

## POSL studies on indigenously developed $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C

M S Kulkarni<sup>a\*</sup>, D R Mishra<sup>a</sup>, K P Muthe<sup>b</sup>, S K Gupta<sup>b</sup> & D N Sharma<sup>b</sup>

<sup>a</sup>Radiation Safety Systems Division, <sup>b</sup>Technical Physics & Prototype Engineering Division  
Bhabha Atomic Research Center, Mumbai 400 085, India

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The pulsed optically stimulated luminescence (POSL) technique is known for its good signal to noise ratio, fast, and multiple readout features in radiation dosimetry in general and personnel monitoring in particular. Apart from this the POSL method also provides the estimation of the luminescence lifetime  $\tau$  which cannot be measured in CW-, LM OSL techniques. The POSL signal is recorded on the indigenously developed  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C using 532 nm diode pumped solid state laser and high intensity blue (470 nm) light emitting diode cluster for different pulse widths (5–20  $\mu$ s) and different repetition rates. The results are also compared with commercially available single crystal  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C. The luminescence life time is estimated to be  $\approx$  35 ms is observed in both the samples. The POSL studies show the developed sample do not have long decay tail in time profile of POSL curve indicating suitability of the developed material for POSL routine dosimetry and qualitative difference of defect formation in developed sample as compared to those formed in the commercially available sample.

**Keywords:** Optically stimulated luminescence, POSL,  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C

The technique of POSL scores advantages for its more conventional contra parts CW and LM OSL in terms of faster (<1 s), multiple OSL readout and highest signal to noise ratios<sup>1,2</sup>. The fast readout is achieved using successive narrow stimulation light pulses (<1  $\mu$ s) having pulse separation < luminescence life time of recombination centers. Thus, only for very short time duration stimulation is incident on the sample (<1% as compared to the total time) for which OSL is to be recorded. This leads to minimization of scattering of high intensity stimulation light reaching to the photomultiplier tube (PMT) and excessive optical filtering as seen in case of CW and LM-OSL techniques. The total POSL signal is recorded in < 1 s; hence the dark count contribution due to PMT is further reduced. All these factors results in very high signal-to-noise ratio in case of POSL measurement. Also, the fact that only a small fraction of the trapped charges are depleted in the POSL readout, it provides an option for acquiring remaining information at a later time. Therefore, for routine personnel monitoring application using OSL dosimeter, POSL technique is more appropriate.

The recent advances made at BARC in field of OSL dosimetry with integrated TL/OSL reader system<sup>3</sup> and development of indigenous OSL sensitive

phosphors<sup>4-5</sup> has made it possible to explore some of the high end application aspects of OSL dosimetry. Considering this in mind indigenously developed dosimetry grade  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C OSL phosphor was investigated for its POSL applications. The 532 nm second harmonic of YAG:Nd laser and LED with 470 nm peak wavelength is used for pulse optical stimulation of phosphor material.

The present paper discusses the POSL characteristics of developed sample under laser and LED stimulations and analysis of fast and slow POSL components. The results are compared with commercially available dosimetry grade  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C single crystal phosphor.

### Experimental Procedure

The commercially available  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C samples (supplied by Landauer Inc. USA) and indigenously developed  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>:C samples using PGTI technique<sup>4</sup> were used for the POSL studies. The samples are irradiated to <sup>90</sup>Sr/<sup>90</sup>Y 2.2 MeV,  $\beta$ -source for different absorbed doses. The POSL set-up consist of two type of stimulation light sources a 532 nm CW laser (Nd:YAG) and high power LEDs ( $\lambda_p \approx$  470 nm). The CW laser light beam (3 mm dia) is pulsed by chopping it using an audio speaker coil (removing the diaphragm of the speaker) to improve high frequency performance as shown in Fig. 1. A high peak pulse

\*For correspondence (E-mail: ksmkund@yahoo.com)

