Chapter IV

Electro-Optical Studies of Barium and strontium Tartrate Crystals

IV.1 Introduction

Most of the tartrate compounds are insoluble in water and decomposes before melting. Hence crystals of such type of compounds cannot be grown by either slow evaporation or melt techniques. In this situation gel method is the appropriate one for the growth of barium tartrate crystals. Crystal growth in gels offers itself as a simple and inexpensive method for useful experiments on the growth of tartrate crystals for scientific investigations. Henisch [1] and Arora [2] carried out surveys of crystal growth in gels. Compounds of tartaric acid find several practical applications in Science and Technology [3]. Tartrate single crystals show many interesting physical properties such as ferroelectric, piezoelectric, dielectric, optical and other pertinent characteristics. They are used for non-linear optical devices based on their optical Second Harmonic Generation and optical transmission characteristics. They are also used for fabrication of crystal oscillators, resonators and controlled laser emission [4-9].

Barium tartrate, (BT), (BaC₄H₄O₆) and strontium tartrate, (ST), (SrC₄H₄O₆) crystals crystallize in orthorhombic system in the space group P2₁2₁2₁ (C₂ᵥ) containing four molecules/unit cell. Their unit cell dimensions are a = 7.59000nm, b = 23.78000nm and c = 7.53600nm
(JCPDS – CAS: 66904-98-1) and a = 0.948nm, b = 1.096nm and c = 0.946nm [10] respectively. The detailed analysis of the FTIR vibrational spectra of strontium and rubidium tartrate has been reported [11]. Thermal behaviour of gel grown tartrates of yttrium and samarium [12], mixed rare earth [13], Iron [14] and strontium [15] was also reported. The dielectric behaviour of various tartrate compounds such as calcium tartrate [16], sodium-ammonium tartrate [17] and zinc tartrate [18] was also observed. Strontium tartrate is identified for pyroelectric and ferroelectric transitions [19]. The non-linear properties of strontium doped calcium tartrate crystals were also reported [20].

In this chapter, we present the structural, optical and electro-optical properties of BT and ST crystals and the effect of Mn doping on these properties. The electro-optical phenomena, which are mainly considered here, are (i) photoconductivity (PC), (ii) photovoltaic (PV) effect, (iii) photoluminescence (PL), and (iv) electroluminescence (EL). In a quantum system photoelectronic phenomena can occur through the absorption or emission of photons [21].
IV.2 Results and Discussion
IV.2.1 Structural Studies
IV.2.1.1 X-Ray Diffraction

The structure of the tartrate ion has been determined by many authors using X-ray diffraction [22–27]. The ion consists of two planar halves, each containing a carboxyl group, a tetrahedral carbon atom and hydroxyl oxygen atoms. The chain of carbon atoms is almost planar. The planes of two \( \text{CO}_2 \) groups are inclined nearly at 60° to the plane. Hence \( C_{2v} \) symmetry is given for the tartrate ions. Structure of the BT and ST crystals are studied by taking XRD using Cu K\( \alpha \) (\( \lambda = 0.154056 \text{nm} \)) radiation.

![XRD Pattern of Mn doped BT crystal.](image)

Fig.4.1. XRD Pattern of Mn doped BT crystal.
The XRD patterns of BT and ST crystals (undoped and doped at different concentrations of Mn) are given in Fig. 4.1 and Fig. 4.2 respectively. The XRD analysis of BT crystals shows crystalline nature along (013) plane at $2\theta = 36.192^\circ$. The presence of other orientations such as (040), (121), (131) and (230) was also detected at $2\theta = 14.808^\circ$, $18.287^\circ$, $19.872^\circ$ and $26.015^\circ$ respectively with lower intensities. The calculated ‘d’ values, (hkl) and peak intensities of BT crystals were compared with those of Barium tartrate for orthorhombic crystals reported in JCPDS data files.

