THIN FILM MEASUREMENTS AT NUFAB

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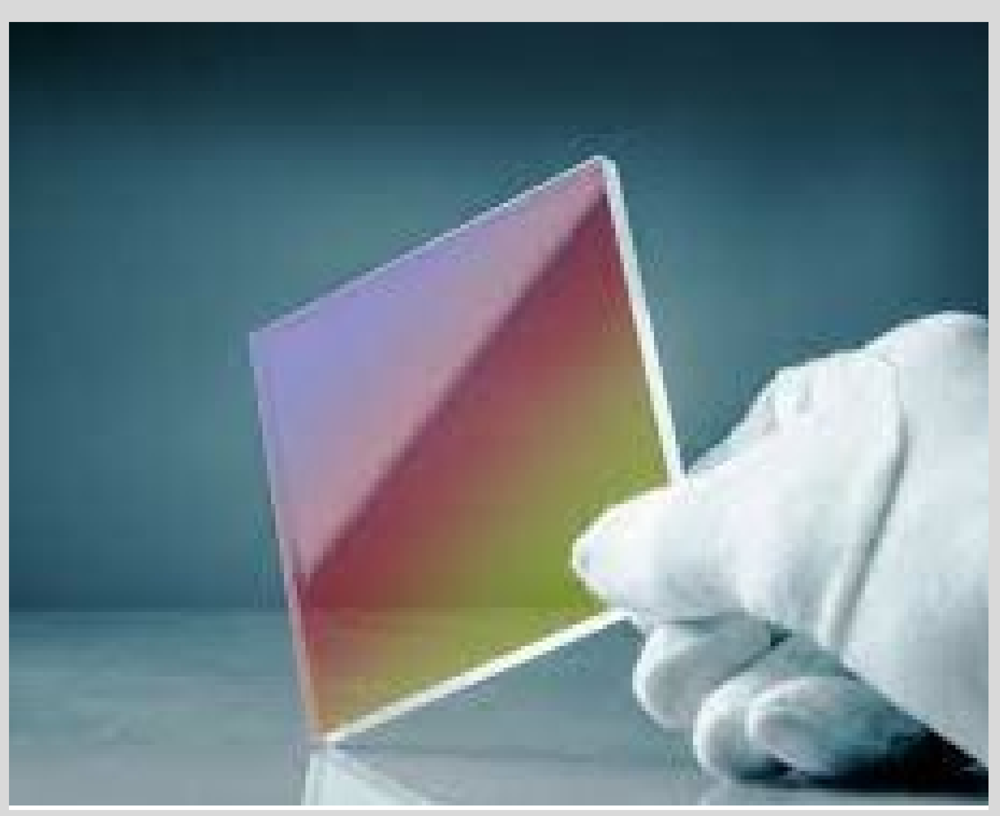
Outline

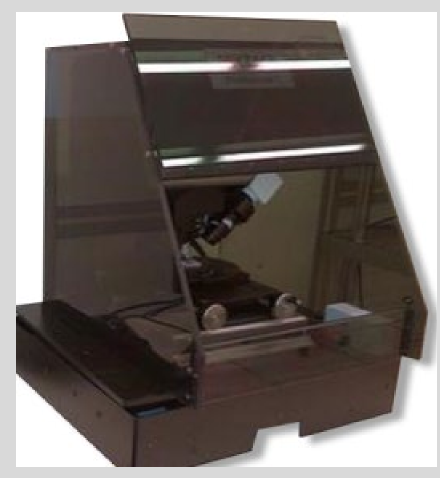
- Available equipment at NUFAB
- Working principles and limits
- Parameter comparison
- How to choose an equipment

Thin film characterization



- Thickness
- Optical constants, n & k
- Roughness
- Mechanical properties, e.g. stress
- Electrical properties, e.g. sheet resistance

