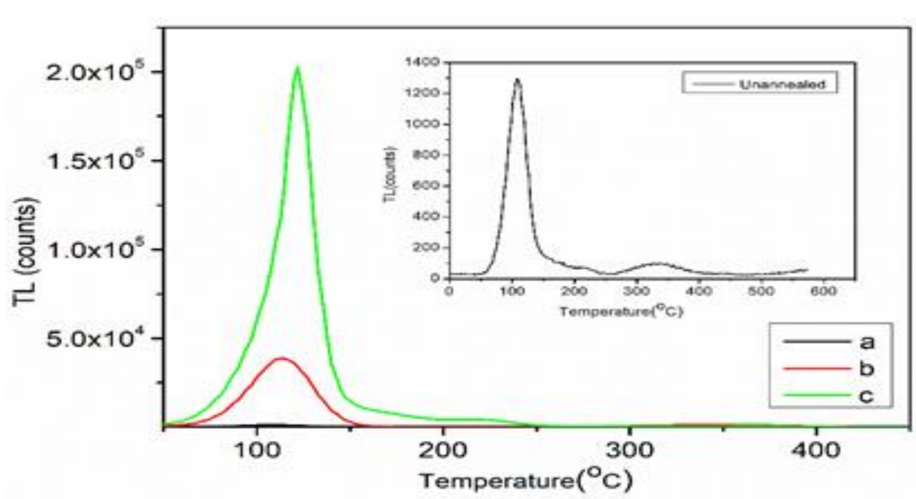

Figure 1: TL glow curves of unannealed and annealed sample irradiated by 5.04 Gy

(a) Unannealed (b) 600 oC annealed (c) 1000 oC annealed.
David et al has suggested that [11] substantial increase of the sensitivity by firing to temperatures between 500 oC and 1000 oC (with no prior irradiation). They emphasized that the originally alpha quartz changes at 573 oC to beta quartz and at 870 oC to tridymite. Such structural changes in quartz material are possible under influence annealing temperature and hence it may responsible to changes in TL intensities. However, R Chen et al[12] has suggested that the annealing of the synthetic quartz removes the competitors which result in an increase in the sensitivity. In present investigation, the 1000 oC annealed sample may reduce competing electrons traps followed by noticeable TL sensitivity in material.
Effect of optical bleaching temperature on TL glow peak of annealed sample: The present study emphasizes on the thermal and optically sensitive nature of glow peaks which are observed in optically unbleached annealed samples. However, the effect of optical bleaching at room temperature and 160 oC temperature for 100 seconds on TL glow curves of annealed samples followed by 5.04 Gy beta dose were also studied. In addition, substantial contributing high temperature glow peaks' TL dose response curves were obtained. The excellent linear relationship between TL intensity and absorbed dosage is a key characteristic of TL material. TL= a(Dosage)k is a common formula for expressing the observed TL dose responses. The dose response nature scale displays the dose response across the log (TL)-log (Dose) scale, with k is equa1 to being linear, k 1 being sublinear, and k is greater than 1 being superlinear. After optical bleaching at room temperature; the 600 oC annealed sample shows three separate TL glow peaks around 120 oC, 232 oC and 380 oC by the 80 % bleaching of 110 oC TL glow peak and complete bleaching of 350 oC compare to optically unbleached 600 oC annealed sample (Figure 2).

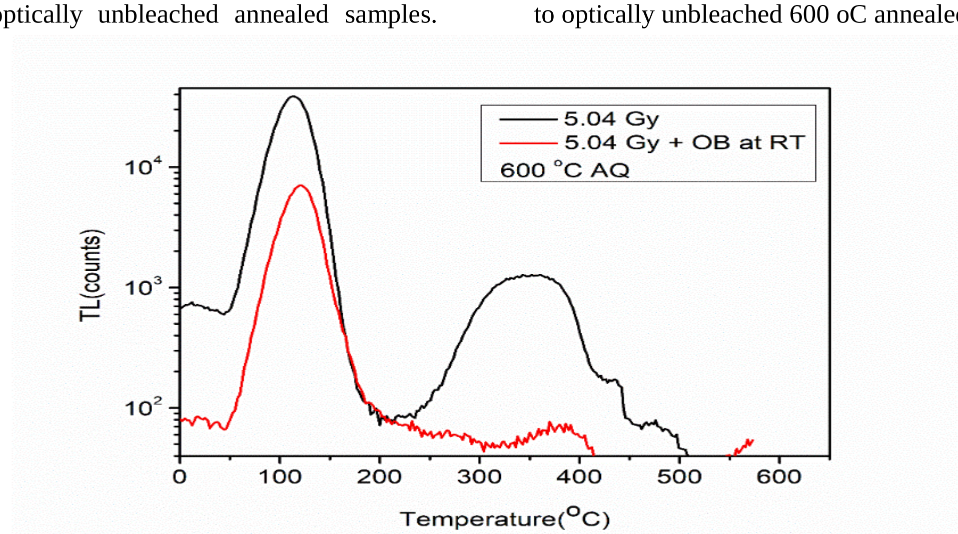

Figure 2: Comparative TL glow curves of 600 oC annealed sample with and without optical bleaching at room temperature

However, the 1000oC annealed samples exhibits four separate TL glow peaks around 110 oC, 171 oC, 223 oC and 375 oC with TL intensities of 10702 counts, 1717 counts, 974 counts and 85 counts respectively by the 94 % of bleaching of 110.00 oC TL glow peak, the 78 % of bleaching of 220 oC TL glow peak, the 88 % of bleaching of 375 oC TL glow peak and complete bleaching of 300 oC TL glow peak compare to optically unbleached 1000 oC annealed sample (Figure 3).

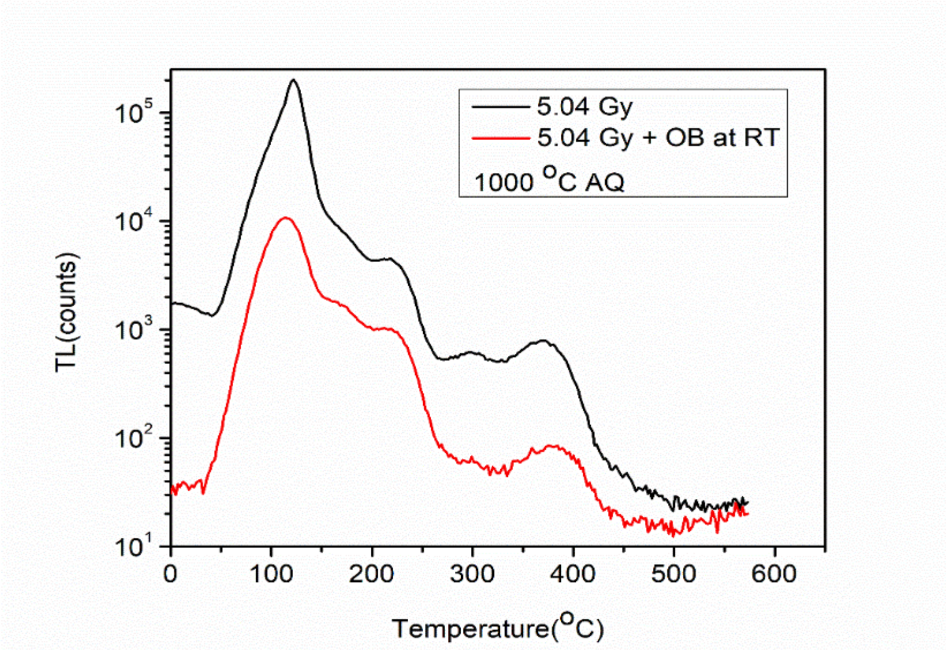

Figure 3: Comparative TL glow curves of 1000 oC annealed sample with and without optical bleaching at room temperature

