



The non-exponential shape of OSL decay curve for treated samples at different experimental conditions: A case study

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Abstract

The OSL decay curves are recorded at room temperature (25°C) and elevated temperature (160°C) for different physical treatments to the synthetic quartz material. These physical treatments include (i) Annealing sample for 1hour duration followed by 25.2Gy beta dose (ii) Thermally treated sample held at 290°C for different durations (iii) Samples were Optically bleached at desired temperature for cyclic periods. The 400°C annealed sample of 1hour duration exposed to 25.2Gy beta dose exhibits non-exponential shape of decay curves at both measurement temperatures. These patterns of decay curves are also observed in thermally treated beta irradiated sample and held at 290°C for 0, 5, 10, and 30seconds. The pattern persists even after repeated bleaching followed by optical stimulation at 160°C. The changes in non-exponential pattern of decay curve with the growth of OSL signal are observed during optical stimulation at 160°C. The non-exponential shape of decay curve can be attributed to the negligible recombination of the electron at recombination centers compared to significant retrapping of the electrons into intermediate and deep traps. This has been supported by resolution of OSL decay curves by TL glow curves recorded after the optical stimulation at room temperature and elevated temperature.

Highlights

The predominant effect of non-exponential shape of OSL decays over the typical exponential shape of OSL decay.

Keywords: annealing, radiation, shape of decay, OSL

Introduction

In optically stimulated luminescence (OSL) mechanism, the trapped electrons in the sample which has been previously irradiated are released under the influence of optical stimulation wavelength from visible part of the spectrum and recombined with the hole at recombination center. [1] These process graphically explained by OSL intensity against optical stimulation time plot which is

represented in the form of typical exponential shape of OSL decay curve. Either shape of decay curve or OSL signals are depend upon physical treatments to the sample and experimental condition.[2] The exponential shape of OSL decay suggests maximum recombine probability of trapped electrons in recombination centers during optical stimulation and hence it gives best OSL output.[3] But under certain physical

conditions, the shape of decay curve is neither exponential in nature nor gives better OSL output which happened loss of OSL signal by re-trapping of the electrons in the sample during the optical stimulation. [4] In view of these, researchers have often focused over the exponential shape of decay curve followed by recovering OSL signal rather than non-exponential shape of decay curve. The present work is mainly focused over the non-exponential pattern of OSL decay curve. The behavior of these patterns under influence of physical treatments to the sample and experimental conditions are studied followed by interpretation as case study.

Experimental Details

The fine powder of 63-53 μ m grains of synthetic quartz crystal was prepared through standard sieves. It was annealed at 400°C for 1h duration with the help of muffle furnace which has temperature range up to 1200°C \pm 1°C accuracy. After the completion of required annealing duration, material was brought to room temperature for annealing-quenched process. The batches of treated sample were irradiated by 25.2Gy beta dose (dose rate 0.084Gy/sec) prior to OSL and TL measurements. The following protocols were implemented for present study.

Protocol-1 sample + 400°C; 1h + 25.2Gy + OSL for 100sec at 25°C + TL recorded from 25-573°C

Protocol-2 sample + 400°C; 1h + 25.2Gy + OSL for 100sec at 160°C + TL recorded from 25-573°C

Protocol-3 sample + 400°C; 1h + 25.2Gy + pre-heat 290°C for 0, 5, 10 and 30seconds + OSL for 100 sec at 160°C + TL recorded from 25-573°C

Protocol-4 sample + 400°C; 1h + 25.2Gy + 1st OSL for 100sec at 160°C + 2nd OSL for 100sec at 160°C + 3rd OSL for 100sec at 160°C + TL recorded from 25-573°C

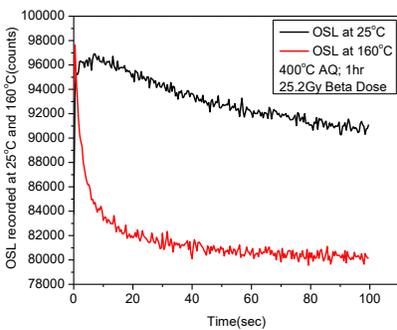
Each batch of 5mg of samples were prepared to measure OSL at 25°C and 160°C followed by TL recorded from 25-573°C through RISO (TL/OSL-DA-15) system. The TL glow curves were recorded after being optical simulation without keeping any time lag.

