AIM:

1. To study the characteristics of Optically stimulated luminescence material (Al_2O_3:C-Alumina)
    a. To Study the output OSL intensity with the stimulating input optical signal.
2. To calibrate the OSL research Reader in terms of absorbed dose and find out the unknown dose.

APPARATUS REQUIRED:

- Alumina discs
- OSL research reader
- Radiation generating equipment (LINAC)
- Blue light Bleaching machine

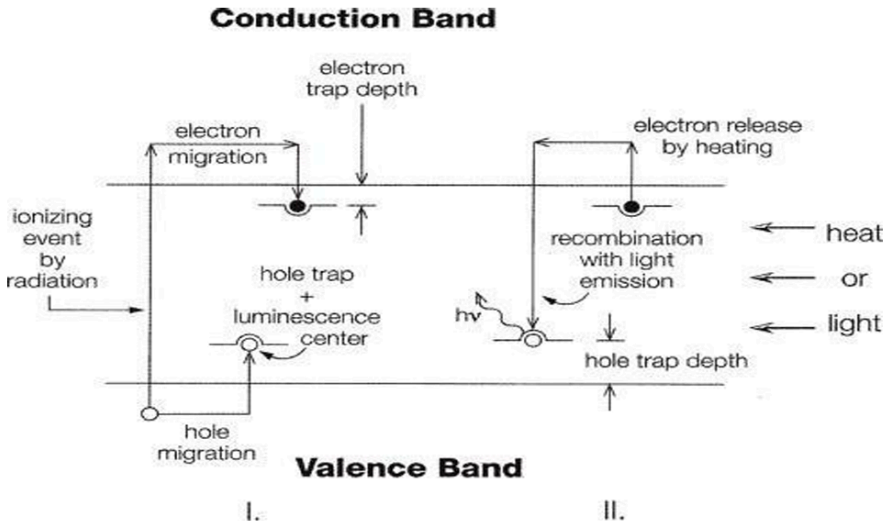
THEORY:

Optical luminescence is the property of certain materials which emit visible light upon being stimulated by light sources. This emission of light is due to the recombination of the trapped electrons in the defect or vacancies with holes in the material. These vacancies can be created by adding impurities to the material and are stable over time. This property of the material can be used for dosimetry of Ionizing Radiation. It measures Ionizing radiation exposure by measuring the intensity of visible light emitted from a crystal when the crystal is optically stimulated. OSL Dosimeters have profound applications in Radiation Dosimetry, where they are used to measure radiation doses accurately.

PROPERTIES OF OSLD

The term "OSLD" stands for Optically Stimulated Luminescence Dosimeter. These dosimeters work on the principle of optical luminescence. The phenomenon in which visible photons get released, from an exposed (by radiations like α, β, γ) crystalline material (insulator, semiconductor), when stimulated by light source (e.g LASER or LED lights) is known as optically stimulated luminescence.

The crystalline material has a valence band and conduction band within it. The band gap between the valence band and conduction band is normally high for these materials and hence it is not possible for an electron to escape from valence band to conduction band in normal temperature. When these materials are subjected to irradiation by Ionizing radiations, the electrons from the valence band absorb the radiation and move to the conduction band. The de-excitation process releases an energy which is normally difficult to observe. These transition energies can be visible by adding impurities to the material. These impurities create trapping centers (electron trap and hole trap) or metastable energy levels within the band gap.



(Fig-1:Diagram showing working Principle of OSL Phosphor)

Now when these crystals are irradiated by ionizing radiation, electron-hole pairs are created and they move randomly inside the crystal until they get trapped at these trapping sites. The number of traps in the crystal is directly related to the amount of radiation given to the material. At room temperature these electrons cannot escape from the traps. If sufficient energy is provided by any LASER light or LED source, the trapped electrons get ejected out from the electron traps and migrate towards the hole traps, where they recombine with the holes to produce light. The wavelength of light emitted lies in the visible region which is then collected by a PMT that converts the luminescence into "counts".

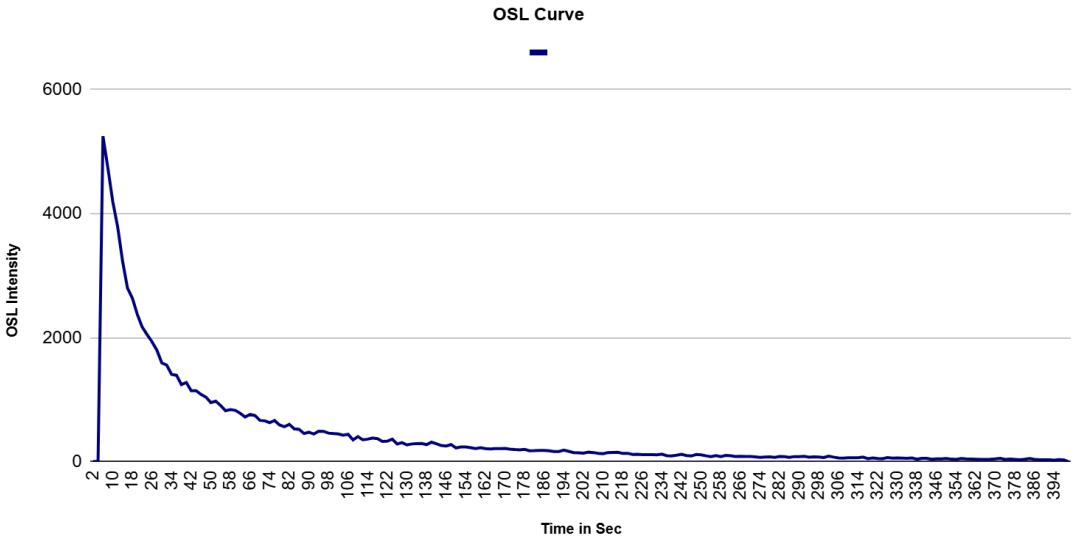
One such OSL material that has been extensively studied is Alumina doped with Carbon Al_2O_3:C. The Carbon is added as dopants to enhance the OSL sensitivity.