At 600 oC annealed sample; the 110 oC glow peak shows systematic TL growth from 2721 counts to 58030 counts with beta doses. It shows sublinear TL dose reply dose response curve of 110 oC glow peak. Also, 375 oC TL glow peak show systematic TL growth from 30 counts to 2872 counts with beta doses followed by superlinear nature of TL dose response curve. But, as an intermediate TL glow peak, the 230 oC varies up to 258 oC with beta doses and hence TL dose response was not recorded Figure 4 and Figure 4A.

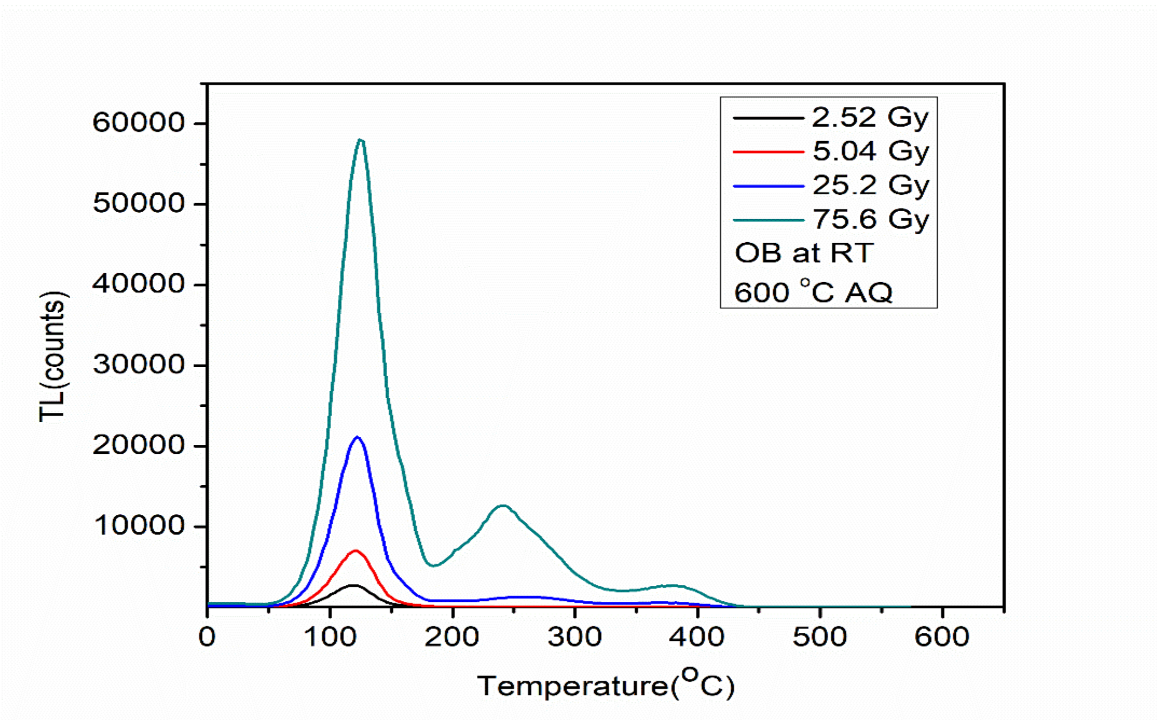

Figure 4: TL glow curves of 600 oC annealed sample of different beta doses under optical bleaching at room temperature

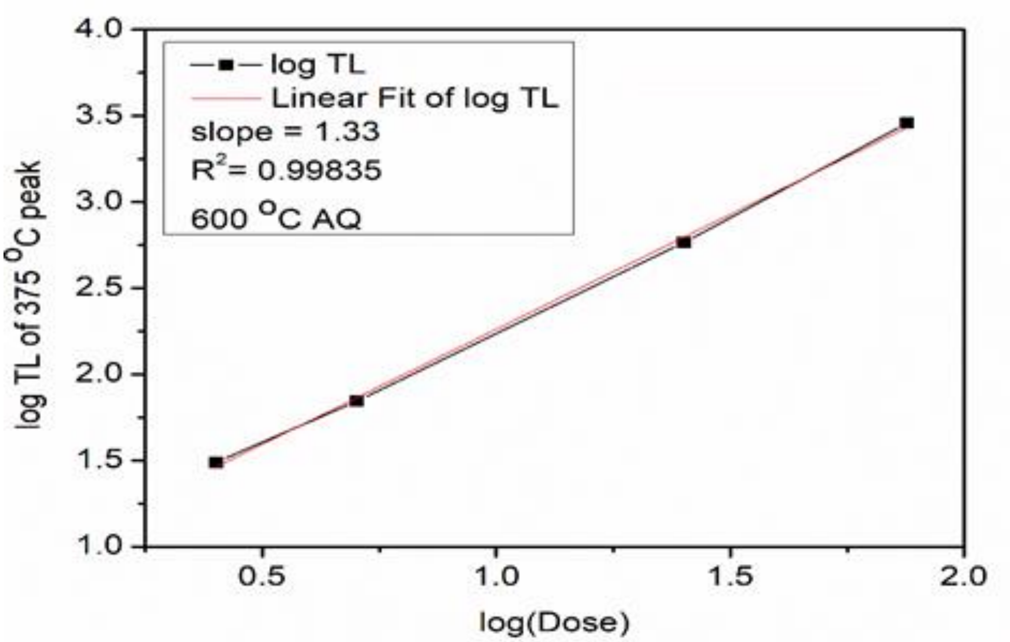

Figure 4A: TL-DRC curve of 375 oC glow peak of 600 oC annealed sample under optical bleaching at normal room temperature

At 1000 oC annealed sample, the nature of TL dose response curve of 110 oC and 375 oC are identical to 600 oC annealed sample even though it shows more TL sensitive response with beta doses[13], [14]. At the same time, the intermediate TL glow peak stabilize around 220 oC and hereafter it shows systematic growth with identical beta doses followed by superlinear TL dose response curve as shown in Figure 5 and Figure 5A and Figure 5B.