On Mn doping few extra peaks were detected with lower intensities but the intensity of the prominent peak is decreased and that of certain other peaks were increased for both crystals. On increasing the concentration of the dopant, the intensity of the prominent peak further decreased and others increased due to the decrease and increase in the atomic density of Mn in these planes respectively. The decrease in peak intensities is due to the replacement of $\text{Ba}^{2+} / \text{Sr}^{2+}$ ions with $\text{Mn}^{2+}$ ions in the lattice of BT and ST crystals. Increase in dopant concentration leads to the movement of $\text{Mn}^{2+}$ ions to the interstitial sites and also an increase in disorders.
**IV.2.1.2 Thermal Studies**

The thermal decomposition behaviour of the samples is studied by Thermogravimetry (TG). In TG analysis weight of the BT sample taken is 12.494 mg and that of ST sample is 11.695 mg. Heating rate was maintained at 10 °C/min in N₂ atmosphere. Fig.4.3 shows the TG curve recorded for BT crystal. Here the decomposition starts at 280°C. The first stage of decomposition continues up to 300 °C, leading to the
Fig. 4.3. TG curve of BT crystal.

Fig. 4.4. TG curve of ST crystal.
formation of barium tartrate monohydrate. The second stage of decomposition starts at 310°C resulting in the formation of barium oxalate monohydrate (BaC$_2$O$_4$. H$_2$O). In the third stage between 345°C and 380°C Barium oxalate monohydrate eliminates water molecules and decomposes into Barium carbonate (BaCO$_3$).

Fig. 4.4 shows the TG curve recorded for ST crystal. Here the decomposition starts at 140 °C. The first stage of decomposition continues up to 220 °C, leading to the formation of strontium tartrate monohydrate. The second stage of decomposition starts at 250°C resulting in the formation of strontium oxalate monohydrate (SrC$_2$O$_4$. H$_2$O). In the third stage between 340°C and 400°C strontium oxalate monohydrate eliminates water molecules and decomposes into strontium carbonate (SrCO$_3$). The results of both BT and ST crystals are quite similar to those reported [15, 28 and 29].

**IV.2.1.3 FTIR Studies**

The FTIR spectra are recorded in the frequency range corresponding to 100-4000 cm$^{-1}$. The FTIR spectra of BT and ST crystals are shown in Fig.4.5 and Fig.4.6 and their observed vibrational data and corresponding assignments are given in Tables 4.1 and 4.2 respectively. The results are found to be in good agreement with that of tartrates reported [11].
Fig. 4.5. The FTIR spectrum of BT crystal.

Fig. 4.6. The FTIR spectrum of ST crystal.
Table 4.1. The observed vibrational data and their assignments of BT crystal.

<table>
<thead>
<tr>
<th>Wave number (cm⁻¹)</th>
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<tr>
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<td>$\delta$(CH)</td>
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<tr>
<td>691.94</td>
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<tr>
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Table 4.2. The observed vibrational data and their assignments of ST crystal.

<table>
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<th>Assignments</th>
</tr>
</thead>
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<tr>
<td>478.20</td>
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<td>934.48</td>
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<td>995.04</td>
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<td>1079.33</td>
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[δ-Bending mode, ν- Stretching mode, $\rho_\ell$ - Rocking mode, $\rho_t$ - Twisting mode, $\nu_{as}$- Asymmetric stretching mode and $\nu_{s}$ - Symmetric stretching mode.]
IV.2.2 Diffused Reflectance Spectroscopy

Optical band gap ($E_g$) is measured from Diffused Reflectance Spectroscopy (DRS). Diffused Reflectance Spectrogram for BT and ST crystals with percentage of reflectivity $R$ versus wavelength $\lambda$ [30] are given in Fig.4.7 (a) and Fig.4.8 (a). $E_g$ is found by extrapolating the straight line graph of $\{(k/s)h\nu\}^2$ versus $h\nu$ in Fig.4.7 (b) and Fig.4.8 (b) at $k = 0$ and is found to be 5.49 eV for BT crystal and 5.46 eV for ST crystal (where $k$ is the absorption coefficient and $s$ is the scattering coefficient). Wide band gap compounds are especially promising for light emitting devices in the short wavelength region of visible light.

![Graph](image)

Fig.4.7. (a). Reflectivity $R$ versus wavelength $\lambda$, (b). $\{(k/s)h\nu\}^2$ versus $h\nu$ of BT crystal.
Fig. 4.8. (a) Reflectivity $R$ versus wavelength $\lambda$, (b) $\{(k/s)\nu\}^2$ versus $\nu$ of ST crystal.