READOUT PROCEDURE

The readout procedure is performed in a dark chamber or with minimal light. For the establishment of the dosimetric characteristics, these optically stimulated luminescence dosimeters were exposed to X-ray Radiation of maximum energy 20MeV from a linear accelerator. OSL dosimeters were irradiated to various lower to higher doses. The Irradiated dosimeters were kept in OSL research readers and stimulated by Blue light (460-470 nm). Then the trapped electron will de-excite and emit visible photons. These emitted visible photons will be detected by the PMT connected to the Output Circuit. The plot of light output with time or temperature is called a Glow curve. From this glow curve the absorbed dose can be estimated by taking light output per area under the curve. In case of OSL phosphor the shape of the glow curve varies based on the nature and composition of the phosphor material, population of electrons and hole traps and mode of stimulation.There are three modes of stimulation available for OSLDs which are briefed below-

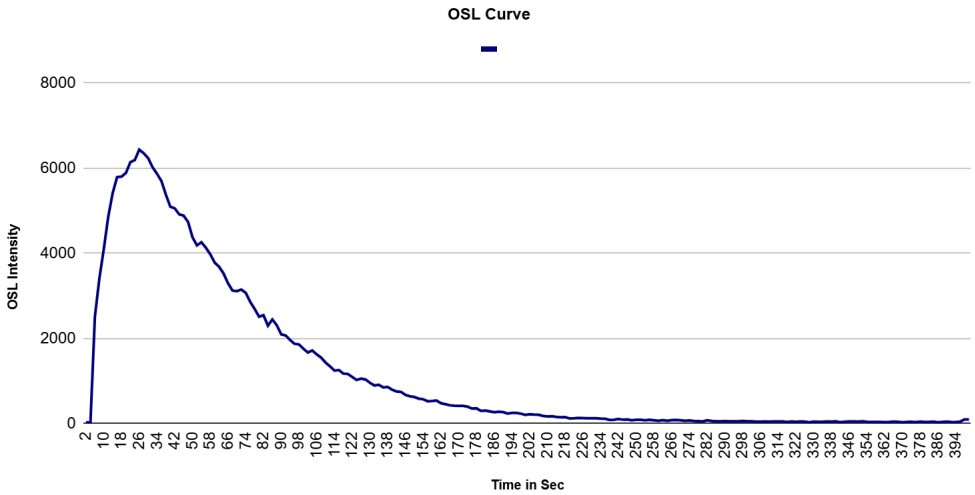
CONTINUOUS-WAVE TECHNIQUE

- Stimulation light has a constant intensity.
- The OSL signal will decrease exponentially as the trapping centers are emptied.



LINEARLY-MODULATED TECHNIQUE

- In this mode the stimulation power is increased linearly with time.
- The OSL signal first increases with the stimulation intensity approaches maximum then decreases .



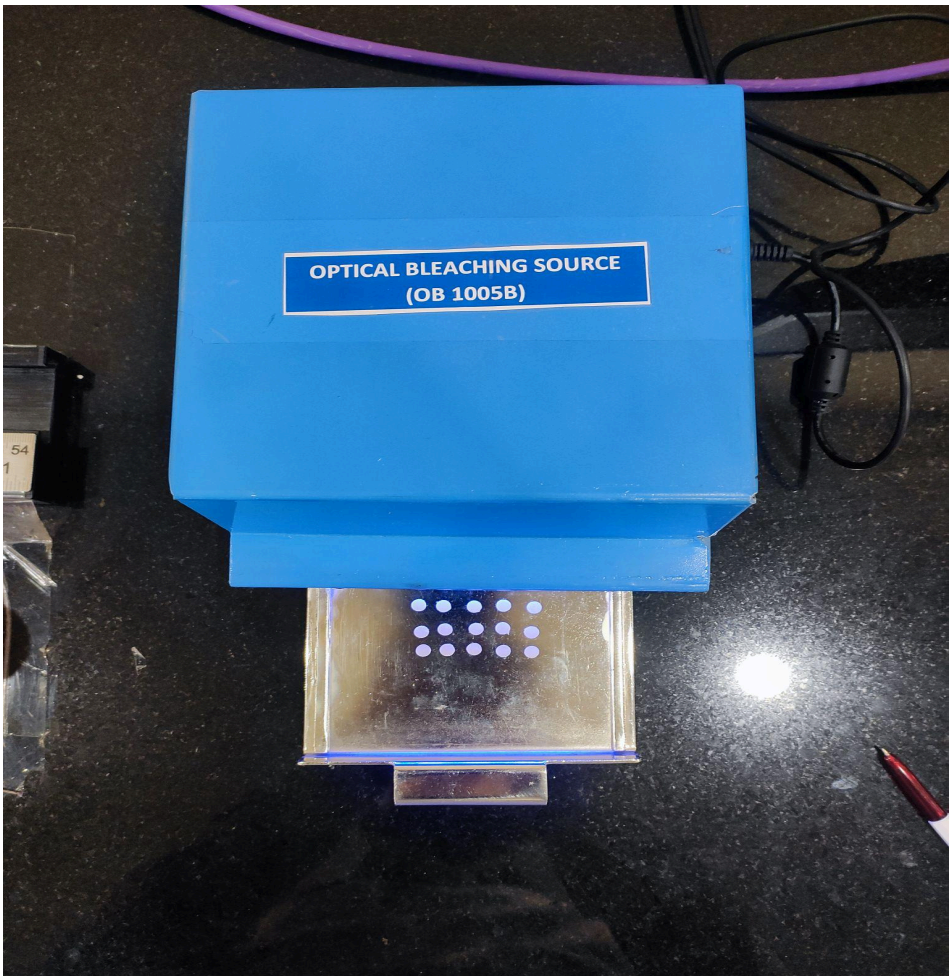
PULSED OSL TECHNIQUE

- The stimulation consists of a series of short pulses of light with readout done during the periods when the stimulation source is off.
- This approach provides a better signal-to-noise ratio, but does not substantially impact the practical use or precision of the system.

We don't have the facility of PULSED OSL technique.

