



THERMALLY ASSISTED OSL: A POTENT TOOL FOR IMPROVEMENT IN MINIMUM DETECTABLE DOSE AND EXTENSION OF DOSE RANGE OF $\text{Al}_2\text{O}_3:\text{C}$

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Received 31 January 2013

Accepted 2 September 2013

Abstract: The influence of electron-phonon interaction on the shape of the optically stimulated luminescence decay curve of $\text{Al}_2\text{O}_3:\text{C}$ has been studied using thermally assisted optically stimulated luminescence (TA-OSL). The minimum detectable dose (MDD) of a phosphor depends on the standard deviation of the background signal which affects the signal-to-noise ratio. The standard deviation of the background signal reduces at lower stimulation light intensity while the readout time increases. Further, measurement at higher temperature enhances the OSL signal with faster decay due to the temperature dependence of photo-ionization cross-section. To achieve the same decay constant and more signal, the temperature of measurement was raised. As a result of lowering the stimulation intensity at higher temperature (85°C) the overall MDD of $\alpha\text{-Al}_2\text{O}_3:\text{C}$ was found to improve by 1.8 times. For extension of dose linearity in higher range, deeper traps were studied by simultaneous application of CW-OSL and thermal stimulation up to 400°C, using a linear heating rate of 4K/s. By using this method, two well defined peaks at 121°C and 232°C were observed. These TA-OSL peaks have been correlated with two deeper defects which can be thermally bleached at 650°C and 900°C respectively. These deeper defects are stable up to 500°C, so they can store absorbed dose information even if the sample is inadvertently exposed to light or heat. The dose vs. TA-OSL response from deep traps of $\alpha\text{-Al}_2\text{O}_3:\text{C}$ was found to be linear up to 10 kGy, thus extending its application for high dose dosimetry.

Keywords: decay constant, photo-ionization cross-section, thermally assisted OSL (TA-OSL).

1. INTRODUCTION

Optically stimulated luminescence (OSL) is a phenomenon directly associated with the presence of metastable trapped charges in wide band gap insulators/semiconductors. The conventional way of stimulat-

ing a phosphor is continuous wave (CW)-OSL mode, where the stimulation light intensity is held constant with respect to time and decay of OSL signal thus recorded. The decay constant of such a CW-OSL curve under first order kinetics contains information about photo-ionization cross-section (probability of interaction of incident photon with the trapped electron in the trap) of traps participating in OSL phenomenon. The relatively

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long time of CW-OSL recording generates considerable amount of background counts due to scattering of stimulating light from the sample holder, LED light leakage due to inadequate optical filtering of the stimulated light by optical filter combination. This results in a degradation of the overall signal to noise ratio of the instrument. The minimum detectable dose (MDD) of a phosphor depends on the total signal and the standard deviation of the background signal of the readout instrument. The standard deviation in the background signal and thus the signal-to-noise ratio can be improved considerably by taking CW-OSL readout at lower stimulation intensities. However, this reduction in stimulation intensity affects the decay constant and increases the readout time and total signal also gets affected. The decay shape is dependent upon the sample, the absorbed dose, the illumination intensity and the temperature of readout McKeever *et al.*, (1997). The dependence of the optical excitation probability on temperature is reported in the literature and mostly assigned to the so-called thermal assistance or to the presence of the shallow trap that is thermally depopulated at the temperatures of OSL measurement which leads to give more signal as compared to that at room temperature (RT). Bailey (2001) and McKeever *et al.* (1997) give brief reviews of some attempts that were undertaken in order to explain the experimentally observed changes of the OSL decay rate with measurement temperature. The paper of McKeever *et al.* (1997) also shows that shallow traps can strongly affect the shape of OSL curves in the case of complex systems. The related effects depend not only on the temperature but also on the intensity of stimulation light and on the radiation dose applied for the excitation of OSL. In general, there are two ideas in this approach, one postulating the existence of an intermediate shallow level (Hütt *et al.*, 1988; Poolton *et al.*, 1995) and another one referring to the assistance of lattice vibrations but eventually, in the experiment interpretation, introducing an excited state of trap with a definite energy (Spooner, 1994). Although the first proposed mechanism is possible in some particular cases, the second one seems to be more fundamental, at least in the idea that the temperature dependence observed in the production of OSL is inherent to the photo-ionization mechanism. Spooner (1994) studied the temperature dependent nature of photo-ionization cross-section in quartz by taking elevated temperature isothermal CW-OSL measurements and suggested that the temperature dependence of photo-ionization cross-section follows the Arrhenius law. It is suggested that the photo-ionization cross-section consists basically of two parts – one is temperature independent and the other depends on temperature exponentially. This dependence of photo-ionization cross-section of intermediate traps on the decay constant can be utilized for the improvement in the MDD of various OSL phosphors.

