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PC Controlled TL / OSL Research Reader

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Abstract— *Need for single sample, low cost PC CONTROLLED TL/OSL RESEARCH READER was greatly felt, by the luminescence research community in India, who have been quite active in this field. Nucleonix systems, decided to develop such a system and make it available to TL/OSL researchers and also across the globe.*

TL/OSL Research reader is a compact integral unit, designed primarily to meet the requirements of TL / OSL research community in R&D labs & universities who are engaged in luminescence studies of TL /OSL materials. The drawer & sample holder of this system facilitates, single TL/OSLsample acquisition & analysis, at a time.

System has, precisely designed/machined, stimulation & detection chamber, opto- electronics & photon counting module with appropriate filters, focusing lenses & sample drawer assembly with heating arrangement, all enclosed in a single mechanical chamber. System facilitates loading of the TL/OSL samples on to kanthal strip.For OSL samples separate cups/ planchets can be provided.

TL/OSL data acquisition & analysis is controlled by PC software. In case of OSL, optical stimulation by BLUE & GREEN LEDs provided, is also, controlled by, PC software and electronic circuits &embedded code in the microcontroller. System can be operated in TL or OSL or TL-OSL modes as required by the user. Photon counting module acquires, luminous intensity data for both TL & OSL samples. Two modes of OSL stimulation have been provided in this system namely.

CW - OSL (Continuous wave OSL) and LM - OSL (Linearly modulated OSL).

Keywords— *TL/OSL Research Reader, TL emission, CW-Mode, LM-Mode, Photon Counting Module, Thermocouple, HV Module, GUI, Stimulation-Detection Chamber, Green & Blue LEDs, Detection Filter Basket.*

1. INTRODUCTION

Luminescence arises upon stimulation either thermally (TL) or optically (OSL) of minerals and other phosphors that have been previously exposed to ionizing radiation. During exposure, radiation energy accumulated and stored in the crystal lattice and metastable states are created. During the stimulation trapped charges recombine with opposite charges as a result luminescence (TL/OSL) occurs.

A versatile PC CONTROLLED TL/OSL RESEARCH READER, has been developed to meet the requirement of researchers to study both TL& OSL of samples, in a single system and also to meet the following objectives.

- To facilitate study of both TL/OSL materials by researcher, using single equipment.
- Choice of stimulation by multiple LED sources (GREEN, BLUE and optionally IR LED sources)
- To facilitate study of TL materials in different forms such as pellets, powders, discs, micro-rods, chips etc.
- System to facilitate programmable levels of stimulation intensities, to shine on to the sample in OSL mode.
- Single board electronics PCB with microcontroller and embedded code makes it more compact & reliable.
- User friendly software and GUI to facilitate the researchers to be more comfortable in using the system.
- Minimal controls on front & rear panels for user convenience.
- Ease of temperature calibration through software, in TL mode.
- User configurablefeatures, facilitate one, to programme for desired heating profile in TL mode & select requiredacquisition parameters in OSL mode.

2. SYSTEM DESCRIPTION

2.1 Block Diagram Description of Tl/OSL Reader Unit

Entire system electronics in the form of functional block diagram is shown fig (1). This inconjunction with PC