BLEACHING PROCEDURE

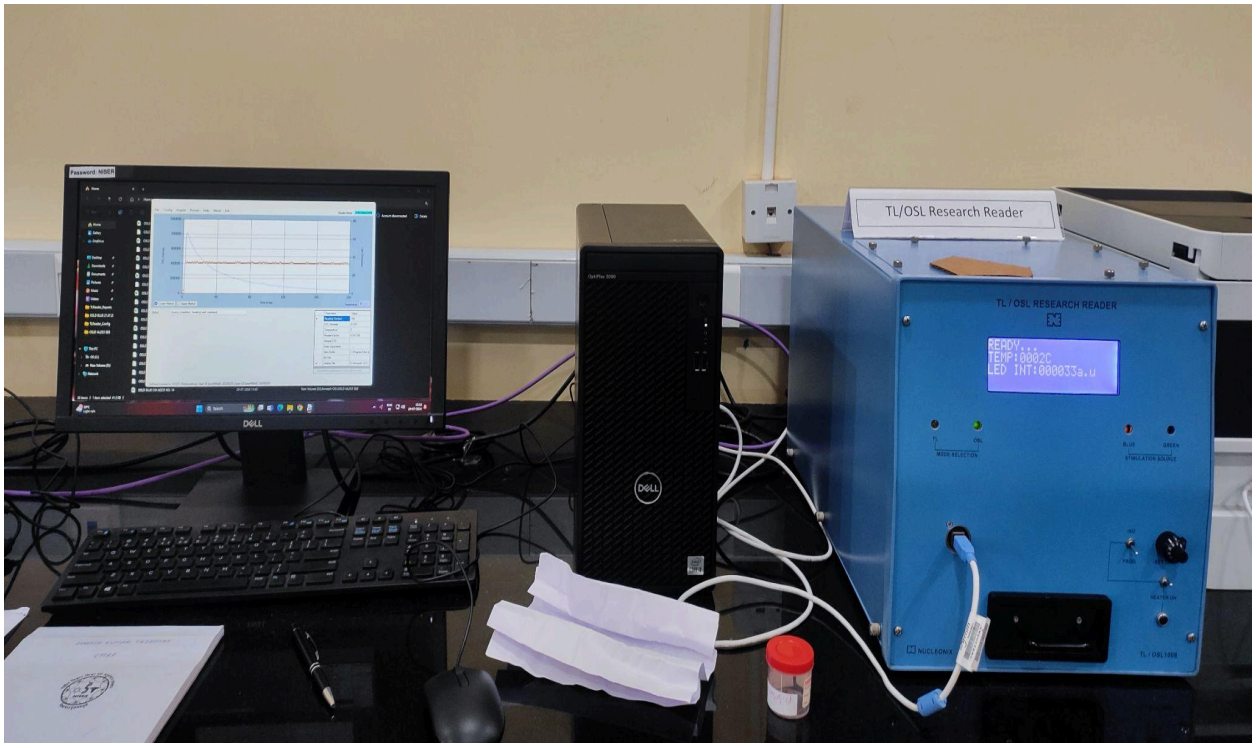
After the readout process, there is always a probability of presence of some residual traps inside the OSL phosphors. To eliminate the effects of previous exposure, bleaching of the OSL phosphor is done without causing any damage to the phosphor and to stabilize the electron traps in order to use it again. For this Blue Light is used. All the OSL phosphors are allowed to take a blue light shower for a period of at least 30 minutes (100mW/cm2 blue light for 10 mins). After bleaching OSL phosphor can be reused.



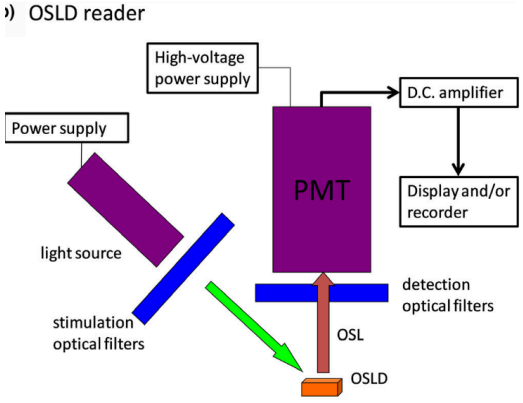
(Fig-2: Optical Bleaching setup)

OSL RESEARCH READER OSL-1008

Manufactured by Nucleonix systems, it is a compact integral unit operated by computer software. The drawer & sample holder of this system facilitates single sample OSL acquisition & analysis, at a time. Data acquisition & analysis is controlled by PC software. In case of OSL, optical stimulation by BLUE & GREEN LEDs is provided and is also controlled by PC software and electronic circuits & embedded code in the microcontroller. Two modes of OSL stimulation have been provided in this system namely. CW - OSL (Continuous Wave OSL) and LM – OSL (Linearly Modulated OSL). Below figure shows the circuit arrangement of a typical OSL reader.



(Fig-3: TL/OSL 1008) Reader



(Fig-3: Schematic diagram of OSLD Reader Components)

SPECIFICATION

1. OSL Stimulation & Detection chamber-

It is a light leakage free, precisely fabricated mechanical assembly, that houses a photon counting module (PMT) with detection filter basket and LED stimulation assemblies i.e (four) diagonally placed LEDs around the photon counting module cylindrical enclosure.

2. Optical Stimulation Assembly-

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 that can be used for stimulation. These LEDS are placed diagonally 180^0 opposite, with suitable lens arrangement, and provide uniform luminous intensity onto the sample area.

3. Light Source (s)-

- Blue LEDs cluster, each of 3 watt output placed 180^0 degrees opposite gives stimulation output with peak wavelength emission of 465 nm, having Luminous flux radiometric power of 30mW @ 700mA & emission wavelength band is (460‑ 470)nm.
- Two Green LEDs cluster has peak wavelength emission of 525 nm and gives 99mW radiometric power @ 700mA. Emission wavelength band is (520 ‑535)nm.
- 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 Filter-Each of the LEDs assembly is provided with a stimulation filter of 12.5mm dia. This prevents the scattering light below 420nm, entering the PMT directly.
- Focusing Lenses-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.
- Heat Sink-Each of the LED assembly has been provided with a specially designed Heat sink (cylindrical) to keep the LED at lower temperature to obtain uniform illumination, onto the sample holder.
- Photo Diode / Photo sensor- A suitable photodiode, with appropriate electronics reads stimulation intensity & proportionately plots on Y‑axis in the software through ADC.