Available equipment at NUFAB



Profilometer
Dektak

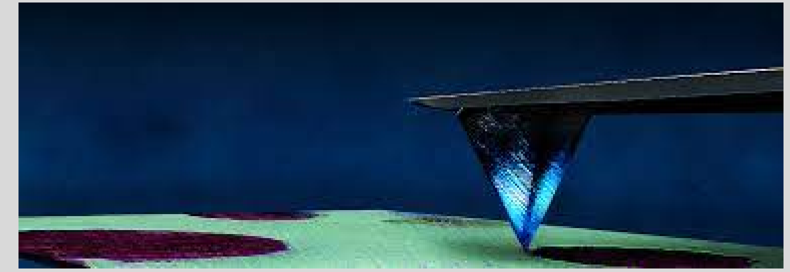
Optical Profilomete
Zygo

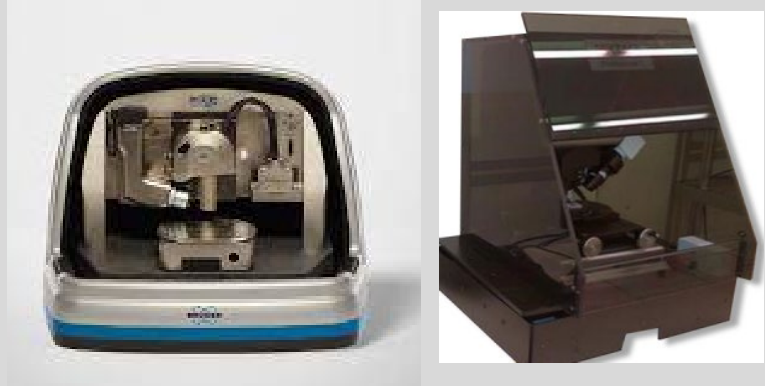
eflectometer
Filmetrics

AFM
Bruker

Two major categories

Mechanical – usually contact



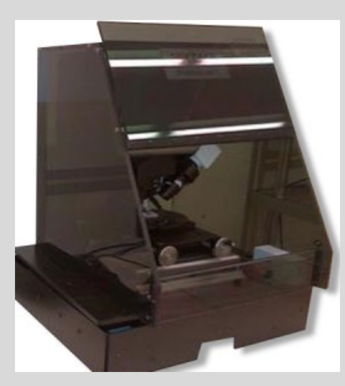


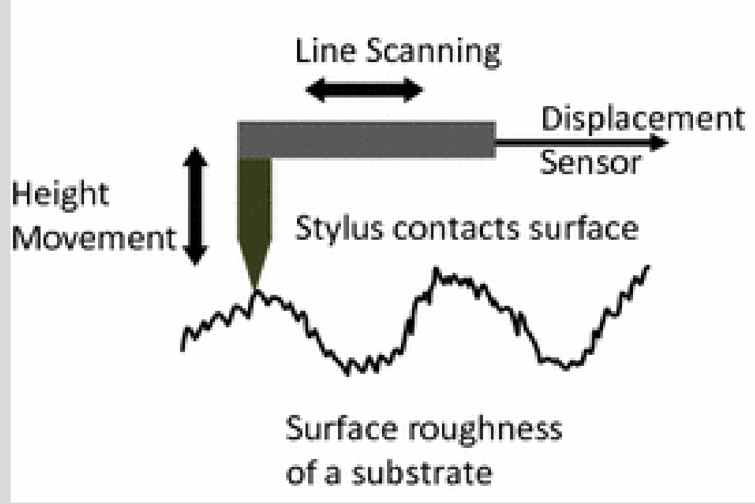
AFM, profilometer

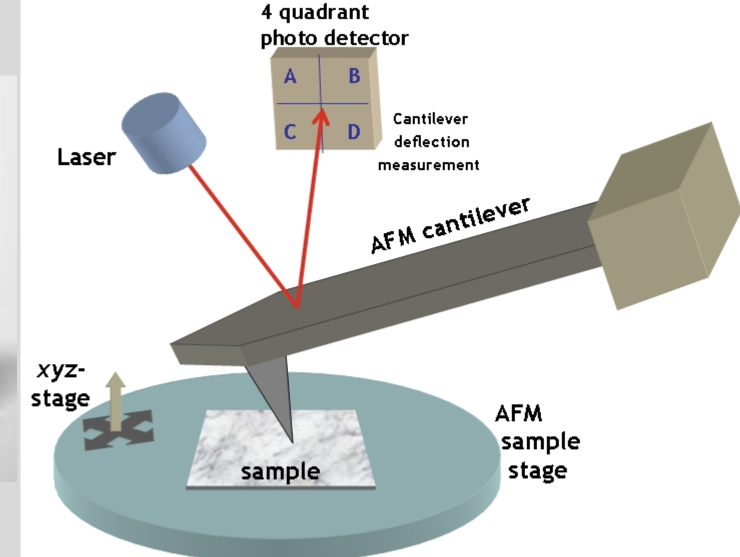
Optical - noncontact

Optical profilometer, ellipsometer, reflectometer

