Photo-Alignment Materials and Technology
Physics and Application in Liquid Crystal Devices:
Static Addressing Ferroelectric liquid crystal and Field Sequential Color Display

Student: Chan Yat Lung, Lau Ka Tsun, Mak Lai Ki
Project Supervisor: Professor Chigrinov VG

Project Overview:

Photo-alignment is one of the non-contact methods of aligning the liquid crystal during the fabrication of a liquid crystal cell. This method has been already adopted by many different microelectronic companies improving the LCD display because it has the high anchoring energy, high order parameter, and the excellent alignment stability after polarization as well, and also easy to adjust the pre-tilt alignment on curved and 3D surfaces and etc. This technology has designed for multi-domain, an ultraviolet-induced, vertical alignment on liquid crystal molecules basing on combining different materials with the usage of processing technologies and also the UV exposure equipment.

This final year project aims at producing a 14-segment display with ferroelectric liquid crystal (FLC) by making use of field-sequential color system. Different parameters of cells and systems, such as pre-tilt angle, polar anchoring strength are adjusted in order to ensure the quality of cells and achieve the expected result. Different methods and parameters are tried and tested for choosing the best method to make the qualified cells. For the electronic part, circuit is designed to connect the LED Backlight, 14-segment display and microcontroller. Microcontroller is programmed to control the segment display and LED Backlight to display certain patterns and colors on the display.

Ferroelectric liquid crystal (FLC) is used because of its fast response time and reduced power consumption compared with other anti-ferroelectric liquid crystal. Unlike other types of liquid crystal, color filter is not required and the three primary colors, red, green and blue can be switched with rapidity in order to produce a large amount of colors by having different combinations of these three colors. With all these appropriate properties, FLC is suitable to be use in our final year project and the qualified cells can be produced by making use of FLC and supported by the designed circuit and program in the microcontroller.

Methodology:

FLC electro-optical mode: Deformed Helix Ferroelectric Liquid Crystals (DHFLC)

In fact, there are two different FLC electro-optical modes, they are surfaced stabilized ferroelectric liquid crystals (SSFLC) and deformed helix ferroelectric liquid crystals (DHFLC). Surfaces of cells will suppress the helixes of SSFLC, while DHFLC does not.

DHFLC is used in this project as the depending on the effectiveness of birefringences, Dnecf of FLC cells on voltage amplitude applied, voltage, and frequency. Using DHFLC in this project is much more reliable than SSFLC because of its well electrically controlled. The birefringence of FLC cells will be returned to the beginning position. This can also switch the color by electrical controls as well.

Electrically suppressed helix modes (ESH):

The FLC display will be more popular in the next generation of LCD. It has advantages of the high resolution, low consumption of power and color gamut which attract the researchers interest. The target response time in FSC display should not be more than 1 ms (240 Hz frame frequency). Nowadays, sensors and real-time detection require the fast response of the liquid crystal. In order to achieve this, fast electro-optical modes in FLC, which include the surface stabilized (SS), electrically suppressed helix (ESH) and also the deformed helix ferroelectric (DHF), were being developed.

The electro-optical response in DHF and ESH mode are shown as follows:

The dependence of E-field of the time response and it represents the helix unwinding (Ec). When E<=Ec, FLC will be in DHF mode while E>Ec, ESH mode will be resulted in. In our prototype, we need a fast response time, so the ESH modes are chosen.

Results

Our finished cell is shown in the following photo and this is used as fourteen-segment display our project. Fourteenth-segment display is a form of electronic display device for displaying decimal numerals “0-9” and words “A-Z”.

The three primary colors, red, blue, and green are displayed in a sequence with a very faster rate. Human eyes observe different colors based on the mixing and different sequences of these three primary colors. In the 14-segment display, the LED Backlight displays the red, green and blue colors in sequence with the cycle time of 4.17ms. The positive width of each red, green and blue color is about 1.39ms.

With the increasing voltage applied, almost it has 90% in bright state transmittance and less than 5% in black were obtained by the cell. From the results of measurement, it works well in 5000 Hz and with perform well in color saturation, with fast response time.