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CONTINUOUSLY TUNABLE LARGE APERTURE LIQUID CRYSTAL BASED  
LENS FOR DE-FOCUS AND ASTIGMATISM CORRECTION (213 PP.)

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In imaging system, de-focus and astigmatism are the most common optical aberrations, and finding non-mechanical approach of correcting these aberrations is of great interest. Although non-mechanical correction of de-focus has been widely studied, astigmatism correction remains relatively unexplored. Motivated by this gap, this Ph.D. thesis focuses on the development of a new type of gradient refractive index (GRIN) liquid crystal (LC) lenses capable of non-mechanical correction of both astigmatism and de-focus. The proposed device consists of a stack of three electrically tunable cylindrical lenses that implement a concentric stripe electrode and segmented phase profile design. This system offers several advantages, including a simple, low-cost structure, a large aperture size (50 mm), low voltage drive, and a compact design. Compared to conventional mechanical approaches, this non-mechanical solution has significant potential for various applications such as wavefront correction in large telescopes, microscopy, augmented reality/virtual reality, and prescription eyeglasses.

In the second part of the thesis, challenges associated with concentric electrode-based large aperture (50 mm) LC lenses with segmented phase profile designs are investigated, including haze-related and diffraction-related issues. Effective solutions are

provided to enhance the optical quality of these lenses (reduction of fringing field effect with an insulator layer and inclusion of black mask). By addressing these challenges, a 50 mm aperture size electrically focus tunable LC spherical lens with enhanced optical quality is developed. The proposed tunable lenses exhibit lightweight ( $<2$  g), slim ( $<2$  mm), and compact flat designs with fast switching speeds ( $<750$  ms) and low driving voltages ( $<5$  V), making them suitable for important near-to-eye applications such as accommodation-convergence mismatch correction in augmented reality (AR)/virtual reality (VR) head-mounted displays (HMDs) and presbyopia correction in smart eyeglasses.

Throughout the thesis, the design methodology, numerical computer simulations, experimental characterization, and fabrication process improvements for both types of large aperture LC lenses are presented, providing a comprehensive exploration of LC based large area tunable lens technology.

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A dissertation submitted  
to Kent State University in partial  
fulfillment of the requirements for the  
degree of Doctor of Philosophy

by

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August 2023

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## TABLE OF CONTENTS

<b>LIST OF FIGURES .....</b>	<b>XI</b>
<b>LIST OF TABLES .....</b>	<b>XXI</b>
<b>DEDICATION .....</b>	<b>XXII</b>
<b>ACKNOWLEDGEMENTS .....</b>	<b>XXIII</b>
<b>CHAPTER 1 INTRODUCTION.....</b>	<b>1</b>
1.1 Dissertation scope .....	1
1.2 Overview of the chapters.....	2
1.2.1 Basic working principle of large aperture LC lens .....	2
1.2.2 Large aperture LC lens for tunable astigmatism and de-focus correction .....	2
1.2.3 Issues related to optical quality in large aperture LC lens .....	3
1.2.4 Large aperture varifocal LC lens for near-to-eye application .....	4
1.2.5 An optimized tunable focus LC lens for near-to-eye application .....	5
<b>CHAPTER 2 ELECTRICALLY TUNABLE LARGE APERTURE LC LENS .....</b>	<b>6</b>
2.1 Background .....	6
2.2 Basic working principal of LC lens.....	9
2.3 Challenges of large aperture lens .....	14
2.4 Approach to make large aperture size lens.....	15
2.5 Consideration of other factors .....	17
2.5.1 Viewing angle .....	17
2.5.2 Basic driving mechanism .....	18
2.5.3 Polarization dependency .....	20

2.5.4	Parallax effect.....	20
2.6	Summary .....	20
<b>CHAPTER 3 CONCEPT OF DYNAMIC ASTIGMATISM AND DE-FOCUS</b>		
	<b>CORRECTION LC LENS.....</b>	<b>21</b>
3.1	Introduction .....	21
3.2	Device concept .....	24
3.3	Proof of concept .....	28
3.4	Numerical simulation .....	29
3.4.1	Spot profile for the stack of three cylindrical lens .....	30
3.4.2	Device performance evaluation.....	32
3.5	Summary .....	33
<b>CHAPTER 4 DESIGN, FABRICATION AND CHARACTERIZATION OF</b>		
	<b>LARGE APERTURE ASTIGMATISM AND DE-FOCUS CORRECTION</b>	
	<b>LC LENS .....</b>	<b>34</b>
4.1	Introduction .....	34
4.2	Design of example 50 mm diameter lens .....	36
4.3	Modeling of the example lens .....	38
4.3.1	Method .....	38
4.3.2	Tunable astigmatism .....	38
4.3.3	Tunable focus and astigmatism .....	40
4.4	Fabrication.....	41
4.4.1	Driving scheme .....	41