α -Al₂O₃:C is a well-established passive TL and OSL detector widely used for various applications in radiation dosimetry. The intermediate traps in α -Al₂O₃:C, called

dosimetric traps, are reported to have the MDD of ~20 μ Gy and show sub-linear dose response for doses >1 Gy (Akselrod *et al.*, 1990) using the CW-OSL technique, hence putting limitations in the high dose range. In α -Al₂O₃:C, the deeper traps were found to give their presence at 873 K and 1173 K respectively (Akselrod *et al.*, 1993). Such deep traps have a large thermal trap depth and are difficult to access by TL. Secondly, at such high temperatures the loss of signal due to very high thermal quenching (Akselrod *et al.*, 1998) and interference of high infrared background makes TL measurements difficult beyond 750°C. Apart from this, the conventional OSL technique at RT is also incapable of accessing such deep traps, as the photo-ionization cross-section of these traps is expected to be very low at RT. The present work describes a new experimental method using temperature dependence of photo-ionization cross-section to access the signal from deep traps without heating the sample to temperatures higher than 400°C and limiting the readout time up to 120 s. The measured signal can be used to extend the applicability of α -Al₂O₃:C powdered OSL phosphor for accident dosimetry in harsh conditions of light exposure and temperatures.

2. TEMPERATURE DEPENDENCE MODEL FOR Al₂O₃:C

In general, the temperature dependence of OSL is complicated if a sample contains a significant number of shallow traps which become inactive as the temperature increases. When OSL measurements are carried out at RT, a long tail in the OSL curve is often observed. This can be attributed to the influence of shallow traps which localize charges released during illumination and slowly release them again at a rate determined by the trap depth and the sample temperature. Since at low temperatures, where the half-life of the charge in the shallow traps is much longer than the decay time, a small OSL signal is obtained due to trapping in the low temperature traps. At high temperatures, where the trap lifetime is very small, a much increased OSL is obtained. The signal increases initially then decays non-exponentially. In this way shallow traps may slow down the OSL decay processes. Furthermore, shallow traps give rise to a temperature dependent OSL component since at higher temperatures they become less effective at trapping charge. Measurement at elevated temperature reduces the effect of the shallow traps considerably since these states cannot store any charge which is optically transferred to them from deeper traps. These effects were shown in computer simulations by McKeever and Morris (1994) and were demonstrated experimentally for Al₂O₃ by Markey *et al.* (1996).

Another way, in which a thermally activated process may occur, is via a thermally assisted transition into the delocalized band. For example, OSL is observed from feldspars following illumination with infra-red light. At

these wavelengths direct optical excitation from the deep trap into the conduction band is unlikely and thus a thermally assisted transition was postulated by Hütt *et al.* (1988) in which the IR excites the electron into an excited state, from where it may be thermally excited into the delocalized band with a thermally activated probability which follows an $\exp\{-E_A/kT\}$ law. In either of the above cases, the OSL is seen to be thermally activated, but the interpretation of the activation energy is quite different. Spooner (1994) postulated the existence of an array of available states in the ground state of the trap. The upper levels of this array are accessed at higher temperatures, with activation energy, requiring a smaller optical energy to excite the charges into the delocalized bands. In case of $\text{Al}_2\text{O}_3:\text{C}$, the stimulation is not restricted to one particular wavelength, transition of charges from the deeper traps to the higher electronic states is unlikely, instead it moves to a higher vibrational state of the same electronic state as an effect of temperature. Mishra *et al.* (2011a) formulated the theory of TA-OSL for $\text{Al}_2\text{O}_3:\text{C}$. Fig. 1 shows the energy level diagram representing the electronic transition involved in the photo-transfer process from various traps in $\alpha\text{-Al}_2\text{O}_3:\text{C}$. The various energy levels have been reported by earlier investigators (Yukihara *et al.*, 2003) which have been used to plot Fig. 1. The TA-OSL model for $\alpha\text{-Al}_2\text{O}_3:\text{C}$ showing the vibrational level of deep energy level DT_1 and DT_2 defects participating in thermally assisted OSL.

