Ellipsometry

140922
INTRODUCTION

• Measures change in polarization of light as it reflects or transmits from the sample.

• Provides information about amplitude ratio, $\psi$ and phase change, $\Delta$.

• This helps in determining refractive index, roughness and film thickness.
WORKING

Polarizer

source
SOURCE
50 W Quartz tungsten halogen lamp
Consists of tungsten filament and inert gas with small amount of halogen gas.
Application of voltage evaporates tungsten.
Tungsten reacts with halogen.
At higher temperature the halide dissociates, tungsten is deposited on the filament.

POLARIZER
Polarizes the incoming light.
WORKING

- Source
- Polarizer
- Rotating compensator
Rotating Compensator

Fast and Slow axis

Delays phase by 90° if aligned along the axis

Increases sensitivity of $\Delta$.

Helps in measuring depolarization effects.
WORKING

Source

Polarizer

Sample holder

Rotating compensator

Polarizer
Sample holder

Uses vacuum to hold sample in place.

X, Y and Z adjustments to align the sample.

Data is collected at multiple angles (35-75°).

Measurement is done close to Brewster angle of the sample.

In case of wetting experiments, wetting cell is used.

Data is collected at single angle (75°)
WORKING

Source

Polarizer

Rotating compensator

Sample holder

Polarizer

Four quadrant detector

Slide

4% of the light
Four quadrant detector

Used to align the sample.

4 % of the light is reflected from the slide towards 4 quadrant detector.

To make sure sample is held flat and the beam is centered.
WORKING

- Source
- Polarizer
- Rotating compensator
- Sample holder
- Detector
- Four quadrant detector
- Slide

4% of the light
Detector
Charge coupled device

Consists of large number of light sensitive elements (pixels).

Incident photon separates electrons and holes.

Electrons are attracted and moved by application of positive voltage.
**Ellipsometry: Coating Thickness**

- **Light Source**
- **Polarizer**
- **Rotating Compensator**
- **Film**
- **Substrate**
- **Detector**

**Measures**

- $\Psi$: amplitude ratio of $p$ and $s$ wave components
- $\Delta$: phase difference of $p$ and $s$ wave components

**Snell's Law:**

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1}; n_2 > n_1$$

**Figure 22. Ellipsometry block diagram.**
Wave Polarization

Figure 23. Image (left) and animations (right) of wave polarization.

DATA ANALYSIS

\[
\begin{align*}
    r_s &= \frac{n_i \cos \Phi_i - nt \cos \Phi_t}{n_i \cos \Phi_i + nt \cos \Phi_t} \\
    r_p &= \frac{n_t \cos \Phi_i - ni \cos \Phi_t}{n_i \cos \Phi_t + nt \cos \Phi_i} \\
    \tan \psi e^{i\Delta} &= \frac{r_p}{r_s}
\end{align*}
\]
DATA ANALYSIS