4.4.2	Fabrication Steps .....	43
4.5	Characterization .....	45
4.5.1	Phase profile.....	45
4.5.2	Experimental PSF.....	46
4.5.3	Resolution of spot profile.....	48
4.6	Demonstration of arbitrary axis correction .....	49
4.6.1	Evaluation of device for white light application.....	51
4.6.2	Correction of astigmatism .....	51
4.6.3	Correction of focus and astigmatism.....	52
4.6.4	Experimental image resolution test.....	53
4.7	Limitation of the device .....	55
4.8	Summary .....	57
<b>CHAPTER 5 OPTICAL PERFORMANCE FACTORS OF CONCENTRIC</b>		
<b>ELECTRODE BASED SPP LC LENS.....</b>		<b>58</b>
5.1	Introduction .....	58
5.1.1	The problem of haze due concentric ring electrode .....	58
5.1.2	The problem of haze due to SPP .....	60
5.1.3	Impact on near-to-eye application.....	64
5.2	Methods for problem investigation .....	65
5.2.1	Example lens for testing.....	65
5.2.2	Numerical methods for simulations .....	67
5.3	Reduction of haze from the edge of the electrode.....	68

5.3.1	Numerical results .....	68
5.3.2	Experimental results.....	69
5.4	Reduction of haze from SPP design.....	72
5.4.1	Numerical analysis (FDTD).....	72
5.4.2	Numerical analysis (Scalar diffraction analysis).....	74
5.4.3	Proposed solutions based numerical calculations .....	75
5.4.4	Experimental results.....	77
5.5	Summary .....	79
<b>CHAPTER 6 DESIGN, MODELING, FABRICATION AND</b>		
<b>CHARACTERIZATION OF 50 MM DIAMETER FOCUS TUNABLE LC</b>		
<b>LENS WITH ENHANCED OPTICAL PERFORMANCE ..... 80</b>		
6.1	Introduction .....	80
6.2	Design.....	80
6.3	Modeling .....	84
6.3.1	Defining the system.....	84
6.3.2	Numerical Point Spread Function (PSF).....	85
6.3.3	Numerical Modulation Transfer Function (MTF).....	87
6.3.4	SPP Lens Performance and Human Perception .....	88
6.4	Fabrication.....	89
6.4.1	Driving scheme .....	89
6.4.2	Fabrication steps.....	91
6.5	Characterization .....	95



6.5.1	Phase profile.....	95
6.5.2	Experimental MTF measurement.....	97
6.5.3	Continuous tunability and experimental PSF measurement .....	102
6.5.4	Switching speed measurement .....	105
6.5.5	Effect of parallel polarizer for light scattering reduction, if needed .....	106
6.6	Summary .....	108
<b>CHAPTER 7 LARGE APERTURES FOCUS TUNABLE LC LENS WITH</b>		
	<b>HYBRID PHASE PROFILE .....</b>	<b>109</b>
7.1	Introduction .....	109
7.2	Limitation of segmented parabolic phase profile.....	109
7.3	Segmented hybrid phase profile to improve optical performance. ....	111
7.4	Numerical Simulation .....	113
7.4.1	Direct comparison .....	114
7.4.2	Linear phase region spot profile as a function of human eye pupil size .....	117
7.4.3	Linear phase region spot profile as a function of human eye accommodation power	119
7.5	Experimental result .....	121
7.5.1	Phase profile.....	121
7.5.2	Imaging resolution test.....	122
7.6	Summary .....	124
<b>CHAPTER 8 CONCLUSION AND FUTURE WORK.....</b>		<b>125</b>
<b>APPENDIX A MODELING OF LC LENS.....</b>		<b>128</b>

<b>APPENDIX B FABRICATION DETAILS OF LC LENS.....</b>	<b>157</b>
<b>APPENDIX C CHARACTERIZATION DETAILS OF SPP LC LENS.....</b>	<b>174</b>
<b>REFERENCES.....</b>	<b>186</b>