3. EXPERIMENTAL DETAILS

The dosimetry grade single crystal of $\alpha\text{-Al}_2\text{O}_3:\text{C}$ (TLD 500, Landauer Inc.; 5 mm in diameter, 0.8 mm thick) was irradiated using a calibrated $^{90}\text{Sr}/^{90}\text{Y}$ beta source. The TA-OSL and CW-OSL was recorded at various temperatures and various stimulation intensities for the irradiated samples in integrated TL/OSL measurement set-up (Kulkarni *et al.*, 2007) consisting of a high intensity ($50 \text{ mW}/\text{cm}^2$) blue light emitting diode ($\lambda_p = 470 \text{ nm}$, $\Delta\lambda = 20 \text{ nm}$) cluster as a stimulating light source. The samples were optically bleached with $\sim 100 \text{ mW}/\text{cm}^2$ blue LED (470 nm) light for 10 min., before the irradiation. The TL and TA-OSL curves were recorded at a constant heating rate of 4 K/s and all OSL measurements were performed in the CW-OSL mode. The light intensity at the sample position was measured using an Si photodiode (OSD-5) giving approximately $48.8 \text{ mW}/\text{cm}^2$. The GG-435 and UG-1 optical filters were used across the LED cluster and PMT to prevent the stimulating light from reaching the PMT.

4. RESULTS AND DISCUSSIONS

Signal to Noise Ratio (S/N) Analysis for CW-OSL

The overall background in the recorded OSL signal can be expressed as (Mishra *et al.*, 2011b)

$$\text{OSL counts } (N_{\text{OSL}}) = N_{\text{PMT}} + N_{\text{sc}} + N_{\text{e}}, \quad (1)$$

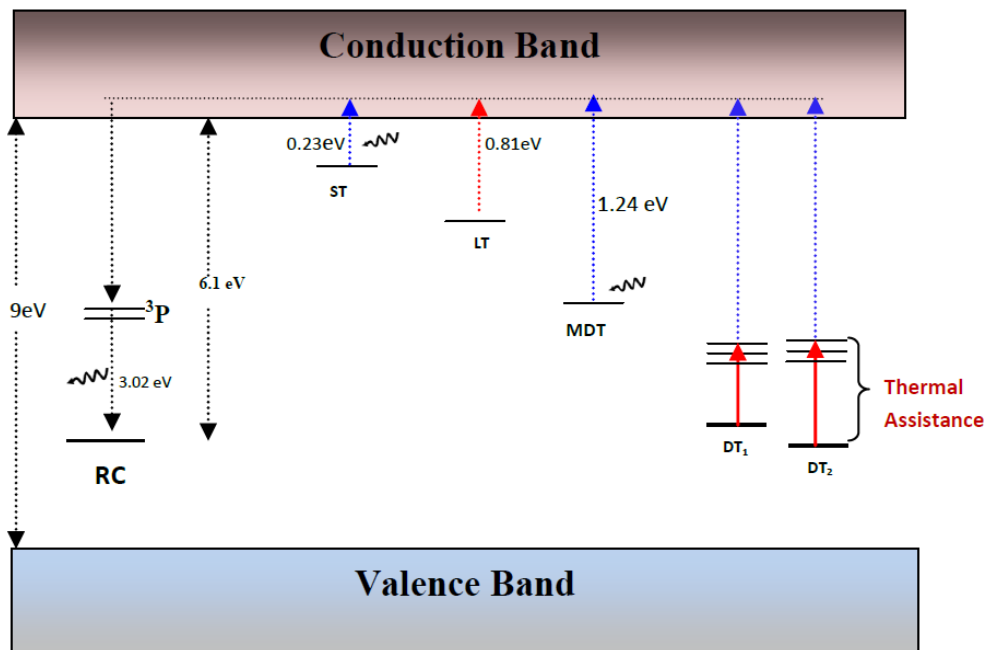


Fig.1. Energy level diagram showing various electronic transition involved in the phototransfer process including thermal assistance from deep traps in $\alpha\text{-Al}_2\text{O}_3:\text{C}$ powder.

where N_{PMT} – dark counts of the photomultiplier tube (PMT), N_{sc} – background signal generated due to scattering of stimulation light from sample / sample holder and inadequate optical filter action which does not fully cut off stimulation wavelength, N_e – background counts contributed due to electronics hardware / circuit used for stimulation as well as detection of PMT output signals at the amplifier and pre-amplifier.