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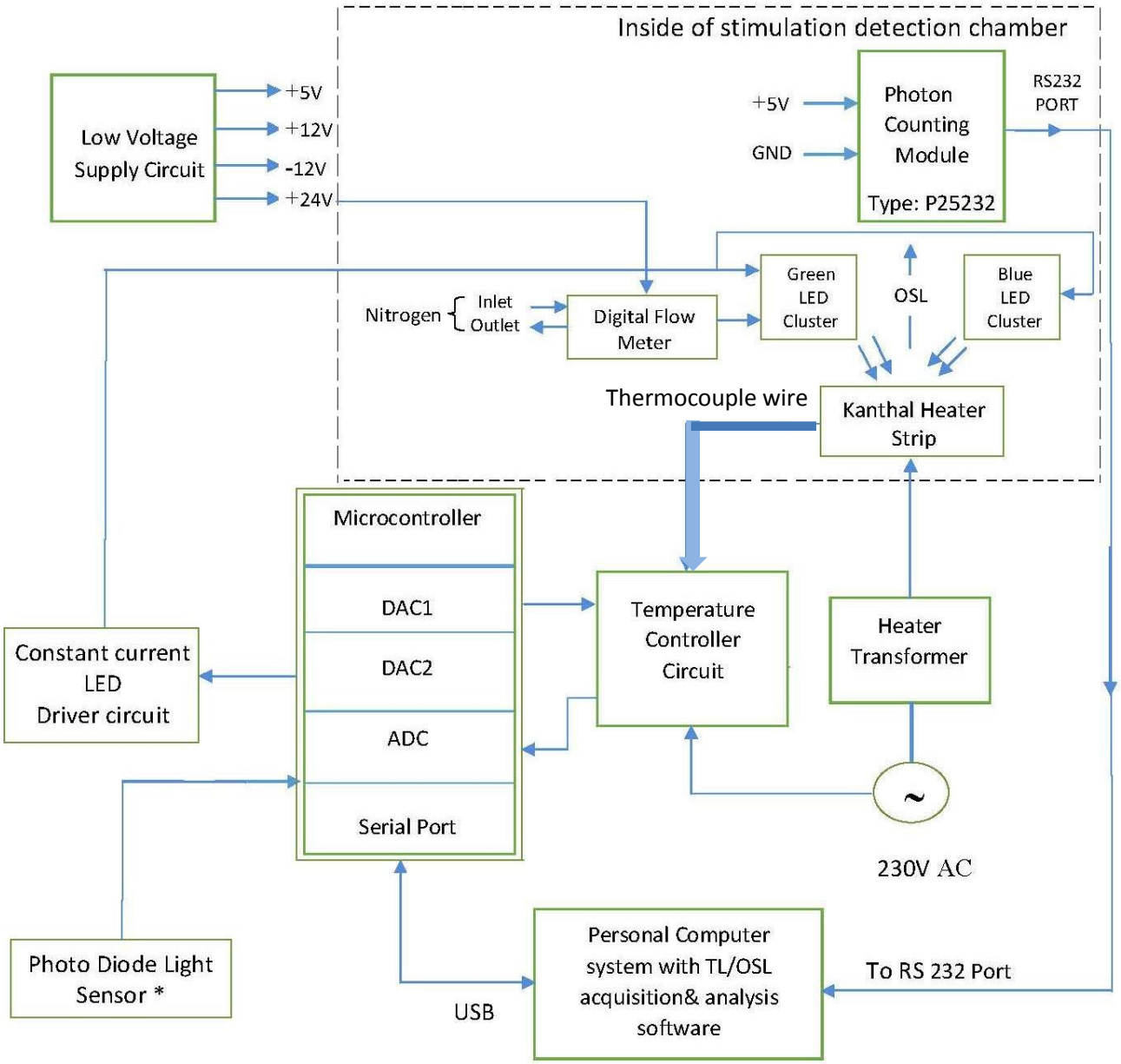

Fig. 1: Block diagram of TL/OSL Research Reader. Blocks enclosed inside dotted lines, are housed in stimulation-detection chamber as shown in fig: (2)

*Photo diode light sensor is mounted in proximity to Kanthal sample holder to sense part of stimulation light from the LED cluster

system and software, works, as the PC CONTROLLED TL/OSL RESEARCH READER.

Figure1consists ofthe following blocks,namely:

- Low Voltage Supply Circuits (to generate +5V, +/-12V,+24V)
- Stimulation-detection chamber with Green & Blue LEDs, photo counting module
- Stimulation-detection chamber with green & blue LED's and photon counting module
- Electronics PCB consisting of Microcontroller with embedded code, peripheral devices such ADC, DAC 1&2, Temperature controller, constant current LED driver, serialport, etc
- Photo diode sensor
- Digital flow meter
- Personal computer systemand
- Data acquisition and analysis software