Mechanical methods







Measures

1. Thickness, roughness
2. Mechanical properties
3. Not optical properties

Pros:

1. **Signal reliable**
2. Regardless film optical properties

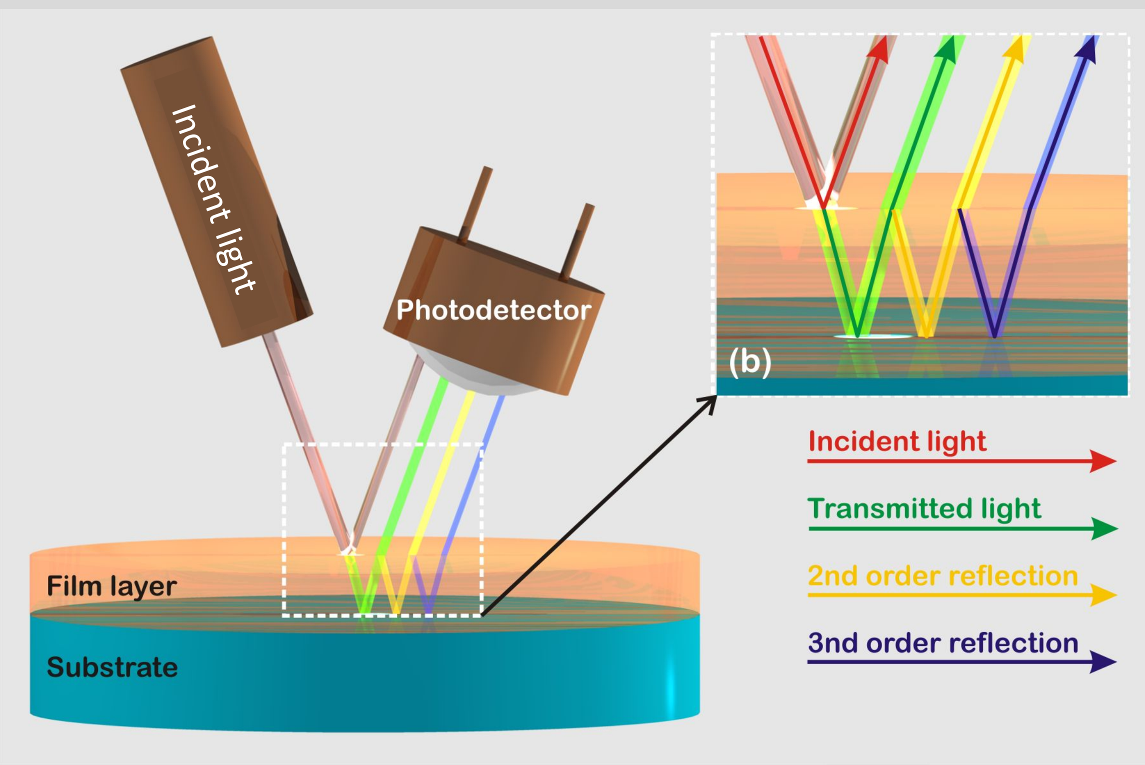
Cons:

1. Signal to noise ratio - measurement setting tuning
2. Requires a step to measure film thickness
3. Contact measurement (except AFM noncontact mode).
4. Relatively slow measurement, especially for mapping