Results and Discussions

As a case study, the effects of sample treatments and experimental conditions on shape of OSL decay curves are studied. Prior to these experimental works, it is essential to understand the behavior of OSL decay curve at room temperature for thermally treated beta irradiated sample.

OSL recorded at 25°C for 100sec followed by TL measurement.

The 400°C annealed sample of 1hour duration followed by 25.2Gy exposed sample was optically stimulated for 100sec at room temperature. [Graph-1]



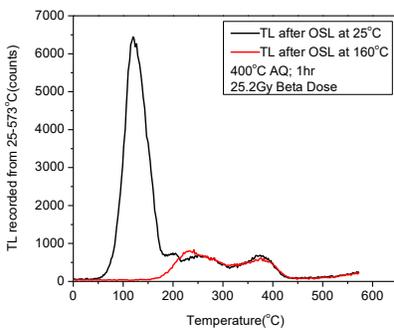
Graph-1 OSL recorded at 25°C and 160°C for 100sec

It is observed that shape of decay curve is not typical exponential (maximum OSL obtained at 0 sec stimulation) in nature. For initial stimulation, it shows exponential growth from 0 to 6.8seconds and then decay started in usual manner which suggests the non-exponential or slower pattern of the decay curve. This pattern of decay curve gives maximum OSL by 96922 counts at 6.8sec instead of 0 second. It is suggested that, under influence of thermal treatment and irradiation, traps are generated which are not much optically sensitive and during optical stimulation there is negligible possibility of recombination of the electron with hole at recombination centers. The literatures [3] report on the luminescence models for OSL/TL, the non-exponential pattern of OSL decay curve is responsible to significant re-trapping probability of an electron in same traps, shallow TL traps and thermally disconnected traps during optical stimulation. These clarifications may correlate with the wider span of TL glow curves appeared at

120°C, 203°C, 256°C and 377°C which are recorded after being optical stimulation for identical treated sample. [Graph-2] Due to these models the losses of OSL are possible and hence they have recommended elevated temperature protocol for optical stimulation protocol to avoid such problem. [5]

OSL recorded at 160°C for 100sec followed by TL measurement

Under this protocol, optical stimulation is carried at 160°C for 100sec in identical annealed sample of 25.2Gy beta dose [Graph-1] and outcomes are compared with the results of earlier protocol-1. During elevated temperature stimulation, the OSL signal is little bit increased by 700 counts compare to room temperature optical stimulation. But pattern of the OSL decay curve is significantly changed which gives maximum OSL counts at 0.4sec. In other word it can say that during initial stimulation from 0 to 0.4sec, curve shows linear growth followed by normal decay. The changes from exponential growth to linear growth during initial stimulation at present experimental condition indicate minor re-trapping probabilities of the charges or contribution of less optically sensitive traps still active/exist. It is resolved by TL glow curve are recorded after the optical stimulation at 160°C. [Graph-2]



Graph-2 TL recorded from 25-573°C after the OSL at 25°C and 160°C

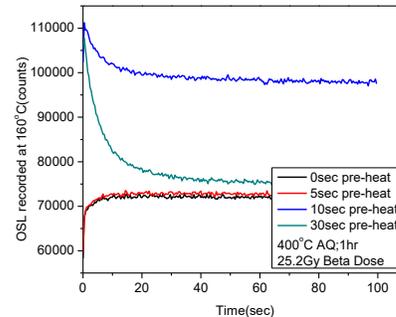
Obviously, the stimulation at 160°C erases the involvement of shallow glow peaks (110°C) and stability of higher temperature TL peaks is sustained at 242°C and 372°C due to transferring of the charges during stimulation. It could propose that these traps appeared in TL results of protocol-1 which may optically sensitive and hereafter responsible to better OSL or accountable for re-trapped the charges due to higher thermal stability of peaks. To resolved these noticeable contribution of 242°C and 372°C under influence of optical stimulations, the duration of pre-heat treatment followed by irradiation protocols are studied

