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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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DEDICATION

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