**IV.2.3 Electro-Optical Studies**

**IV.2.3.1 Photoconductivity Studies**

Photoconductivity (PC) is the increase in the electrical conductivity of the material because of additional carriers created due to optical absorption. The important processes involved in PC are absorption, photo generation and recombination. The study of PC of semi conducting materials has gained industrial importance owing to its use in PV devices [31]. The samples are annealed to various temperatures such as 50°C, 100°C, 150°C and 200°C. As the PC cell is exposed to excitation source, the photocurrent increases with time and reaches saturated value. (Saturated value of photocurrent of sample is measured for each case separately). A representative plot of the time dependence of Photocurrent
(primary photocurrent) of both tartrate crystal samples annealed at 100°C is shown in Fig.4.9.

![Graph showing variation of photocurrent of BT and ST crystals with respect to time.]

Fig.4.9. Variation of photocurrent of BT and ST crystals with respect to time.

Saturated photocurrent increases as annealing temperature of the samples is increased and obtained maximum for B T and S T crystals annealed at 100°C and then starts decreasing as annealing temperature increases which is shown in Fig.4.10. The main purpose of annealing is to increase the crystallinity of the crystals, which produces an increment in photocurrent [32]. Increase in saturated photo current with annealing temperature up to 100°C can be explained on the basis of defects or impurity effect in the material. Imperfections having high probability for capturing the minority carriers with subsequent small probability for capturing a majority carrier increase the photosensitivity [33].
The decrease in saturated photo current when annealed beyond 100°C is due to the increase in the disorders [32]. Also imperfections acting as efficient recombination centers, decrease the photosensitivity [33].

It is found that saturated value of photocurrent increases with increasing intensity of excitation (Fig.4.11) and also with increasing applied voltage (Fig.4.12) for both crystals. When the intensity of light and the applied voltage increases, more and more charge carriers reach at the respective electrodes and the photocurrent increases [33]. The non-linearity in Figs. (4.11 and 4.12) represents the dependence of saturated photo current (secondary photocurrent) on the intensity of excitation and applied voltage. The variation in saturated photo current can be expressed in terms of a two-centre model. According to this model when the hole demarcation level is lowered through the level of sensitizing centers by increasing the light intensity at a constant temperature, the photo sensitivity
increases as the electron life time increases, giving rise to super-linear or sub-linear photoconductivity [33].

Fig.4.11. Variation of saturated photocurrent of BT and ST crystals with intensity of light.

Fig.4.13 depicts the variation of the saturated value of photocurrent with concentration of the dopant Mn, for BT crystal and that of ST crystal at room temperature. As the concentration increases from 0.5M to 5M, the charge carriers also increase and hence photocurrent increases. It is observed that photocurrent reaches maximum at 1.5M concentration of Mn. At this concentration the charge concentration seems to be optimum for better PC [33]. As the concentration of Mn increased from 1.5M, photocurrent is decreased due to concentration quenching.
Fig. 4.12. Variation of saturated photocurrent of BT and ST crystals with applied voltage.

Fig. 4.13. Variation of saturated photocurrent of BT and ST crystals at different concentrations of the dopant (Mn).
IV.2.3.2 Photovoltaic Studies

Photovoltaic (PV) effect is involved, when absorption of radiation by a material causes the appearance of a p.d. between the two portions of the material. The PV effect is essentially a minority carrier phenomenon [34]. The photovoltage increases with time and reaches saturated value as the PV cell is exposed to excitation source. (Saturated value of photovoltage of samples is measured for each case separately). A representative plot of the time dependence of photovoltage of BT and ST crystals annealed at 100°C is shown in Fig.4.14.