Ref: https://www.youtube.com/watch?v=2scVWMopjvQ
https://www.bruker.com/en/news-and-events/webinars/2020/an-overview-of-surface-roughness-measurements-choice-of-technique-and-analysis.html

	Profilometer Dektak	AFM Bruker Edge
Measured properties	Thickness, roughness, stress	Thickness, roughness
Thickness range	50 nm – 1mm	1 nm – 10 µm
Height resolution	4~10 nm	sub nm
Lateral measurement range/resolution	Range: < 8 inch Resolution: 5 µm	Range: < 90 µm
Speed	Defined by user, typical: 0.5mm, 20 sec	

Optical methods



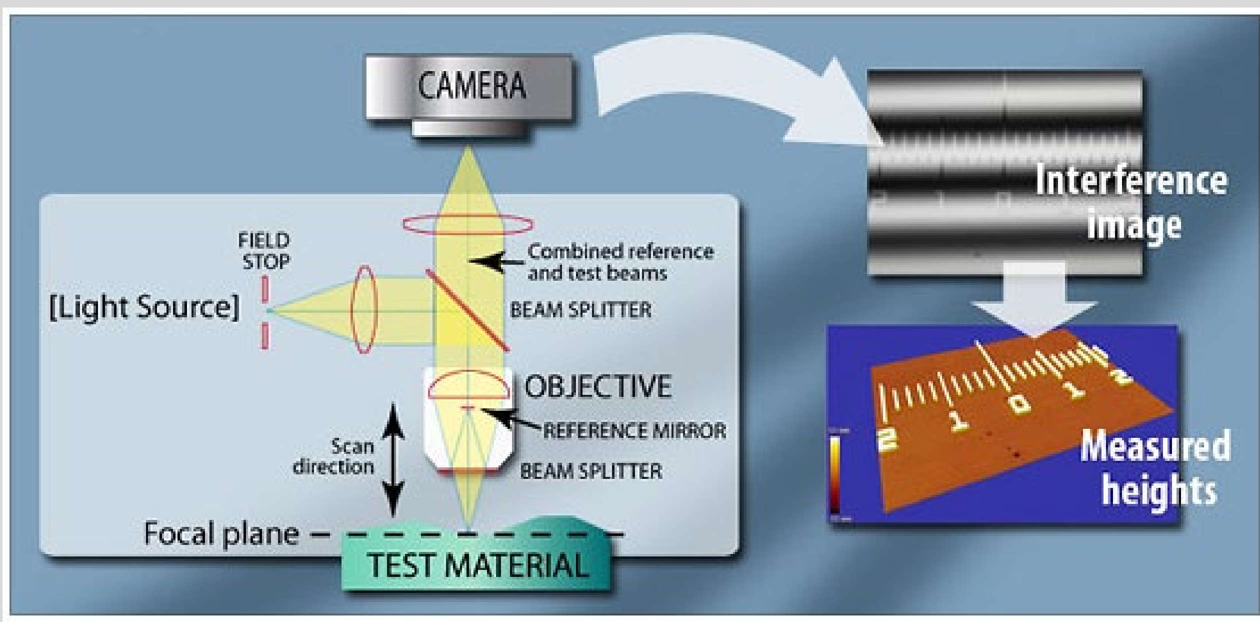
Measures
1. Thickness, roughness
2. Optical constants (except zygo)
3. Not mechanical properties

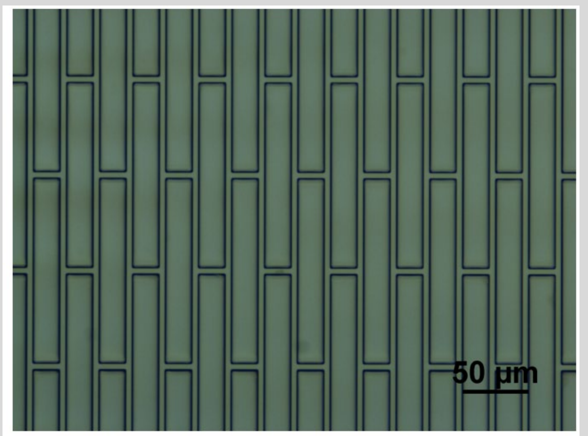
Pros:
1. Noncontact
2. High resolution
3. Fast
4. Don't need a step to measure thickness (except zygo)