4. OSL READER-Light Detection System/Photon CountingModule-

Photon counting module, is an integral part of the OSL Reader. Photon counts received from the luminescence emission from the OSL materials are counted in this module & the data counts are transferred to PC, through RS232 interface. This module consists of a selected 25mm diameter end window PMT, a positive high voltage power supply, high speed amplifier‑discriminator, counter & a microcontroller. All these are encapsulated within a cylindrical mumetal (Nickel-Iron soft magnetic alloy) case providing a high level of external magnetic shielding.

- PMT: 25 mm PMT with ultra‑low dark counts.
- Count rate capacity: 100 MHz
- High Voltage: Built in & set to optimum value.

- PC Interface: RS-232 serial port or serial USB port.

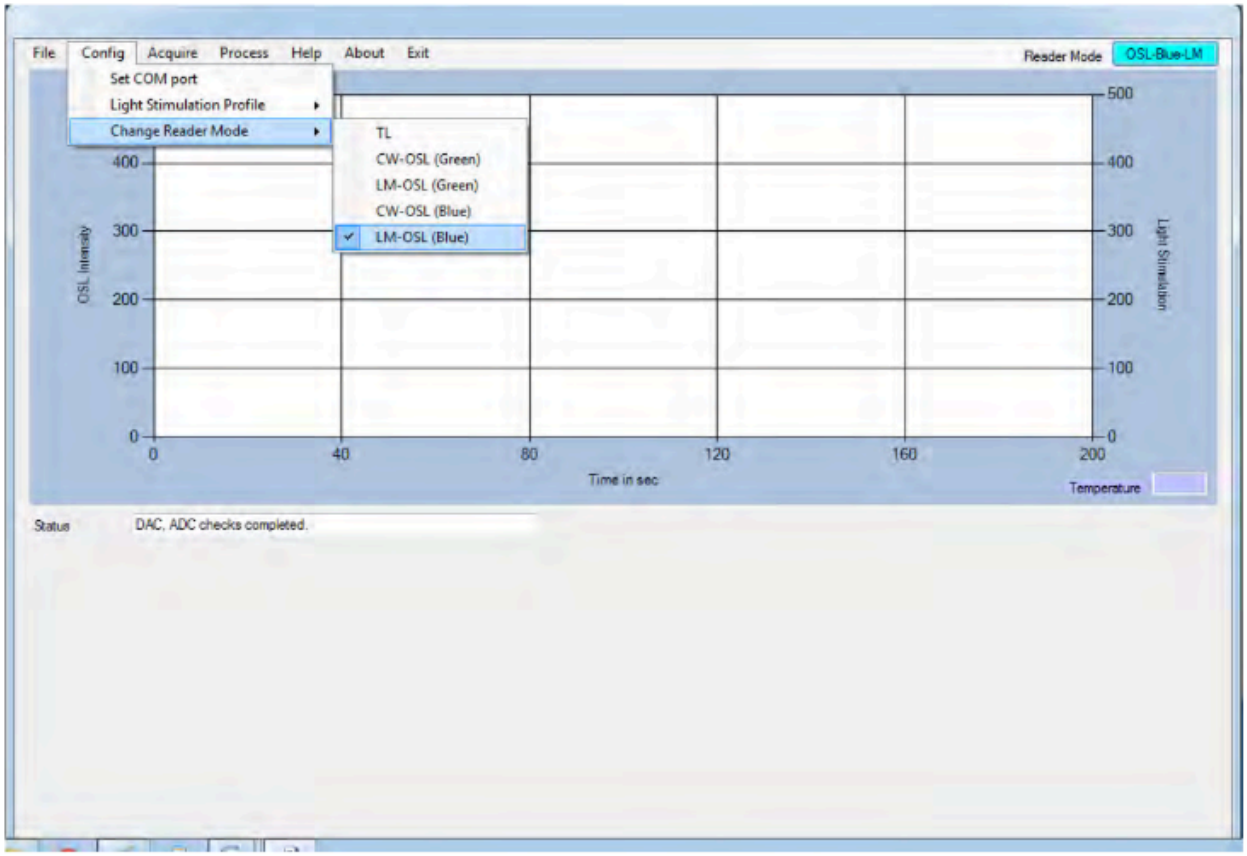
5. Software features -

OSL reader system operates by 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, it can be saved or further processed depending upon the requirement.

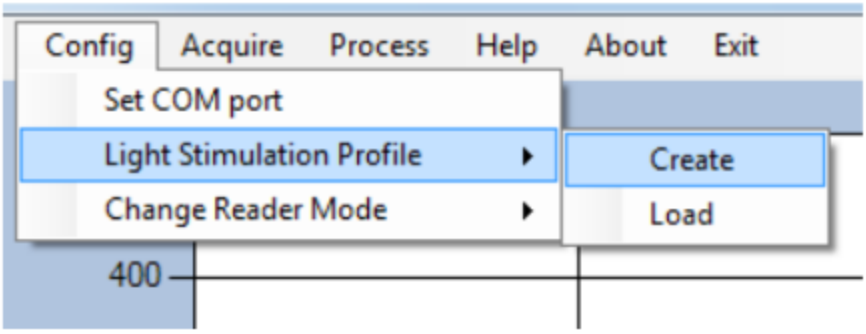
PROCEDURE-

Readout process & Study of the Glow Peak:

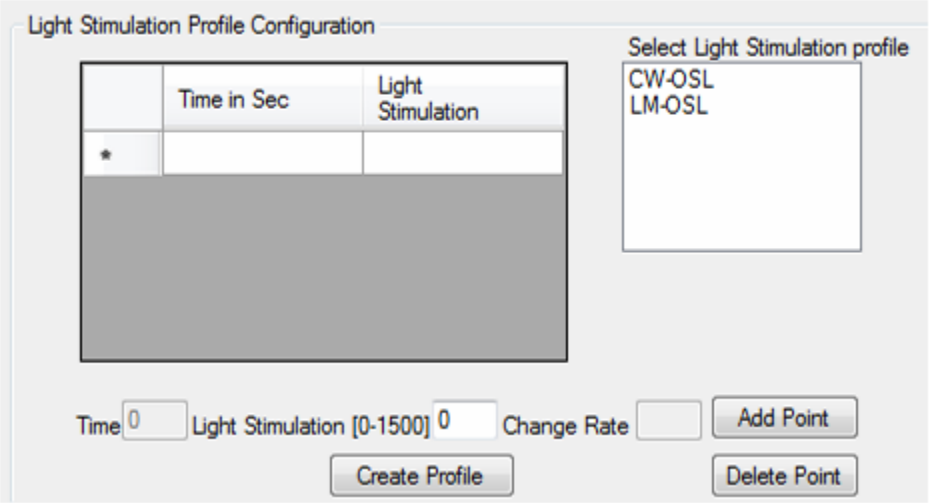
- Make sure that OSL filter Basket like U-340 or UG-1 (U1) insertion in the Dark chamber
- The ambient light should be subdued or Dim (Otherwise sample may lose the stored irradiated dose) during the measurement process.
- Switch ON the Reader, by using 'Rocker switch' on the Rear panel.
- Open the TL Research Reader application Software.
- Select the Change Reader Mode to Required OSL mode(CW-OSL or LM-OSL) as shown in fig.



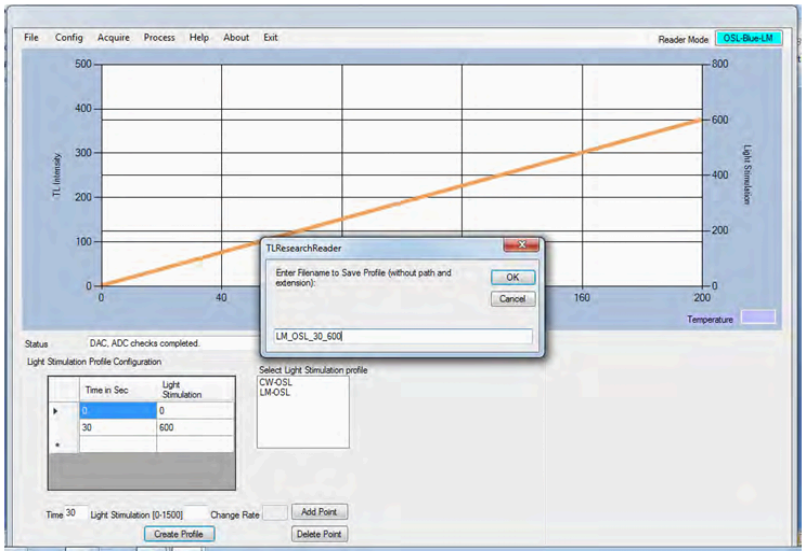
- Create or Load the stimulation profile by clicking **Config Menu→ Light Stimulation Profile → Create** (Or **Load** if already Created)



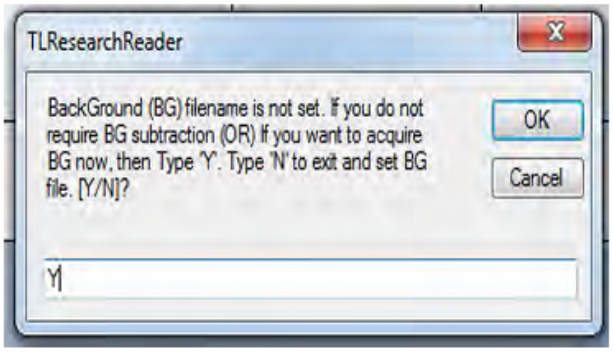
- If the user wants to run the sample with **LM-OSL** mode, he has to configure starting Light stimulation (typically zero) intensity at zero time, add that point and enter the run time (400 sec), require Light stimulation and add the point.

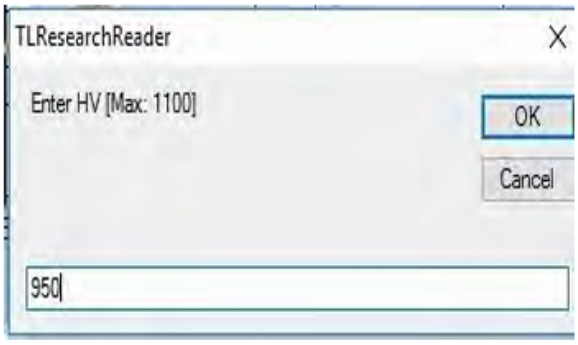


- Now Create and save the profile

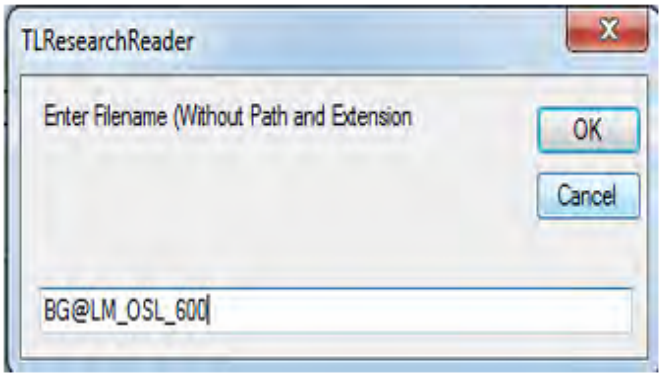


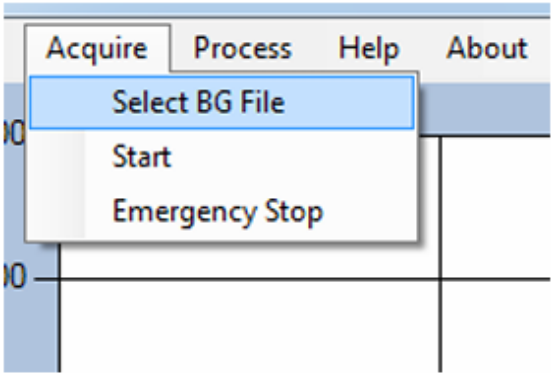
- If user wants run the sample with **CW-OSL** mode, he has to configure a Light stimulation intensity at zero time, add that point and enter the run time (400 sec) & same Light stimulation and add the point
- Place an unirradiated phosphor in the planchet and click on **acquire menu→ start,** then acquire the Background by entering **N** on the empty space appeared in the popup.



