Why Measure Film Thickness?

Example 1: Raw Material Thickness

Wafer Substrates

Fabricated by bonding a GaAs wafer to a supporting substrate and then grinding and polishing it.

Used for communications circuits.

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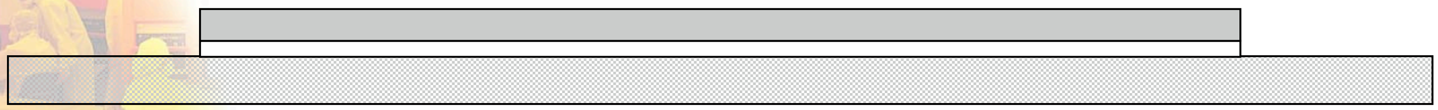
Monitoring of substrate thickness during grinding and polishing.

In-plane distribution of substrate thickness.



Why Measure Film Thickness?

Example 2: Multilayer Film

Semiconductor Epi Film

Multilayer semiconductor film formed on semiconductor substrate.

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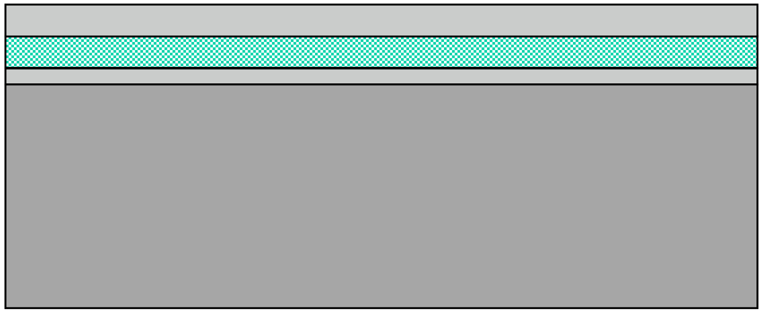
In-plane distribution of each layer's thickness is measured.

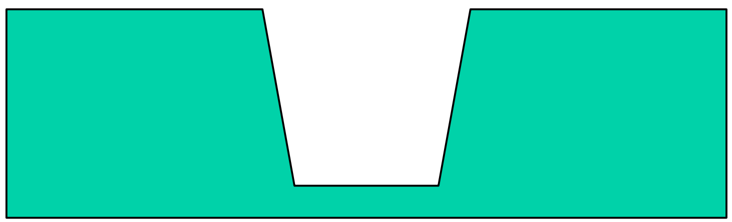


Why Measure Film Thickness?

Example 3: Residual Thickness of Etching

Semiconductor Sensors

Semiconductor sensors employing micromachines.
Fabricated using etching technology.
↓
Residual thickness of etching is measured.



Why Measure Film Thickness?

Example 4: Structures

Reflective LCD Panels

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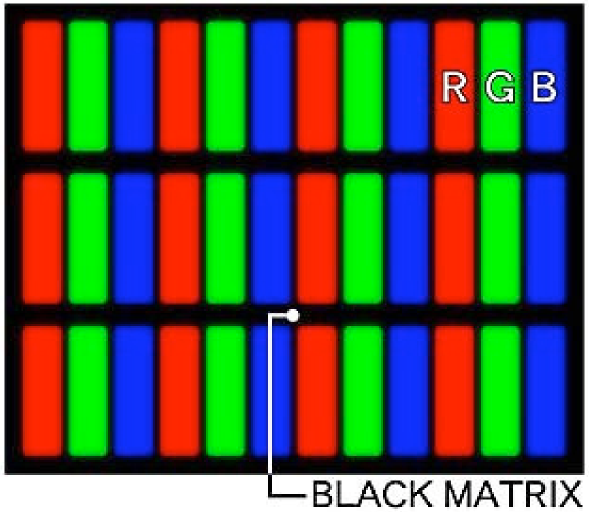
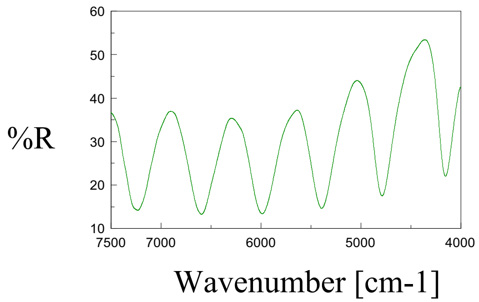
Cell gap is measured.

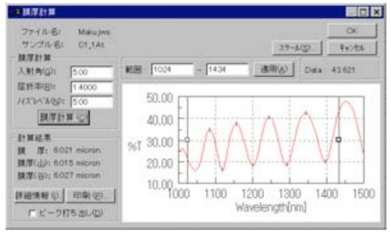


Metrology of Film thickness by light

Nondestructive, Noncontact, High speed, and Handy

1. Fringe method
   - Spectrometer (ultraviolet · visible · near-infrared · infrared)
   - Range: 100nm ~ 100 μm
   - Not feasible for Thin film (<100 nm)





$$d = \frac{1}{2\sqrt{n_0^2 - \sin^2\theta}}\left[\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right]^{-1}$$

d: Film thickness

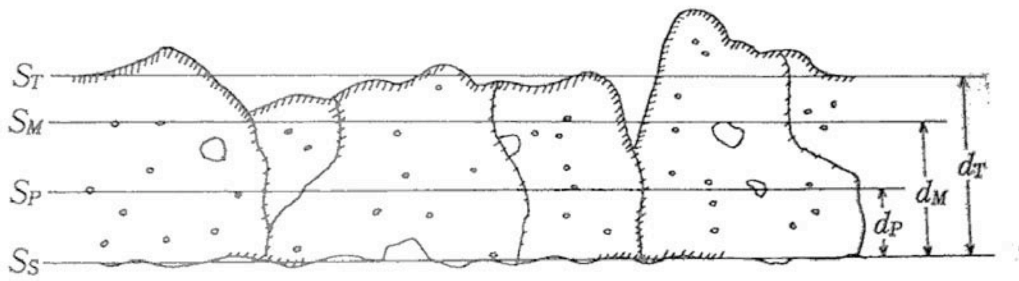
θ: Incidence angle

n_0: Refractive index

λ_1, λ_2: Wavelength of two adjacent peaks

2. Ellipsometry
   - Ellipsometer
   - Range: 1-1000 nm
   - Sensitive for thin films

Classification of Film Thickness



Substrate

- ////// Absorption layer, oxide layer, and diffusion of other gas molecules
- Voids
- Lattice defects such as holes and clusters
- Grain boundary

Geometrical thickness dT / Mass thickness dM / Physical thickness dP

Film Measurement Technique 1: Geometrical Thickness

Method	Technique
Mechanical	Contact system Pneumatic micrometry
Optical	Multiple beam interferometry (MBI) Fringes of equal chromatic order (FECO) interferometry Two-beam interferometry
Other	Scanning electron microscopy (SEM)

Film Measurement Technique 2: Mass Thickness

Method	Technique
Mass	Chemical balance
	Microbalance
	Torsional balance
	Crystal oscillator
Atomicity	Colorimetry
	X-Ray fluorescence
	Ion probe
	Radioactivation analysis
	Beta ray back-scattering

Film Measurement Technique 3: Physical Thickness

Method	Technique
Electrical	Electrical resistance
	Hall voltage
	Eddy current
	Capacitance
Optical	Interference spectrum
	Polarization analysis
	Light absorption