

## SUMMARY

Silicon dioxide ( $\text{SiO}_2$ ) is the most common constituent of the mother earth. A crystalline variety of silicon dioxide, stable at room temperature, is known as alpha-quartz. In nature, alpha-quartz is found in the form of sand and rock like sandstone, quartzite and vein quartz. Single crystal of quartz is an important raw material for the several industries. Electronic grade quartz single crystals exhibit piezoelectric property, which allows them to be used for accurate electronic frequency control as resonator, and for selection as filters, in electronic circuitry. In short, the crystal unit enables a radio to 'tune in' to a particular wavelength without wandering or drifting, when either transmitting or receiving.

Recently, it is also used for mobile and optical communication devices and projection equipments as an optical product, and an electronic component for personal computers and other digital equipments. Thus, synthetic quartz crystal is a technologically important material. However, single crystals as found in nature, are generally not suitable because of the presence of twins and other imperfections which degrades its electronic properties. It is because of this reason that natural quartz single crystals have gradually been replaced by laboratory grown synthetic quartz single crystals. Since the synthetic quartz crystal can be produced without any twins or other imperfections, and can be grown in such a manner that the material loss can be kept to be minimum during fabrication of electronic components. Literature shows the thermoluminescence (TL) properties of the material is the most structure sensitive. Therefore, TL of the natural as well as synthetic quartz was widely studied systematically from the correlation of defects and prior physical treatments point of view.

Conflicting experimental results have been reported on the same material by various investigators. They are explained on account of

structural changes of minute amount of several metal cations (unavoidably present defect in the material) due to the prior treatments given to the material. The location and concentration of such defects get influence with different physical conditions such as pre-thermal treatment, irradiation, bleaching and powdering etc.

The studies reveal that upon UV-illumination on the material the high temperature TL peak transfers to the sensitive low temperature TL peak. This phototransfer thermoluminescence (PTTL) is attributed to optically sensitive traps. The effect of UV radiation is to evict electrons from the deep traps and some of these are re-trapped at low temperature traps. PTTL is proportional to the electron population at high temperature traps. Hence, the PTTL can be used to evaluate the dose absorbed in the material by many workers. Optically Stimulated Luminescence (OSL) arises from the recombination of charge, which has been optically released from meta stable energy levels within a crystal. During exposure to the specimen the OSL signal is observed to decrease to a low level as the metastable charge is depleted. Since OSL measures only the component of the trapped electron population (that is most sensitive to light), it is widely used in geological as well as archeological dating.

In order to establish a definite correlation between defects, color centers and TL/OSL (under different physical conditions) systematic efforts are made in the present work using synthetic quartz. This study helps to understand the influence of different protocols followed for sample preparation in different applications. Hence it can suggest the best protocol to be followed for the specific applications area of this material. The study is also aimed to understand the stability of various color centers responsible for the luminescence emission. An attempt also has been made to suggest the use of synthetic quartz with a defined protocol as a promising dating as well

as dosimetric material. OSL decay characteristics of powdered synthetic quartz crystal have been studied using 470nm blue light for 100sec stimulation for various protocols at and above room temperature with respect to different physical conditions such as pre-thermal treatment, radiation and duration of pre-thermal treatment systematically.

The observed results are classified as per their protocol given to the material. The TL of synthetic quartz in present studies revealed the remarkable contribution of 375°C TL peak along with two TL peaks at 110°C and 230°C at room temperature.

The detail mechanism of luminescence emission in these cases is explained systematically. However, for high temperature TL (>250°C) peaks of quartz, it is concluded that the TL in this region is the result of the recombination of electrons with the holes at  $Al^{+3}-h^+$  centers. But researchers suggested that the TL at 110°C should emit at the same wavelength as that at the higher temperatures. Further, they also explained that at 110°C TL peak emits predominately at 380nm with a weaker emission band ~470nm.