PREVIEW

## LIST OF FIGURES

Figure 2-1 a) Molecular structure of typical Nematic LC material (5CB), b) Schematic representation of average molecular orientation of nematic LC. LC director is denoted by $\mathbf{n}$ .....	7
Figure 2-2 a) Illustration of refractive index of LC, b) refractive index of an isotropic material .....	8
Figure 2-3 Change of LC director tilt angle along LC cell thickness using simple nematic LC with application of electric field. Adapted from Yang <i>et al.</i> [13] .....	8
Figure 2-4: Illustration of change of wavefront travelling through an LC cell. a) when all LC director is parallel to the polarization direction of travelling light, b) when all LC director is perpendicular to the polarization direction of travelling light, c) when LC director has gradient change in the orientation with respect to the polarization director of light .....	9
Figure 2-5 Illustration of working principal of an LC lens, a) when LC lens is at OFF state, b) when LC lens is at ON state.....	11
Figure 2-6 (a) Inter-ring resistor design; (b) Lens design diagram showing relative locations of resistors and bus lines; (c) Close-up at enclosed area. ....	13
Figure 2-7: A) Ideal parabolic phase B) 2D phase map of the designed LC Fresnel lens with 5 segments. .	16
Figure 2-8: Illustration of LC director in the LC lens with two SPP at lens ON state. Colorbar represent the voltages on electrode.....	17
Figure 2-9: Illustration of LC director orientation when two LC cells with antiparallel rubbing direction are stacked. Two off axis light propagation is illustrated by red arrow line, where it can be seen that change of refractive index in Cell 1 is compensated by the change of refractive index of Cell 2 .....	18
Figure 2-10: Plot of change of OPD of LC material with respect to applied voltage. Eight square region represents regions where the change of phase is linear with the applied voltage. The eight driving voltages of the LC lens is indicated by the black arrow.....	19
Figure 3-1 A) is a schematic diagram of the device; the rectangles represent top view of three cylindrical lenses. The change in the intensity of color shows the voltage variation on each lens. B) is a vector representation of the symmetry axis of the three cylindrical lens system. Green, blue, and red color	

double arrow represent cylindrical power $D_0$ , $D_{90}$ , and $D_{45}$ , respectively. Black color double arrow represents the resultant cylindrical power $D_C$ with angle of cylindrical symmetry axis $\alpha$ ; C), D), and E) show phase gradient on the plane of the lens of $L_0$ , $L_{90}$ , and $L_{45}$ , respectively.....	25
Figure 3-2 Contour phase map of the proposed device, A) when the power of three lenses are $D_0 = -4.634$ D, $D_{45} = 1.0$ D, $D_{90} = -6.366$ D. The resultant power of three lens stack, $D_S = -6$ D, $D_C = +2$ D and $\alpha = 15^\circ$ ; B) When a spherical lens of $+6$ D is added to the lens stack of (A).....	29
Figure 3-3 (A,1), (A,2) represents 2D <i>OPD</i> map, and far-field spot respectively for the considered example lens system with $D_0 = 1.00$ D, $D_{45} = -0.50$ D, and $D_{90} = 0.50$ D; resulting $D_C = 0.71$ D and $D_S = 0.15$ D. (B,1), (B,2) represents 2D <i>OPD</i> map, far-field spot, respectively for same $D_0$ , $D_{90}$ , and $D_{45}$ power as (A), but spherical power of the equal but opposite value added ( $D_{spherical\ added} = -0.15$ D) to show the spot profile which contains cylindrical components only. (C,1), (C,2) represents 2D <i>OPD</i> map, far-field spot, respectively for same $D_0$ , $D_{45}$ , and $D_{90}$ power as (A), but cylindrical power of the equal but opposite value ( $D_{cylindrical\ added} = -0.71$ D) added to show the spot profile which contains spherical component only. ....	31
Figure 3-4 Numerically calculated PSF and MTF for performance evaluation of the designed three cylindrical lens stack device compare to the diffraction-limited ideal lens system. Blue solid line represents results from an ideal lens, red dashed line represents results from actual three cylindrical LC lens stack a) PSF at focal length, b) MTF curve .....	32
Figure 4-1 a) Schematic diagram of the dynamic astigmatism and de-focus corrector device in top view. The three rectangles represent three tunable LC based cylindrical lenses. The color change on the rectangle represents the voltage gradient in the plane of each lens. The phase gradient and principal axis of $L_{90}$ and $L_{45}$ are rotated by $90^\circ$ and $45^\circ$ , respectively, compared to phase gradient and principal axis of $L_0$ . b) 3D perspective view of patterned electrode of $L_{90}$ c) side view of $L_{90}$ under no voltage application. Blue cylinders in between patterned strip electrode and common ground represent LC director orientation. Green arrow represents the rubbing direction of two plates. d) side view of LC director in $L_{90}$ under voltage distribution over stripe electrodes. ....	35

Figure 4-2 Phase maps of designed individual 5 cm diameter cylindrical lenses with 28 phase segments.