The dark counts of the PMT (N_{PMT}) can be reduced by properly controlling the bias voltage, providing adequate cooling of the PMT, shielding it against external magnetic field by μ -shielding material. The major background component in OSL reader systems is the counts originated due to leakage of stimulation light (N_{sc}). It depends on many factors; most important among them is the selection of the cut-off optical filters. The contribution of these background signals increases with an increase in the value of stimulation intensity and reflectivity of the sample/sample holder. The contribution of this signal can be reduced substantially by reducing the reflectivity of the sample holder and stabilizing the stimulation intensity, so that the large part of this background signal can be subtracted as a constant background. Therefore, in brief, the background counts generated due to scattering of stimulation light N_{sc} can be reduced if the total integrated stimulation flux incident on sample during readout is reduced without compromising the total OSL signal. For the S/N consideration, we have to compare the S/N for higher stimulation intensity to that at lower stimulation intensity at room temperature (RT) as follows

$$\frac{{}^{RT}(S_H / N_H)}{{}^{RT}(S_L / N_L)} = k \quad (2)$$

where S_H/N_H and S_L/N_L are the signal to noise ratios for higher and lower stimulation intensity, respectively. However assuming the first order decay and acquisition of complete area lead to same amount of signal ($S_H=S_L$), i.e., the dose is the same for both cases, the values of k which is the measure of the figure of merit is given by

$$\frac{{}^{RT}(S_H / N_H)}{{}^{RT}(S_L / N_L)} = k = \frac{{}^{RT}N_L}{{}^{RT}N_H} \quad (3)$$

So the value of k is nothing but the ratio of noise at lower stimulation intensity to that at higher stimulation intensity. Now the differential noise for any stimulation intensity at RT is given by

$$\frac{{}^{RT}dN}{dt_R} = N_{sc} + N_{PMT} + N_e \quad (4)$$

$${}^{RT}N = \int_0^{t_R} (N_{sc} + N_{PMT} + N_e) dt_R \quad (5)$$

$${}^{RT}N = t_R (N_{sc} + A) \quad (6)$$

where $A = N_{PMT} + N_e$, which is independent of stimulation intensity whereas N_{sc} is a function of stimulation intensity and t_R is total time of readout. Therefore the value of k is given by

$$\frac{{}^{RT}N_L}{{}^{RT}N_H} = \frac{t_{RL} (N_{sc}^L + A)}{t_{RH} (N_{sc}^H + A)} \quad (7)$$

where, N_{sc}^L and N_{sc}^H are the scattering noise for lower and higher stimulation intensity respectively and t_{RL} and t_{RH} are the time of readout for lower and higher stimulation intensity respectively. As $N_{sc} \gg A$, the value of k can be written as

$$\frac{{}^{RT}N_L}{{}^{RT}N_H} = \left(\frac{t_{RL}}{t_{RH}} \right) \left(\frac{N_{sc}^L}{N_{sc}^H} \right) \quad (8)$$

$$k = \eta * \xi \quad (9)$$

where,

$$\eta = \left(\frac{t_{RL}}{t_{RH}} \right) \text{ and } \xi = \left(\frac{N_{sc}^L}{N_{sc}^H} \right) \quad (10)$$

where ξ is independent of temperature, while η is a function of temperature. At RT $\eta > 1$ ($t_{RL} > t_{RH}$) for taking complete signal and $\xi < 1$ as per Fig. 3 of Mishra *et al.* (2011b).

Evaluating k for 48 mW/cm² and 30 mW/cm² at RT from Eq. 9 by putting $t_{30} = 90$ s, $t_{48} = 70$ s, $N_{sc}(P_{30}) = 220$ and $N_{sc}(P_{48}) = 380$ from Fig. 3 of Mishra *et al.* (2011b), we obtain $k = 0.74$. Therefore the signal to noise ratio (at RT) at higher stimulation intensity is slightly better than that at lower stimulation intensity. This value of k is for commercial reader (having highest detection threshold) where one will get almost the same signal ($S_H = S_L$) for two values of stimulation intensities so we canceled the S term in Eq. 2. However for moderate sensitivity reader system (laboratory reader system) signal (S) is never the same ($S_H \neq S_L$) for two different values of stimulation intensities due to the problem of detection threshold of the PMT. In such cases one cannot cancel S in Eq. 2 for two different intensities. S will be higher for higher stimulation intensity as compared to that at lower stimulation intensity. Thus, for practical reader system k is slightly greater than 1 due to $S_H > S_L$. For such reader system we get higher signal to noise ratio at higher stimulation intensities.