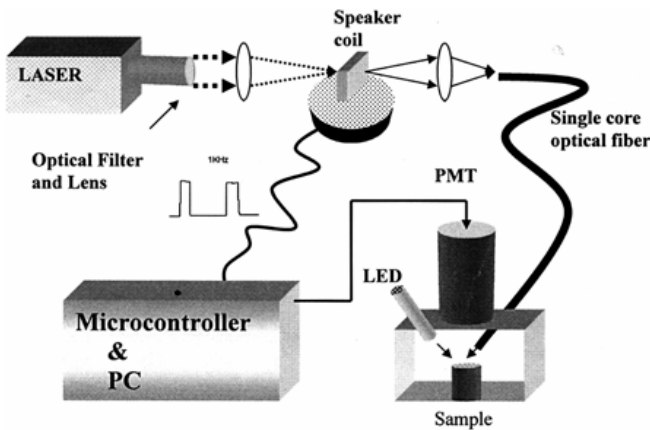


Fig. 1—Laser and LED based POSL Reader set up

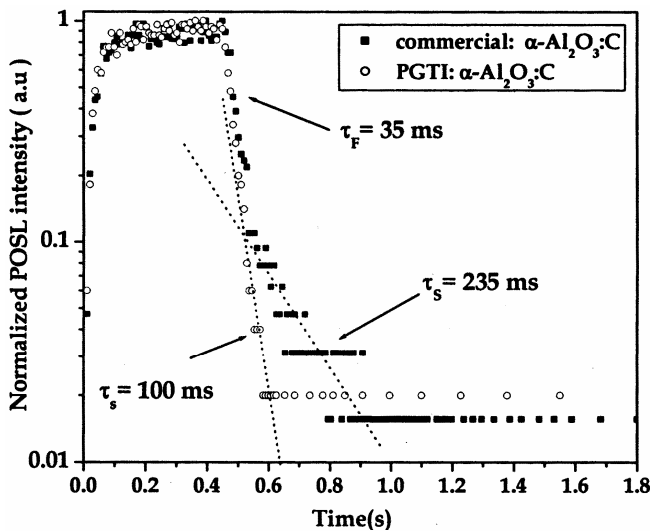


Fig. 2—Typical POSL response recorded on developed and commercially available  $\alpha\text{-Al}_2\text{O}_3\text{:C}$  samples, for 20 mGy absorbed dose from  $^{90}\text{Sr}/^{90}\text{Y}$  beta source. Pulse width 20  $\mu\text{s}$ , pulse separation 220  $\mu\text{s}$  at 532 nm stimulation

current (~5A) to speaker coil produces 5 mm peak-to-peak vertical displacement which is sufficient to chop the laser beam. In case of LED light source, a GG-435 optical colour glass filter is placed on the blue LED cluster inside the channel to cut off the stimulating wavelength below 435 nm. An UG-1 optical color glass filter is placed across the PMT to prevent the stimulating light from reaching the PMT.

**Results and Discussion**

Figure 2 shows the typical POSL recorded on both indigenously developed and commercial dosimetric grade  $\alpha\text{-Al}_2\text{O}_3\text{:C}$  samples. The POSL curve of both the samples show a fast luminescence lifetime ( $\tau$ )  $\approx$  35 ms corresponding to the excited state of F-center recombination. However, the basic difference in both

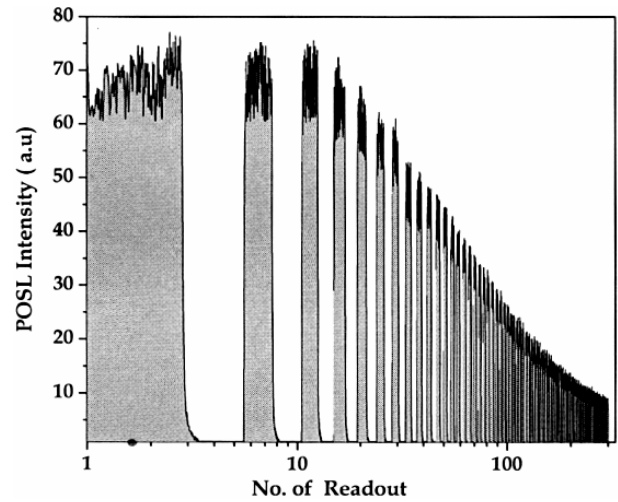


Fig. 3—POSL readout of developed  $\alpha\text{-Al}_2\text{O}_3\text{:C}$  with 532 nm stimulation of Laser at 1ms pulse width and 400 Hz for 20 mGy dose of 2.2 Mev  $\beta$ - irradiation

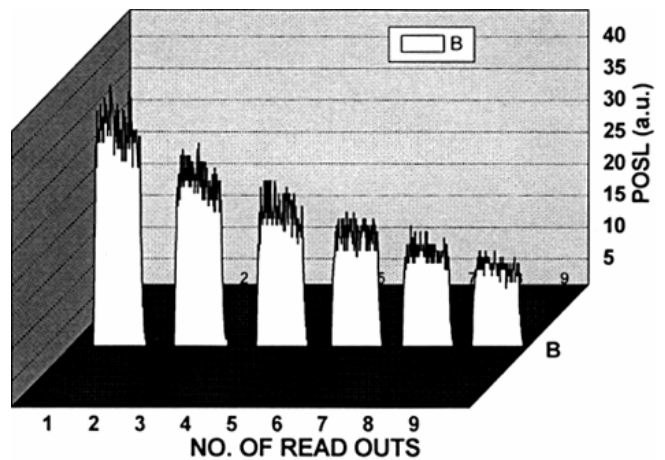


Fig. 4—POSL readout of developed  $\alpha\text{-Al}_2\text{O}_3\text{:C}$  with 532 nm green stimulation of Nd: YAG laser 500mW for 1ms pulse width @400 Hz for 20 mGy 2.2 Mev  $\beta$ - irradiation

