CHAPTER VI

GENERAL SUMMARY AND BIBLIOGRAPHY
GENERAL SUMMARY

The main purpose of the present work is to study the energy loss of charged particles (e.g., α-particles and electrons) while travelling through some ionic crystals containing imperfections, created either by incorporation of foreign impurities or by thermal treatment or by both. The present investigation comprises the following works.

1) Arrangement for growing of single crystals, its shaping and surface preparation by wet-cut technique.

2) Production of F-centers by irradiation with α-particles of energy between 28 MeV and 50 MeV in pure and defect-inundated crystals of NaCl and KCl at room temperature.

3) Production of F-centers by irradiation with 50 KeV electrons in pure and impurity doped crystals quenched from different temperatures to room temperature.

4) Arrangement for the photoelectric scanning of the F-absorption spectra.

5) Estimation of depth of penetration of charged particles in the crystals by surface-stripping technique.

Samples of NaCl<100>, NaCl<110>, NaCl<100>:Mg (0.1, 0.01, 0.0001 at. %) and NaCl<100>:Al (0.1, 0.01 and 0.0001 at. %) crystals were irradiated with 28 MeV α-particles and the samples
of KCl<100>, KCl<110>, KCl<100>; Mg (0.01 at.) and KCl<110>; Mg (0.01 at.) were irradiated with 30 MeV α-particles. The irradiation dose was maintained at 0.12 μC in all cases. F-centers were produced uniformly over the surface of the crystals. The characteristic features of the F-absorption band of colored crystal, i.e. the position of maximum F-absorption (λ_m) and half-width (W) are found to remain almost the same in all the specimens of similar kind. The efficiency-value (average energy required to form an F-center) in KCl is found to be greater than that in NaCl. But for a particular specimen, the value of efficiency is independent of the crystal orientation and concentration of impurities present.

The range of α-particles in all the specimens were estimated from F-coloration depth. It is observed that the range value decreases as the concentrations of impurities increases in the crystals. This behaviour of the variation of range has been explained as due to the distortion of lattice potential by the impurities. The anomalous reduction of range due to impurity incorporation is attributed to dechanneling of α-particles arising from the impurity atoms displaced by irradiation.

The range of 28 MeV α-particles in NaCl and that of 30 MeV α-particles in KCl were theoretically calculated from energy-loss equation (3.6). The comparison between theory and experiment shows that the calculated range fits fairly well with
experimentally observed values in NaCl crystals but not in KC1 crystals. Similar type of discrepancy in KC1 crystals has been reported but no report on theoretical investigation is yet available.

Thin flakes of NaCl<100> and KC1<100> crystals were cleaved from single crystal lump and their surface preparations were made. In order to generate vacancies in the crystal, one sample of NaCl<100> was heated in an electric furnace for an hour at 473K and quenched to room temperature. Other samples were similarly heat treated at temperatures 673K, 773K, 873K and 973K respectively. All the heat treated samples (along with one untreated sample) were subjected to 40 MeV α-particle irradiation at room temperature. Another set of similarly prepared samples of NaCl NaCl<100> were subjected to 45 MeV α-particle irradiation under identical conditions. The irradiation dose was maintained at 0.12 μC in each case. A similarly heat treated set of KC1<100> was irradiated with 50 MeV α-particles under identical conditions. The position of maximum F-absorption and half-width remains almost unchanged in all the specimens. The F-center formation efficiency, an important parameter increases with the increase in energy of the α-particles but for a particular α-particle energy and for a particular sample, the value is independent of the temperature of heat treatment. The ranges of α-particles in all the specimens were estimated from the depth of coloration produced by irradiation of α-particles. The value of range was
found to decrease with the rise of temperature of heat treatment i.e., with the rise of concentration of vacancies in the crystal. At some critical value of temperature of heat treatment the range exhibits a minimum in its value. The range then gradually increases with further rise of temperature of heat treatment. This observation on the anomaly of range values, particularly in case of α-particles in ionic crystals has been explained in the light of the effect of vacancies on the axially channeled α-particles and the reduction of this effect as a result of aggregation of vacancies into clusters at higher temperature of heat treatment.

Samples of undoped NaCl<100> and NaCl<100> crystals doped with Mg (0.001, 0.01 and 0.1 at. %) and Al (0.001, 0.01, and 0.1 at. %) impurities were subjected to a series of heat treatment at 300, 373, 473, 573, 673, 773, 823, 873, 923, 973, and 1023K. After each heat treatment all the samples were irradiated with a beam of 50 KeV electrons. The F-absorption curves were drawn and range measurements were conducted.

The position of maximum F-absorption and the half widths were estimated for all the samples and the values are found to be independent of the concentration of different impurities and temperature of heat treatment. The efficiency of F-center formation was estimated in all cases and their values are found to be independent of both the temperature of heat treatment and
the concentration of impurities introduced into the crystals.

The ranges in undoped crystals were seen to decrease with the increase of the temperature of heat treatment up to a critical value and above that the range begins to increase with temperature of heat treatment. This behaviour of the variation of range is attributed to the effect of defect and defect-complexes on the channeled electrons. For doped crystals quenched from 923K or above a further decrease in range value is observed. This anomalous behaviour of the range of electrons in doped NaCl crystals was explained in the light of the interactions among different defect complexes in the crystals.