CHAPTER 6

C O N C L U S I O N S

CHAPTER 6 CONCLUSIONS

In this thesis the electro-optic properties of a comparatively thick cell of a ferroelectric liquid crystal, whose helical structure has been deformed by an electric field are investigated. Though relatively higher switching voltages are required in this case, the cell thickness and quality of alignment are not that critical, as in the case of thin film configurations, in deciding the electro-optic properties of the cell. Further it reveals some novel electro-optic effects.

A new ferroelectric material OBOB is studied in this work. The phase transition sequence is studied by differential scanning calorimetry and texture observations. It shows that on heating, from the ferroelectric SmC* state the material passes to cholesteric state instead of the usual SmA phase observed for most of the ferroelectric liquid crystals. Further OBOB has a high degree of twist (pitch of the order of tenths of microns) and a comparatively high value of spontaneous polarisation which is a characteristic feature of materials with this phase transition sequence. This gives rise to a critical unwinding field of very high value and hence to a range of partially unwound states corresponding to different applied fields.

From DSC studies and texture observations the temperature range, in which OBOB is ferroelectric is confirmed as 65° C to 74° C. All the material parameters of the ferroelectric liquid crystal such as spontaneous polarisation, rotational viscosity and dielectric constant are evaluated in this temperature range. The variation of these properties with temperature also has been studied by various methods. Results show that OBOB has a fairly large value of spontaneous polarisation (25 nC/sq.cm) and rotational viscosity (900 m.Pa.S). A high value of spontaneous polarisation reduces the response time where as that of rotatonal viscosity increases it. But a moderately high value of rotational viscosity is necessary for stabilising the switched state. The fact that OBOB exhibits fast response and a latched state shows that the compromise between these two material constants is ideal in this material. The dielectric anisotropy of the material is determined for various frequency ranges and is found to be negative. This shows that ac field stabilisation methods can also be used to align the material in specific configurations.

Response times of the order of hundreds of microseconds are obtained for cell thickness of 15 to 20 microns. After switching, the ferroelectric liquid crystal retains the optical transmission levels for a long time. Further the extent of switching is found to depend both on height and duration of the square pulse.

Below a certain value of pulse height there is no electro-optic switching, irrespective of the width of the pulse. Thus the switching shows a threshold behaviour which is a prerequisite for multiplexing. Hence when this ferroelectric liquid crystal is used as pixels for such multiplxed displays cross talk will be minimum.

Another interesting result is that a pulse whose height/ width combination is near to but lower than that of the threshold value, can bring the high transmission state back to opaque state. Hence these pulses can be used as reset pulses. To avoid cumulative switching in pixels such pulses can be applied in between two information signals.

The presence of an optical threshold voltage, a memory state and a one to one correspondense of optical transmission level to a pulse width/ height combination shows that this ferroelectric liquid crystal can be used as pixels for multiplexed dynamic displays.

A ferroelectric liquid crystal material used as an electro-optic modulator or light valve will be subjected to signals of continuously varying frequency and amplitude. A detailed study is conducted to evaluate the performance of

OBOB under such conditions.

When samples of OBOB, prepared in planar orientation is subjected to sine wave signals, the light passing through the material is not properly modulated. But on applying the signal along with a dc bias, exellent modulation of light is obtained. Experiments done with continuously varying signals and audio signals showed that up to 5kHz good modulation depth is obtained in this material. Experiments done with thin samples (still $d>p$) showed similar results.

A qualitative analysis based on the change in direction of the average optical axis under an applied field explains these results. At moderate voltages, due to the extremely high value of the critical unwinding field of OBOB, the helix is only partially unwound. When a low voltage, time varying signal is applied to such a deformed helix, small perturbations are produced to the molecular orientations. Then the variations in the space averaged value of the projection of the phase angle on the cell plane ($\langle \theta \rangle$) will be linear to the applied field. This explains the variations in light intensity with the signal. This property makes the material suitable for applications in electro-optic modulators.

This modulating property of the ferroelectric liquid crystal can find applications in the field of optical communication and optical information processing such as pattern recognition and optical computing. One of the important problems that remains in this field is the development of a high contrast, high resolution spatial light modulator capable of performing functions such as incoherent to coherent image conversion, light amplification and spatial information storage. Presently nematic liquid crystals are used as light modulators along with some photoconductors. Instead, if ferroelectric liquid crystals in the deformed helix configuration are used as modulators, cosiderable improvement in response time, contrast ratio and resolution will be attained.

From these investigations and discussions it is evident that the electro-optic effects in the SmC* state of OBOB have many advantages over other known liquid crystal effects. Most important is the director orientation under the influence of electric fields of different signs. Here one can achieve a high rate of switching from one optical state to another. The experiments showed the possibility of obtaining 100% modulation of light beam for frequencies upto 5 kHz. As the condition d>p can be maintained for OBOB even at one or two micron thickness, such materials can be very usefull in fabricating integrated devices. With ferroelectric liquid crystals of higher spontaneous polarisation and lower rotational viscosities higher switching speeds and modulation corresponding to higher frequencies can be realized.