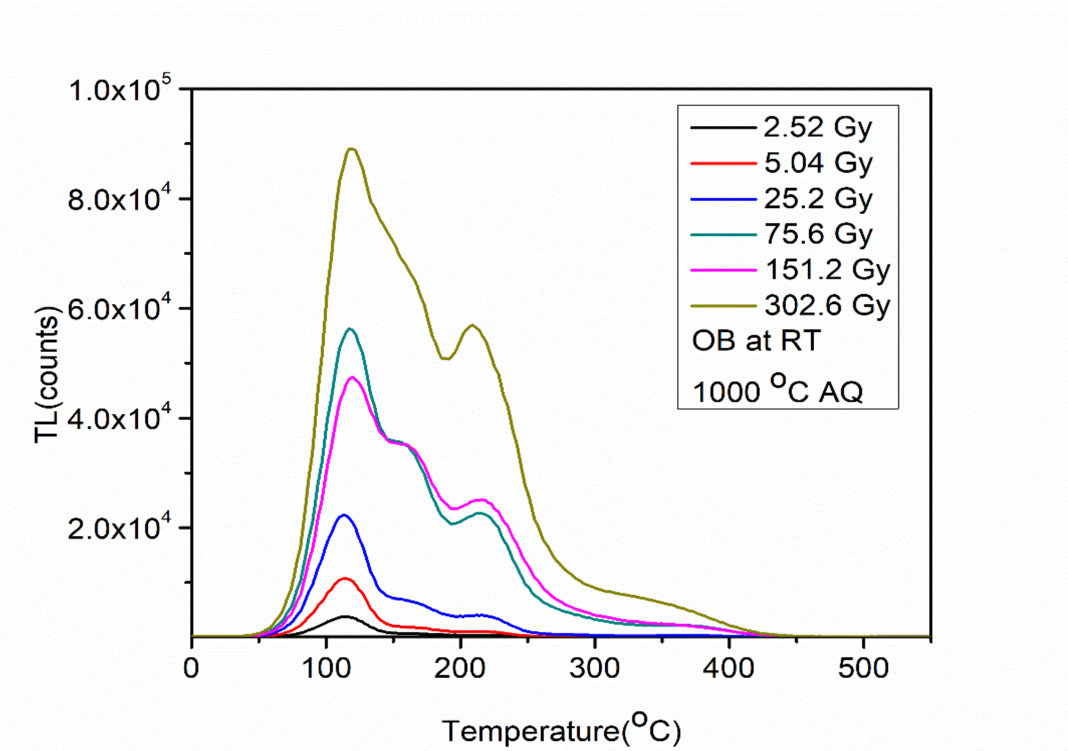

Figure 5: TL glow curves of 600 oC annealed sample of different beta doses under optical bleaching at room temperature

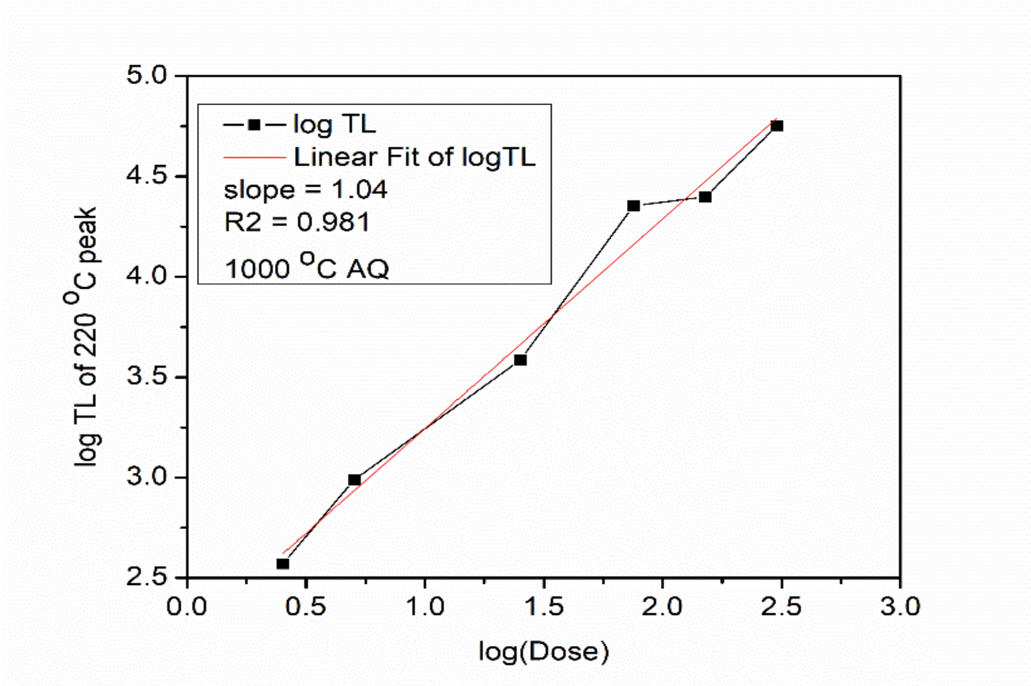

Figure 5A: TL-DRC curve of 220 oC glow peak of 1000 oC annealed sample under optical bleaching at room temperature

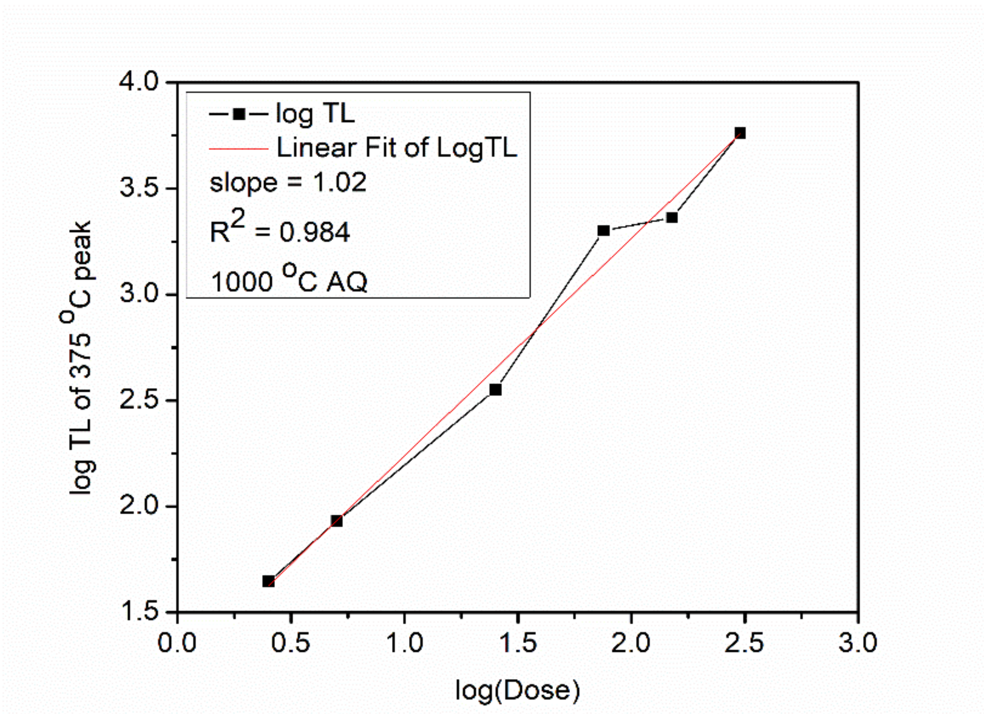

Figure 5B: TL-DRC curve of 375 oC glow peak of 1000 oC annealed sample under optical bleaching at room temperature

After optical bleaching at 160 oC temperature; the 600 oC annealed sample show single TL glow peak around 375 oC by complete bleaching of 350 oC TL glow peak. However, the 1000 oC annealed sample show two glow peaks around 220 oC and 375 oC TL glow peaks by complete bleaching of 300 oC TL glow peak. Also, in both the annealed samples, the contribution of 110 oC TL glow peak disappeared obviously optical bleaching at 160 oC restricts to re-trapping of optically released electrons into 110 oC TL traps compare to unbleached annealed samples as shown in Figure 6 and Figure 7.