Now considering the effect of temperature in Eq. 9, the value of $\eta \sim 1$ at elevated temperature, i.e., (${}^{TH}t_{RL} = t_{RH}$) due to temperature dependence of photoionization cross-section (where ${}^{TH}t_{RL}$ is the time taken to record the complete signal at lower stimulation intensity with higher temperature). As the signal increases at high temperature due to thermally assisted OSL we have (${}^{TH}S_L \sim S_H$). Therefore the value of k at a higher temperature will only depend on ξ which is smaller than 1. Thus, the

signal to noise ratio with lower stimulation intensities at elevated temperature is better than the one with higher stimulation intensities at lower (or room) temperature.

TA-OSL: Improvement in MDD

The MDD of any phosphor not only depends on the defects, quality of the material but also on the readout technique and the instrument used. The relatively long time of CW-OSL recording generates considerable amount of background counts due to scattering of stimulating light from sample holder. This results in degradation of the overall signal to noise ratio. The contribution of background signals increases with increase in the value of stimulation intensity and reflectivity of sample/sample holder. The contribution of this signal can be reduced substantially by reducing the reflectivity of sample holder and statistically stabilizing the stimulation intensity, so that the large part of this background signal can be subtracted as a constant background. The reduction in stimulation light intensity and hence the scattering component reduces the standard deviation in the total background signal. Fig. 2 shows the reduction in standard deviation in background count as a function of CW-stimulation light intensity with sample stimulated for fixed time at 25°C. However, the reduction in stimulation light intensity increases the readout time due to the dependence of decay constant of OSL signal on the former. The decay constant depends on the photo-ionization cross-section of the OSL active traps in the phosphor participating in OSL phenomenon and thus on the readout temperature due to the temperature dependence of photo-ionization cross-section. Fig. 3 shows the CW-OSL at various temperatures for a given set of experimentally evaluated (Mishra *et al.*, 2011a) values, with fixed CW stimulation intensity $\phi_0 = 48 \text{ mW/cm}^2$ of 470 nm light. Inset of Fig. 3 shows CW-OSL at various stimulation intensities at 25°C. In order to achieve the same decay constant for two sets of measurements for $\alpha\text{-Al}_2\text{O}_3\text{:C}$ i.e. to take the OSL measurement in the same time at lower stimulation light intensity as that taken for higher light intensity, the temperature of measurement for $\alpha\text{-Al}_2\text{O}_3\text{:C}$ for the former was raised. Besides, the increase of readout temperature does not affect the standard deviation in the background signal of OSL readout. The optimized elevated temperature for $\alpha\text{-Al}_2\text{O}_3\text{:C}$ was found to be 85°C as the main dosimetric peak starts giving signal 90°C onwards due to depletion of its filled traps. Therefore the decay constant of the CW-OSL was increased without compromising on the total OSL signal. Fig. 4 shows the CW-OSL readout of $\alpha\text{-Al}_2\text{O}_3\text{:C}$ at two different stimulation intensities 30 and 48 mW/cm^2 at 25°C, showing the change in the CW-OSL decay constant as a function of stimulation intensity. The CW-OSL signal taken at 30 mW/cm^2 (lower stimulation intensity) takes more time to decay to the same level as compared to that at higher intensity (48 mW/cm^2). In order to achieve the same decay constant, i.e. to take the OSL measurement in the same time at 30 mW/cm^2 stimu-

lation light intensity as that at 48 mW/cm^2 light intensity, the temperature of measurement for $\alpha\text{-Al}_2\text{O}_3\text{:C}$ was raised (inset of Fig. 4). At even lower stimulation power ($<30 \text{ mW/cm}^2$), the standard deviation in the background further decreases which can further improve the MDD. However, at even lower intensities, the decay time increases accordingly, i.e. it will take more time to take the complete signal, which will demand temperature more than 85°C to reduce the decay constant. In case of $\alpha\text{-Al}_2\text{O}_3\text{:C}$, we restricted readout temperature at 85°C only as the main dosimetric peak starts giving the signal from 90°C onwards. On taking the OSL signal at temperature more than 85°C, the signal will be lost in TL mode,

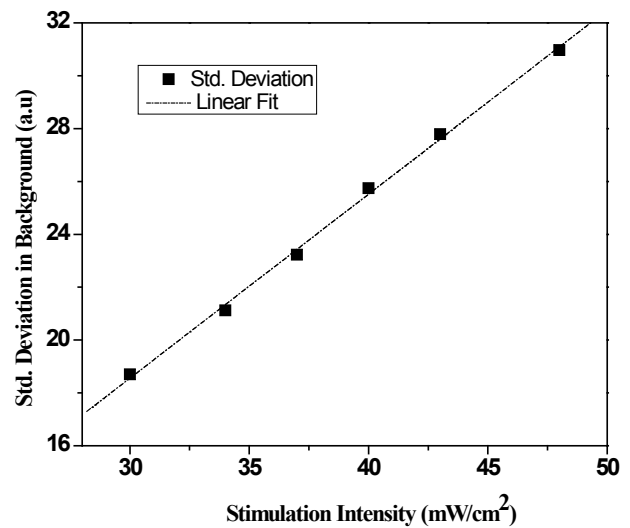


Fig. 2. Standard deviation in background count vs. CW-stimulation light intensity with sample stimulated for fixed time at 25°C.

