Preface

Nonlinear optical (NLO) materials play a key role in the advancement of Photonic technology the most widely exploited NLO phenomena being optical frequency conversion and electro-optic modulation The Thesis reports the fabrication and characterization of novel materials which can be exploited for two particular second order NLO applications the electro-optic (EO) light modulation and optical second harmonic generation (SHG) These materials by virtue of their strong polar nature, also find wide applications as pyroelectric sensors piezoelectric transducers ferroelectric memory elements etc

In the recent past electro-optic activity has been demonstrated in transparent materials comprising of ferroelectric crystallites dispersed in a glass matrix The advantage of these materials over the conventionally used electro-optic materials like polycrystalline transparent ceramics and single crystals lies in the capacity and diversity of glass-forming processes It is comparatively easier to achieve transparency through the controlled nucleation and growth of minute crystals in a glass matrix than by most other ceramic processes Optical transparency in these diphasic systems can be achieved either by controlling the size of the crystallites to be much smaller than the wavelength of visible light or by ensuring optical isotropy i e matching the refractive index of the dispersed crystallites and the surrounding medium The fabrication and characterization of novel materials comprising of electro-optic crystallites dispersed in glass matrices are reported in this Thesis It is envisaged that these materials will emerge as viable alternatives to bulk single crystals in electro-optic applications

The major limitation with electro-optic light modulation scheme is the high electric field requirement One of the ways by which the voltage requirement of an electro-optic modulator can be significantly reduced is to operate it at its piezoelectric resonance frequency At the piezoelectric resonance frequency of the modulating medium, the piezo-optic effect dominates the modulation process The photoelastic contribution to the birefringence can be so large that the driving field is reduced by orders of magnitude Hence an *apriori* knowledge of the frequency response of the EO materials would help in exploiting these materials for resonance enhanced EO modulation Dielectric dispersion studies in electro-optic molecular crystals have culminated in the identification of strong piezoelectrically induced resonances The present findings facilitate the exploitation of these crystals in piezo-resonant electro-optic modulators

The following research publications are largely based on the investigations conducted as part of the research reported here

(a) Refereed Journals

1 K B R Varma M V Shankar and G N Subbanna Structural and Dielectric characteristics of Strontium tetraborate Bismuth Vanadate Glass Ceramics *Mater Res Bull*, 31 5 (1996) 475

2 M V Shankar and K B R Varma, Dielectric and Optical Properties of Strontium tetraborate glasses *J Mater Sci Lett* 15 (1996) 858

3 M V Shankar K B R Varma R T Bailey F R Cruickshank, D Pugh and J N Sherwood, Dielectric dispersion and piezoelectric resonance in an organic NLO crystal MBA NP *J Appl Phys* 81 (5) (1997) 2370

4 M V Shankar and K B R Varma, Piezoelectrically stimulated dielectric dispersion in KAP single crystals *Mater Chem and Phys* 49 (1997) 78

5 M V Shankar and K B R Varma, Piezoelectric Resonance in KAP single crystals *Ferroelectrics Lett* 21 (1996) 55

6 M V Shankar K B R Varma, G V R Sharma, A Srikrishna B R Prasad C K Subramaniam and P S Narayanan Microstructural and non linear optical properties of hot pressed ethoxy methoxy chalcone (EMC) *Ferroelectrics* 156 (1994) 141

7 M V Shankar G N Subbanna and K B R Varma, A novel nanocomposite $Bi_2VO_{5.5}$ SrB_4O_7 *Bull Mater Sci*, 18 7 (1995) 931

8 M V Shankar and K B R Varma Dielectric dispersion induced by piezoelectric resonance in Benzil single crystals grown by Bridgman-Stockbarger technique, *Bull Mater Sci* 19 5 (1996) 791

(b) Books and Conference Proceedings

9 K B R Varma and M V Shankar Structural and dielectric characteristics of novel Bi_2O_3 TiO_2 SrB_4O_7 glasses IEEE Proceedings of the International Symposium on the Application of Ferroelectrics (1996) (In Press)

10 M V Shankar and K B R Varma, Structural and dielectric characteristics of Bi_2O_3 V_2O_5 SrB_4O_7 glass-ceramics **IEEE Proceedings** of the International Symposium on the Application of Ferroelectrics (1996) (In Press)

11 M V Shankar and K B R Varma, Ferroelectricity and second order optical non linearity in TeO_2 $LiNbO_3$ surface crystallised Glasses *Applications of Photonic technology* Vol 2 (G A Lampropoulos and R A Lessard eds) **Plenum Publ** NY (1996) (In Press)

12 K V R Prasad M V Shankar G N Subbanna and K B R Varma, Principles of SEM for structural characterisation, *Handbook of Advanced Materials Testing* (N P Cheremisinoff and P N Chermisinoff eds) Marcel Dekker (1994) 51

13 Sheela K Ramasesha K V R Prasad M V Shankar and K B R Varma, The dielectric properties of $Bi_2VO_{3.5}$ under pressure
Advances in High pressure Science and Technology (A K Singh ed) Tata McGraw Hill New Delhi 85 (1994)

14 M V Shankar K B R Varma, T J Reddy and A Srikrishna, Growth and character isation of organic NLO crystals (Benzil and EMC), Proc Conference on Emerging Optoelectronic Technologies (CEOT 94) Tata McGraw Hill (1994) 63

15 M V Shankar and K B R Varma, An inexpensive system for the growth of organic NLO crystals Proc Fifth National seminar on Crystal Growth (1993) 136

16 M V Shankar and K B R Varma, Novel nanocrystalline glass-ceramics Proc International conference on the physics of disordered materials, India (1997) (In Press)

(d) Papers communicated

17 M V Shankar and K B R Varma, Nanocrystallisation of ferroelectric bismuth vanadate in SrB_4O_7-Bi_2O_3 V_2O_5 glasses (J Non Cryst Solids) (1997) (Communicated)

18 M V Shankar and K B R Varma, Fabrication and characterization of transparent strontium tetraborate glasses containing ferroelectric barium titanate, (Phys & Chem Glasses) (1997) (Communicated)

(e) Manuscripts under preparation

19 M V Shankar and K B R Varma, Crystallization and Piezo-resonant characterization of strontium tetraborate glasses containing ferroelectric bismuth titanate, (J Appl Phys)

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20 M V Shankar and K B R Varma, Fabrication and characterization of novel glasses in the $SrB_4O_7 - Bi_2O_3 - TiO_2$ and $SrB_4O_7 - Bi_2O_3 - TiO_2 - Nb_2O_5$ systems (J Mater Chem)

21 M V Shankar and K,B R Varma, Pyroelectricity ferroelectricity and optical nonlinearity in TeO_2 glasses containing $LiNbO_3$ microcrystallites (J Mater Res)

22 M V Shankar and K B R Varma, Dielectric and optical characteristics of Cesium lithium borate glasses (Mater Res Bull)