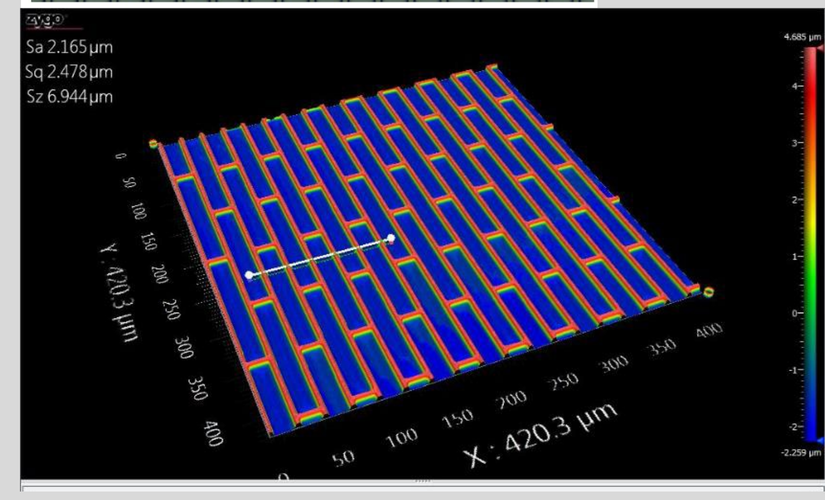
Cons:
1. Complex signal analysis, usually involves modeling and fitting
2. Usually have material limits