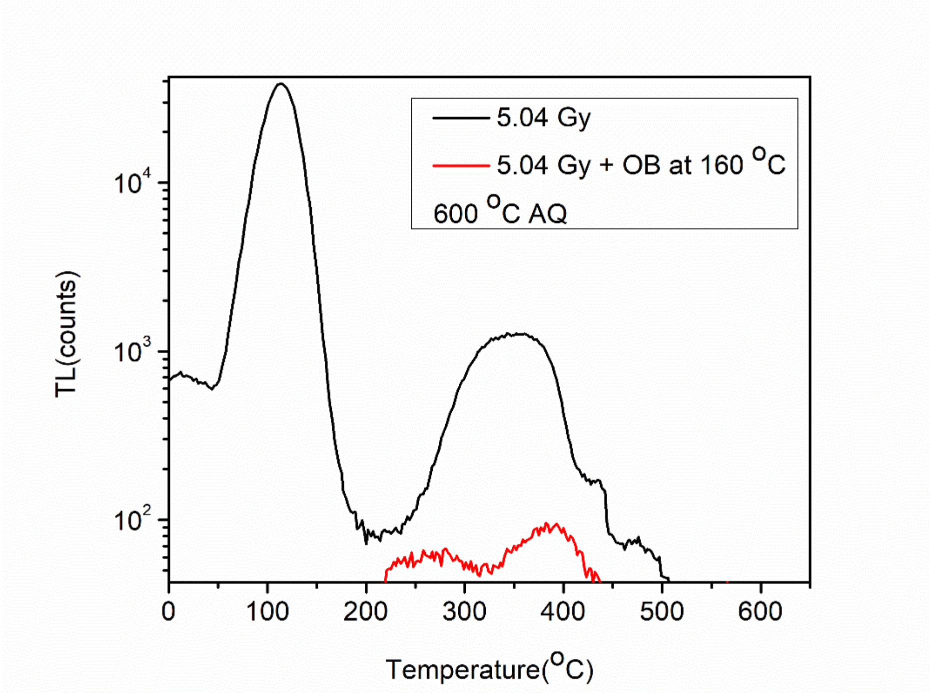

Figure 6: Comparative TL glow curves of 600 oC annealed sample with and without optical bleaching at 160 oC

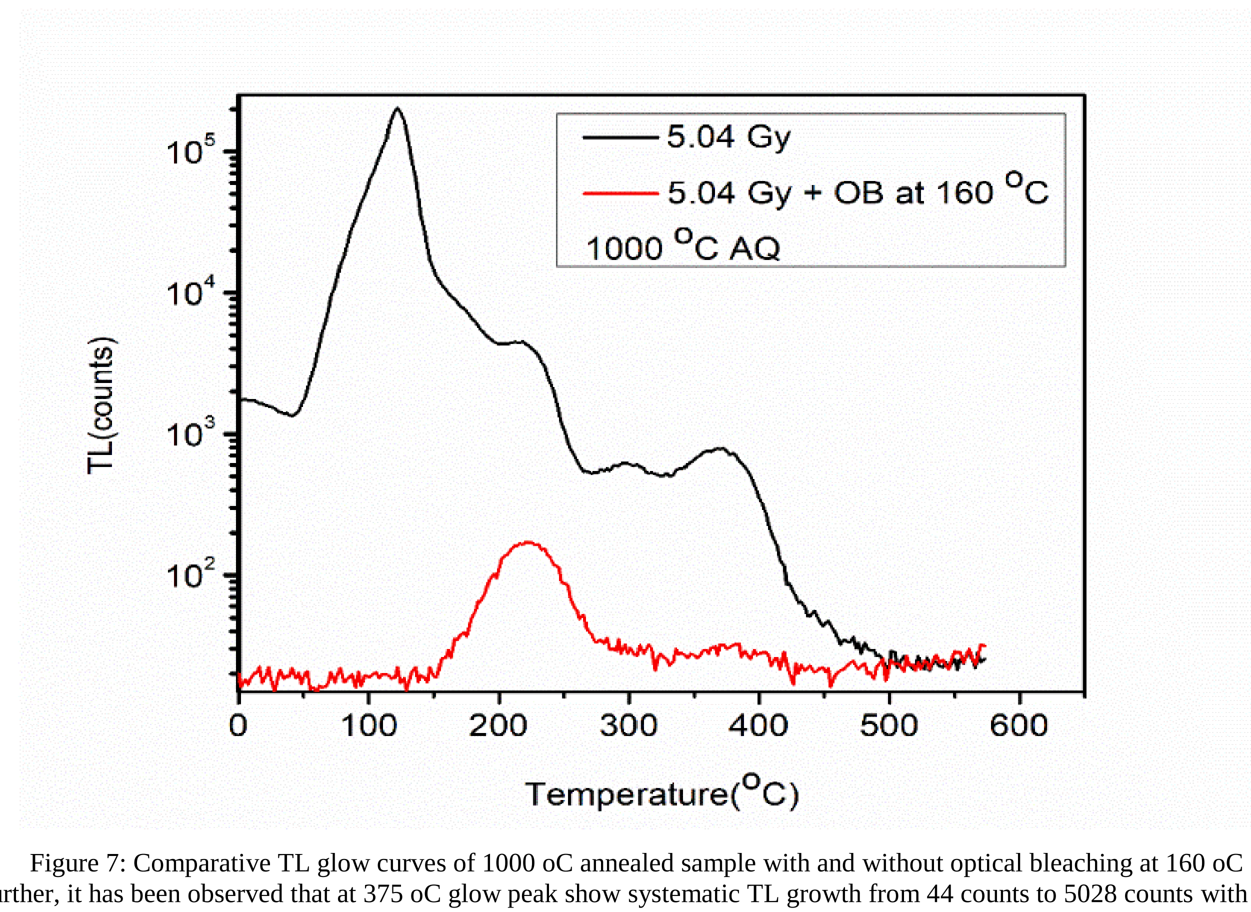

Figure 7: Comparative TL glow curves of 1000 oC annealed sample with and without optical bleaching at 160 oC

Further, it has been observed that at 375 oC glow peak show systematic TL growth from 44 counts to 5028 counts with beta doses followed by superliner TL dose response curve in 600 oC annealed sample as shown in Figure 8 and Figure 8A.