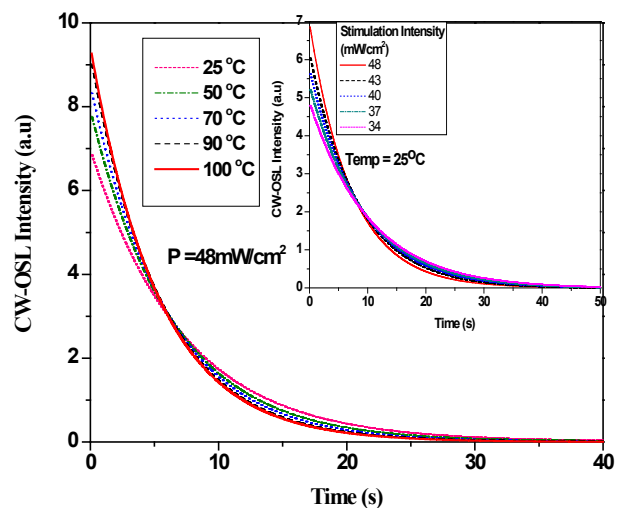


Fig. 3. Numerically simulated CW-OSL at various temperatures for a given set of experimentally evaluated (Mishra *et al.*, 2011a) values, with fixed CW stimulation intensity $\phi_0 = 48 \text{ mW/cm}^2$ of 470 nm light. Inset figure shows CW-OSL at various stimulation intensities at 25°C.

so 85°C is the optimized temperature for α -Al₂O₃:C. However, for those phosphors in which the dosimetric peaks starts at even higher temperatures such as 150°C onwards, one could go to even lower stimulation intensities (<30 mW/cm²) to further improve the MDD.

Table 1 gives the variation of decay constant at various temperatures and optical power. Henceforth this technique will be referred to as thermally assisted CW-OSL (TA-CWOSL). As a result of lowering the stimulation intensity (30 mW/cm²), the standard deviation in the background signal was found to be improved 1.8 times and taking CW-OSL at higher temperature (85°C) increases the decay constant (i.e. the readout is faster). Thus the overall MDD of α -Al₂O₃:C by TA-CWOSL was found as 11.4 μ Gy as compared to 20 μ Gy by CW-OSL method i.e., improved 1.8 times. **Fig. 5** shows the improvement in MDD as a function of stimulation intensity and experimentally evaluated values of decay constant at various combination of readout temperature and stimula-

tion intensity. The MDD was measured in the following way:

- 1) Measurements of background on five freshly annealed, unirradiated Al₂O₃:C detectors to determine 3 standard deviations of the background signal (X).
- 2) Expose six annealed crystals to a dose of D = 500 μ Gy and determine mean output of these detectors Y/D (μ Gy⁻¹).
- 3) Calculate MDD as : MDD (μ Gy) = X*D / Y

Table 2 shows the comparison of MDD and the respective OSL readout time for various stimulation techniques. It is clear that POSL gives the best signal to noise ratio and thus the MDD and is reported as 5 μ Gy (McKeever *et al.*, 1996). The MDD for LM-OSL was compared with that of CW-OSL by recording them for same final stimulation intensity and integration time and it was found that LM-OSL gives lower MDD as compared to CW-OSL a factor of 1.3 and comes out as 15.38 μ Gy. Further, NL-OSL has been reported to give 1.2 times better MDD as compared to LM-OSL (Mishra *et al.*, 2011b) and thus comes out as 12.80 μ Gy.

