CHAPTER VI

CONCLUSIONS
In the present thesis, the TL glow curves of virgin as well as various thermally pre-treated, unirradiated, powdered synthetic quartz crystals have been recorded. The TL glow curves have also been recorded for such specimens after beta exposure. To study the effect of thermal pre-treatment in detail, two basic methods have also been employed namely changing the duration of the thermal pre-treatment. The TL studies have been carried out for different incident beta doses, on this laboratory grown synthetic quartz and the corresponding defect dynamics under the influence of above mentioned different physical conditions, the trapping level characterisation is also being carried out systematically. The optical absorption and x-ray diffraction measurements of this specimen have been studied to confirm the hypothesis, proposed based on the earlier mentioned measurements. They have strengthened the offered suggestions.

The proposed facts may help professionals to select synthetic quartz for particular applications in various fields. They also help to develope the devices used in electronic and optical applications with improved performance in particular, for precision frequency control applications of this material, such defects and its defect dynamics play vital role. There such studies are of great importance. The conclusions drawn from present research
work are as follows—

1. Either virgin or thermally pre-treated synthetic quartz specimens do not exhibit noticeable TL emission, if not irradiated, however even virgin specimen exposed to beta radiation at room temperature displayed significant TL emission around 145°C. This suggests that the TL emission is purely radiation induced. The TL glow peak observed in this specimen generally referred as 110°C glow peak. However, its position varies from 98°C to 150°C. Its exact position is highly variable depending upon sample type, annealing conditions, electrolytic sweeping, radiation dose, heating rate etc.

2. This emission is explained on the basis of dissociation of (Al-M) centres as a result of beta radiation at room temperature, which are otherwise present in the material substitutionally at Si sites.

3. Enhancement of TL intensity with incident beta dose is observed in virgin synthetic quartz material. It is explained on the basis of increased concentration of luminescent centres, with rise in beta dose.

4. In order to understand the influence of thermal pre-treatment on this material and hence centres present in it; specimens have been annealed at different elevated temperature and air-cooled followed by beta radiation. The TL observed for such specimens indicated rise in TL intensity with rise in temperature of anneal up to 300°C.
The further increase in temperature of anneal up to 600 °C induces a new peak around 280 °C along with the enhancement in TL intensity. The observed results have been interpreted in terms of annealing of competing electron traps present in the material, this increases probability for radiative electron hole recombination at the proposed luminescence centre, with increase in temperature of anneal up to 300 °C; while the results of the specimens annealed beyond 300 °C have been explained on the premise of the conversion of Al-hydrogen complex into Al-M centres again.

5.) The specimens annealed at 600 °C and suddenly air-cooled to room temperature displayed sudden rise in the TL intensity. This has been attributed to the change of Alpha quartz to Beta quartz for the specimen annealed beyond 573 °C.

6.) The shifting of the glow peak towards lower temperature side with in duration of the thermal pre-treatment, seems to be due activation of pre-existing traps, generation of large number of luminescence centres and hence interaction among themselves with rise in duration of pre-heat treatment.

7.) The trapping level characteristics under the influence of different physical conditions have shown interesting results. The influence of these conditions on the specimen
clearly affected the associated trapping site and therefore, trap spectroscopic information. The observed changes in these data could be explained on the basis of suggestions have been offered.

8.) The above mentioned suggestions have been confirmed using optical absorption and x-ray diffraction measurements, as they witnessed influence of variation of these conditions on their results, under identical conditions.
FIG. 1  TL Glow curves of as-obtained Virgin synthetic quartz specimen under different beta doses.
a = 9.0 \times 10^3 \text{ rad}

b = 1.35 \times 10^3 \text{ rad}

c = 2.7 \times 10^3 \text{ rad}

d = 4.5 \times 10^3 \text{ rad}

e = 9.0 \times 10^3 \text{ rad}

f = 1.35 \times 10^3 \text{ rad}

g = 2.7 \times 10^3 \text{ rad}

h = 4.05 \times 10^4 \text{ rad}

i = 1.35 \times 10^4 \text{ rad}
FIG. 2 TL Glow curves of as-obtained Virgin synthetic quartz specimen with three different beta doses;

\[ a = 1.35 \times 10^4 \text{ rad}, \quad b = 2.7 \times 10^4 \text{ rad}, \]
\[ c = 4.05 \times 10^4 \text{ rad.} \]
FIG. 3 (i) TL Glow curves of as-obtained Virgin synthetic quartz specimen without irradiation.

(ii) TL Glow curves of thermally pre-treated synthetic quartz material without irradiation.
FIG-3

(i) Thermally untreated

(II)

TL INTENSITY (Arbitrary units) x 10^7

TEMPERATURE (°C)

FIG-3
FIG. 4 TL glow curves of virgin (vir), annealed and air-quenched (AQ) quartz specimens.

Annealing Duration: 1 hour

Beta dose: $1.35 \times 10^4$ rad.