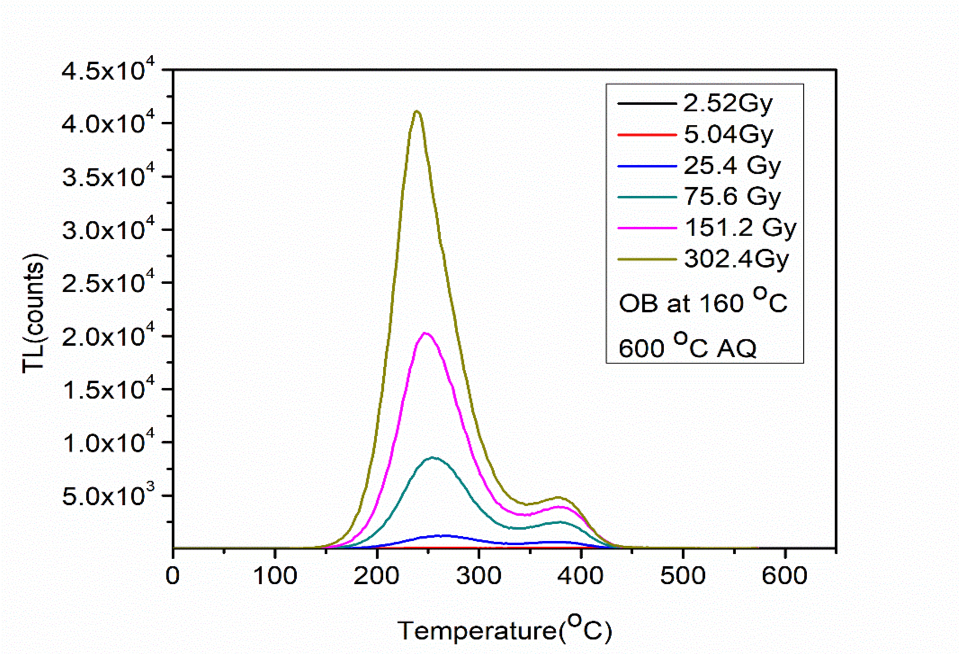

Figure 8: TL glow curves of 600 oC annealed sample of different beta doses under optical bleaching at 160 oC

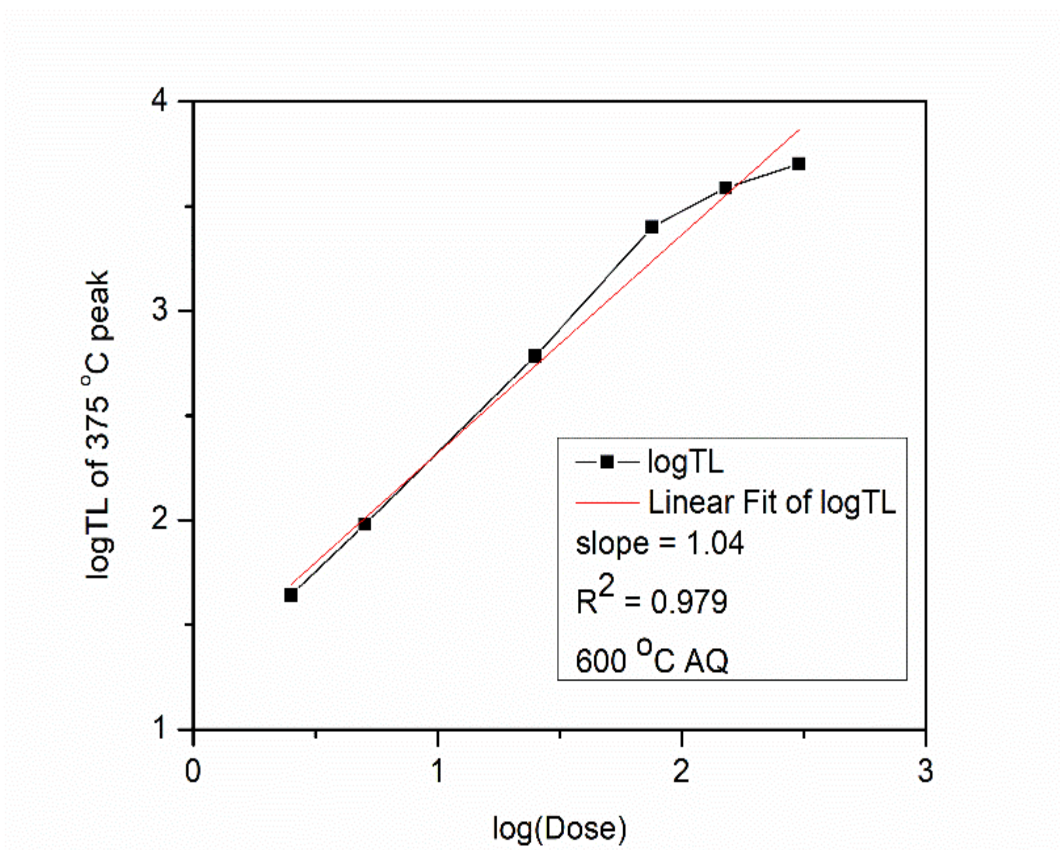

Figure 8A: TL-DRC curve of 375 oC glow peak of 600 oC annealed sample under optical bleaching at 160 oC

However, the identical TL growth with beta dosed superliner TL dose comeback curve of the 375 oC TL glow peak is observed in 1000 oC annealed sample (Figure 9 and Figure 9A)

