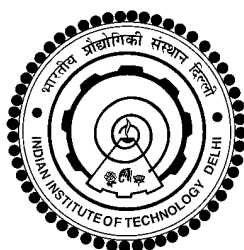


EFFECT OF NANO-MATERIALS ON THE ELECTRO-OPTICAL PROPERTIES OF DEFORMED HELIX FERROELECTRIC LIQUID CRYSTALS AND THEIR APPLICATIONS

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MAY 2010**

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By

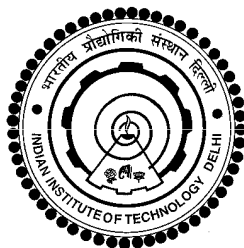
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DOCTOR OF PHILOSOPHY

to the



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MAY 2010

CERTIFICATE

This is to certify that the thesis entitled **“EFFECT OF NANO-MATERIALS ON THE ELECTRO-OPTICAL PROPERTIES OF DEFORMED HELIX FERROELECTRIC LIQUID CRYSTALS AND THEIR APPLICATIONS”** being submitted by **Jai Prakash** to the Indian Institute of Technology Delhi for the award of the degree of **“DOCTOR OF PHILOSOPHY”**, is a record of the authentic research work carried out by him under our supervision and guidance. He has fulfilled all the requirements for submission of this thesis, which to the best of our knowledge has reached the required standard.

The material contained in this thesis has not been submitted in part or full to any other University or Institute for the award of any other degree.

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Date:

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ABSTRACT

Liquid crystals (LCs) have shown their importance as a promising materials in various display as well as non-display (optical devices based on LC) applications in modern technology. Most of the displays currently available in the market are based mainly on LCs. Present work is an attempt to bring the attention of researchers in exploring the potential of nano-materials doped LC or ferroelectric LCs (FLCs) in other disciplines apart from parent area of LCs, i.e. optical devices, photoluminescent LC displays (LCDs), faster LCDs and memory devices. In the present study, effect of nano-materials on the electro-optical properties of deformed helix FLC (DHFLC) and their applications has been discussed. These studies can be applied in various disciplines of science and engineering for the fabrication of several devices.

Chapter 1 presents the introduction of LC, its classification and various applications along with a brief review of the present status of the field.

Chapter 2 describes the techniques used in the fabrication of sample cells, instruments involved in the characterization of these cells. To carry out the LC research, the systematic study of LCs is very important to know the physical, chemical, electro-optical and dielectric properties of LC. The methods used for the determination of material constants of LCs have also been described in this chapter.

Chapter 3 demonstrates the critical conditions for bistability in DHFLC. The bistability in surface stabilized FLCs (SSFLCs), in which the thickness of the sample

cell is kept less than the pitch value of the material, is a consequence of broken symmetry and is an inherent feature of the SSFLC geometry. The bistability phenomenon in DHFLCs is not like the conventional FLC material where it is due to surface stabilization effect. As the pitch value of the DHFLC material is in submicron range, the bistability in DHFLC is entirely a different concept related to helix deformation and molecular reorientation process. However, a bistable switching and a memory element with a reasonable working voltage and response time have been observed in DHFLC. In this chapter, we have presented introduction, history, and salient features of DHFLC material including basic mechanism of DHF effect. The dynamics of bistability in DHFLC have been demonstrated in detail. The threshold voltage studies and the molecular reorientation processes have also been presented to explain dynamics of bistability in DHFLC.

Chapter 4 presents the effect of surface anchoring on optical bistability in DHFLC. The important part in the construction of LCDs relies on the process of alignment. The surface anchoring effect plays a key role in the field of LC in order to get alignment (whether it is homogeneous, homeotropic, or hybrid). There are several alignment techniques to align LC molecules. The surface anchoring effect in FLCs are difficult to study due to complexity in surface interactions caused by the introduction of spontaneous polarization and layer structure. In this chapter, it has been shown that an ultraweak anchoring lowers the saturation voltage and favors the best memory effect in DHFLC. The lowering of the saturation voltage has been confirmed by taking the variation of tilt angle for different DC voltages in weakly anchored DHFLC cells. This chapter also

proposes the perfect memory effect in broad frequency range in DHFLC material without any surface treatment which has been shown for the first time. The current chapter also describes the dependence of response time on the surface anchoring and the cell thickness.