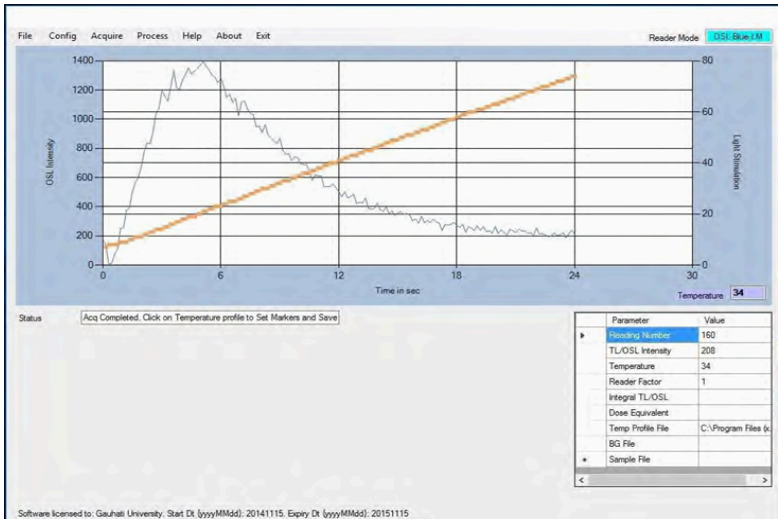


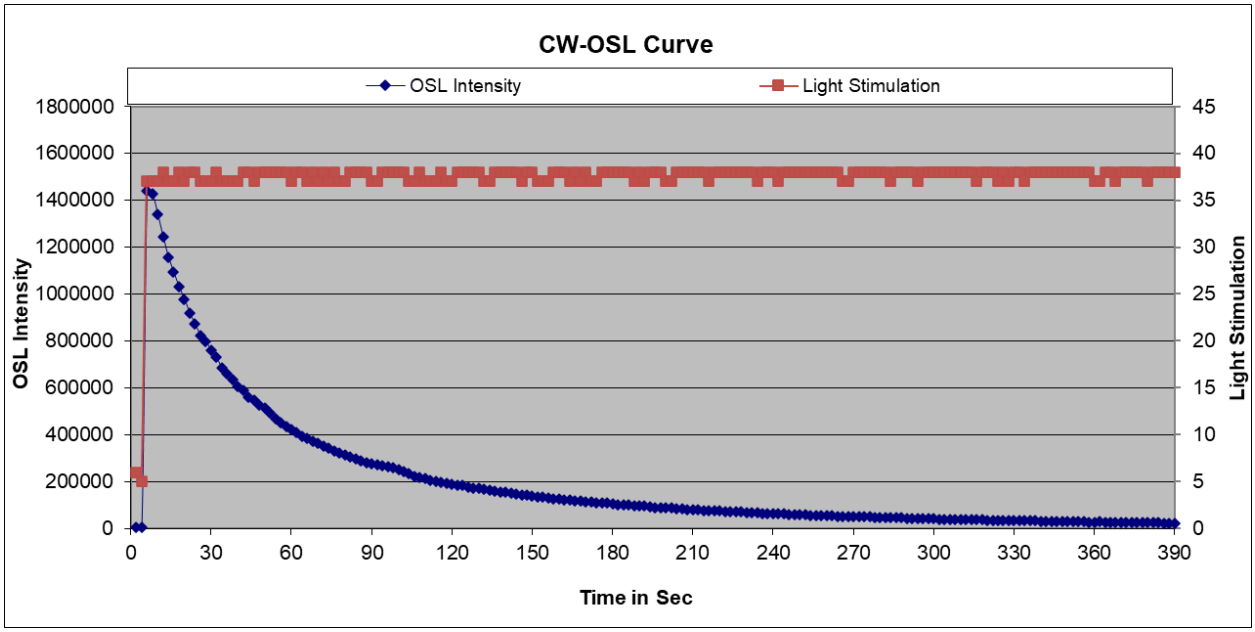
- Save the background glow curve and select the same file if you want to subtract automatically from the sample data. Otherwise you can subtract it later.