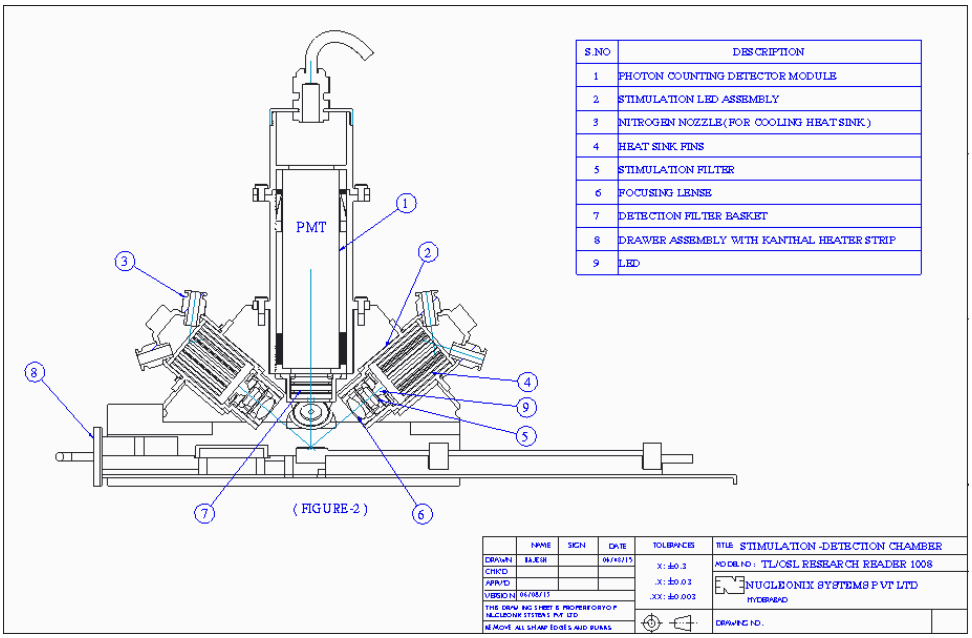

Fig. 2: Outline drawing of stimulation detection chamber-TL/OSL Research Reader

i) Low Voltage Supplies— LV supplies namely +5V, +/-12V and +24Vrequired by the system are generated using conventional power supply circuits and DC to DC converter.

ii) Optical Stimulation & Detection chamber

Optical Stimulation Assembly (Refer to Fig-2)

It is a light leakage free, precisely machined fabricated mechanical assembly, houses photon counting module with detection filter basket, LED stimulation assemblies (four) diagonally placed around photon counting module cylindrical enclosure. TL / OSL sample holderwith (kanthal heater strip)& drawer arrangement are also built-into this chamber.Optical Stimulation System consists of BLUE & GREEN LED cluster(s) with, each LED of 3 watt power. Either BLUE or GREEN LED cluster(s) each cluster containing two LEDs can be stimulated. These LEDs are placed diagonally 180^0 opposite, with suitable lens arrangement, provide uniform luminous intensity onto the sample area.

iii) Light Source (s)

i) Two Blue LEDs cluster, each of 3 watt output gives stimulation output with peak wavelength emission of 465nm, having Luminous flux radiometric power of 30mW @ 700ma & emission wave length band is (460-470)nm.

ii) Two Green LEDs cluster,each of 3 watt has peak wavelength emission of 525nm,and gives 99mW radiometric power @ 700mA. Emission wavelength band is (520 -535)nm.

iv) Constant Current Driver

Electronic circuits built-in provide Constant current drive to each of the LED clusters with dimming control, to vary the luminous intensity. Stimulation intensity control is achieved through DAC2 which provides analog voltage proportional to the intensity level, which intern drives the current, both in LM&CW-OSL modes.

Each of the LEDs assembly is provided with a long pass, stimulation filter of 420nm of 12.5nm dia. This prevents the scattering light below 420nm, entering the PMT directly.

A suitable focusing Plano-concave lens is provided in front of the LEDs to focus the light on to the OSL samples placed in the planchet / kanthal heater strip.

Each of the LED assembly has been mounted on a specially designed Heat sink cylindrical with cooling fins to keep the LED function at lower temperature so as to obtain uniform stimulation, onto the sample holder.

Additionally Nitrogen gas flushing arrangement through a digital rotometer with flow rate control has been provided for cooling the fins of the LED heatsinks. Flow/Rate of 1 lpm to 2 lpm or as desired can be set for cooling the heat sink fins. A circular tubular path from gas inlet connects sequentially to all the four LEDs (two pairs of Green & Blue LEDs) & the gas is sent to outlet on the rear panel of the system.

