Overview

In this project, a liquid crystal polarization grating is built to diffract circularly polarized light utilizing photoalignment technology, which is a non-contact method used to align azo-dyes on the liquid crystal cell in order to avoid damaging and deposing impurities on the surface of the cell. The direction of incoming polarized light can alter the pretilt angle of liquid crystal.

The polarization grating produced is aligned depending on the pitch, provides different first-order diffraction angles without mechanical movements, and thus achieves its steering purpose, which is a technology used to focus and redirect light rays towards a specific direction. It has an advantage over normal polarization gratings because the alignment property can be manipulated by applying voltage to the liquid crystal cell to change the handedness of light.

Methodology

The liquid crystal polarization grating diffracts light towards multiple steering directions according to its handedness. The grating has two states, on-state and off-state. At on-state, voltage is applied and light rays do not diffract (zeroth-order diffraction). At off-state, no voltage is applied and light rays undergo first-order diffraction.

To control the handedness of light, a half-wave plate is used. A half-wave plate is an optical device, for which its thickness is half of the wavelength of the incoming light beam. A right-handed circularly polarized light is changed to left-handed, vice versa. A beam steering lens is formed by combining the polarization grating and half-wave plate. By adjusting its cell gap and pitch, a specific diffraction angle can be obtained. The lens is tested by measuring the diffraction angle and the experimental results are compared with the theoretical value according to the equation

\[ \sin \theta = \frac{1}{\lambda} \]

Results

Using the electro-optical setup with a green light source of wavelength 530 nm, a diffraction angle of 16° is obtained at off-state; no observable diffraction at on-state, which is consistent with the methodology proposed. As shown in the figures below, the images of the words are shifted at off-state and there is no observable shift at on-state.

The special optical properties of the liquid polarization grating shown can be applied to different devices such as tunable filters, optical switches, broadband beam splitters and others. Future works like increasing the number of half-wave plates and polarization gratings can be done to achieve a multi-stage beam steering devices.