![Fig.4.14. Variation of photovoltage of BT and ST crystals annealed at 100°C with respect to time.](image)

As the annealing temperature increases the saturated photovoltage increases and reaches maximum, for both the samples annealed at 100 °C (Fig.4.15) and then start decreasing as annealing temperature increased beyond 100 °C. This increase in photovoltage with annealing temperature up to 100°C and the decrease in PV beyond 100°C of both samples can be explained in a way similar to that of its PC variation (section IV.2.3.1).
Saturated value of the photovoltage of BT and ST crystals also increases with increasing intensity of excitation (Fig.4.16). With the increase in intensity, more and more charge carriers are separated at the respective electrodes and hence the photovoltage increases. Fig.4.17 depicts the variation of the saturated photovoltage of BT and ST crystals with concentration of the dopant Mn at room temperature and it is observed that saturated photovoltage is maximum at 1.5M concentration of Mn. PV increases on increasing the concentration of Mn and reaches the maximum at 1.5M concentration and decreases further on increasing the concentration. The increase in photovoltage with concentration of Mn is due to enhancement of charge carrier concentration and decrease is due to the concentration quenching and increase of amorphous phase.
Fig. 4.16. Variation of saturated photovoltage of BT and ST crystals at different intensities of light.

Fig. 4.17. Variation of saturated photovoltage of BT and ST crystals at different concentrations of the dopant (Mn).

**IV.2.3.3 Electroluminescence Studies**

Electroluminescence (EL) is the phenomenon of the emission of electromagnetic radiation from condensed matter, subjected to an external electric field. In order to convert the electrical energy from an applied
potential difference in a crystal at ordinary temperature into visible or near visible radiation, three distinct steps are involved. (i) Excitation of crystals by applied electric field to an energy state at least few electron volts above the ground state. The excited state can be an ordinary conduction state of the crystal, an excited state of an impurity system or a state of high kinetic energy within the conduction or valence band. The excitation process may be by means of injection of minority carriers, valence electrons from field ionization of host atoms or impurities, or acceleration of charge carriers within a band to optical energies. (ii) Transfer of the excitation energy through the crystals to a region where de-excitation can occur with large probability for radiative transition. The energy transport can be by charge carriers, excitation migration or by resonance transfer. (iii) Radiative de-excitation thus involves localized states of impurity systems; inter band transition or intraband transitions [35]. Various combination of these excitation, energy transport and emission processes can occur in actual crystals [36].

The experimental AC/DC powder EL cells used for the present investigation is essentially a parallel plate condenser with the powdered crystal between a transparent conducting SnO₂ film and a copper plate. No binder is used for enhancing the dielectric strength. The light emitted from the EL cell on application of suitable voltage was detected by the PMT and the corresponding current is measured with the help of a digital nanoammeter.
IV.2.3.3.1 AC Electroluminescence

In the AC EL process, the electrons and holes are injected into the host material from both the electrodes and also from the defects on the application of the field. The electrons from the donor centers or from the intrinsic electron traps are freed by the electric field and they enter the conduction band, where they are accelerated by the positive half cycle of the field, until they gain sufficient kinetic energy to ionize or excite activator centers by the elastic impact. In the reverse half cycle of the field, these electrons recombine with the luminescence centers with emission of characteristic radiation. This mechanism corresponds to the impact ionization of the activator centers [37-40]. If the next pulse is of the same polarity as the preceding one, the system is already partially polarized, so that the light output is necessarily reduced, due to the lower internal electric field and the fewer electrons trapped at the defects. Luminescent centers formed at the cracks, voids, dislocations and stacking faults and provide sites for the precipitation of the excess carriers if it is produced.

The integrated light intensity, (brightness) B, produced during each cycle of the field is accurately given by the expression (equation 1.1)

\[ B = A \exp\left(-\frac{C}{\sqrt{V}}\right) \rightarrow (4.1) \]

where V is the applied voltage, A and C are constants independent of the voltage. The constant A describes the source of charge carriers responsible for the excitation process while C is a complex quantity, which relates to the local field intensity. This expresses that the mechanism of excitation is acceleration-collision type. Log (B) versus V^{-1/2}, of BT electroluminor is given in Fig.4.18 and that of ST electroluminor is given in Fig.4.19. Linearity of the plots holds the above
relation. The photoelectronic phenomena are much influenced by presence of defects in the original lattice [33].

Fig. 4.18. Plot of Log (B) Vs. V\(^{-1/2}\) of BT crystal.