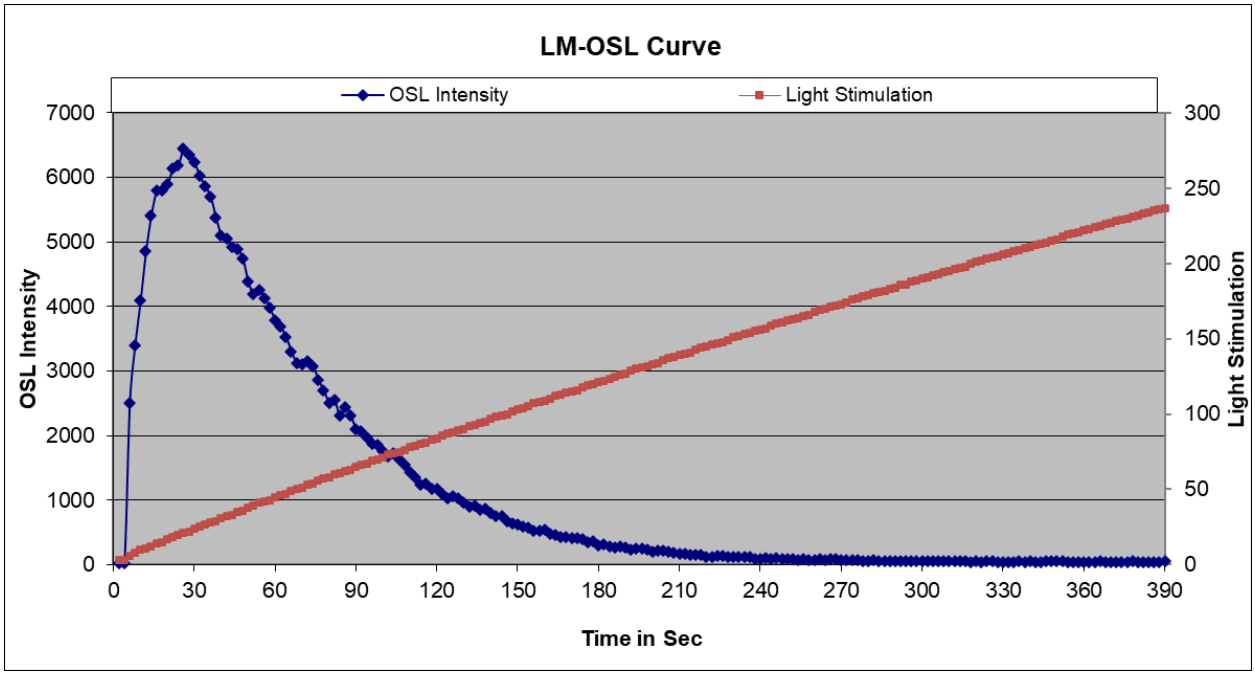




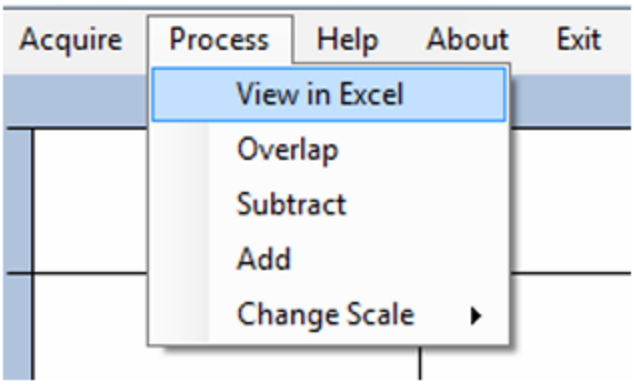
- Now place the irradiated sample on the middle of the planchet.
- Acquire the glow curve and save the file **(File → Save As)**.



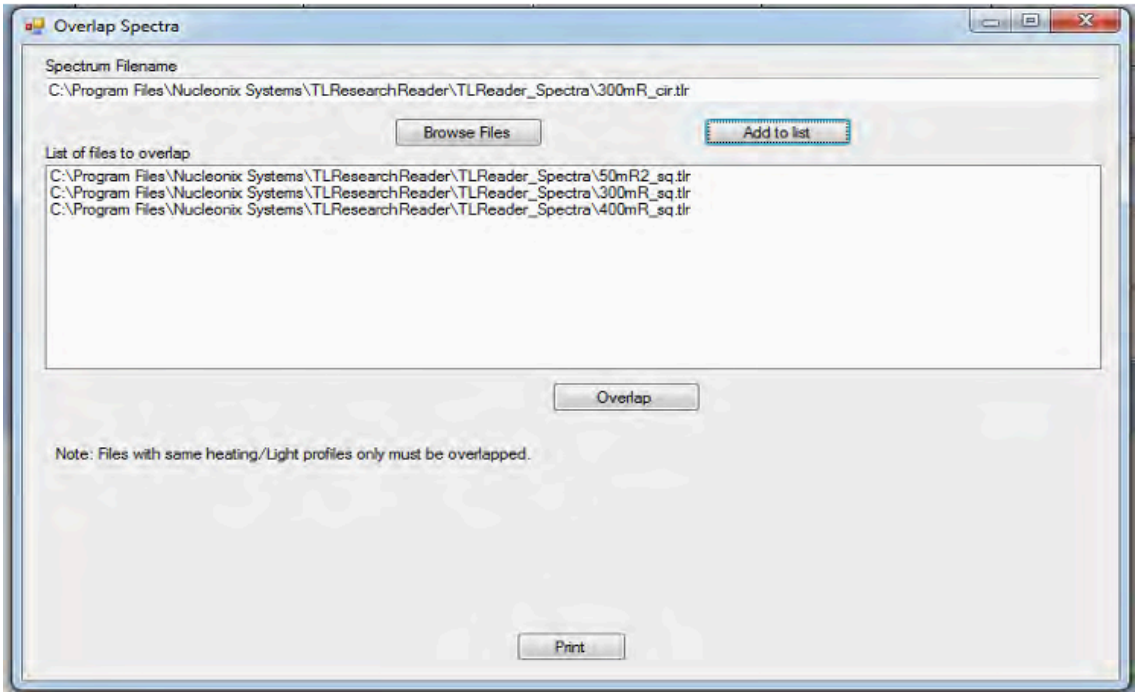




- You can select the Region of Interest (ROI) by clicking the required extreme points on the glow curve. Integral OSL will be displayed in Table on the right bottom of application Software.
- One can open the previous glow curves from the File menu Open select the desired file.We can process or utilize the raw data (Stimulation, Illumination output Intensity) by viewing in excel format (**Process men8u → View in Excel→ select** the desired file).

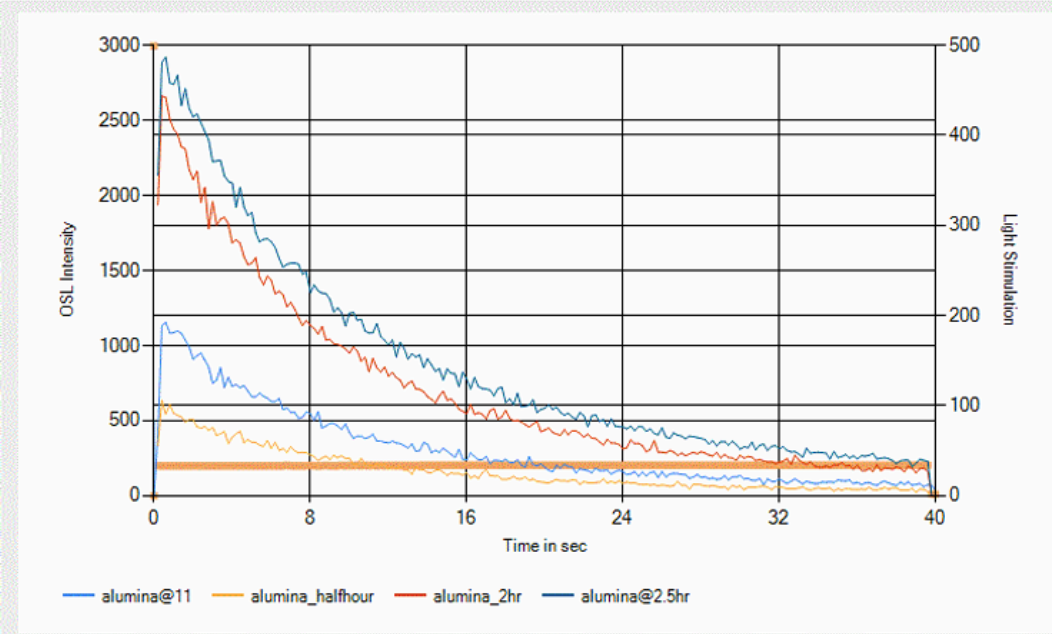


- In order to do comparative studies one can overlap different glow curves (With same type of Profiles).Go to **process menu →Overlap → browse** the required files and add to list one by one.



