CHAPTER 10

CONCLUSIONS AND SCOPE FOR FUTURE WORK

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10.1 INTRODUCTION

As already mentioned in the preface, the main purpose of the thesis has been to carry out a systematic study to obtain single crystals of calcium molybdate, through a synthetic method, after choosing the best suitable technique from a wide variety of available ones and to study their important properties e.g., dielectric, electrical, magnetic, mechanical etc. The systematic studies thus carried out have been described and discussed in the preceeding chapters. Finally, in the present chapter the author intends to evince some general conclusions drawn from the studies carried out and a scope for the future work.

10.2 CONCLUSIONS FROM THE FLUX GROWTH OF $CaMoO_4$

The normal flux technique employed by the author is different from the flux reaction technique in which it is necessary to put the chemical constituents of the eventual crystal into a state of mobility and then to provide conditions conductive to reassembling the products atom by atom or molecule by molecule, to form continuous crystal domain. Here, the artificially prepared solution is made to supersaturate at a desired, much higher than the normal - room temperature but below the melting temperature. Thus the normal flux method, employed in the present work, is intermediate in character between high temperature and solution methods, having much in common with each.

The single crystal growth by flux method, as of calcium molybdate, is studied by two ways : by slow cooling and by isothermal evaporation, after collecting the solubility data, at a particular temperature, and then determining the necessary optimum compositions of the solvent and the solute. Crystal morphology, crystal quality and crystal size are sensitive to different growth conditions, namely, composition of the starting materials, soak period, soak temperature and the employed cooling rates. After selecting the appropriate growth parameters, one can obtain the desired size, morphology and quality of the crystals. Large evaporation periods impair the quality of the crystals. Hence the growth must be carried out at moderate temperatures, employing not-so-large evaporation period and the cooling rate as low as possible for a better quality of the crystals. The microstructures of the habit faces bear a good correlation with growth conditions so that one can derive the latter from a study of the former. The commonly observed dendrites on the as-grown faces of the flux-grown crystals may be due to faster solute deposition rate during the terminating stage of growth at the eutectic of the fluxed melt which takes place by the rapid increase of supersaturation. Besides, the upward surface of a floating crystal shows hopper formation. The typical striations, growth hillocks are generally not uncommon for the crystals grown from the flux. The exact growth mechanism is governed by several factors such as the growth rate, growth direction, defects in crystals, etc. In addition, some factors hitherto unknown need thorough probing.

The kinetics of crystallization is studied with a view to understand the growth mechanism. The author studied them through the unstirred supersaturated solutions of lithium chloride at 700 and 750°C, as mentioned in chapter 6. It is concluded that both the diffusion and the convection are important phenomena inductive to controlling the growth velocity. But, in the case of relatively smaller crystals (10 μ), convection may be neglected in view of the very low velocity of growth fronts in normal gravity fields. In the present case, the growth of the longer side of the bipyramidal crystal is diffusion rate controlled upto an extent of more than 60 % in the temperature range of 700 and 750°C. One is also inclined to believe that the final crystal size and number are much dependent on the temperature of crystallization.

10.3 CONCLUSIONS FROM CHARACTERISTIC PROPERTIES

To understand the mechanical behaviour of the grown crystals, microindentation studies are worth to be carried out on the different faces, at different temperatures. The softness of atomic packing along the crystallographic cleavage direction has been confirmed. It is also suggested doubtlessly that the variation in Vickers microhardness number, in the load independent region, depends on the nature of different thermal treatments given to the sample, like quenching and/or annealing. The Vickers hardness is seen to increase with increase in the quenching temperature and to decrease with increase in the annealing temperature. The development of different surface cracks and their propagation, the material chipping and erosion in and around the indentation marks are all found to depend on the applied load within proper limit. Moreover, the two micromechanical quantities, namely, Vickers hardness number and the velocity of crack propagation, bear close mutual dependency to certain extent. One can assess qualitatively the general nature of subsurface damage beneath the indenter by an assessment of the surface damage around the indentation mark.

To study and understand the different polarization mechanisms in solids, dielectric constant and dielectric loss tangent measurements have been carried out as a function of frequency and temperature on single crystals and pellets. Both the dielectric constant and the dielectric loss tangent decreased with increase in the frequency and increased with increase in the temperature. The higher values of dielectric constant at low frequencies are to be understood by the space-charge polarization caused by unidentified impurities or low concentration of crystal defects.

With a view to understanding the defect chemistry of the crystalline solids, their electrical conduction has been studied as mentioned in chapter 9. The variation in conductivity with temperature is found to depend on the type of electrode material used. The migration of the defects in the oxide sublattice probably contributes to the conductivity in the intrinsic region, while the extrinsic conduction may be attributed to some sort of impurities.

10.4 SCOPE FOR FUTURE WORK

There are still a considerable number of aspects which deserve further investigations in detail, to add definitely something to the existing knowledge of the most fascinating branch of materials science, namely "Crystal Growth and Characterization".

The studies carried out in better growth conditions, i.e. very slow cooling rates, using well-programmed temperature controls, are expected to give better quality and also the size of crystals. Crystalline perfection must be studied by Lang microfocus topography. A lot of work on growing rare-earth doped crystals and mixed matrices with other compounds of the Scheelite family can be accomplished and the consequent changes in the properties would open challenging fields for further research work. The work can be furthered on the study of the mechanical properties in detail e.g. breaking strength, elastic-plastic properties in the case of pure and doped crystals. The work can be extended to the study of transport properties, employing a wider range of the working frequencies, temperature, bias voltage, etc. Beta radiations absorption by Scheelites can also be investigated, if very thin sections of these samples are made available. The study of scattering coefficients at grain boundaries in crystals and the usefulness of synthetic species in commercial laser-maser units is worth seeking.