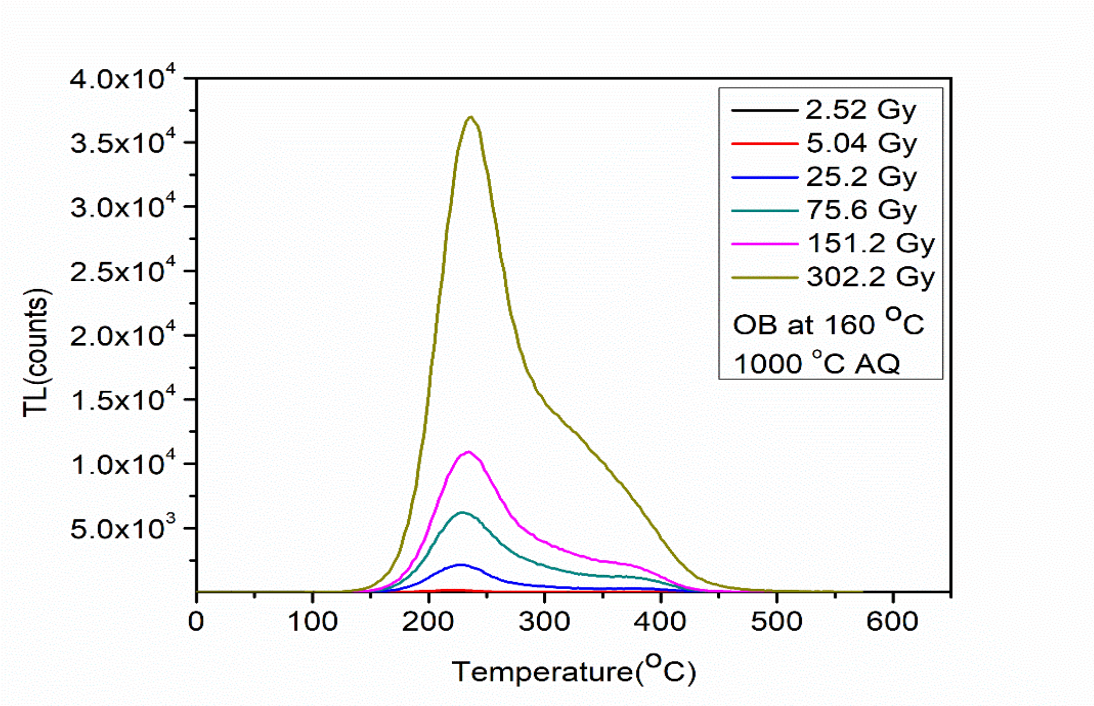

Figure 9: TL glow curves of 1000 oC annealed sample of different beta doses under optical bleaching at 160 oC

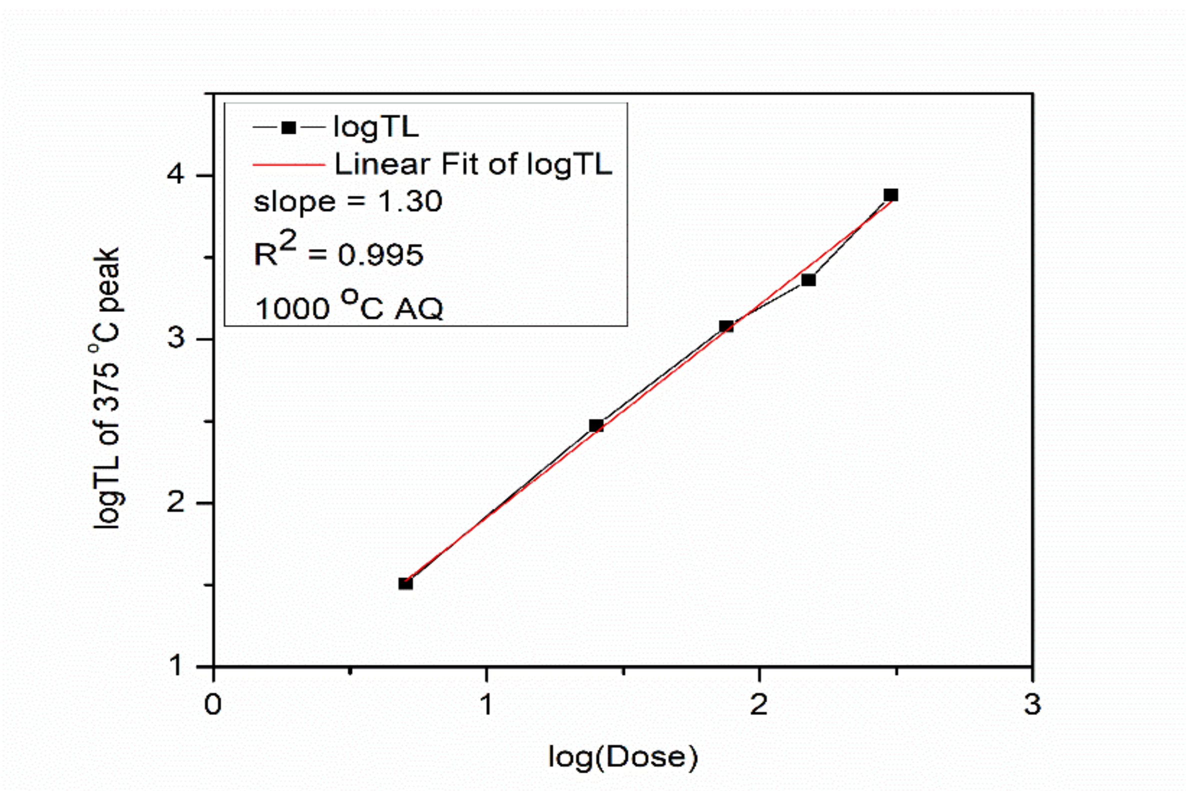

Figure 9A: TL-DRC curve of 375 oC glow peak of 1000 oC annealed sample under optical bleaching at 160 oC

Additionally, at 220 oC TL glow peak shows systematic growth with identical beta doses followed by superlinear TL dose response curve as shown in Figure 9

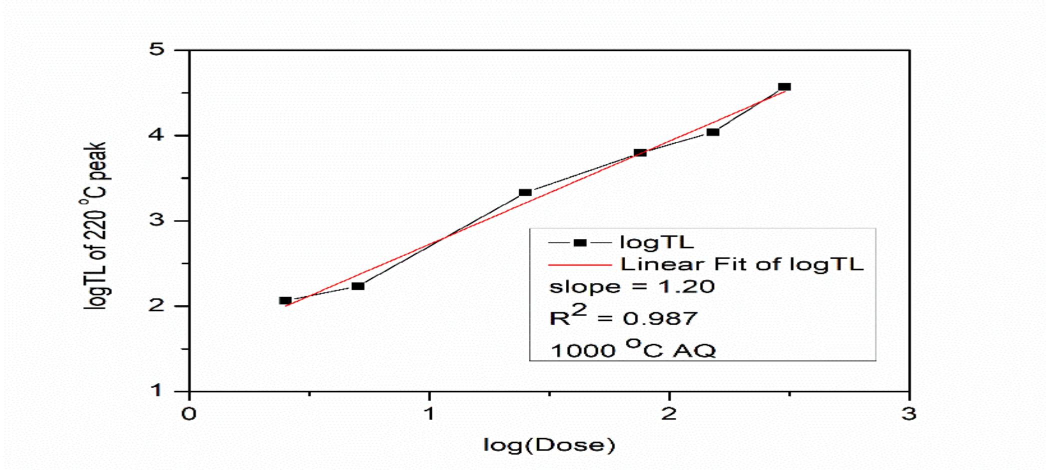

Figure 9B: TL-DRC curve of 220 oC glow peak of 1000 oC annealed sample under optical bleaching at 160 oC