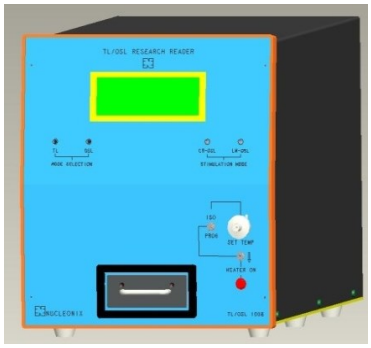

Fig. 3: TL/OSL Reader Isometric View

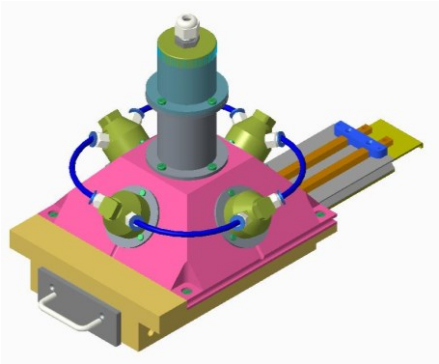

Fig. 4: TL/OSL Stimulation & Detection Chamber

v) Photo Diode / Photo sensor

A suitable photo diode, with built in amplifier placed close to the kanthal sample heater strip, senses the part of the stimulation intensity, (proportional to that falling on to the sample) and is read by ADC of the microcontroller board, which in turn, plots 'stimulation intensity signal' on Y2 axis, in both LM and CW modes of OSL acquisition.

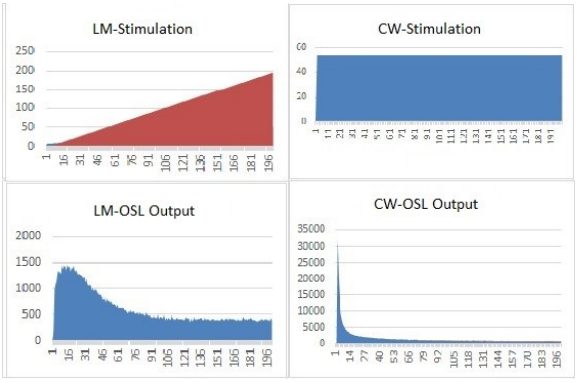

Fig.

Stimulation modes provided are (i). CW-OSL-continuous wave OSL(ii). LM-OSL Linearly modulated OSL. In CW-OSL mode stimulation intensity is kept constant throughout the acquisition. Of course the level of stimulation intensity is programmable and can be set to desired level through config menu initially. On the other hand in LM-OSL mode, one can choose initial intensity, final intensity and the acquisition time through config menu. Accordingly, linearly, stimulation intensity raises gradually to reach its final value at the end of acquisition time.

vi) TL-OSL READER-Light Detection System / Photon Counting Module

The light detection system consists of a plug-and-play photo detector packages configured for photon counting. It comprises of a selected 25mm diameter end window photomultiplier tube. Positive high voltage power supply, high speed amplifier-discriminator, counter and micro-controller. All are encapsulated within a cylindrical mu-metal case, providing a high level of immunity from the effects of external magnetic fields. Low voltage and signal output connections to these packages are by flying leads.

Three options from Electron Tubes range of 25mm end window photomultipliers are offered to cover the spectral range from UV to IR spectral response curves.

P25232: Selected bialkali photomultiplier with high blue sensitivity and ultra-low dark counts.

Photon counting module— Provides a fast, accurate light measurement via an RS232 interface to a host PC. Some of the important features are-

Simplicity of operation, Minimal set up time, Compact cylindrical assembly, Electrostatic and magnetic shielding,RS 232 interface, UV window option, 100 MHz count rate capability, Automatic dead time correction, Operates from +5V supply,Pre-set discriminator level and HV are factory set for optional performance.

vii) TL Acquisition Mode

In this mode of operation user has to set the following conditions for TL acquisition. The filter basket has to have heat absorbing glass/ IR filter combination. In the software menu select the TL mode. Followed by this,three point temperature calibration is to be carried out. Set ISO/PROG switch to PROG mode place the heater ON/OFF switch to ON position. Now user can load the TL sample on to the kanthal hater strip. One can configure for the required heating profile and carry out the TL acquisition. TL intensity is acquired and plotted on the y1 axis by the photon counting module. On y2 axis temperature is plotted.

viii) TL Heating System

Heating Element: (Heater Strip)

Kanthal strip (72% Fe, 23% Al and 2% Cr or Nichrome) is used as a heating element.

