### Project Overview

Optical security film provides a wide range of applications for governments and various industries. Unique and flexible features, easy-to-detect effects will be achieved to provide different levels of security. This final year project is to accomplish an optical security film based on new technology, photo-alignment, to provide a more reliable and unique protection for any products for governments, central banks and companies.

Photo-alignment is an advanced technique to align liquid crystal molecules, which is crucial for fabricating LC crystals and devices. It is a good alternative to rubbing, a conventional process of aligning liquid crystals molecules. Photo-alignment:
- A noncontact method providing high-quality alignment of molecules in LC cell.
- Enables elimination of electrostatic charges and impurities and mechanical damage of the surface.
- Possesses high thermo and UV stability and ionic parity, a controllable pretilt angle and anchoring energy of liquid crystal cell.
- Allows efficient LC alignment on curved and flexible substrates.

There is potential increase of manufacturing yield, especially in LCDs with active matrix addressing. Photo-alignment technology can be applied to optical security film in order to produce a higher-quality product.

The unique and easy-to-verify features of optical security films allow sufficient protection against forgery and avoid privacy invasion. Identity documents can be easily forged if the technology is dated. In order to ensure the privacy and protect citizens against fraud, advanced technology for security measures is needed. Besides identity documents, enhancement of security features of banknotes, cheques and other monetary documents are vital. In addition, brand protection against forgery is crucial since preservation of customer trust is important in brand recognition. Authenticity of monetary documents, identification for citizens and products can be achieved by our optical security film based on photo-alignment.

### Methodology

This project is to design a security film by using glass plate. It is feasible to design by using plastic plate for more flexible and multipurpose use. First, the glass plate is used to fabricate different patterns and colors of security films. Then, we tried to fabricate the pattern on plastic plate. Finally, security films are built and can be examined under the polarizer. The left graph below shows the structure of optical security film and the right graph shows the main procedure of security film.

In our proposed design, unpredictable technical problems are encountered. We have already finished the fabrication of one direction polarization film. However, more layers are required on the fabrication to create different patterns in security film. It is a challenge for us to integrate different layers into the glass plate. Also, it is difficult to control the drops of solvents onto the glass plate at the beginning. The solvent cannot spread evenly and cause unclear pattern. The graphs below show the errors of uneven solvents in spin coating and the unclear pattern on greyscale image.

### Results

#### Patterned Quarter-wave Plate

For patterned quarter-wave plate, it possesses the greatest contrast ratio and is rotation sensitive.

- Figure 3.1: Result of (a) bright state and (b) dark state when rotating linear polarizer.

#### Patterned Half-wave Plate

For patterned half-wave plate, the brightness of image will change according to the rotation angle.

- Figure 3.2: Process of using security film to detect QR code.

#### Bent Security Film

- Figure 3.4: Plastic Polymer

#### Color Security Film (Thickness : 3.95 µm)

Different color change is observed in color security film due to the change in liquid crystal polymer thickness.

- Figure 3.5: Result of (a) dark state and (b) bright state for spin coating five times.

#### Complex Security Film

Complex security film provides a higher security as it possesses four states which requires different polarizers for observation.

- Figure 3.7: Result of (a) dark state and (b) bright state when rotating circular polarizer.