N A Spooner has also revealed that fading studies on the normal TL of quartz inferred that the source traps seen at 325 oC TL top were the main snare promptly bleachable by apparent light. It has restricted by exhibiting the relationship of the 325 oC TL top to the OSL by quartz under enlightenment by 514.5 nm light. Additionally, the distinguish the photograph ousting instrument by which these snares go through optical fading. In present work, as a complete bleachable TL glow peaks under optical bleaching either at room temperature or 160 oC, the 350 oC and 300 oC TL glow peaks are observed in 600 oC and 1000 oC annealed sample respectively. It may suggest that the sensitization of TL traps associated with these TL glow peaks are influenced by condition of annealing temperature. However, the behavior of these TL glow peaks under optical influence may same as typical rapidly bleachable TL glow peak of 325 oC and hence complete depletion of 350 oC and 300 oC TL glow peaks may possible alternative to correlation between typical 325 oC TL and OSL. Apart from these, the existence of 375 oC TL glow peak by complete optical bleaching of 350 oC glow peak in 600 oC annealed sample might be responsible to the charge transfer from optically sensitive traps to deep TL trap corresponding to 375 oC TL glow peak. But, the thermal stability and optical sensitivity of this peak is sustained in 1000 oC annealed sample accordance with new 220 oC TL glow peak by complete optical bleaching of 300 oC glow peak. It suggests the thermal and optical sensitive TL properties of 220 oC and 375 oC TL in present material.

Effect of pre-heat treatment at 290 oC for different cutoff duration on TL glow peak of annealed sample

In order to investigate, the researchers [15] have reported that under laboratory irradiation the low temperature traps will holds the charges which would other wise be trapped at the deeper optically sensitive traps. The impact can be remunerated by warming the example, after the light, to some temperature which discharges shallow snares and a portion of their substance to more profound snares, however doesn't essentially thermally disintegrate the profound optically touchy snares. Likewise, the n preheat of research facility illuminated examples is expected to guarantee the equivalent reallocation of the charge. In present investigation, the influence of post irradiations heat treatment at 290 oC for 10 seconds of cutoff durations followed by optical bleaching at 160 oC on higher temperature TL glow peaks of identical annealed sample were studied. It is observed that 375 oC and 220 oC TL glow peaks appeared in the 600 oC and 1000 oC annealed samples respectively. Both peaks show systematic TL growth with sublinear nature of TL dose response curve as shown in Figure 10 and Figure 10A, Figure 11 and Figure 11A.

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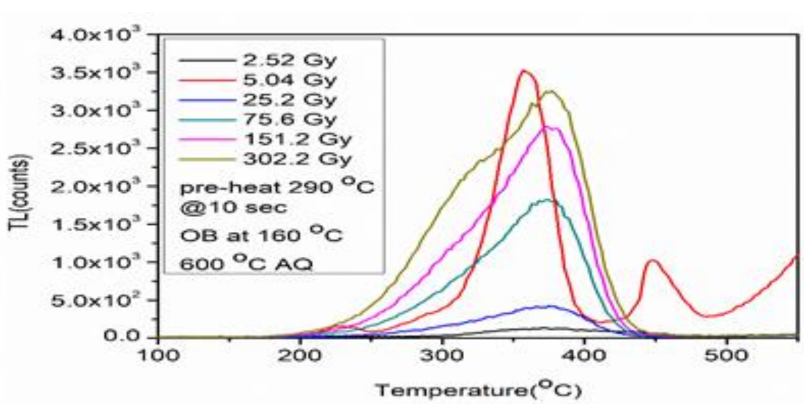

Figure 10: TL glow curves of 600 oC annealed sample of different beta doses under pre-heat at 290 oC and optical bleaching at 160 oC

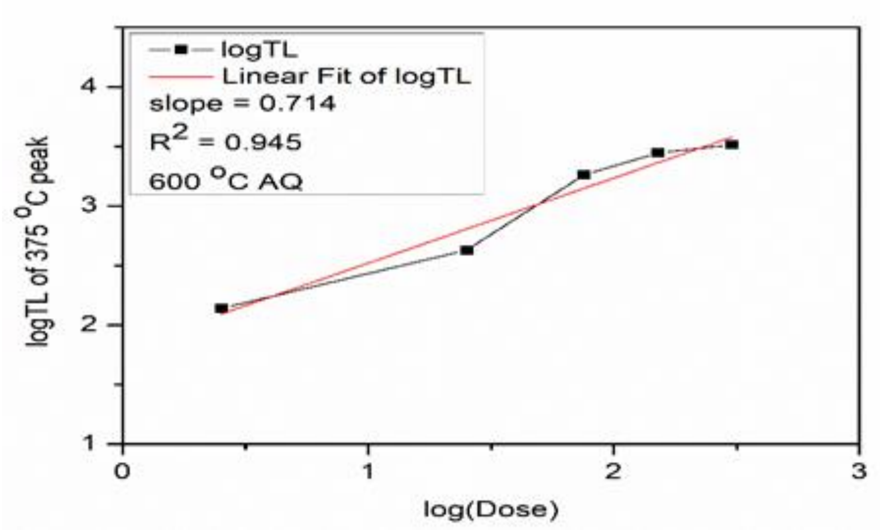

Figure 10A: TL-DRC curve of 375 oC glow peak of 600 oC annealed sample under pre-heat at 290 oC and optical bleaching at 160 oC

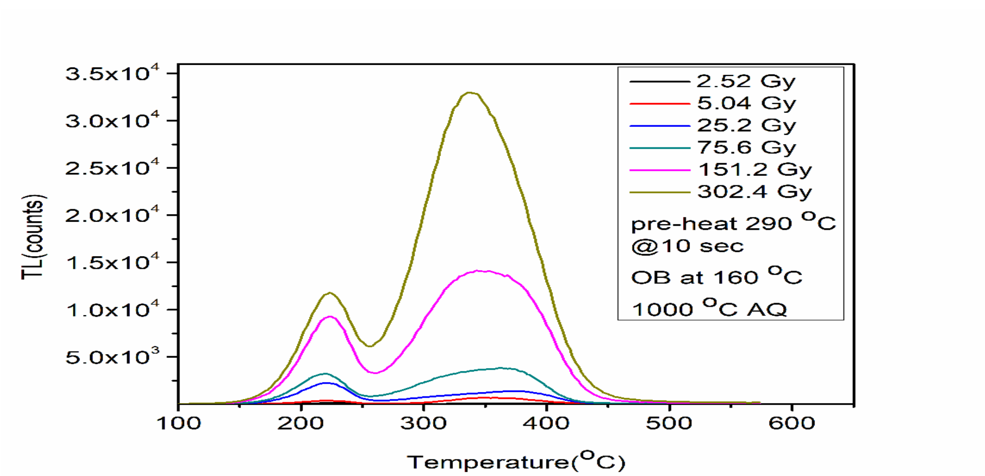

Figure 11: TL glow curves of 1000 oC annealed sample of different beta doses under pre-heat at 290 oC and optical bleaching at 160 oC