Optical method 1: interference

Optical profilometer - Zygo







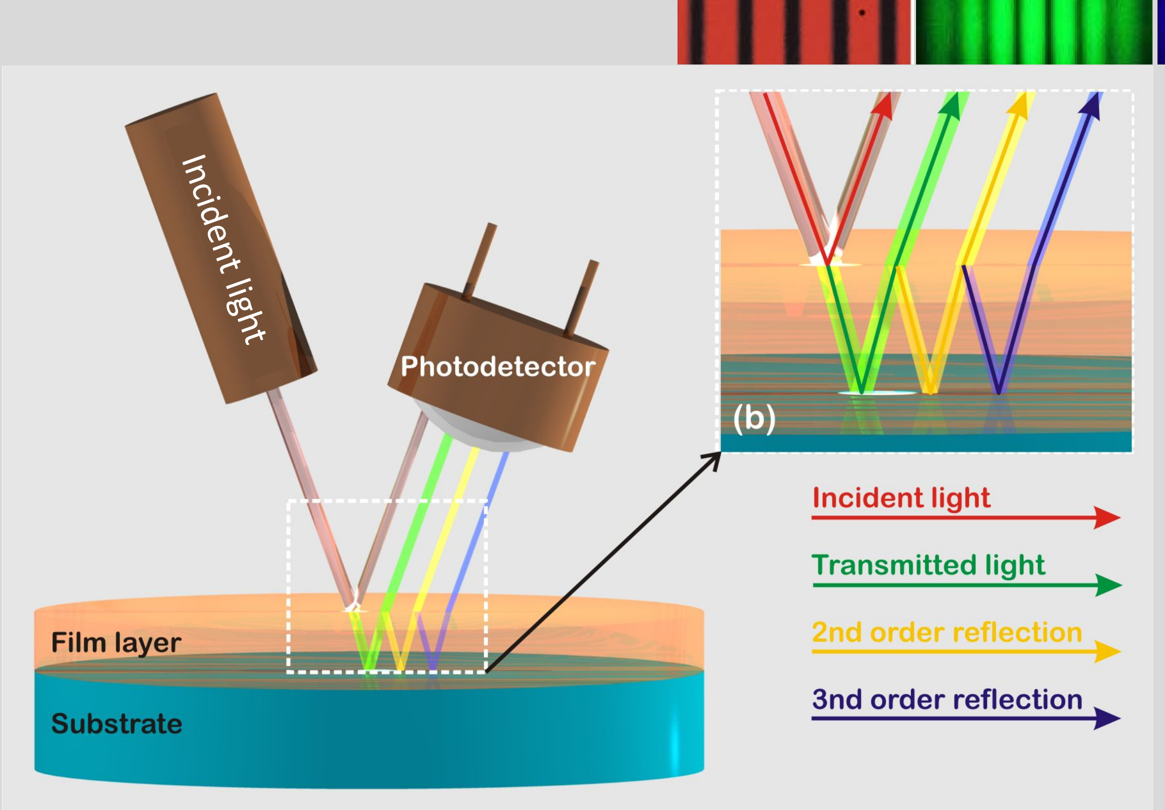
Compares incident and reflected light

Measures surface topography with high resolution, fast and 3D mapping

Ref: https://www.zygo.com/support/technologies/csi-techology

	Optical profilometer zygo	Profilometer Dektak	AFM Bruker
Working principle	Optical – interference	Mechanical	Mechanical
Measured properties	Thickness, roughness	Thickness, roughness, stress	Thickness, roughness
Thickness range	Sub nm - 1mm	50 nm – 1mm	1 nm -10 µm
Height resolution	Sub nm	4~10 nm	Sub nm
Lateral measurement range/resolution	Range: 3.3 x 3.3 mm^2 without stitch, 8 inch with stitch Res. : 1 µm	Range: 8 inch Res. : 5 µm	Range: 90 µm
Speed	Height dependent, Usually < 1min	Defined by user, typical: 20 sec for 0.5mm line scan	