Chapter 5 covers the effect of doping of nanoparticles (NPs) on the memory of DHFLC material. The NPs doped LCs have been studied extensively for observing the different aspects such as electro-optical, dielectric, memory effect, phase behavior *etc.* Much of the reported work has been focused on nematic LCs. In this chapter, a long lasting nonvolatile memory effect in gold NPs (GNPs) doped DHFLC material has been demonstrated. The long lasting memory effect in DHFLC cells has been observed by using dielectric and electro-optical methods. The memory effect in such systems has been explained on the basis of the electric field induced charge transfer effect and the stabilization of helix deformation process.

Chapter 6 describes the effect of carbon nanotubes (CNTs) on the response time of DHFLC. The doping of CNTs in LCs has been pursued for improving their electro-optical properties, dynamic response and other physical parameters. This chapter deals the results of the fast electro-optic response of multi walled CNTs (MWCNTs) doped DHFLC material. The fastening of the response in MWCNTs doped DHFLC has been explained on the basis of decrease in rotational viscosity, increase in anchoring energy, loosening of molecular packing. This chapter also proposes the increase in conductance in MWCNTs doped DHFLC.

Chapter 7 gives the effect of doping of GNPs on the photoluminescence of DHFLC. The main drawbacks of the LC based display devices are their low brightness and energy efficiency due to the use of polarizers and absorbing color filters. The enhanced electromagnetic fields generated near the metallic NPs surfaces can enhance the fluorescence of chromophores (light emitting centers) in close proximity to the surface as well as metal itself. The present chapter describes the characterization of newly synthesized DHFLC material, namely LAHS19, using different experimental techniques. The chapter too illustrates the enhancement of luminescence intensity in GNPs doped DHFLC material on the basis of interaction of DHFLC molecules with GNPs. The enhanced photoluminescence in GNPs doped DHFLC material would provide a cutting edge tool in the realization of enhanced photo luminescent LCDs.

Chapter 8 presents the application of LC in optical devices (we have taken the example of phase shifting interferometer). The realization of LC based phase shifting interferometer has been described. Phase-shifting interferometry is a common optical technique for non contact surface profilometry. The application of LC technology to a lateral shearing phase-shifting interferometer has also been described. The difference between a traditional shear plate and the LC version is the additional phase that is accumulated owing to the LC layer. The present chapter describes the realization of LC based phase shifting interferometer because the contrast of the fringes presented in earlier LC based phase shifting interferometer was poor. The improvement in the contrast of fringes was achieved by coating the LC cell surfaces with reflecting material. The voltage

dependent phase shifting has been presented in nematic LC based phase shifting interferometer.

Chapter 9 summarizes the important findings and results obtained from electro-optical properties of pure and nano-materials doped DHFLCs as discussed in chapters 3 – 7. The conclusion of application of LC technology to the realization of phase shifting interferometer (as presented in chapter 8) has also been discussed in this chapter. The future scope has been explored on the basis of above work from both basic and applied research points of view and presented in this chapter.

CONTENTS

<i>CERTIFICATE</i>	i
<i>ACKNOWLEDGEMENT</i>	ii
<i>ABSTRACT</i>	iv
<i>CONTENTS</i>	ix
<i>LIST OF FIGURES</i>	xv
CHAPTER 1:	
INTRODUCTION	1-3
1.1 Introduction	1
1.2 Classification of liquid crystals	2
1.2.1 Thermotropic liquid crystals	4
1.2.1.1 Non-chiral calamatic phases	4
1.2.1.2 Chiral calamatic phases	8
1.2.1.3 Discotic mesophase	13
1.2.2 Lyotropic liquid crystals	14
1.3 Ferroelectric liquid crystal	15
1.3.1 Early picture of ferroelectricity in liquid crystals	16
Initial studies (1974-1980)	
1.3.2 Surface stabilized ferroelectric liquid crystals	23
1.3.3 Deformed helix ferroelectric liquid crystals	27
1.3.4 Electroclinic liquid crystals	29
1.4 Other type of liquid crystals	31
1.4.1 Polymer liquid crystals	31
1.4.2 Polymer dispersed liquid crystals	31