these sample is in their slow decay components. In the developed  $\alpha\text{-Al}_2\text{O}_3\text{:C}$  samples, the observed life time of slow components is 100 ms as compared to 235 ms in the commercial sample. If one assumes the origin of these slow decay component from shallow traps, then the  $\alpha\text{-Al}_2\text{O}_3\text{:C}$  developed using PGTI technique must have shallower defects and spreading in the energy levels of shallow traps is narrow as compared to commercial sample. Figure 2 also show spread in lifetime of slow decay component in the commercial samples. The repeated POSL readout on the developed sample exposed to 20 mGy dose of 2.2 Mev  $\beta$  are shown in Figs 3 and 4. The integrated area under each POSL curve is found to decrease exponentially with each POSL readout (more clearly seen in signal height of POSL in Fig. 4).

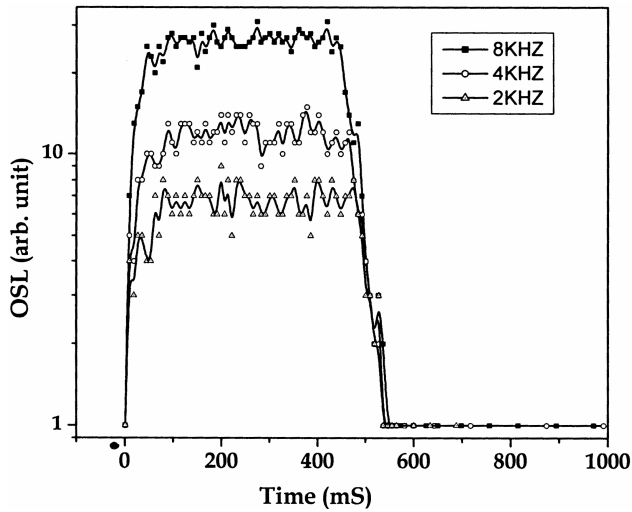


Fig. 5—Recorded POSL on the developed  $\text{Al}_2\text{O}_3:\text{C}$  samples for 40 mGy 2.2MeV beta dose. The stimulation light source is 470 nm LED, 20  $\mu\text{S}$  pulse width for various frequencies and fixed time of 1

The effects of pulse frequency of stimulation light on POSL intensity is tested on the developed  $\text{Al}_2\text{O}_3:\text{C}$  samples using 470 nm LED light stimulation. Figure 5 shows that the height as well as the area under POSL curve increases for a fixed stimulation pulsed width (20  $\mu\text{S}$ ) with increase in stimulation frequency. On the other hand if one takes the POSL readout for fixed number of pulses at different stimulation frequency (Fig. 6), it results in the variation in POSL height. However, the area under POSL curve is conserved in both the cases. Therefore, under low frequency, POSL signal decrease in height but gets expanded in time scale.

### Conclusions

The POSL results indicate that the PGTI method of synthesis of  $\alpha\text{-Al}_2\text{O}_3:\text{C}$  phosphor is capable of

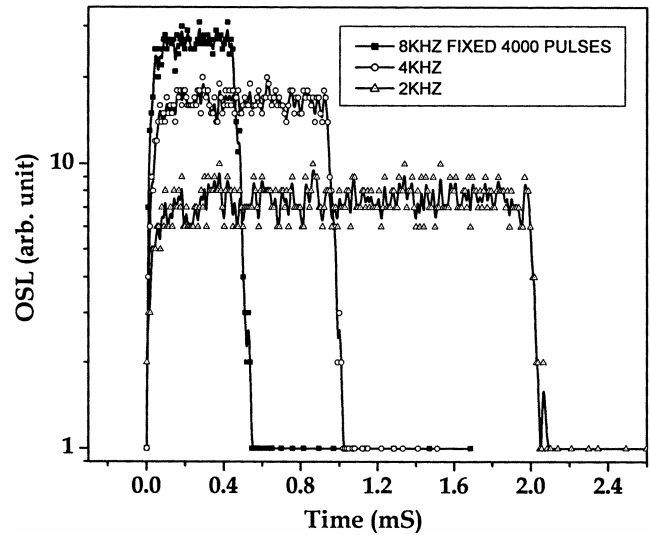


Fig. 6—POSL for 470 nm LED stimulation, 20  $\mu\text{S}$  pulse width for different frequencies at 40 mGy beta dose for fixed 4000 pulses.

providing OSL grade material and is suitable for readout using POSL technique. The absence of slow decay life time in the developed samples has an added advantage for its dosimetric response.

### References

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