Fig. 4.19. Plot of Log (B) Vs. V\(^{-1/2}\) of ST crystal.
AC EL Brightness as a function of applied a.c voltage of both electroluminors at different concentrations of the dopant (Mn) is given in Fig.4.20 and Fig.4.21 respectively. EL intensity increases with increasing Mn concentration and reaches the maximum at 2 M then decreases on increasing concentration due to concentration quenching.
AC EL intensity of the two electrolumirors at different annealing temperatures is given in Fig. 4.22 and Fig.4.23. EL intensity increases with increasing annealing temperature (crystallinity increases) and reaches the maximum at 100°C then decreases on increasing annealing temperature due to the increase in the amorphous phase and disorders. The overall AC EL emission of both electrolumirors is bluish.
AC EL emission photographs of the two electroluminors taken with a digital camera are given in the figures, Fig. 4.24 for BT crystal and Fig. 4.25 for ST crystal.

**IV.2.3.3.2 DC Electroluminescence**

On the initial application of a DC voltage, a high current flows and no light is observed. This is because the high conductivity of the phosphor surface and the interparticles themselves. At a critical power density, the current falls and light emission appears at the positive electrode. An increase in applied voltage produces a temporary rise in current density but this falls rapidly and the brightness increases. This is termed as forming process. The forming process does not occur simultaneously over the whole of the panel area but usually begins where the shortest current path that exists between the electrodes. This represents the region of
higher density. When forming takes place, the resistance of the phosphor increases and the current density falls. This increases the current density in adjacent unformed areas and forming will take place at this region. Thus the formed region will spread across the panel area until a complete plane of high resistance phosphor develops between the electrodes. These devices, except when pulsed, are invariably operated at a final forming voltage. On continuing the increase of the voltage, it leads to a further increase in resistance of the panel. Practically all the applied voltage is then dropped across the formed region and EL emission is obtained from the formed layer.

Fig.4.26. DC EL of BT crystal at different concentrations of the dopant (Mn).

Fig.4.27. DC EL of ST crystal at different concentrations of the dopant (Mn).
DC EL Brightness as a function of applied d.c voltage of B T electroluminor at different concentrations of the dopant (Mn) is given in Fig.4.26 and that of S T electroluminor is given in Fig.4.27. EL intensity increases with increasing Mn concentration and reaches the maximum at 2 M then decreases on increasing concentration due to concentration quenching.

Fig.4.28. DC EL of BT crystal at different annealing temperature.

Fig.4.29. DC EL of ST crystal at different annealing temperature.
DC EL intensities of both electroluminors at different annealing temperatures are given in Fig.4.28 and Fig.4.29. EL intensity increases with increasing annealing temperature and reaches the maximum at 100°C, then decreases on increasing annealing temperature due to the increase in the amorphous phase and disorders. The overall DC EL emission of the electroluminors is also a bluish one. DC EL emission photographs of the two electroluminors taken with a digital camera are given in the following figures (Fig 4.30 for BT and Fig 4.31 for ST crystals).

![Fig.4.30. DC EL emission photograph of BT crystal.](image1)

![Fig.4.31. DC EL emission photograph of ST crystal.](image2)

**IV.2.3.4 Photoluminescence Studies**

Photoluminescence (PL) is the spontaneous emission of light from a material under optical excitation. PL excitation and emission spectra are recorded in the wavelength range of 400-650 nm by using Flourimeter. Emission peaks of undoped BT crystals are observed around emission wavelength $\lambda_{em} = 409$ nm (see Fig.4.32), 508 nm (see Fig.4.34), and 610 nm (see Fig.4.36) with excitation wavelength $\lambda_{exc} = 372$ nm. Emission peaks of undoped ST crystals are observed around $\lambda_{em} = 417$ nm (see...
Fig. 4.38), 513 nm (see Fig. 4.40), and 620 nm (see Fig. 4.42), with excitation wavelength $\lambda_{ex} = 379$ nm.