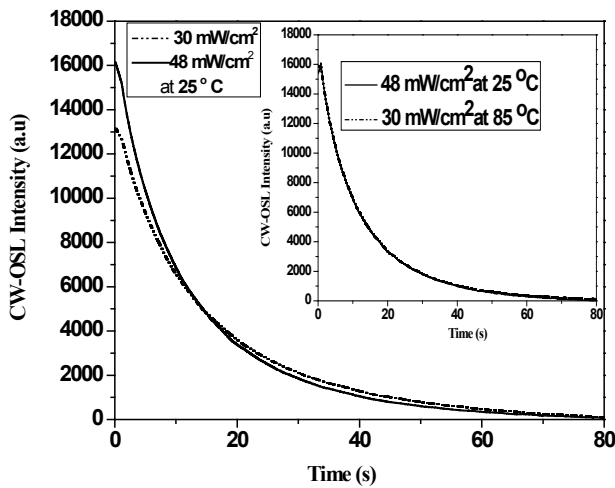


Fig. 4. Experimentally evaluated CW-OSL of α -Al₂O₃:C at two different stimulation intensities at 25°C, showing the change in the CW-OSL decay constant as a function of stimulation intensity. Inset figure shows the effect of temperature to achieve the same CW-OSL decay constant at different stimulation intensities.

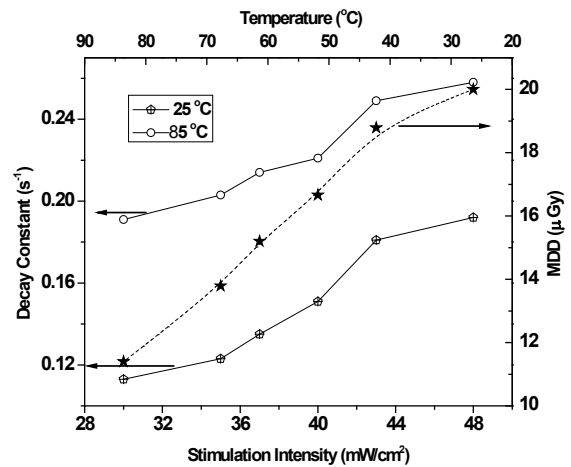


Fig. 5. Experimentally evaluated CW-OSL decay constant of α -Al₂O₃:C at various stimulation intensities and two different temperatures (25°C, 85°C) showing the change in the CW-OSL decay constant as a function of stimulation intensity. The other graph shows the improvement in MDD as a function of stimulation intensity.

Table 1. Variation of Decay constant at various temperatures and optical power (CW-OSL and TA-CWOSL method).

Power (mW/ cm ²)	Decay Constant (f= σφ) (s ⁻¹)				Std Dev. in Bkg	Improvement factor in MDD	MDD of Al ₂ O ₃ :C (μGy)	Respective temperatures (°C) for same decay constant (0.192)
	25°C	45°C	60°C	85°C				
48	0.192	0.221	0.245	0.258	30.96	1	20.00	25
43	0.181	0.210	0.232	0.249	28.79	1.07	18.79	35
40	0.151	0.183	0.208	0.221	25.65	1.20	16.66	50
35	0.123	0.151	0.182	0.203	21.23	1.45	13.79	65
30	0.113	0.130	0.161	0.191	17.69	1.75	11.40	85

Table 2. Stimulation Techniques and Dose threshold with respective OSL readout time. (MDD for POSL and NL-OSL are reported in McKeever et al., 1996 and Mishra et al., 2011b respectively).

Stimulation Techniques	Low Dose limit (μ Gy)	Readout Time (s)	Power Used (mW/cm ²)
CW-OSL	20.00	90	48
POSL	5.00	1	48
LM-OSL	15.38	90	48
NL-OSL	12.80	90	48
TA-CWOSL	11.40	90	30

CW-OSL: Continuous wave-optically stimulated luminescence,

POSL: Pulsed optically stimulated luminescence,

LM-OSL: Linearly Modulated optically stimulated luminescence,

NL-OSL: Non-linearly optically stimulated luminescence,

TA-CWOSL: Thermally assisted- continuous wave optically stimulated luminescence.

5. TA-OSL: EXTENSION OF DOSE LINEARITY

The deeper defects of α -Al₂O₃:C were studied using TA-OSL method to study the dose response of the phosphor. In order to record the TA-OSL response of deep traps, the sample was first subjected to TL readout up to a temperature of 400°C to deplete the signal due to 185°C main dosimetry TL peak. The sample was subsequently subjected to CW-OSL readout along with simultaneous application of temperature profile at a linear heating rate at 4K/s. As a result two well-defined TA-OSL peaks at 121°C and at 232°C occur in time as well as temperature domain which are different from the main dosimetric TL peak which occurs at ~185°C (Fig. 6a, 6b). The linearity of the integrated TA-OSL signal has been measured as a function of absorbed dose and found to be linear in the