From the same viewpoint of Figure 4-1 (a); a), b), c) represent cylindrical lenses which have symmetry axis along  $90^\circ$  ( $L_{90}$ ),  $45^\circ$  ( $L_{45}$ ), and  $0^\circ$  ( $L_0$ ), respectively..... 37

Figure 4-3 1.35 D dynamic astigmatism correction in every  $30^\circ$  degrees of principal axis. (a)-(g) represents 1.35 D astigmatic power with principal axis angle  $\alpha$  equal to  $-90^\circ$ ,  $-60^\circ$ ,  $-30^\circ$ ,  $0^\circ$ ,  $30^\circ$ ,  $60^\circ$ ,  $90^\circ$ , respectively. Optical power configuration in  $L_0$ ,  $L_{45}$  and  $L_{90}$  for each case is shown in Table 1. .... 39

Figure 4-4 Numerically calculated far-field spot profiles of the designed device at 125 cm distance. a) When all LC lenses are 0 D, monochromatic light source of wavelength 543.5 nm and beam width 5 mm is passed through the simulated device, b)  $L_0 = +0.80$  D,  $L_{90} = +0.80$  D and  $L_{45} = 0$  D; and c) all three LC lenses ( $L_0$ ,  $L_{90}$ ,  $L_{45}$ ) on the device stack are  $+0.80$  D..... 41

Figure 4-5 a) Photomask layout of the cylindrical lenses. The orange color represents the stripe electrodes within the active area and the green color shows the buslines that supply voltages to the phase segments. The white line on the active area presents the position of the boundaries of the continuous phase segments. b) zoomed view of the blue square region of (a), the red square represents the position of via interconnect on the photomask. The resistors on the stripe electrodes are represented by yellow color schematically. On the bottom left corner of the figure, resistors in a fabricated cell is indicated by yellow arrow within the zoomed area..... 42

Figure 4-6 a), b) Schematic diagram of step-by-step fabrication process of a lens cell of the proposed device in side view and top view, respectively. On the lower right, definition of the different layers of cell schematic diagram is provided; c) shows top view of the one fabricated LC cell, d) shows top view of the device (stack of three cylindrical LC lenses) ..... 44

Figure 4-7 a) Phase profile of single cell within entire aperture when voltage profile is tuned for  $+0.40$  D. In the optical setup, the fabricated cell is placed between cross polarizers and the rubbing direction of the cells are along  $45$  degrees to cross polarizers. b) Intensity modulation plot of the built lens cell compared to an ideal curve of same optical power within first segmented phase region. Red and blue solid curve represents intensity modulation for ideal lens case, LC lens case, respectively. Positions of the interference fringes is the main consideration of this comparison. (c)- (g) shows the phase

modulation when power configurations of the three lenses on the device are ( $L_0 = 0.40$ D, $L_{45} = 0$ D, $L_{90} = 0$ D), ( $L_0 = 0$ D, $L_{45} = 0$ D, $L_{90} = 0.40$ D), ( $L_0 = 0$ D, $L_{45} = 0.40$ D, $L_{90} = 0$ D), ( $L_0 = 0.40$ D, $L_{45} = 0$ D, $L_{90} = 0.40$ D), ( $L_0 = 0.40$ D, $L_{45} = 0.40$ D, $L_{90} = 0.40$ D), respectively. ....	46
Figure 4-8 Optical setup for measuring point spread function (PSF) of the device. ....	47
Figure 4-9 Experimental far-field spot profiles of the built device at 125 cm distant. Red circle shows the original beam size and shape. a) When all LC lenses are OFF, 5 mm wide beam is captured by the detector b) $L_{90} = +0.80$ D, $L_{45} = 0$ D, $L_0 = 0$ D; c) two cross cylindrical lenses have power only: $L_0 = +0.80$ D, $L_{45} = 0$ D, $L_{90} = +0.80$ D. Zoomed view of the spot is shown within yellow square box insert. d) all three LC lenses ( $L_0$ , $L_{90}$ , $L_{45}$ ) on the device have optical power $+0.80$ D. ....	48
Figure 4-10 Comparison of far-field intensity profile A) Numerically calculated intensity profile of the modeled device at power configuration described for Figure 4-4 (b); and B) experimentally obtained intensity profile from fabricated device for the same condition .....	49
Figure 4-11 Example of experimental and simulated spherocylindrical properties of the device that demonstrates non mechanical correction. Power of the three cylindrical lenses are $+0.40$ D, $+0.40$ D, $0$ D on $L_0$ , $L_{45}$ , $L_{90}$ , respectively. a), b) show the experimentally measured and numerically calculated far-field spot profile of the device at the focal plane of $D_c$ , respectively. c), d) show the experimentally measured and numerically calculated far-field spot profile of the device at the focal plane of $D_s$ , respectively. ....	50
Figure 4-12 Shows astigmatism compensation with a built device. a) only 1951 USAF under white light illumination; b) image taken when commercial glass cylindrical lens of power $+0.75$ D along $0^\circ$ is added to the optical setup and all the lens of the built device is kept at $0$ D; C) same condition as (c) but built device power configuration is $-0.80$ D, $0$ D, $0$ D on $D_0$ , $D_{45}$ , $D_{90}$ , respectively. ....	52
Figure 4-13 Evaluation of the device for white light application. a) image of the Air Force chart taken without the presence of the device, b) image of Air Force chart when optical aberration is imposed by $-1.50$ D spherical lens and $-1.50$ D cylindrical lens with principal axis along $45^\circ$ , c) image of the Air Force chart after correcting optical aberration using the built device. Optical power of the three	