As enough attention has not been paid to these TL peaks and its dynamics, the OSL studies were conducted for different protocols such as-

- (i) OSL measured at room temperature.
- (ii) OSL measured at elevated temperature (160°C).
- (iii) OSL measured at elevated temperature (160°C) after Post Irradiation Heat Treatment (PIHT) at 290°C for different durations.
- (iv) Study of OSL under cyclical succession at 160°C measured.

The TL glow curves were also recorded at room temperature after each OSL decay curve.

The OSL measured at room temperature for the material exposed to less than 25.2Gy beta dose followed by 400°C pre-thermal treatment showed that the shape of OSL decay curve is non-exponential in nature with less

OSL intensity. While specimen exposed to higher beta dose ( $>25.2\text{Gy}$ ) followed by higher pre-thermal treatment ( $>400^\circ\text{C}$ ) exhibits completely exponential shape of OSL decay curve with rise in OSL intensity. Also for either critical dose or critical pre-thermal treatment the shape of decay curve is non-exponential, thereafter it shows exponential pattern of OSL decay curve with enhancement in OSL intensity. Such types of OSL results are attributed to the inference of low temperature TL traps, which are present in the material. On investigation of TL after OSL it is noticed that the reduction of electrons from optically sensitive trap to TL traps takes place, which give rise to significant growth of  $110^\circ\text{C}$  as compared to  $230^\circ\text{C}$  and  $370^\circ\text{C}$  peaks. However, present work carried out the OSL study at elevated temperature ( $160^\circ\text{C}$ ), to increase the OSL efficiency by reducing the contribution of low temperature traps. But it is noticed that the results are more or less identical to earlier protocol. It could be because of closely spaced peaks in the region  $160^\circ\text{C}$  to  $220^\circ\text{C}$  do not make significant contribution.

The TL curve of the above specimen exhibits peaks at  $230^\circ\text{C}$  and  $375^\circ\text{C}$  with rise in TL intensity, but not for  $110^\circ\text{C}$  TL peak. This is suggested to be due to the recuperation process occurring in the present material.

The researchers used the OSL/ TL method for dating and dosimetric applications of quartz by applying suitable pre-heat procedure after irradiation. However, present research carried out for OSL at elevated temperature after PIHT at  $290^\circ\text{C}$  for 0 to 30sec. It is believed that OSL sensitivity doesn't show consistent behaviour with the duration of heating at  $290^\circ\text{C}$ . It is believed that during above procedure electrons are removed from shallower traps and be captured at deeper traps in more or less number.

The corresponding TL exhibits more sensitivity to the given annealing treatment of  $375^\circ\text{C}$  peak compared to  $230^\circ\text{C}$  peak. It is suggested that the

electrons released from shallower trap during heating at 290°C are captured more in deeper traps, which are slowly bleachable (at 290°C).

The study of OSL under cyclical succession at 160°C showed that OSL intensity consistently decreases in successive cycle. This feature is presumed to arise from the depletion of electrons from bleachable centers. In another experiment, after subjecting the specimen to successive OSL cycles, the specimens were studied for TL. The TL glow curve displays two stable peaks at 230°C and 375°C having nearly equal growth. It is suggested that the growth of 230°C and 375°C peaks is due to trapping of electrons released during cyclical OSL runs.

The Electron Spin Resonance (ESR) spectra were recorded for the specimens after following protocols as similar to that of OSL studies. The spectra were also recorded before and after UV exposures. It is observed that the ESR signal changes with either rise in temperature of annealing or with rise in beta dose. It is suggested that there are a noticeable contribution of  $E_1'$  and Ge centers. Such study gives definite correlation with OSL/TL traps.

The thesis is presented in the form of six chapters. The basic knowledge about subject, scope and objective of the resent work are given in chapter-1. The second chapter explains basic physical, chemical and mechanical properties of synthetic quartz along with its structure and area of applications. Chapter-3 provides information of experimental set-up. The experimental observations of OSL at and above room temperature as well as TL measurements before and after OSL for different protocols are explained in chapter-4. Correlation between defects and OSL/TL measurements as well as ESR experimental data are presented in chapter-5. Final parts of the thesis work in the form of conclusions are presented in chapter-6.