- Now click Overlap and save the file at the desired destination.

Typical Overlap file will be as shown in figure

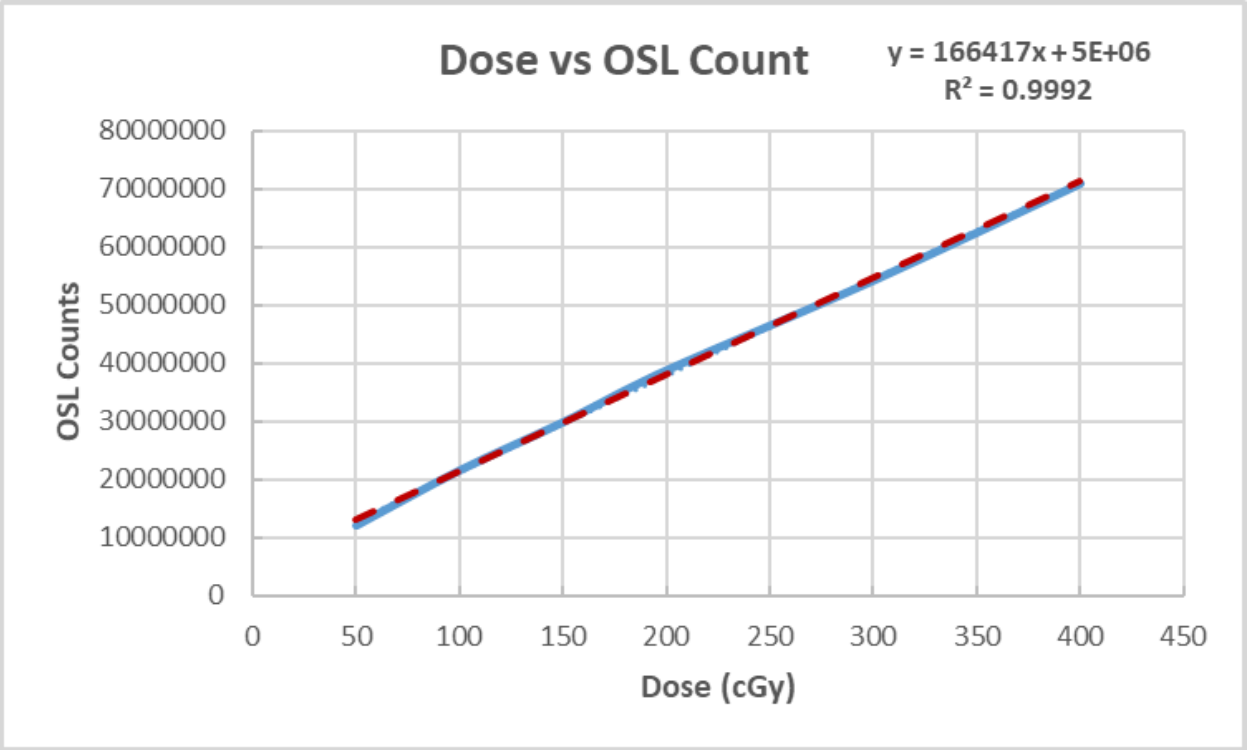


Calibration procedure and determination of Unknown dose:

- Obtain the glow curves for samples irradiated to known doses.
- Find out the integral OSL intensity or counts by determining the area under the glow curve.
- For better results take an **average** value of at least **3 sample** readings.
- Plot a graph of OSL intensity/counts vs Dose. The plot should be linear.
- Find the polynomial equation of the curve from the plot.
- To obtain the dose for an unknown sample , first do the measurement, obtain its glow curve, from the data find its integral counts. Then put these counts in the linear equation obtained to find out the corresponding dose value.

Tabulation:

Dose (cGy)	OSL Counts 1	OSL Counts 2	Average Counts	BKG	OSL counts
50	11697525	12637405	11610262	4691	11605571
100	21536822	21828327	19888119	4691	19883428
150	29437956	30496211	26419031	4691	26414340
200	40124733	37662407	38893570	4691	38888919
300	54046598	54653791	49674139	4691	49669448
400	70526376	71495502	64575160	4691	64570469



Calculation & Results :

The plot of Dose Vs Counts was found to be a straight line given by

$$Y = 166417X + 5\times 10^{6}$$

Validation of unknown dose:

OSL intensity from an unknown sample = 40741651
OSL intensity from an unknown sample after background subtraction = 40741651 - 4691
= 40736960

Dose of unknown sample = $\frac{40736960 - 5000000}{166417} = \frac{35736960}{166417}$
= 214.74cGy

Actual dose given = 235cGy

% Error = $\frac{214.74 - 235}{235} \times 100$ = -8.6%

Conclusion: The dose of unknown sample found out as 214.74cGy with -8.6% error.

Precaution:

- Do not increase the PMT voltage beyond 1000 Volts.
- Please ensure the correct mode (TL/ OSL) is selected.
- Do not open the drawer while the measurement is going on.
- Ensure that the heater switch is in off condition.
- Switch on the TL/ OSL Reader power button after turning on the main supply.
- Always wear gloves while handling the samples during the measurement and the bleaching procedure.
- Make sure that the room light should be subdued or Dim during the measurement process.
- Do the insertion of the OSL filter in the Dark room (switch off all the lights and close the windows properly).
- Make sure during the OSL reading, the heater is off.