(a) AQ from 100° C  (b) AQ fro 200° C
(c) AQ from 300° C  (d) AQ fro 400° C
(e) AQ from 500° C  (f) AQ fro 600° C
FIG. 5 TL glow curves of virgin (\(\text{Virgin}\)), annealed and air-quenched (AQ) quartz specimens.
Annealing Duration: 2 hour

Beta dose: \(1.35 \times 10^4\) rad.

(a) AQ from 100\(^\circ\) C  (b) AQ from 200\(^\circ\) C
(c) AQ from 300\(^\circ\) C  (d) AQ from 400\(^\circ\) C
(e) AQ from 500\(^\circ\) C  (f) AQ from 600\(^\circ\) C
FIG-5

TL INTENSITY (Arbitrary units) x 10^7

TEMPERATURE (°C) →

FIG-5
FIG. 6  TL glow curves of virgin (V), annealed and air-quenched (AQ) quartz specimens.
Annealing Duration : 3 hour

Beta dose : 1.35 \times 10^4 \text{ rad.}

(a) AQ from 100^\circ \text{C}  (b) AQ fro 200^\circ \text{C}
(c) AQ from 300^\circ \text{C}  (d) AQ fro 400^\circ \text{C}
(e) AQ from 500^\circ \text{C}  (f) AQ fro 600^\circ \text{C}
FIG. 7 TL glow curves of virgin (V), annealed and air-quenched (AQ) quartz specimens.

Annealing Duration: 3 hour

Beta dose: $2.70 \times 10^4$ rad.

(a) AQ from 100°C (b) AQ fro 200°C
(c) AQ from 300°C (d) AQ fro 400°C
(e) AQ from 500°C (f) AQ fro 600°C
FIG-7

TL INTENSITY (Arbitrary units) $\times 10^{-7}$

TEMPERATURE ($^\circ$C)
FIG. 8 TL glow curves of virgin (V), annealed and air-quenched (AQ) quartz specimens.
Annealing Duration: 3 hour

Beta dose: $4.05 \times 10^4$ rad.

(a) AQ from 100°C  (b) AQ from 200°C
(c) AQ from 300°C  (d) AQ from 400°C
(e) AQ from 500°C  (f) AQ from 600°C
FIG. 9 TL glow curves of virgin (d), and 100°C AQ quartz specimens.

Beta dose: $1.35 \times 10^4$ rad.,
Annealing Duration:
(a) One hour  (b) Two hour  (c) Three hour
FIG. 10 TL glow curves of virgin (d), and 300°C AQ quartz specimens.

Beta dose : $1.35 \times 10^4$ rad.,
Annealing Duration:
(a) One hour  (b) Two hour  (c) Three hour
FIG-10

TL INTENSITY (Arbitrary units) \times 10^7

TEMPERATURE(°C) →

FIG-10
TL glow curves of virgin (d), and 600°C AQ quartz specimens.

Beta dose: $1.35 \times 10^4$ rad.,
Annealing Duration;
(a) One hour  (b) Two hour  (c) Three hour
Figure 11

TL Intensity (Arbitrary units) x 10^(-7)

Temperature (°C)

FIG-11
FIG. 12

TL glow curves of virgin (d), and 600°C AQ quartz specimens.

Beta dose: $2.70 \times 10^4$ rad.,
Annealing Duration;
(a) One hour  (b) Two hour  (c) Three hour
FIG-12

TL INTENSITY (Arbitrary units) x 10^7

TEMPERATURE (°C)
TL glow curves of virgin (d), and 600°C AQ quartz specimens.

Beta dose: $4.05 \times 10^4$ rad.,
Annealing Duration;
(a) One hour (b) Two hour (c) Three hour
FIG. 14 TL glow curves of virgin (d), and 100°C AQ quartz specimens.
Annealing Duration: One hour
Beta dose:

(a) $1.35 \times 10^4$ rad.
(b) $2.7 \times 10^4$ rad.
FIG. 15  TL glow curves of virgin (d), and 300°C AQ quartz specimens.
Annealing duration : One hour
Beta dose:
(a) $1.35 \times 10^4$ rad.
(b) $2.7 \times 10^4$ rad.
(c) $4.05 \times 10^4$ rad.
FIG. 16 TL glow curves of virgin (d), and 630°C AQ quartz specimens. 
Annealing Duration: One hour 
Beta doses:
(a) $1.35 \times 10^4$ rad.
(b) $2.7 \times 10^4$ rad.
(c) $4.05 \times 10^4$ rad.
FIG. 17: Glow curves of virgin (d), and 600°C AQ quartz specimens.
Annealing Duration: Two hour
Beta dose:
(a) $1.35 \times 10^4$ rad.
(b) $2.7 \times 10^4$ rad.
(c) $4.05 \times 10^4$ rad.
FIG. 18 TL glow curves of virgin (d), and 600°C AG quartz specimens. Annealing Duration: Three hour Beta dose:

(a) $1.35 \times 10^4$ rad.
(b) $2.7 \times 10^4$ rad.
(c) $4.05 \times 10^4$ rad.
TL INTENSITY (Arbitrary units) x 10^{-7}

TEMPERATURE →

FIG-18
FIG. 19 | Computationally best fitted TL glow curve of virgin, irradiated synthetic quartz specimen.