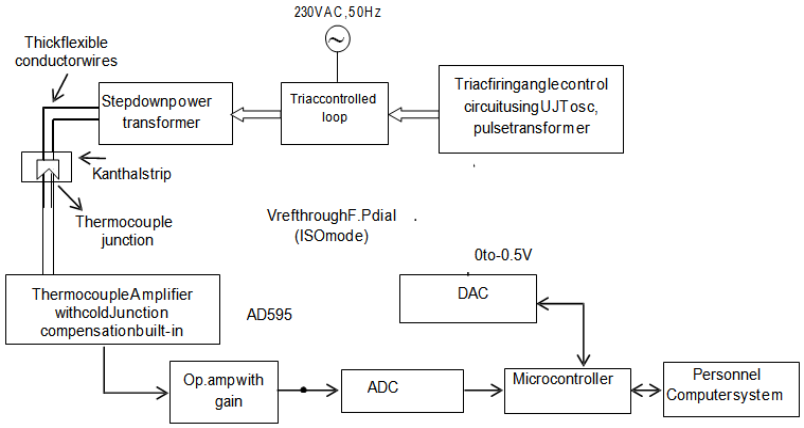

Fig. 5: Temperature controller part of the circuit, for sample heating on kanthal strip

Kanthal Strip has a circular depression of 14mm to hold discs and powder samples. Additionally flat heater strips also can be provided on request.

Sample Heating Process

Sample heating can be done in two modes:

"PROG MODE" of Temp. Control through personal computer program.

"ISO MODE" (Internal mode) of Temperature Control, by varying the ten turn dial.

From room temperature up to 500^0 C linear & plateau heating (Single / Two / Three plateau heating are possible).

ix) Temperature controller circuit

Figure5isthetemperaturecontroller&sampleheatingsystem**.** Thermocouple'mv'outputreceived from the Kanthal heater strip is, fed to a monolithic thermocouple amplifier with cold junction compensation. Output from this is fed to an op.amp amplifier. And it goes to ADC chip whose value is read by microcontroller& interpreted in terms of temperature through PC program,subsequently.

Programmable heating of Kanthal heater strip is achieved, by firing a triac& controlling theconduction angle of 230V, A. C power. Conduction angle controll oop circuite ssentially hasaUJT oscillator synchronized with 50Hz A.C. power. UJT oscillator generates a trigger pulse through pulsetransformer which controls the conduction angle of triac. This enables 230V AC primary loop of apower transformer which is stepped down to 2.5V@40 ampere.Secondary of this transformer heats up Kanthal strip. The control of conduction angle is by a D.C control voltage 0 to -500mV which heats from room temperature up to 500°C. This control voltage is fed from at enturndialin ISO mode & from DAC1 which is programmed through microcontroller to generate various heating rates from 2°C/ sec to 40° C / sec & also various heating profile(s) such as single / multipleplateaus.

V. RECOMMENDED PC CONFIGURATION

Computer system with Intel Core i3 @ 3.06Ghz, 2GB DDR2 RAM, 500GB SATA, DVD R/W, Keyboard and Internal ready Optical scroll, 19" TFT Monitor, Laser jet printer, Windows licensed OS-Windows 7.0.

VI. SOFTWARE FEATURES

TL / OSL reader system operates thru PC controlled user friendly software. Software performs Self diagnostics of the system & reports faults. Software facilitates one to choose TL or OSL mode for sample data acquisition, allows the user to configure for the required heating profile in TL mode & other parameters as required in OSL mode. Once data is acquired, acquired data can be saved or further processed depending upon the requirement.

Software Key features:

- *Mode Selection*— TL / OSL Green / OSL Blue. In OSL, Continuous Wave (CW) & Linear Modulated (LM) modes are available.
- *Heating profiles in TL mode*— Various Heating profiles can be configured – Linear, Single & Multi-plateau.
- *Temperature Calibration*— The software provides an easy & user friendly method for Temperature calibration.
- *Light Stimulation Profile*— Light stimulation profile can be configured for CW or LM modes.
- *Acquisition*— Data is acquired based on the selected Mode & Profile. Background spectrum / Sample data can be acquired.
- *Background Subtraction*— There is a provision to do background subtraction automatically during acquisition.

Table 1

ConfigureMenu	*Data Acquisition Menu*	*FileMenu*	*Report Menu*
▪ Set COM Port ▪ Temp.Calibration(Three point) ▪ Temp.Profile ▪ Light Stimulation Profile ▪ Change Rader ▪ Mode.	▪ Acquire ▪ Select BG File	▪ Open Glow Curve File ▪ SaveAs	▪ View in Excel ▪ Overlap ▪ Subtract ▪ Add ▪ Plot

- *Export Spectrum data to Excel*— Software allows the spectrum data to be exported to Excel, which gives the convenience to the user for further processing.
- *Spectrum overlap*— Multiple spectra can be overlapped (up to 10) for comparative studies.
- *Spectrum subtraction*— 2 spectra can be mutually subtracted & resulting spectrum can be saved.
- *Help*— Software manual is provided which gives installation & usage instructions.