cylindrical lenses of the device in this case are +1.55 D each, which led to resultant spherical power to be +1.55 D, resultant cylindrical power to be +1.55 D and resultant principal axis to be 45°. .....	53
Figure 4-14 Direct MTF measurement under white light condition. According to the optical setup group (1) element (1) corresponds to 10 cyc/degrees. a) Intensity modulation plot along red line of group (1) element (1) for without device case as shown in Figure 4-13 (a); b) Intensity modulation plot along blue line of group (1) element (1) at with device utilized case as shown in Figure 4-13 (b). .....	55
Figure 4-15 Limitation of the device discussed from the closer look at phase profile of the lens. Bright and dark color represents the interference fringes. a) phase discontinuity at the edge of the stripe electrodes, which causes large angle light scattering. Viewing region on the lens surface is shown schematically on the right. b) phase discontinuity at the phase resets. Although fringe color matches from one SPP to the next one, the discontinuity at the boundaries of the reset causes light scattering issue. ....	56
Figure 5-1 Phase stepping and corresponding layer structure on LC lens without floating electrode and with floating electrode; a) represents retardation color change pictures of the built cells under cross polarizer without floating electrode. White arrow shows the position of the 2 $\mu\text{m}$ electrode gap. b) with floating electrode. White arrow shows the edge of the floating electrodes. ....	60
Figure 5-2 SPP LC lens director simulation; a,1), b,2) represent equipotential field line for voltage distribution over electrodes in lens region with SPP and corresponding director orientation within adjacent phase reset regions, respectively, in X-Z plane. Voltage magnitude on the patterned electrodes is shown in color bar on the right. a,2), b,2) represents zoomed view within rectangle area of (a,1) and (b,1), respectively. ....	62
Figure 5-3 a) OPL of SPP LC lenses around the phase reset compared to ideal SPP type lenses (red dotted plot) b) change of analytical diffraction efficiency of 5 cm lens due to LC director distortion for different LC lens cell thickness. c) change of number of resets within 5 mm pupil diameter at different lens area corresponds to different gazing angle from the center of the LC lens. ....	64
Figure 5-4 Phase variation across fabricated 50 mm aperture of lens cell with SPP design tuned for + 0.20 D. The lens cell is placed at 45 degrees between a cross polarizer and the picture is taken with green	

( $\lambda = 543 \text{ nm}$ ) light filter. Red and blue square region representing the zoom view of the center and off-center lens area, respectively.....	67
Figure 5-5 Simulated OPL curve to study the fringe field effect on ring electrode. Blue and red curve represents the change of OPL calculated from LC director orientation in the presence of fringing field effect, and with reduced fringe field effect, respectively. ....	68
Figure 5-6 a) Phase stepping and corresponding layer structure on LC lens with floating electrode and top insulator later. Change of color represents change of retardation of the built cells under cross polarizer. b) Phase stepping variation of LC lens cell without floating electrode (red dashed curve), with floating electrode (blue dashed curve) and with floating electrode including the top insulator (black curve).....	69
Figure 5-7 Optical quality test at the center of the LC lens, a) LC lens off, b) LC lens on at +0.80 D with non-optimized edge effect of floating electrode, c) LC lens on at +0.80 D with reduced edge effect of floating electrode after process optimization, d) MTF comparison; black, blue and red color plot represents the diffraction limited MTF, measured MTF after floating electrode process optimization, measured MTF for non-optimized case, respectively. ....	71
Figure 5-8 FDTD study of calculated SPP LC lens; a) shows wave-train propagation through calculated LC director orientation at incident light angle $0^\circ$ . The color bar on the right presents the change of amplitude of propagating electric field. The green arrow indicates the rays that are propagating in the expected direction, whereas red arrow shows the undesirable light propagation from the phase reset boundaries. The red marked portion on top of dashed blue line represents the width where phase disturbance is observed. Zoom view around the phase reset is shown within the pink color box b) simulated far-field spot profile of SPP LC lens. Top and bottom subfigures on the right are zoomed portion of the regions that represent the main diffraction peaks and large angle diffraction peaks, respectively.....	73
Figure 5-9 Scalar diffraction analysis at a close distance from the LC lens, a) spot profile at the observation plane, where the light source aperture size, position of the phase resets, and scattered light are indicated by green dashed circle, orange arrow line, and red arrow line, respectively; b) shows	