Pre-heat at 290°C for different durations followed OSL at 160°C and TL measurement

The thermal transfer process assists to transfer the charges as possible as from shallow traps to higher temperature traps and optically sensitive traps which are beneficial to enhance of OSL with thermal stability. [6] An irradiated samples pre-heat

to 290°C for 0sec, 5sec, 10sec and 30sec followed by optical stimulation at 160°C.

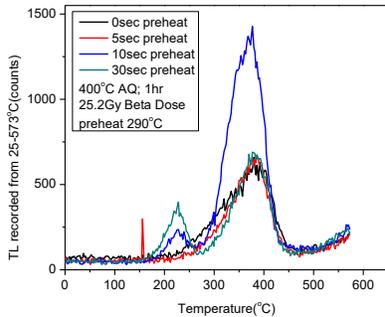
[Graph-3]



Graph-3 OSL recorded at 160°C after the dose followed by pre-heat at 290°C for different durations

As increased in durations of pre-heat temperature, the changes in exponential growth of initial OSL to linear growth of initial OSL by reducing stimulation times from 43.2seconds into for 0.4seconds. It recommends that decay curves shift toward exponential side but not achieved a typical pattern of exponential decay curve which indicate that little bit slower pattern of decay or re-trapping of the charges under influence of this protocol still exist. The OSL counts are increased with the pre-heat time which may responsible to successive transfer of the charges into optically sensitive trap. But at higher durations of pre-heat treatments, OSL counts are decreased which could be due to the strength of physical treatments, experimental conditions and activeness of re-trapping of the charges. The TL results after the implemented of these protocol report

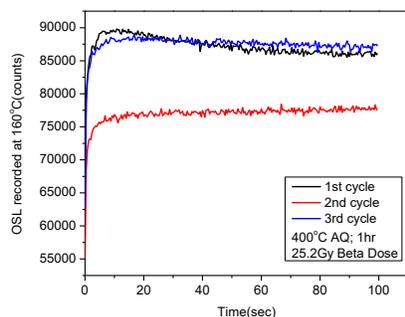
significant contribution of $\sim 220^{\circ}\text{C}$ and $\sim 375^{\circ}\text{C}$ glow peaks which are more dynamic under this physical treatments. [Graph-4]



Graph-4 TL recorded from 25-573°C after dose followed by pre-heat at 290°C for different durations and OSL at 160°C .

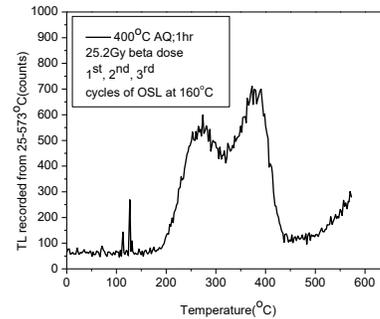
Cyclic OSL at 160°C and TL measurements

The repeated stimulation at 160°C for 100seconds shows no significant effect on the pattern of decay curves. The non-exponential pattern of decay curves or exponential growth for initial stimulation time are sustain with at higher durations of initial stimulation time. It may be due to less emptied of optically sensitive traps. [Graph-5]



Graph-5 cyclic OSL recorded at 160°C for annealed sample followed by 25.2Gy dose.

It is justified by noticeable appearance of stable TL peaks 276°C and 375°C . [Graph-6]



Graph-6 TL recorded from 25-573°C after the cyclic stimulation

Conclusions

The changes in physical treatments to the sample and experimental conditions are neither sufficiently effective to change the non-exponential pattern for decay curves nor reduced the time span of initial exponential growth of OSL decay curve.

The non-exponential shape of decay curve is attributed to the negligible recombination of the electron at recombination centers compared to major retrapping of the electrons into intermediate and deep traps rather than well-defined shallow traps.



References

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