6.1 Menu options

Personal computer system with TL/OSL data acquisition & analysis software

Personal computer (PC) system with software provides required GUI (Graphic User Interface) & TL/OSL glow curve data acquisition and analysis software. Features provided include the followingoptions under differentmenus.

(i) *Configuration menu*— It facilitates the user to set the temperature profile or Light stimulation profile connected to the system through serial port of the computer.

Set COM Port— It allows the user to enter the correct com port number related to the TL/OSL research reader serial port to the software.

6.2 Temperature Calibration

If facilitates the user to carry out three point temperature calibration. By this, PC software will read & know the correlation between ADC value of amplified output of thermocouple output, DPM (Digital Panel Meter) indication. This facilitates the user to choose & program for required temperature profile. Of course communication between PC&TL research reader unit is through USB serial port.

6.3 Temperature Profile

It also allows the user to determine the heating rate to which the TL phosphor sample placed on the kanthalstripis subjected to acquire the required glow curve. Also this software has the option of configuring the heating profile for single, two or three plateau heating profiles, witha facility to clamp the temperature to any value for required time duration. Of course cooling ofthe sample / heater strip is by natural cooling method only by cutting off the heating systemthrough software which is shown in Fig.6.

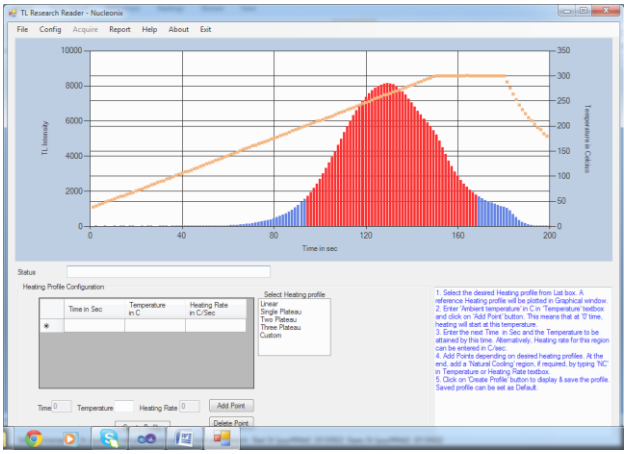

Fig. 6: Temperature profile configuration dialogbox

Figure above shows temperature profile configuration dialog box with at ypical temperature profile. On user's request to set the temperature profile the dialog box pops up with default profile loaded into it. If the user wishes to change the profile he can do it by just keying in the values, such as rise time, set temperature, clamping time and run timeetc.

Light Stimulation Profile— It allows the user to configure for required stimulation intensity and time of acquisition, in both CW and LM modes of OSL acquisition.

Change Reader Mode— It allows the user to select any one of modes of acquisition as follows.

TL, CW-OSL (Green), LM-OSL (Green), CW-OSL (Blue) and LM-OSL (Blue).

(ii) *Acquisition and processing of 200 channel TL data*— Once the required temperature profile isset the user can go directly for acquisition of 200 channels TL data for either fixed Wt. Samples orpowder samples. To change the sample type either fixed Wt. Samples or powder samples user has to justclick on the menu option sample type and select the required sample type. After acquisition is done, thedata from the system is automatically downloaded to the computer's memory and aglowcurve is plotted with the down loaded data with aline indicating the temperature profile and a curve

intensity *vs* time. For better understanding the CasO4 glow curve is shown in Fig.7. Once glow curve is acquired it facilitates one to select ROI under the peak. As shownbelow:

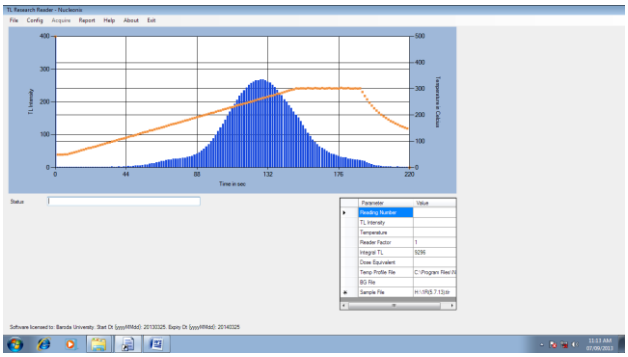

Fig. 7: CaSO4 glow curve, afteracquisition

Of course for calibration of the reader, initially one can acquire glow curve with a known exposeddose & obtain 'Reader Factor' (RF) for the instrument. Subsequently R.F. can be used to compute and evaluate doses by multiplying the R.F. with the integralarea.