intensity variation along the yellow line of the spot profile shown in Figure 5-8 (a). The scattered light in the background is indicated by red arrow mark.....	74
Figure 5-10 Reduction of light scattering observed from computer simulation, a) simulated far-field spot profile of SPP LC lens from FDTD calculation. Top and bottom subfigures on the right are zoomed portion of the regions that represent the main diffraction peaks and large angle diffraction peaks, respectively. b)- d) represents figures for near field simulation using scalar diffraction analysis. b) shows the design lens SPP structure with BM (black circles) and red circle on the structure represent the simulated region, c) near field spot profile with BM inclusion, d) shows intensity variation along the yellow line of (c). ....	76
Figure 5-11 Reduction of light scattering observed experimentally, a) shows closer look at the phase profile around reset boundaries on a fabricated lens, where phase disturbance is indicated within the gap between red double arrows. b) shows position of the aligned black mask on a fabricated device, the black mask is covering the distorted phase region. (c) and (d) shows the higher exposure picture of USAF target for LC lens without BM, and with BM, respectively; e) shows the intensity modulation around the group 0 element 1 for without back mask (taking intensity modulation along blue line of (c)) and with BM (taking intensity modulation along red line of (d)). f) shows the haze (%) measurement on different lens location for without BM (solid blue line) and with BM case (dashed red line) .....	78
Figure 6-1 a) Design of phase profile of a SPP LC lens with 28 segmented phase region compared to an ideal refractive type lens of similar power. The blue solid and red dashed color curve represents LC lens and continuous parabolic shape phase profile ideal lens, respectively. b) Top view of the segmented phase region of the 5 cm lens. The black circles within the width of the lens represent the position of the phase resets.....	83
Figure 6-2 Illustration of different PPs and the corresponding 2D phase profile on the lens surface. (a)- (e) represents PP1, PP2, PP3, PP4, PP5, respectively. Center of gazing angle of 5 mm pupil for (a)- (e) are 0°, 14°, 27°, 36° and 46°, respectively. (f)- (j) represent the 2D phase phase map on the LC lens	

for PP1, PP2, PP3, PP4, PP5, respectively. The color shows the phase change with lens area. Each phase reset gives stepwise increase of $16\lambda$ of optical path difference. ....	85
Figure 6-3 Modeled PSF of the designed lens at designed wavelength, $\lambda = 543.5$ nm when phase step is multiple of one wave ((a) to (e) for PP1, PP2, PP3, PP4, PP5, respectively) and non-designed wavelength when phase step is multiple of half-wave ((f) to (j) for PP1, PP2, PP3, PP4, PP5, respectively) including the BM .....	87
Figure 6-4 Simulated MTF of the designed lens at different PP. a) at maximum diffraction efficient, when viewing wavelength of light cause phase steps in the segmented resets to be multiple of one wave, b) at minimum diffraction efficiency, when viewing wavelength of light cause phase steps in the segmented resets to be multiple of half-wave .....	87
Figure 6-5 a) Mask diagram of the 5 cm focus tunable LC lens. Green, orange, black colors is representing the driving busline channels, ITO concentric ring electrodes, positions of the phase resets. Closer look at within the central blue sq. region is shown in b) and c). b) shows the 1 <sup>st</sup> layer of the ring shape discrete electrodes. The resistors and the location of the via's are indicated, c) shows top view with 2 <sup>nd</sup> layer of ITO (floating electrode) visible, which hides the underneath electrode gaps and the resistors.....	91
Figure 6-6 Schematic diagram of step-by-step fabrication process (in top view). Processes are defined for each step. The side view of the layers of an assembled cell is shown in side view on bottom left. ....	94
Figure 6-7: Fabricated device and closer look at the features under reflective light condition.....	95
Figure 6-8 a) Phase profile of the lens within entire aperture (5 cm) for +0.40 D; b) – e) closer look at the four square region on the lens area indicated of (a); f) comparison of position of interference fringes of the built LC lens device compared to an ideal lens, g) comparison of the phase profile with respect to parabolic fit within multiple phase reset region. Black arrow mark indicates position of the phase reset on the phase profile.....	96
Figure 6-9 Image resolution evaluation for central vision, a) without SLG, b) With SLG at ON state with optical power +1.60 D (focal length is not adjusted compared to case (a)), c) With SLG ON state with optical power +1.60 D after focal length is adjusted to find the best focus. ....	98

