ABSTRACT

The emergence of practical and widely useful IR (Infrared) systems has been made possible by advances in IR sensing components. The growing requirement for sensitive infrared detectors which operate at room temperature has motivated the development of the pyroelectric detectors. The pyroelectric detector is one of the practical devices because it has proven to outperform other uncooled thermal detectors. With increasing demand for pyroelectric detector crystals, growth of these crystals in bulk becomes inevitable. The applications of these crystals include military systems, astronomical telescopes, earth observation cameras, laser technology, environmental analysis monitors, medical vidicons and Fourier Transform Infrared (FT-IR) instrumentation.

Single crystals for IR detection must have the low cost, low power requirement, wide operating range of temperature and frequency response, less hygroscopic and high chemical stability. It is very difficult to find materials with all the above properties. Pyroelectric single crystals required for the IR detection must have large pyroelectric coefficient, high resistivity, low dielectric constant, low thermal capacity and also the crystals have to be grown without much difficulty. Triglycine sulphate (NH$_2$CH$_2$COOH)$_3$H$_2$SO$_4$ is one of the best pyroelectric materials used for high performance IR detectors. The IR detectors fabricated from TGS crystals have advantages over photovoltaic detectors which need high power
and sophisticated cooling requirements. The fundamental characteristic of a detector is its voltage responsivity $R_v$, the ratio between the pyroelectric coefficient ($P$) and the specific heat ($c_p$). The high $R_v$ of TGS together with the relative ease of growing large high quality crystals has made TGS and its family crystals the most popular materials for pyroelectric detectors. In order to modify and still improve the properties for applications in IR detection, the addition of organic dopants in TGS were carried out. For the fabrication of IR detectors and imaging systems, large size TGS crystals of wide $b$-plane are required for which studies on fundamental growth parameters such as the solubility and metastable zone width measurements are very essential. Many authors have investigated the solubility of pure and doped TGS but the reports on the basic growth parameters are scarce.

In TGS, glycine itself is one of the amino acids. The substitution of another amino acid in the place of glycine has been found to improve the crystal properties by contributing to effective internal bias in these crystals which in turn inhibits ferroelectric switching giving a permanently poled single domain crystal. This improves the device characteristics and hence L-alanine and L-valine doped TGS crystals have been investigated in the past by many researchers.

The present investigation deals with the nucleation, growth and characterization of pure and doped Triglycine sulphate (TGS) crystals. The classical theory of homogeneous nucleation has been employed to evaluate the nucleation parameters. The rates of nucleation were evaluated by the induction time measurements for pure and amino acid doped TGS crystals.
The presence of impurities has enhanced the rates of nucleation and hence reduced the induction time. The interfacial energy for pure and doped solutions has been calculated.

Growth conditions and stability of pure and amino acid doped TGS crystals have been investigated. Computer controlled optically heated constant temperature bath with a high precision temperature control to an accuracy of ± 0.01°C has been fabricated. An investigation has been made on the basic growth parameters such as the solubility and metastable zone width. It has been found that both the solubility and metastable zone width reduce with doping of amino acids. The type of seed used for the growth experiments play a vital role in the external habit formation of the crystal. Seeds of different orientation have been investigated and it was found that while using a fabricated (001) seed, the crystal ended with a wide b-plane which is a favourable one for IR detector fabrication. Highly transparent TGS crystals of size 9x5x4 cm³ were grown. Morphology and growth rate changes have been observed while doping the crystals with L-alanine and L-Valine.

The electrical and mechanical characterization of pure and amino acids doped TGS crystals have been investigated. The variation of pyroelectric coefficient and dielectric constant as a function of temperature was measured for pure and doped crystals. The addition of amino acids has enhanced the pyroelectric figure of merit which is an essential one for device applications. Lattice parameters have been calculated from single crystal X-ray diffraction analysis. Microhardness measurements were made
for pure and doped crystals which reveal a reduction of hardness due to doping with amino acids. The presence of dopants in the crystals was qualitatively inferred by the FTIR studies.

Growth and characterization of Benzophenone and Urea doped TGS crystals have been investigated. Optical quality single crystals of Benzophenone and Urea doped TGS were grown. The doping has affected the growth rate and morphology. In the case of Benzophenone doped TGS the growth rate along (010), (001) and (100) were less; when compared to that of pure TGS crystal. In case of Urea doping the growth rate was enhanced much higher in the (010) direction leading to a wide (110) face. The pyroelectric coefficient measurements reveal that the pyroelectric coefficient of doped crystals is higher than pure TGS crystal. Dielectric measurements reveal an increase in dielectric constant values for Benzophenone doped crystals. This is attributed to the symmetric structure of Benzophenone. In the case of Urea doping, there is a decrease in dielectric constant leading to a higher figure of merit than the pure TGS crystal. The microhardness measurements reveal that Benzophenone and Urea doping has increased the hardness of the crystal which is a favourable one for IR detector fabrication.

The results presented in the thesis have been published in International journals and presented in several National / International conferences.