Thermoluminescence of synthetic quartz
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Abstract
Thermoluminescence of synthetic quartz annealed at 1000°C for 10 minutes has been studied. The sample was beta irradiated to 10 Gy and then heated at 1°C/ls. The glow curve obtained has three glow peaks, one high intensity component and two weaker-intensity ones. This study was on the main peak sample was beta irradiated to 10 Gy and then heated at 1°C/s. The mean activation energy obtained from these methods was 0.96 ± 0.01 eV. The geometric factor 0.47 ± 0.05 found using the peak shape method indicates first order kinetics. The dose response of the peak position further confirmed this order of kinetics. The rate at which electrons escape the traps was found to be ~ 10²1 ± 1.

Introduction
Thermoluminescence (TL) is the thermally stimulated emission of light from the insulator or semiconductor, following previous absorption of energy from radiation. TL can be emitted from natural or synthetic quartz when the material is heated at an increased rate. TL can be emitted from natural or synthetic quartz when the irradiated material is heated at a controlled rate. TL appears as a series of peaks called a glow curve with each peak associated with an electron trap. We report the kinetic analysis as well as the irradiation induced features of the main TL peak in synthetic quartz.

Experimental Details
Synthetic quartz of grain size 90-500 µm (Sawyer Research Products, Ohio, USA) was used. A few milligrams of sample was placed on stainless steel discs of 1 mm thickness and 10 mm diameter. Thermoluminescence was measured using a RisøTL-OSL-DA-20 Luminescence Reader. An inbuilt 350°/VY beta source was used to irradiate the samples at a dose rate of 0.1028 Gy/s. Luminescence was detected by an EMI9235QB photomultiplier tube through a 7.5 mm thick Hoya U-340 filter (transmission band 280-390 nm). All TL measurements were made in a nitrogen atmosphere to avoid spurious luminescence from air and to improve thermal contact between the sample disc and the heater plate. Samples were annealed at 1000°C for 10 minutes before use in order to remove any residual signal. The quartz is subject to pre-dose and heating effects and the heating also improved its sensitivity by way of thermal activation.

Method: Kinetic Analysis
Kinetic parameters such as frequency factor α, order of kinetics β and activation energy E, are associated with the TL process and so such need be evaluated. These parameters were evaluated using the following methods:

• The Initial Rise Method (IR)
• The Variable Heating Rates Method (VHR)
• The Peak Shape Method (PS)

Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Procedure of Evaluating</th>
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<tr>
<td>PS</td>
<td>Eα/β = C(21/kTm/α) – b(21/kTm) where α = δ, τ, ω and μ = δ/ω</td>
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<tr>
<td>IR</td>
<td>ln(ln(1/R)) + ln(C) slope and intercept of the graph yields E, s</td>
</tr>
<tr>
<td>VHR</td>
<td>ln(1/α) + ln(1/ω) slope and intercept of the graph are used to evaluate both E and s</td>
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Table 1: Equations of the methods Kinetic Analysis

Here E is the trap depth (eV), s frequency factor (s-1), Tm peak position (K), I intensity (a.u.), k Boltzmann’s constant, β heating rate (°C/s) and C constant.

Results

Figure 1: (a) Energy band diagram to describe simple (F)OR model of TL. (b) Peak shape method parameters.

Evaluation of kinetic parameters of the main peak (Figure 2 (a))

Peak shape method

• The activation energy was found to be Eα/β = 0.81 ± 0.01 eV, Eα/β = 0.83 ± 0.01 eV and Eα/β = 0.82 ± 0.01 eV.

• The value of ρ = δ/ω = 0.47 ± 0.05, indicates first order kinetics. The means retrapping of electrons is negligible.

Initial rise method

• This method focuses on the low temperature tail of the main TL glow peak. It is assumed that the amount of trapped charge in this temperature range is constant, thus the TL emission can be described by I(T) = exp(-(E)/kT).

• As shown in Figure 2(b), plotting ln(I/α) against 1/°C yields a straight line with slope E, which in this case is equal to 1.17±0.01 eV.

Variable heating rate method

• Figure 3(a) gives a more accurate value of Eα/β = 0.99 ± 0.01 eV, because it does not need clean peaks. All the data points are included for Tm and s.

• Figure 3(b) shows the relationship between Tm and s for heating rates between 0.5 to 5 °C/s.

Figure 2: (a) A glow curve measured at 1°C/s following irradiation. (b) The graph of ln(β) against 1/°C.

Figure 3: (a) Effect of heating rate, β on peak position Tm. (b) Graph of ln(β) against 1/°C.

Conclusion
Thermoluminescence of synthetic quartz annealed at 1000°C for 10 minutes has been studied. Samples were beta irradiated to 10 Gy then heated to 500°C at 1°C/s. The glow curve for this sample has three peaks. Kinetic analysis of the main peak shows that it is of first order and its mean activation energy is about 1 eV. The position of this peak is independent of dose but increases with heating rate.

References

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