6.4 Acquisition and Processing of 200 Channel OSL Data

Set the system for OSL acquisition in the required mode (LM/CW). Ensure to place appropriate filter combination in the filter basket for the selected stimulation source (Green/Blue). Place the OSL sample on the sample tray and acquire glow curve, having configured for the required acquisition parameters. Typical glow curve acquired in CW-OSL mode for LiMgPo4:T6,B is shown below.

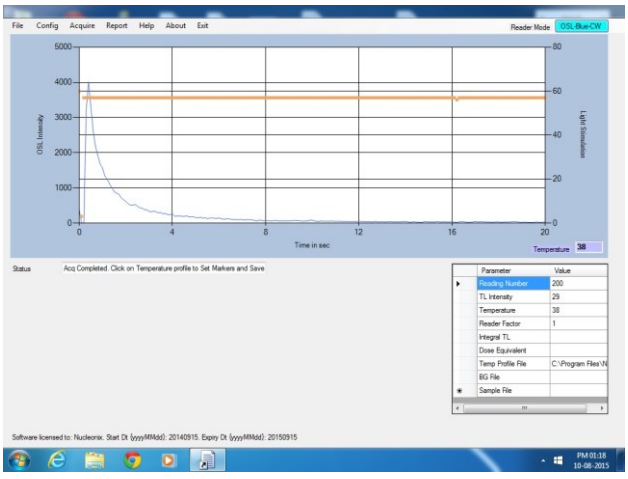

Fig. 8: LiMgPo4:T6, B Glow curve after acquisition

(iii) *Saving / opening the acquired data to a disk file for further access*— This command facilitates to save and load data file pertaining to TL/OSL mode.

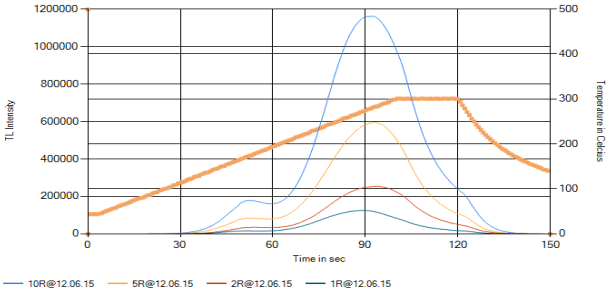

Fig. 9: TL-Glow curves shown in overlappedcondition

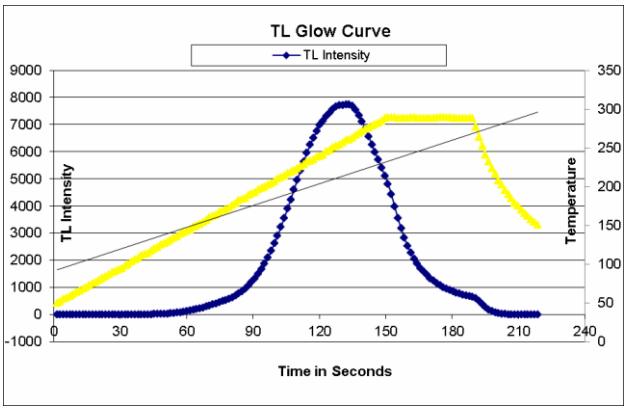

Fig. 10: Typical Glowcurve

The typical TL glow curve is shown in Fig.10, and the experimental data is tabulated in Table 1which contains three parameters: Time, TL intensity andTemperature.

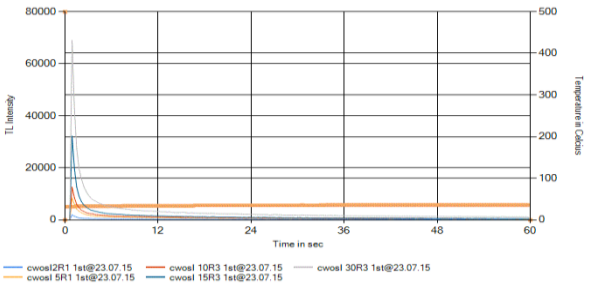

Fig. 11: CW-OSL Glow curves in overlapped condition.