1.5	Applications of liquid crystals	31
1.5.1	Optical devices based on liquid crystal	33
1.6	Effect of nano-materials on the electro-optical properties of DHFLC and their applications	34
CHAPTER 2:	EXPERIMENTAL TECHNIQUES	38-70
2.1	Introduction	38
2.2	Fabrication of liquid crystal cells	38
2.2.1	Deposition of a transparent conducting coating on glass plates	39
2.2.2	Photolithography and etching	41
2.2.2.1	Photolithography	41
2.2.2.2	Substrate cleaning and photoresist application	41
2.2.2.3	Soft baking	42
2.2.2.4	Mask alignment and exposure	42
2.2.2.5	Development and hard baking	43
2.2.2.6	Etching	43
2.2.3	Alignment	44
2.2.3.1	Homogeneous alignment	44
2.2.3.2	Homeotropic alignment	46
2.2.4	Assembling, sealing and filling the cell	47
2.3	Instruments and experimental techniques used for determination of material constants of liquid crystals	49
2.3.1	Transition temperature	51
2.3.2	Tilt angle	51

2.3.3	Helical pitch	52
2.3.4	Spontaneous polarization	53
2.3.5	Measurement of response time	56
2.3.5.1	Electrical method	57
2.3.5.2	Optical method	58
2.3.6	Measurement of coefficient of viscosity	59
2.4	Dielectric measurements	59
2.4.1	Dielectric spectra in chiral smectics	60
2.4.2	Debye and Cole Cole model	63
CHAPTER 3:	CRITICAL CONDITIONS FOR BISTABILITY IN	71-97
	DEFORMED HELIX FERROELECTRIC LIQUID	
	CRYSTALS	
3.1	Introduction	71
3.1.1	History of DHFLC material	73
3.1.2	Salient features of DHFLC materials	75
3.1.3	Basic mechanism of DHF effect	75
3.1.4	Memory effect in DHFLC material	78
3.2	Experimental details	79
3.3	Results and discussions	81
3.3.1	Threshold field (voltage) studies	81
3.3.2	Helix deformation	90
3.3.3	Effect of voltage and frequency on memory	93

3.4	Conclusions	97
CHAPTER 4:	ROLE OF SURFACE ANCHORING IN BISTABILITY IN	98-
	DEFORMED HELIX FERROELECTRIC LIQUID	116
	CRYSTALS	
4.1	Introduction	98
4.1.1	Surface anchoring effect in LCs	99
4.1.2	Weak anchoring effect in LCs	100
4.2	Experimental detail	101
4.3	Results and discussions	103
4.3.1	Effect of surface anchoring on saturation voltage in DHFLC material	103
4.3.2	Effect of surface anchoring on memory in DHFLC material	105
4.3.3	Effect of surface anchoring on response time in DHFLC material	113
4.4	Conclusions	116
CHAPTER 5:	EFFECT OF DOPING OF NANOPARTICLES ON THE	117-
	MEMORY IN DEFORMED HELIX FERROELECTRIC	130
	LIQUID CRYSTALS	
5.1	Introduction	117
5.1.1	Basic properties of gold nanoparticles	118
5.1.2	The early ideas of doping of nanoparticles in liquid crystals	119
5.1.2	The recent development of memory effect in nanoparticles doped liquid crystals	119
5.2	Experimental details	120
5.3	Results and discussions	122

5.4	Conclusions	129
CHAPTER 6:	EFFECT OF CARBON NANOTUBES ON THE	131-
	RESPONSE TIME IN DEFORMED HELIX	145
	FERROELECTRIC LIQUID CRYSTALS	
6.1	Introduction	131
6.2	Experimental details	134
6.3	Results and discussions	136
6.4	Conclusions	144
CHAPTER 7:	EFFECT OF DOPING OF NANOPARTICLES ON THE	146-
	PHOTOLUMINESCENCE IN DEFORMED HELIX	162
	FERROELECTRIC LIQUID CRYSTALS	
7.1	Introduction	146
7.1.1	Recent trends of photoluminescence in metal nanoparticles and nanoparticles doped liquid crystals	147
7.2	Experimental details	149
7.3	Results and discussions	150
7.3.1	Characterization of newly synthesized DHFLC materials	150
7.3.2	Photoluminescence study	156
7.4	Conclusions	161
CHAPTER 8:	REALIZATION AND APPLICATION OF LIQUID	163-
	CRYSTAL PHASE SHIFTING INTERFEROMETER	178
8.1	Introduction	163
8.2	Basic concepts and advantages of PSI	165

8.3	Theory of analysis: Detection of the wavefront phase	166
8.4	Experimental Design and implementation of liquid crystal phase shifting interferometer	169
8.5	Results and discussions	175
8.6	Conclusions	178
CHAPTER 9: CONCLUSIONS AND FUTURE SCOPE OF THE WORK		179-
		184
<i>REFERENCES</i>		185
<i>LIST OF PUBLICATIONS</i>		206
<i>AUTHOR'S BIOGRAPHY</i>		209