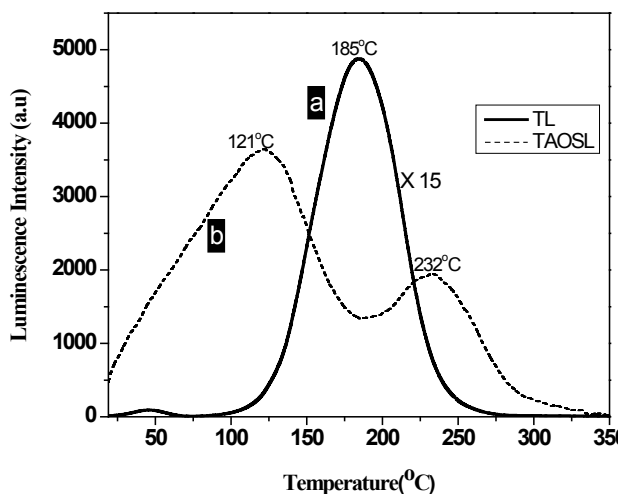


Fig. 6. a) TL glow curve recorded just after irradiation 500 mGy of β dose; b) TA-OSL curve taken after TL readout recorded at 48 mW/cm² stimulation light along with TL heating at 4 k/s.

dose range of 0.1 to 10 kGy as shown in Fig. 7. Hence the dose linearity of Al₂O₃:C has been extended up to 10 kGy which earlier was up to 1 Gy only. The MDD was found to be 10 mGy using the in-house developed TL/OSL reader (Kulkarni et al., 2007). However, it can be further improved on improving the sensitivity of the reader system by using quartz window PMT. It was found that to erase the OSL signal from these defects one must apply thermal treatment at temperature of ~ 400°C along with high intensity of light stimulation power or otherwise the sample has to be annealed at 900°C, however, the former is preferred from the practical considerations. Therefore, even in extreme environment of temperature of about 400°C, these deep traps were found to hold the stored information, if not exposed to intense light. Hence, handling of these samples in room light does not affect appreciably the signal from deeper traps. Due to these properties of deep traps, the TA-OSL technique can be used to assess the dose from previously irradiated dosimeter even if the main OSL traps have been inadvertently bleached due to heat or light, thus proving its capability for accidental and retrospective dosimetry. Further, using TA-OSL method these deep traps are accessible at 121 and 232°C, which otherwise could be detected by Photo-transferred TL (PTTL) (Akesrold et al., 1993), or direct TL measurement up to 600-650°C for the first deep trap and up to 900°C for second deep trap. However, it is very difficult to record these high temperatures TL peaks by direct TL measurement due to the very high thermal quenching in α -Al₂O₃:C and high infrared background at such higher temperatures. However, the TA-OSL measurements require normal TL-OSL reader, having simultaneous TL and OSL readout facility which is also available in commercial Risø reader (Bøtter-Jensen et al., 2000).

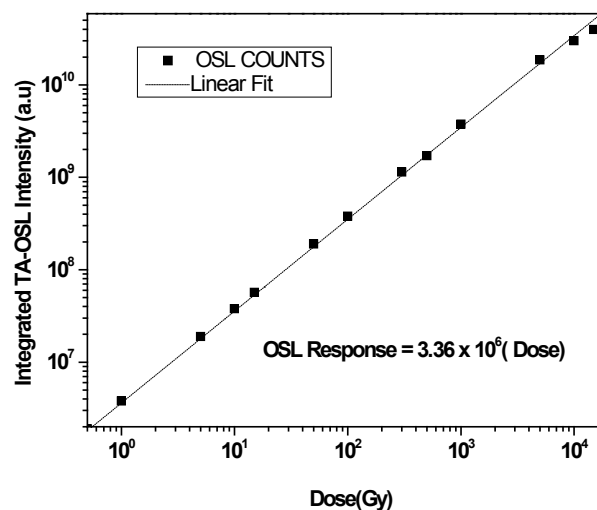


Fig. 7. Integrated TA-OSL dose response from deep traps of α -Al₂O₃:C.

6. CONCLUSIONS

Electron-phonon interactions have been shown to be a possible reason for the dependence of the OSL decay on temperature. The MDD was found to improve by a factor of 1.8 by taking advantage of such interaction. The dose vs. TA-OSL response from deep traps of α -Al₂O₃:C was found to be linear up to 10 kGy, thus extending its application for high dose dosimetry. Hence the dose linearity α -Al₂O₃:C has been stretched in both directions using the TA-OSL method. By using this method, further study on material such as quartz and feldspar will help in extending the dose range of these materials for archaeological and geological dating applications.

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