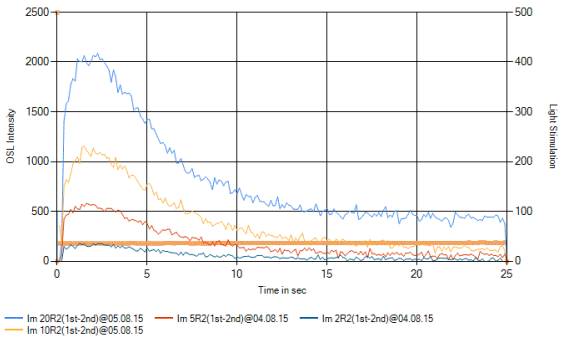

Fig. 12: LM-OSL Glow curves in overlapped condition.

PERFORMANCE EVALUATION AND RESULTS

System performance has been studied and the following are the results, reportedhere.

Temperature calibration accuracy test: Temperature calibration accuracy has been verified fordifferent profiles and is found to be within +/-2°C.

HV bias voltage stability, when tested over 8 hours, is within +/-1volt

Dosere producibility test is found to be with in arange of +/-5% when the discsare exposed and read for the samedose.

Dosimetry linearity test accuracy is within +/-2%.

System performance can be studied using dose rate in mR/hr vs. integral counts which is shownin Fig.13(a), 13(b) and 13(c).

Dose(R)	Int.OSL
0.5	31226
1	43242
2	63245
5	131760
10	201395
15	293539
30	630367

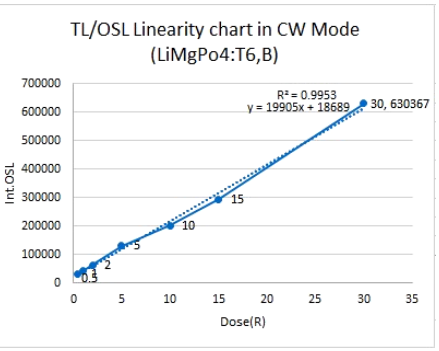

Fig. 13: (a) CW-OSL Performance study

Dose(R)	Int.OSL
2	15005
5	38007
10	78520
20	164613

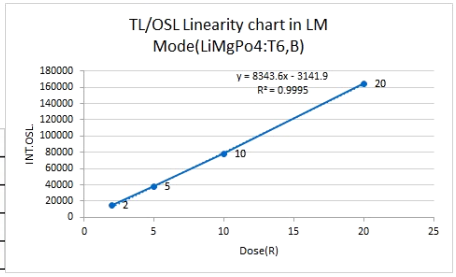

Fig. 13: (b) LM-OSL Performance study

DOSE(R)	INT.TL
0.01	60970
0.02	119987
0.05	345786
0.1	634125
0.5	2785841
1	5442997
2	11578465
5	26780704
10	53844901

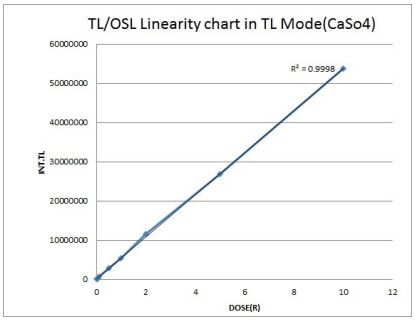

Fig. 13: (c) TL Performance study

The PC controlled TL/OSL instrument can be used to study the Thermoluminescence and Optically stimulated luminance of Phosphors, geological materials, minerals, pottery and for quality check of the instrument[7,8,9]. Personnel monitoring is based on the international recommendations of the ICRP [10]. The primary objective of individual monitoring for external radiation Is to assess, and thus limit, radiation doses to individual workers. Supplementary objectives are to provide information about the trends of these doses and about the conditions in places of work and to give information in the event of accidental exposureetc. as reported by Murthy et al. [11,12].

ACKNOWLEDGMENT

Authors convey acknowledgment to Mr. K. Purna Krishna, Testing Engineer who has been associated with this project in prototype testing and evaluation of the system by studying various TL/OSL samples.

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