Excitation and emission spectra were obtained by changing the excitation wavelength under a fixed emission wavelength and vice versa. PL Excitation spectra are taken for BT crystals with their $\lambda_{em}$'s and they show a band at 372 nm as shown in Fig. 4.32. PL Excitation spectra are taken for ST crystals with their $\lambda_{em}$’s and they show a broad band at 379 nm as shown in Fig. 4.38. The highest resolution used is 0.1nm for excitation and 0.3nm for the emission. The normal luminescent bands are attributed to interaction between emission centers and the host crystal lattice [41]. Thus the luminescent emission depends upon the nature of the activator and its concentration in the host lattice. At higher concentration the activator atoms destroy the matrix, which results in quenching of emission [42]. The presence of traps also influences the PL emission. The emission may be delayed due to their presence [43].
PL emission spectra of BT photoluminor doped with Mn are given in Figs. (4.32 - 4.37). Two separate figures are given to both the photoluminors for each emission wavelength is due to large difference in peak intensity on doping. The peak at 409 nm corresponds to $^2\text{D}_{5/2} \rightarrow ^2\text{P}_0^{3/2}$ transitions (6d - 6p) of Ba [44] and the peak at 610
nm correspond to $^2P^0_{3/2} \rightarrow ^2D_{5/2}$ transition (6p - 5d) of Ba [44]. The luminescent emission at 510 nm is originated because of the presence of some defects in the host lattice, which produces certain impurity site or centres during the preparation [33].

Fig. 4.35. PL emission at $\lambda_{em} = 507$ nm spectra of BT crystal at different concentrations of Mn.

Fig. 4.36. PL emission at $\lambda_{em} = 610$ nm spectra of BT crystal at different concentrations of Mn.
Fig. 4.37. PL emission at $\lambda_{\text{em}} = 610$ nm spectra of BT crystal at different concentrations of Mn.

Fig. 4.38. PL emission at 417 nm and 440 nm with $\lambda_{\text{exc}} = 379$ nm of ST crystal at different concentrations of Mn.
Fig. 4.39. PL emission at $\lambda_{em} = 417$ nm and 440 nm spectra of ST crystal at different concentrations of Mn.

Fig. 4.40. PL emission at $\lambda_{em} = 513$ nm spectra of ST crystal at different concentrations of Mn.
PL emission spectra of ST photoluminor doped with Mn are given in Figs. (4.38 - 4.43). The peak at 417 nm corresponds to $^{2}P_{1/2}\rightarrow^{2}S_{1/2}$ transition (4d - 5s) of ionized Sr [44]. A new broad peak is observed around 440 nm on doping which is due to the fact that the energy levels of host lattice is affected by that of the dopant Mn. This wavelength corresponds to the $a_{4}D_{7/2}\rightarrow a_{6}S_{5/2}$ transition (3d$^{6}(5d)$ 4s - 3d$^{5}4s^{2}$) of Mn [44]. The other two luminescent emissions are originated because of the presence of some defects in the host lattice as mentioned in the above paragraph.

The peak positions are not much affected on doping for both the photoluminors. PL intensity increases with increasing Mn concentration for both photoluminors. The increase in intensity of the peaks on doping is due to transfer of energy by the dopant through the levels of the host crystals. PL intensity reaches the maximum at 1.5 M concentration and
then decreases on increasing concentration due to concentration quenching as reported [45].

Fig.4.42. PL emission at $\lambda_{em} = 620$ nm spectra of ST crystal at different concentrations of Mn.

Fig.4.43. PL emission at $\lambda_{em} = 620$ nm spectra of ST crystal at different concentrations of Mn.
Fig. 4.44. PL emission at $\lambda_{em} = 409$ nm spectra of BT crystal at different annealing temperatures.

PL emission spectra of BT photoluminor at different annealing temperatures are given in Figs. (4.44 - 4.46) and that of Strontium Tartrate photoluminor are given in Figs. (4.47 - 4.49). PL intensity increases with increasing annealing temperature and reaches maximum at $100^0C$, then decreases on increasing annealing temperature for both the photoluminors.

Fig. 4.45. PL emission at $\lambda_{em} = 507$ nm spectra of BT crystal at different annealing temperatures.
Fig. 4.46. PL emission at $\lambda_{em} = 610$ nm spectra of BT crystal at different annealing temperatures.

Fig. 4.47. PL emission at $\lambda_{em} = 417$ nm spectra of ST crystal at different annealing temperatures.
Fig. 4.48. PL emission at $\lambda_{em} = 513$ nm spectra of ST crystal at different annealing temperatures.