Figure 6-10 Image resolution evaluation for peripheral view, a), b), c), d) represent image resolution when SLG is placed with the optical power +1.60 D where center of gaze angle is at 14° (PP2), 27° (PP3), 35° (PP4), 46° (PP5), respectively. ....	99
Figure 6-11 Closer look at the captured image of Group 0 Element 6 of airforce chart using monochromatic light filter when optical power of SLG is +1.60 D. (a) to (e) shows the captured image with designed wavelength color filter ( $\lambda_g = 545$ nm) for the case of PP1, PP2, PP3, PP4, PP5, respectively. (f) to (j) shows the image of the same object but with half-wavelength case color filter ( $\lambda_r = 640$ ) nm for the case of PP1, PP2, PP3, PP4, PP5, respectively. Diffracted images are indicated by pink arrow and diffraction angles are written on the picture.....	100
Figure 6-12: Green channel intensity modulation (a) and comparison of measured and simulated MTF at 10 cyc/deg spatial resolution for all pupil positions (b).....	102
Figure 6-13 Control over phase profile for different tunable optical power, seen from the same region area. Corresponding optical powers are indicated underneath of each phase profile. White bar indicates 2 mm length.....	103
Figure 6-14 Measured PSF at different optical power states. (a) to (e) shows the measured spot profile for LC lens power 0 D, 0.20 D, 0.40 D, 0.60 D and 0.80 D, respectively. f) the measured PSF for different optical power cases.....	104
Figure 6-15 Switching time measurement at different optical power.....	106
Figure 6-16 Demonstration of the use of parallel polarizers for reducing light scattering from the bulk of LC material. a) The LC cell is sandwiched between two parallel polarizer whereas, half of the cell is covered by two polarizers and other half contains portion of one polarizer only, b) schematic diagram of the optical setup of (a) in side view, (c) comparison of intensity along red and blue line of (a) to roughly estimate the change of light scattering because of inclusion of two parallel polarizers. ....	107
Figure 7-1 a) Top view of the structure of the SPP for parabolic phase profile LC lens; b) hybrid phase profile LC lens, c) comparison of analytical diffraction angle of parabolic SPP and hybrid SPP design, human eye resolution (1 arcmin or 0.0160°) is indicated by pink color horizontal line .....	112

Figure 7-2 Illustrated ray tracing, a) ideal lens, b) parabolic SPP LC lens, c) hybrid SPP LC lens.....	114
Figure 7-3 Direct comparison of spot profile. a) Ideal diffraction limited lens of power +0.80 D, b) simulated spot profile of LC lens with parabolic SPP for peripheral vision (center of gazing angle, 46°), c) simulated spot profile of LC lens with hybrid SPP for the same area compared (b).....	115
Figure 7-4 MTF comparison of ideal lens, parabolic SPP LC lens design and hybrid SPP LC lens design for peripheral vision of 5 cm lens (center of gazing angle 46°).....	116
Figure 7-5 PSF of hybrid SPP LC lens for peripheral vision of 5 cm lens (center of gazing angle 46°) mimicking different pupil size of human eye. (a) to (e) represents PSF for pupil size 5 mm, 4 mm, 3 mm, 2 mm, 1 mm, respectively. ....	118
Figure 7-6 MTF comparison of hybrid SPP LC lens for peripheral vision of 5 cm lens (center of gazing angle 46°) mimicking different pupil size of human eye. ....	119
Figure 7-7 Calculated PSF for hybrid SPP LC lens for peripheral vision of 5 cm LC lens (center of gazing angle 46°) mimicking different accommodation power of human eye for fixed pupil size (3 mm). (a) to (d) represents PSF for accommodation power +0.20 D, +0.40 D, +0.60 D, +0.80 D, respectively. .....	120
Figure 7-8 MTF comparison for hybrid SPP LC lens for peripheral vision of 5 cm LC lens (center of gazing angle 46°) mimicking different accommodation power of human eye for fixed pupil size (3 mm)..	121
Figure 7-9 Comparison of phase profile from fabricated device, a) 5 cm diameter SPP LC lens with parabolic phase profile (total 28 phase resets), b) 5 cm diameter SPP LC lens with hybrid phase profile (total 19 phase resets) .....	122
Figure 7-10 Experimental lens performance comparison for peripheral vision of 5 cm lens (center of gazing angle 46°) at +0.80 D optical power. a) image of the airforce chart taken for the case of parabolic SPP design, b) image of the airforce chart taken for the case of hybrid SPP design. Closer look at the red and green square region is shown on the right of each subfigure. ....	123