Zygo limit

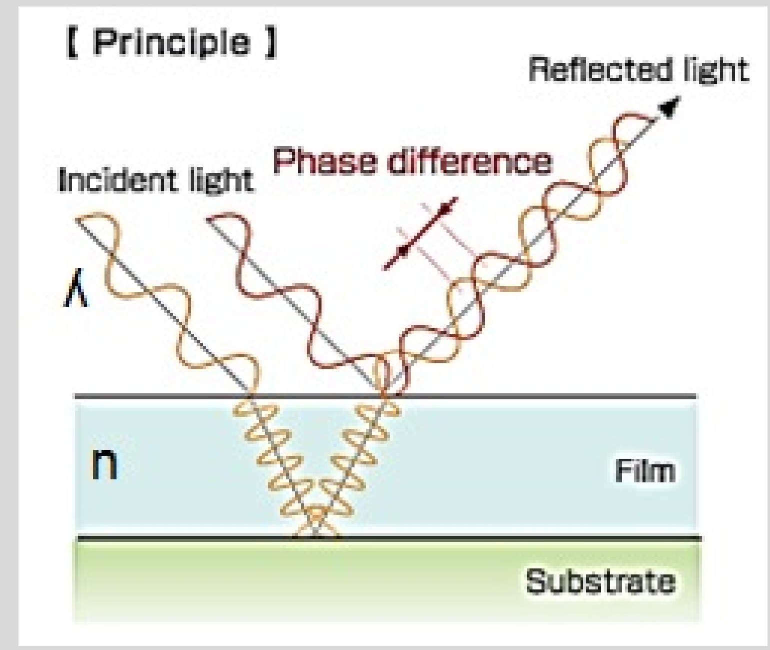


1. Eliminate the transmitted light
   ---- opaque films

2. If transparent, separate the interferences
   ---- thick films, usually > 10 μm

Another interference measurement

Reflectometer - Filmetrics



Specially for transparent films

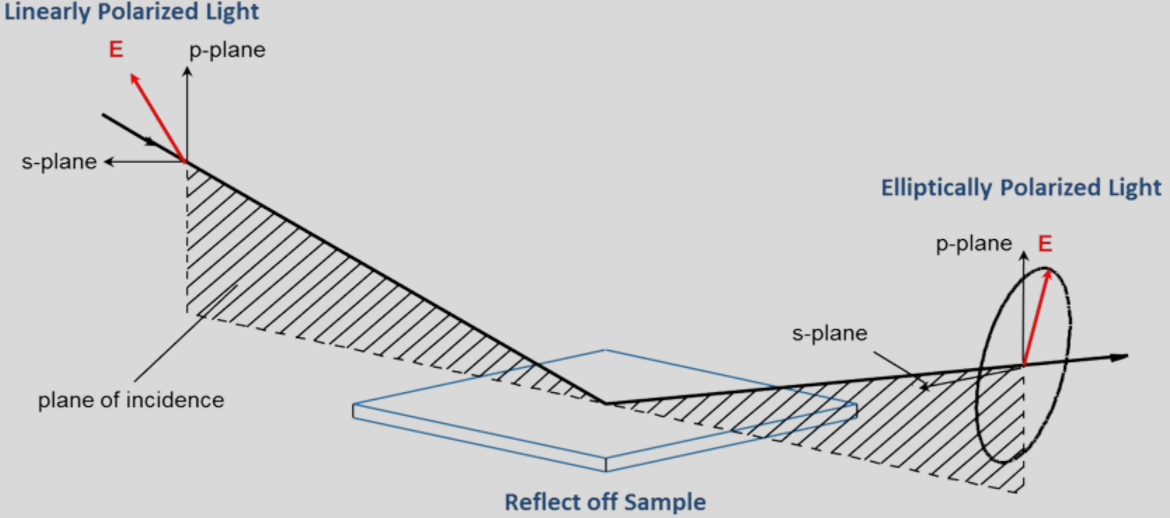
Pros:
1. Quick and easy measurement
2. Easy modeling

Cons:
1. Transparent or semi-transparent film
2. Known material, i.e. well characterized n&k

Ref: https://www.filmetrics.com/technology

Optical method 2: ellipsometry

Ellipsometer – J. A. Woollam



Measure the change in polarization after the light Interact with the material

Pros:

1. Quick and easy measurement
2. High sensitivity, can measure films of 1nm
3. Works well with unknown materials

Cons:

1. Modeling may not be easy
2. Limited to transparent or semi-transparent films

Ref: https://register.gotowebinar.com/recording/4749616861388349199

	Reflectometer	Ellipsometer
Measured properties	Thickness, roughness, n&k	Thickness, roughness, n&k
Thickness range	15 nm – 50 μm	1 nm – 10 μm
Lateral measurement range/resolution	Signal averaged over 3mm Dia.	Signal averaged over 3mm Dia.
Material limit	Known, transparent or semi-transparent	Transparent or semi-transparent
Speed	< 1min	< 1min

	Reflectometer / ellipsometer	Optical profilometer	Profilometer	AFM
Working principle	Optical – interference /ellpsometry	Optical – interference	Mechanical	Mechanical
Measured properties	Thickness, roughness Optical constants	Thickness, roughness	Thickness, roughness, stress	Thickness, roughness
Thickness range	15nm – 50 µm/ 1nm – 10 µm	Sub nm - 1mm	50 nm – 1mm	1 nm – 10 µm
Height resolution	1 nm, modeling matters	Sub nm	4~10 nm	Sub nm
Lateral range /resolution	Average over 3mm dia.	Range: 8 inch with stitch Res. : 1 µm	Range: 8 inch Res. : 5 µm	Range: 90 µm
Speed	~ 1min	Height dependent, Usually < 1min	Defined by user, typical: 20 sec for 0.5mm line scan	

Example cases

Q1: Measure photoresist thickness

A1: profilometer – Dektak (preferred) or reflectometer

Q2: Measure etching depth

A2: If photoresist is still there, use profilometer-Dektak. If not, profilometer-Dektak or optical one –zygo

Q3: Measure a PECVD or LPCVD film. Don't want to create a step

A3: Reflectometer or ellipsometer

Q4: Measure films by e-beam evaporator or thermal evaporator, or metal films by sputter

A4: During deposition, cover the substrate partially to create a step. Measure with profilometer –Dektak (preferred) or optical profilometer – zygo

Q5: Measure films by ALD

A5: Ellipsometer

Q6: Need a beautiful 3D picture for publication

A6: optical profilometer –zygo or AFM depending the scan area. Try to fit your sample in.

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