5. System Operation

Turn on power supply, and place the sample under test on the stage. Turn the knob on the exit arm to "Eyeballing" position to observe the beam on the viewing window. Adjust the height of the stage to achieve the brightest spot.

Rotate the polarizer and the analyser while observing the change in light intensity until a minimum intensity is reached. Now, cover the window and turn the knob to "Detector". Carefully adjust the polarizer and the analyser until a minimum reading is achieved on the meter. Read the angles of the polarizer as P and the analyser as A by combining both readings of the vernier and the disk scales.

Repeat above procedure and acquire another set angles of P and A when extinction occurs.

Calculate average values of the two angles as follows:

(1) Define (P_1, A_1) and (P_2, A_2). Set value A as $0^o \leq A \leq 90^o$ as A_1 and the corresponding value P as P_1. The other group value is (P_2, A_2).

(2) Transform (P_2, A_2) into (P_2', A_2') using the following equations:

$$A_2^{'} = 180\,° - A_2$$

$$P_2' = \begin{cases} P_2 + 90\,° & when \quad 0\,° \le P_2 \le 90\,° \\ P_2 - 90\,° & when \quad P_2 > 90\,° \end{cases}$$

(3) Average (P_1, A_1) and (P_2, A_2) as

$\overline{P} = (P_1 + P_2')/2$,

$\overline{A} = (A_1 + A_2')/2$.

(Note: in theory, $A_1 + A_2 = 180\,°$ and $P_2 - P_1 = 90\,°$)

The next step is to determine the thickness period of the sample. When the wavelength of light source is 632.8 nm, one period of a SiO_2 film is about 283 nm. When the film thickness is larger than one period, one cannot determine the thickness period of the sample from this system solely. Under such case, the following methods are suggested:

(1). Compare with a colour plate

(2). Observe the shift of the interference fringe at the film layer edge using an interference microscope

(3). Determine the thickness period based on the conditions of the film formation (such as deposition time, sputtering time and evaporation time, etc.)

From (P, A) – (d, n) relationship table or chart to find d and n using the acquired $\overline{P}$ and $\overline{A}$.

In theory, this method can accurately determine n value, however, for some specific film thickness, the change of (P, A) is not sensitive to n value, therefore, the derived n value from some individual samples may have change with specific film formation conditions. For the sample provided with the apparatus, n value can be set as 1.46.

6. Notes

1. Do not expose the photo detector to strong laser or other light.

2. Although there may be two light spots observed on the screen due to the surface reflection of the sample under test, one spot as the main light spot should be brighter than the other spot. The main spot should be used throughout the experiment.

3. In need of laser tube replacement (inside the laser head), turn off power, disconnect the three wires from the amplifier, take off the whole laser head assembly from the entrance arm of the main machine, then remove the back cover of the laser head, pull out the laser tube from the thermal dispenser shield. Revise the above steps to install a new laser tube. Adjust the 6 adjustable screws (on the outer tube) to assure laser beam passing through the centers of all optical apertures when both the entrance and exit arms are at 90^{o}. Under this case, the laser spot should be brightest at the observation windows.

4. Normally, there is no need to rotate the quarter-wave plate.

5. It is recommended that the system be verified first using a known sample (wafer with known film thickness and index) before measuring unknown samples.

6. Instrument should be stored and operated at proper lab environment.

7. It is also common to use (Δ, ψ)~(n, d) nomogram. There exists the following relationship between graph (Δ, ψ)~(n, d) and graph (P, A)~(d, n).

$$\psi = A$$

$$\Delta = \begin{cases} 270 - 2P & when \quad 0° \le P \le 135° \\ 630 - 2P & when \quad P > 135° \end{cases}$$

7. Software

1. To install the software, double click “LEOI-44_1.0.0_Setup” and follow prompts to complete the installation.

2. To run the program, double click icon “LEOI-44”, and the program panel pops up.

3. Replace default values of each “Parameter” by correct values of current test.

4. Click “Create Table” button, all the calculated thickness values corresponding to angles of polarizer and analyzer are displayed in the right table.

5. Calculate angles of polarizer and analyzer $\overline{P}$ and $\overline{A}$ based on the above two measurement results, and enter them into corresponding fields at the right-lower of the program panel (Δ will be updated automatically). Set the deviation range ε of the polarizer and analyser at 1.0~10.0. Click “Search” button, a list of thickness values will be displayed in the table with deviation value ε (here, ε is the unbiased variance about film thickness.) Select the value corresponding to the minimum ε as the measured thickness (d).

An example of measurement data and calculation result

Note: Following data are for reference only, not the criteria for apparatus performance

Angle of incidence: $\varphi = 50°$

Angles of polarizer and analyzer (when light extinction): (P1=58.0°, A1=50.45°); (P2=148°, A2=127.2°)

Average angles: P=58°, A=51.63°

Fill above data into software, got thickness result: d=114.40 nm