Fabrication of Patterned Interference-Based and Absorption-Based Polarizers

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Polarizers are optical filters that transmit light of one polarization and block light of other polarizations and have applications in imaging, display, ellipsometry and interferometry. In general, polarizers operate by four fundamental mechanisms: absorption, interference, reflectance, and birefringence (Figure 1). Depending on the polarization of light, polarizers can be categorized as linear and circular polarizers. In the past few decades, the fabrication of arbitrary patterned linear polarizers, such as micro-polarizer, in the visible spectrum has been demonstrated by utilizing absorption-based and reflectance-based mechanisms.[1] In this paper, the chemistry, fabrication process, spatial resolution and optical properties of arbitrarily patterned circular polarizers and infrared (IR) polarizers are presented. Patterned circular polarizers, which are based on optical interference, can be fabricated using cholesteric liquid crystal polymers (Ch-LCP). Patterned IR polarizers, which operate by absorption, can be fabricated using IR dichroic dye as a guest in liquid crystal polymer (LCP) host. Applications of the micropolarizer for polarization imaging will also be presented.

Photoalignments of Ch-LCP and IR-LCP are both achieved by using linearly polarized ultraviolet illumination (LPUV) to align the linearly photopolymerizable polymer (LPP) layer. In patterning IR-LCP, the alignment orientation is defined by the exposure of LPP to LPUV and therefore patterned alignment domains can be defined using traditional contact photolithography techniques with a polarized source. In patterning Ch-LCP, the alignment orientation does not have any patterning effects. Thus, two different patterning methods, thermal annealing and solvent rinse, are developed and investigated. A dark field 1951 USAF resolution chrome mask is used for the lithography and critical dimension analysis.

The patterned IR-LCP is measured using a spectrophotometer as shown in Figure 2. The extinction ratio, which is proportional to the concentration of IR dichroic dye, is measured to be 12 at 937 nm. In addition, a Mueller matrix imaging polarimeter is used to analyze the polarization properties, including depolarization index, diattenuation, and retardance. The measured 4x4 Mueller matrix images of patterned Ch-LCP are shown in Figure 3. Diattenuation as a function of feature size is used to determine the minimum spatial resolution of the patterns. Surface morphologies are also studied by SEM as shown in Figure 4.

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[1] G. Myhre, A. Sayyad, and S. Pau, "Patterned color liquid crystal polymer polarizers," *Opt. Express* **18**, 27777-27786 (2010).

	Mechanism			
Polarization	Absorption	Interference	Reflectance	Birefringence
Linear	Dichroic crystal ***Dichroic dye***	Thin-Film Stacks	Wire-Grid Brewster's type	Birefringent Crystal
Circular	Optical Active Molecule	***Cholesteric Liquid Crystal***	Helical Wire Structure	Optical Active Crystal

Figure 1: Comparison of Polarizers: In this paper, the fabrication of arbitrarily patterned interference-based circular polarizer and absorption-based infrared polarizers are presented.

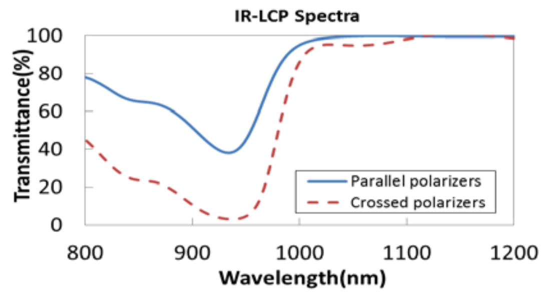

Figure 2: Transmittance Spectra of the Patterned Dichroic IR Polarizer: The dichroic IR polarizer is aligned with a TECHSPEC® NIR linear polarizer and has an extinction ratio of 12 at 937 nm.

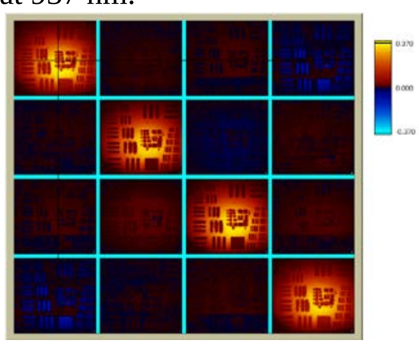

Figure 3: Measured 4x4 Mueller Matrix Image of the Patterned Ch-LCP Polarizer at 550nm: The measured Mueller matrix image can be used to calculate depolarization index, diattenuation, and retardance.

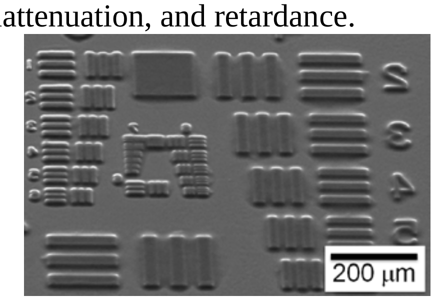

Figure 4: SEM Image of the Patterned Ch-LCP Polarizer: Surface morphologies of patterned polarizers are studied by scanning electron microscopy. 1951 USAF resolution pattern is used here for critical dimension analysis.