Fig. 4.49. PL emission at $\lambda_{em} = 620$ nm spectra of ST crystal at different annealing temperatures.
Increase in PL intensity with temperature up to 100°C can be explained on the basis of impurity effect in the material. Photosensitivity will be decreased if imperfections act as efficient recombination centers. But photosensitivity will be increased if imperfections are having higher probability for capturing the minority carriers than the majority carrier. The decrease in PL intensity beyond 100°C is due to the increase in the expected amorphous nature and disorders on increasing temperature.

**IV.3 Conclusion**

Conditions for the growth of BT and ST crystals by controlled ionic diffusion of reactants through silica hydro gel have been optimized. The material confirmation was done by carrying out XRD, TGA and FTIR spectroscopy. In this chapter we have presented the electro-optical properties of the Mn doped BT and ST crystals. The XRD analysis shows crystalline nature of the BT and ST crystals. On Mn doping a few extra peaks were detected with lower intensities but the intensity of the prominent peak is decreased and that of certain other peaks were increased. This is due to the change in the atomic density of Mn in these planes.

The results of TGA and FTIR studies of BT and ST crystals were quite similar to those reported for tartrates. Band gap ($E_g$) was measured from Diffused Reflectance Spectroscopy (DRS) and is found to be 5.49 eV for BT crystals and 5.46 eV for ST crystals.

PC/PV of the crystals were studied as a function of intensity of light, annealing temperature and concentration of the dopant. PC variation as function of applied voltage is also studied. It is found that saturated value of photocurrent and photovoltage increases with increasing intensity.
of excitation for BT and ST crystals. Photocurrent also increases with increase in applied voltage. It is found that both the materials are more photosensitive at an annealing temperature of 100°C. On Mn doping PC/PV increases and shows maximum value at 1.5 M concentration. ST crystal is found to be more photoconducting and shows more photovoltaic effect than BT crystal.

AC/DC Electroluminescence Brightness increases with the applied electric field. The brightness of a powder EL cell increases non-linearly as excitation voltage is increased. AC/DC EL study on Brightness as a function of applied AC/DC voltage for both crystals at different concentrations of the dopant (Mn) and at different annealing temperatures is carried out. EL intensity increases with increasing Mn concentration and reaches the maximum at 2 M concentration, then decreases on increasing concentration. EL intensity increases with increasing annealing temperature and reaches the maximum at 100°C, then decreases on increasing annealing temperature. The EL phenomenon is very much influenced by presence of defects in the original crystal lattice. The overall AC/DC EL emissions of both electroluminors are bluish one. The AC/DC EL Brightness intensity of ST crystal reveals that it is a better electroluminor than BT crystal.

The Photoluminescence emission is observed for BT crystal around \( \lambda_{\text{em}} = 409 \text{ nm}, 508 \text{ nm}, \text{ and } 610 \text{ nm} \) with \( \lambda_{\text{exc}} = 372 \text{ nm} \) and that for ST crystal is observed at \( \lambda_{\text{em}} = 417 \text{ nm}, 440 \text{ nm}, 513 \text{ nm}, \text{ and } 620 \text{ nm} \) with \( \lambda_{\text{ex}} = 379 \text{ nm} \). The peak of BT crystal at 409 nm corresponds to \( ^2D_{5/2} \rightarrow ^2P^0_{3/2} \) transitions of Ba and the peak at 610 nm correspond to \( ^2P^0_{3/2} \rightarrow ^2D_{5/2} \) transition of Ba.
The peak of ST crystal at 417 nm corresponds to $^{2}p^{0}_{1/2} \rightarrow ^{2}S_{1/2}$ transition of Sr. A new broad peak is observed around 440 nm on doping which is due to the fact that the energy levels of host lattice is affected by that of the dopant Mn. This wavelength corresponds to the $^{4}D_{7/2} \rightarrow ^{6}S_{5/2}$ transition of manganese. But in BT system Mn doping creates no peak corresponding to it. The luminescent emission at 510 nm of BT crystal and the emissions at 513 nm and 620 nm of ST crystal are originated because of the presence of defects in the host lattice. The emission peak intensity reveals that both the materials could be used as a scintillator phosphor. PL intensity increases for both crystals with increasing Mn concentration and annealing temperature and reaches the maximum at 1.5 M and 100°C respectively. The PL intensity peaks reveals that ST crystal is a better photoluminor than BT crystal.
References