Beta dose: $1.35 \times 10^4$ rad.
$E = 0.499 \quad S = 372727.3$

RMSD = 11.26561
BB = 1.1

TL INTENSITY (Arb. units)

TEMPERATURE (°C)

FIG-19
FIG. 20  Computationally best fitted TL glow curve of virgin, irradiated synthetic quartz specimen.

Beta dose : $2.70 \times 10^4$ rad.
FIG. 21  Computationally best fitted TL glow curve of 100°C. AQ quartz specimen:
Annealing Duration : One hour
Beta dose : $1.35 \times 10^4$ rad.
Computationally best fitted TL glow curve of 100°C AQ quartz specimen.

Annealing Duration: One hour

Beta dose: $2.70 \times 10^4$ rad.
$E = 0.5$

$S = 691463.4$

$\text{RMSD} = 2.446955\times 10^{-2}$

$\text{BE} = 1.97$

- TL INTENSITY (Arb. units)
- TEMPERATURE (°C)

FIG-22
FIG. 23 Computationally best fitted TL glow curve of 100°C AQ quartz specimen.

Annealing Duration: Three hour

Beta dose: $1.35 \times 10^4$ rad.
E = 0.49  
S = 341666.6

RMSD = 0.1720746  
BB = 1.6

TL INTENSITY (Arb. units)  
TEMPERATURE (°C)

FIG-23
FIG. 24  Computationally best fitted TL glow curve of 100°C. AQ quartz specimen.

Annealing Duration: Three hour

Beta dose: $4.05 \times 10^4$ rad.
Computationally best fitted TL glow curve of 300°C. AQ quartz specimen.

Annealing Duration: Three hour

Beta dose: $1.35 \times 10^4$ rad.
\[ E = 0.724 \quad S = 1.228537 \times 10^9 \]
\[ \text{RMSD} = 0.1937734 \quad B = 1.9 \]

**TL INTENSITY (Arb-units)**

**TEMPERATURE (°C)**

**FIG-25**
FIG. 26  Computationally best fitted TL glow curve of 600°C. AQ quartz specimen.
Annealing Duration : Two hour
Beta dose : $2.70 \times 10^4$ rad.
E = 0.414
S = 35000
RMSD = 0.8719599
BB = 1.7

TL INTENSITY (Arb. units) vs TEMPERATURE (°C)

FIG-26
FIG. 27 Optical absorption spectra of thermally pre-treated quartz specimen without irradiation.

<table>
<thead>
<tr>
<th>Annealing Temperature</th>
<th>Annealing Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>100°C</td>
<td>Three hour = 1 AQ₃ hr</td>
</tr>
<tr>
<td>400°C</td>
<td>Three hour = 4 AQ₃ hr</td>
</tr>
<tr>
<td>400°C</td>
<td>One hour = 4 AQ₁ hr</td>
</tr>
<tr>
<td>600°C</td>
<td>Two hour = 6 AQ₂ hr</td>
</tr>
</tbody>
</table>
FIG-27

OPTICAL ABSORPTION vs WAVELENGTH (nm)

1 AQ 3hr
4 AQ 3hr
6 AQ 2hr
4 AQ 1hr
FIG. 28 (i) Optical absorption spectra of thermally pre-treated, irradiated quartz specimen.

Beta dose : $1.35 \times 10^4$

<table>
<thead>
<tr>
<th>Annealing Temperature</th>
<th>Annealing Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) $100^\circ C$</td>
<td>One hour</td>
</tr>
<tr>
<td>(B) $300^\circ C$</td>
<td>Two hour</td>
</tr>
<tr>
<td>(C) $600^\circ C$</td>
<td>Three hour</td>
</tr>
</tbody>
</table>

FIG. 28 (ii) Optical absorption spectra of thermally pre-treated, irradiated quartz specimen.

Beta dose : $2.70 \times 10^4$

<table>
<thead>
<tr>
<th>Annealing Temperature</th>
<th>Annealing Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D) $100^\circ C$</td>
<td>One hour</td>
</tr>
<tr>
<td>(E) $300^\circ C$</td>
<td>Two hour</td>
</tr>
<tr>
<td>(F) $600^\circ C$</td>
<td>Three hour</td>
</tr>
</tbody>
</table>
FIG. 29 (i) Optical absorption spectra of thermally pre-treated, irradiated quartz specimen.

Beta dose: $4.05 \times 10^4$

<table>
<thead>
<tr>
<th>Annealing Temperature</th>
<th>Annealing Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(G) $100^\circ C$</td>
<td>One hour</td>
</tr>
<tr>
<td>(H) $300^\circ C$</td>
<td>Two hour</td>
</tr>
<tr>
<td>(I) $600^\circ C$</td>
<td>Three hour</td>
</tr>
</tbody>
</table>

FIG. 29 (ii) Optical absorption spectra of thermally pre-treated, irradiated quartz specimen.

Beta dose:

- (J) $1.35 \times 10^4$ rad.
- (K) $4.05 \times 10^4$
FIG. 30  X - Ray diffraction spectra of virgin quartz specimen.