CHAPTER - VI

SUMMARY AND CONCLUSIONS

C H A P T E R - VI

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The ferroelectricity is an interesting and new field of dielectrics. The ferroelectrics are the materials which possess the spontaneous electric polarization. The ferro-electrics are a subgroup of the pyroelectrics in wihich the direction of spontaneous polarization can be reversed by an electric field. The ferroelectricity is rapidly growing field and efforts are devoted to ferroelectric devices using dielectric, piezoelectric and pyroelectric properties of these materials. As ferroelectrics are cheap source of dielectric and piezoelectric devices. These materials are becoming useful and vital component of the latest technology such as pyroelectric detection, memories, displays, printers, logic circuits, and electro-optic modulators.

Ferroelectrics continue to arouse the interest among the research workers as they hold promise in diverse new area of technology and their understanding is not yet complete. The scope for ferroelectrics is even further broadened in view of the significance of the related phenomena such as piezoelectricity, electro-optics, pyroelectricity, non linear dielectrics and liquid crystals.

In view of this increasing interest of ferroelectrics, in the present investigation an attempt has been made to prepare the crystalline materials, ferroelectric undoped sodium vanadate and doped with different concentrations of Neodymium oxide and studies were carried out on X-ray diffraction, dielectric hysteresis and coercive studies, d.c. electrical conductivity and pyroelectricity. The results have been presented in the chapters II to V of this dissertation.

Out of VI chapters, first chapter, is devoted to introduce sufficient theoretical back-ground based on existing literature.

In the second chapter, the crystalline material of sodium vanadate was grown from a stoichiometric mixture of $NaVO_3$ and V_2O_5 by the method similat to that reported by Feigelson et al (1972) and Hawthorne et al (1977). The mixture was slowly heated in a platinum crucible inside a globar furnace upto 750°C for 4 hr and then allowed to cool upto room temperature. Then the samples were prepared by adding Nd_2O_3 in different percentage from 0.025 to 1 mol% in $NaVO_3$. The Nd_2O_3 additive used was of purity 99.9% from John Baker Inc. Colorado U.S.A. Every batch of the mixture was dry mixed and then mixed wet with ethyl alcohol in agate mortor. After the alcohol was completely evaporated the batches were heated inside a globar furnace at 950°C for 5 hr in a platinum crucible. The pellets were prepared by applying 5 tonnes pressure using hydraulic press. The pressed pellets were sintered on platinum foil at 500°C for 3 hr inside a globar furnace. The pellets were painted with a thin layer of air-drying silver paste for good electrical contact and used for experimental purpose. Also in the second chapter, the lattice parameters of undoped sodium vanadate and doped with different concentrations of Neodymium Oxide were determined from X-ray charts. It is seen that the lattice parameters of undoped sodium vanadate are found to agree with Sorum (1943), Feigelson et al (1972) and Ramani et al (1975). Also, the values of the lattice parameters of sodium vanadate doped with different concentrations of Neodymium oxide are nearly equal to the results of the undoped sodium vanadate.

All ferroelectric materials exhibit the hysteresis loop. A modified form of Sawyer and Tower circuit (1930) was used for studying dielectric hysteresis and coercive field of undoped $NaVO_3$ and doped with the different concentrations of Nd_2O_3. Ferroelectric curie temperatures of the materials were determined by vanishing of hysteresis loop on oscilloscope screen.

Electrical conductivity measurements of undoped and Nd_2O_3 doped sodium vanadate were carried out in the temperature range covering the transition points by applying a constant d.c. voltage of 105 v/cm. This voltage were selected in the study of conductivity. The pellets of the sample were slowly heated in a furnace by applying a d.c. voltage of 105 v/cm and d.c. resistivity measurements were taken. The resistivity data was used to calculate the d.c. conductivity. The temperature variation of $\log\sigma$ against T^{-1} for undoped sodium vanadate and doped with different concentration of Nd_2O_3 was studied. To determine whether conductivity is ionic, electronic or mixed, the variation of electrical conductivity with time was studied at a constant temperature using electrodes which block ionic conduction.

Pyroelectric measurements were carried out by slow heating of the samples. The pyroelectric current was measured at various temperatures and corresponding time was recorded to calculate the rate of heating. Pyroelectric coefficients were calculated from the pyroelectric current measurements and heating rate. Variations of pyroelectric current and pyroelectric coefficients are studied with temperatures.

Dielectric hysteresis studies reveal that the hysteresis loss of these mixtures is small at room temperature, it broadens at a certain temperature. After certain temperature the loop width start to decrease and vanishes at curie temperature of the material. Similar, results were reported for $NaVO_3$ by Sawada et al (1951), Chavan et al (1985) and Patil et al (1988). The width of hysteresis loop depends upon the applied voltage and the sample used. It is found that the curie temperatures of different doping concentrations are different. The coercive field of Nd_2O_3 doped $NaVO_3$ increases for 0.025 to 0.5 mol%, however it decreases for 1 mol% of Nd_2O_3.

D.C. electrical conductivity studies conclude that the conductivity for undoped $NaVO_3$ below the curie temperature is mixed type (ionic-electronic), while above the curie temperature it is electronic. In the case of all doping mixtures the d.c. electrical conductivity below and above the curie temperature is mixed type (ionic-electronic). Electrical conductivity of all the materials increases with increase of temperature exponentially both in ferroelectric and paraelectric regions. A sharp change in electrical conductivity is observed at phase transition temperature, indicating the ferroelectric curie temperatures of all the respective materials. There is change in the curie temperature of undoped $NaVO_3$ doped with different concentrations of Nd_2O_3. It is similar with the results reported by Kuroda and Kubota (1980). The activation energy of all the materials is higher in the paraelectric state than in ferroelectric state and it depends upon doping concentrations of Nd_2O_3. The activation energy is maximum at specific content (0.5 mol%).

Pyroelectric current and pyroelectric coefficients are high for 0.5 mol% of Nd_2O_3. It is found that there is change in the curie temperature of all the samples for different concentrations of Nd_2O_3. The peak values of pyroelectric current and pyroelectric coefficients increase with increase of Nd_2O_3 concentrations upto 0.5 mol% and then decrease for higher concentrations. In the case of all doping mixtures, the pyroelectric current and coefficients are maximum at particular temperature indicating the curie temperatures of respective mixtures. These curie temperatures are confirmed by hysteresis loop method.

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