## LIST OF TABLES

Table 1 Analytical diffraction efficiency and numerically calculated strehl ratio for different phase sampling rate .....	12
Table 2 Analytical diffraction efficiency and numerically calculated strehl ratio for different gap widths..	14
Table 3 List of optical powers on the three cylindrical lenses of the device for resulting $D_c=1.35$ D astigmatic power in every $30^\circ$ degrees principal axis variation .....	40
Table 4: Voltage distribution on the LC lens at different optical power states .....	55
Table 5: Comparison of measured 1 <sup>st</sup> lobe diameter of airy disk pattern compared to theoretical value....	105

## **DEDICATION**

To to my parents, Ajit Bhowmick and Rina Bhowmick, for their unwavering love and support throughout my life. They have been my role models, and I am grateful for all the sacrifices they have made to help me achieve my goals.

To my elder brother, Abhi Bhowmick, who has helped me in my education from the very beginning. I am grateful for his guidance and encouragement, which have helped me to pursue my dreams.

To my beloved wife, Supti Saha, who has been a constant source of love, enthusiasm, and inspiration. Her encouragement and support have been invaluable to me.

## ACKNOWLEDGEMENTS

First and most importantly, I want to say a huge thank you to my supervisor, Dr. Philip J Bos. His constant help, advice, and teaching have been essential in finishing my Ph.D. thesis. Over time, he has shared important knowledge and key skills needed for success in research, like such as critical thinking, problem-solving, and effective communication. I may not have fully mastered all the lessons I learnt from him, but they will undoubtedly serve as an inspiration and driving force for continuous improvement throughout my career.

I am incredibly grateful for the collaboration with Meta Platforms Inc., who provided financial support during my Ph.D. and broadened my perspective on the future of technology. I would like to extend my heartfelt thanks to my Meta collaborators: Dr. Afsoon Jamali, Dr. Nick Diorio, Dr. Sandro Pintz, Dr. Mitya Reznikov, Dr. Christopher Stipe, Dr. Eric Stratton, Dr. Max Palmer, Dr. Thomas Vo, all others who contributed to our joint research efforts.

I also want to express my appreciation to the faculty members of Material Science Graduate Program and those who served on my dissertation committee: Prof. Liang-Chy Chien, Prof. Deng Ke Yang, Prof. Syed Shihab Prof. Antal Jakli, Prof. Oleg D Lavrantovich, Prof. Peter Palffy-Muhoray, Prof. Jonathon Selinger, Prof. Robin Selinger, Prof. Torsten Hegmen. Their exceptional courses and guidance during my academic journey have truly enriched my experience and deepened my passion for liquid crystal research.

I owe a lot to Douglas Bryant and Afsoon Jamali for their assistance with various research related tasks and guidance. My sincere thanks go to Dena Kooijman, Douglas Bryant, Merrill Groom, Bentley Wall, Lu Zhou and Min Gao in the cleanroom and during the characterization process. I also want to thank all the department staff, including Mary A. Kopak, Ashley White, and Jack Dauphars.

My sincere appreciation goes out to my lab mates and colleagues, who made my time at the university both enjoyable and intellectually stimulating: Frankie Fenglin Xi, Brandon Vreeland, Xiayu Feng, Comrun Yousefzadeh, Tim Ogolla, Jissoo Jeong, Roy Hu, Ziyuan Zhou, Xinfang Zhang, Ruilin Xiao, Senay Ustunel, Jiao Liu, Rony Saha, Suman Halder, Md. Shakhawat Hossain Himel, Md. Mostafa Satez, Lincoln Paik. I am grateful for the friendships I have formed, both inside and outside the AMLCI.

Finally, I would like to extend my deepest gratitude to my parents, my wife and my family, who have always been there for me, providing unwavering love and support. Their encouragement has been the driving force behind my achievements, and I am forever grateful for their presence in my life.

Amit Kumar Bhowmick

June 9<sup>th</sup>, Kent, Ohio