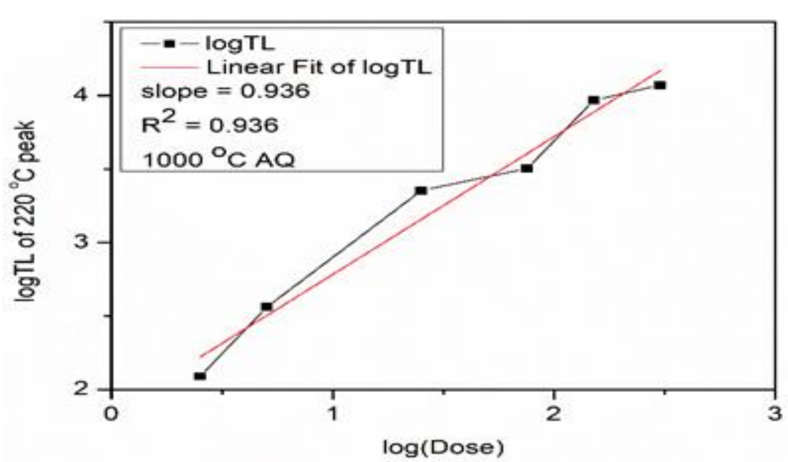

Figure 11A: TL-DRC curve of 375 oC glow peak of 1000 oC annealed sample under pre-heat at 290 oC and optical bleaching at 160 oC

Additionally, the strength of 220 oC TL glow peak growths with rise in duration of pre-heat temperature up 10 seconds. Thereafter, TL intensity decreases by further rise in cutoff duration (Figure 12 and Figure 13).

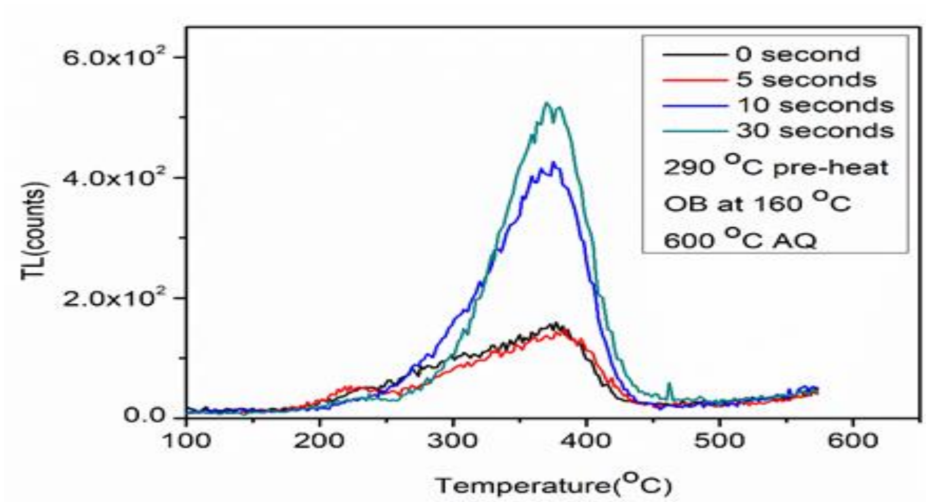

Figure 12: TL glow curves of 600 oC annealed sample of 5.04Gy beta dose under different pre-heat durations and optical bleaching at 160 oC

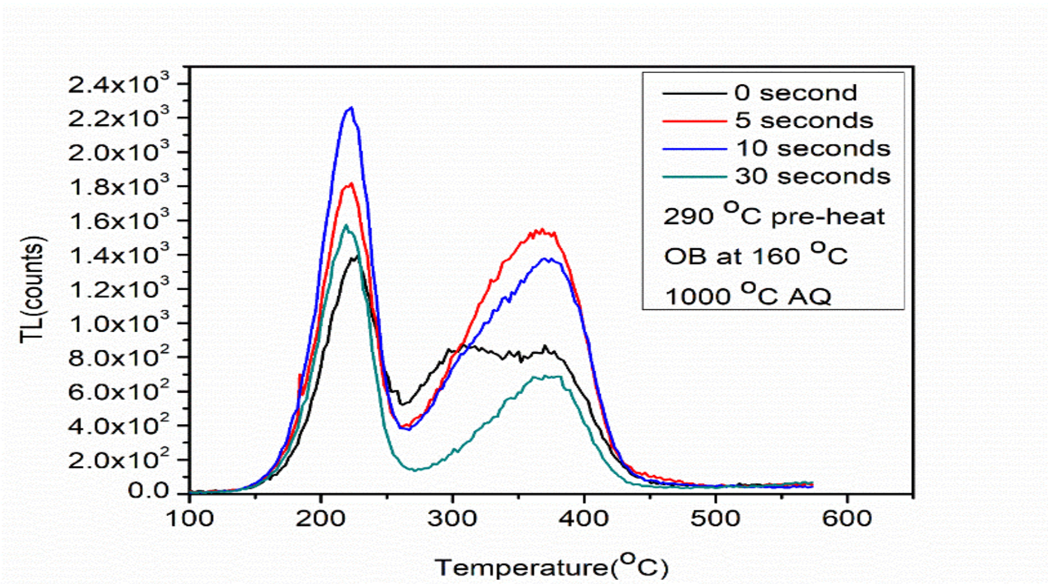

Figure 13: TL glow curves of 1000 oC annealed sample of 5.04Gy beta dose under different pre-heat durations and optical bleaching at 160 oC

Such effect of pre-heat duration is independent for TL intensity of 375 oC TL glow peak. The charge is thermally transferred from light-insensitive traps that are thermally stable to optically sensitive traps above 290 oC temperature in the current study. In addition, the 375 oC TL glow peak has previously been demonstrated to operate as a thermally stable and optically sensitive peak in both annealed samples. However, this TL trap may accumulate sufficient charges during the pre-heat process at the desired temperature, and the charges are optically freed during optical bleaching at 160 oC, but it may re-trap at the same or other locations in the lattice. Therefore, trap corresponding to 220 oC may sensitize as function duration of pre-heat temperature and hence responsible to growth of this TL glow peak.

III. CONCLUSION

The contribution of higher temperature TL traps influenced by condition of annealing temperature followed by beta dose. As the 1000 oC annealed sample exhibits 220 oC, 300 oC and 375 oC glow peaks by eliminating of 350 oC TL glow peak which was observed in 600 oC annealed sample.

Under optical bleaching either at room temperature or 160 oC, the 600 oC annealed sample sustained the position of 375 oC by complete bleaching of 350 oC TL glow peak. While, the 1000oC annealed sample sustained the position of 375 oC TL glow peak accordance with growth of 220 oC TL glow peak by complete bleaching of 300 oC TL glow peak. It is attributed to the generation of new TL centers corresponding to 220 oC TL glow peak in presence of 375 oC TL glow peak. The TL sensitivity and optical bleachability of 220 oC and 375 oC TL glow peak shows the evidence of dual (thermal and optical) nature of glow peak with superlinear TL dose response.

The post irradiation pre-heat treatment at 290oC supports to thermal transfer process of electron from shallow and optically insensitive TL trap to deep thermally stable traps. In presence of optical bleaching at 160 oC, pre-heat treatment at 290oC and its cutoff duration supports to re-establish 220 oC with 375 oC TL glow peaks.

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