Latest Technology in Thin Film Measurements

Dr. Christopher Schmitt
Leybold Optics
Alzenau, Germany

LEYBOLD OPTICS

Outline

- **Motivation (Requirements of good measurement equipment)**
- **Features of new Dual In Situ Sensor**
- **Experimental results**
- **Summary**

Motivation

Main reasons for development of DISS:

- Increase productivity

  → Reduce scrap

- Increase product quality

  → Reduce tolerances

Requirements for good measurement equipment

To avoid scrap
online quality control equipment must enable the operator

- To detect all quality relevant deviations
  - To detect them accurately and immediately
    - To take corrective action fast
      - Verify success of corrective action in real time

→ **minimize the time constant for loop control**

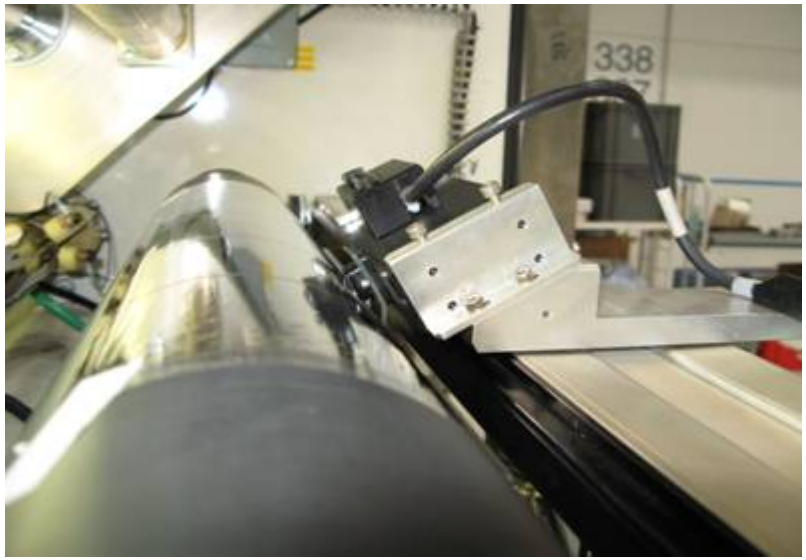
Quality Relevant Parameters

Threats for scrap (accessible to DISS)

- Absolute values for
  - layer thickness of active area and heavy edge
  - Width of free margins
- Uniformity across and along the web for
  - layer thickness of active area and heavy edge
  - Width of free margins
- Alignment of heavy edge, free margins and pattern

Conventional Measurement Equipment

Free **M**argin **M**easurement **S**ystem



Layer **M**easurement **S**ystem LMS

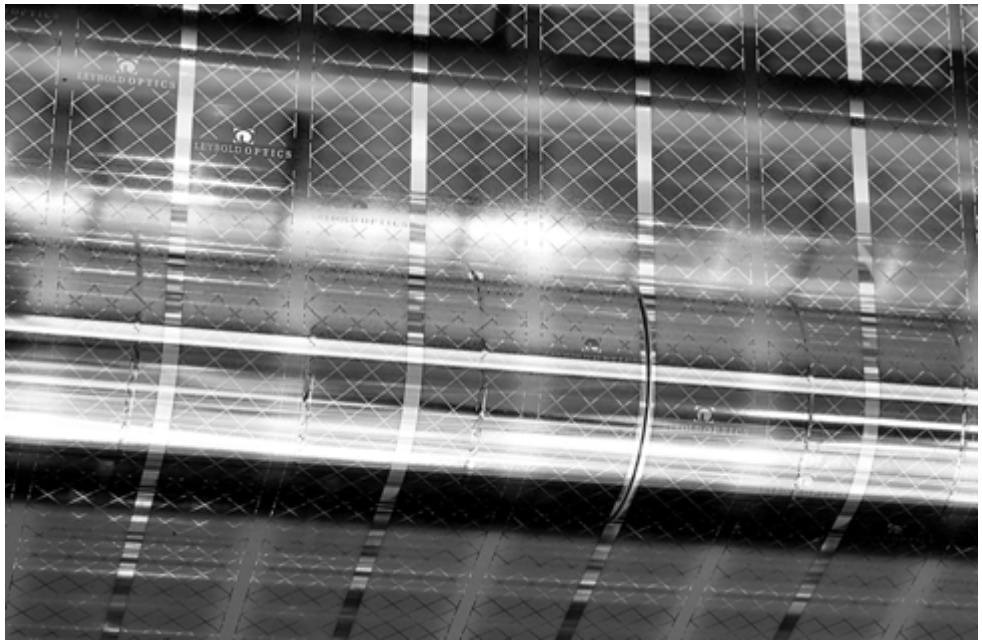
- **Traveling sensors across web width**
- **Supply only one information at a time**
- **Uniformity information across web takes up to 60 sec. (1200 m of web)**
- **Return time after corrective action up to 60 sec. (1200 m of scrap)**

Needed is simultaneous, real time measurement of all quality relevant parameters !

Example: Pattern

Layer Thickness of Patterned Film:

- Present equipment restricted to pattern sizes of > 15 X 15 mm
- Trend towards smaller structures
- Smaller probe area required
- DISS supplies resolution for pattern structures down to 3 x 3 mm^2

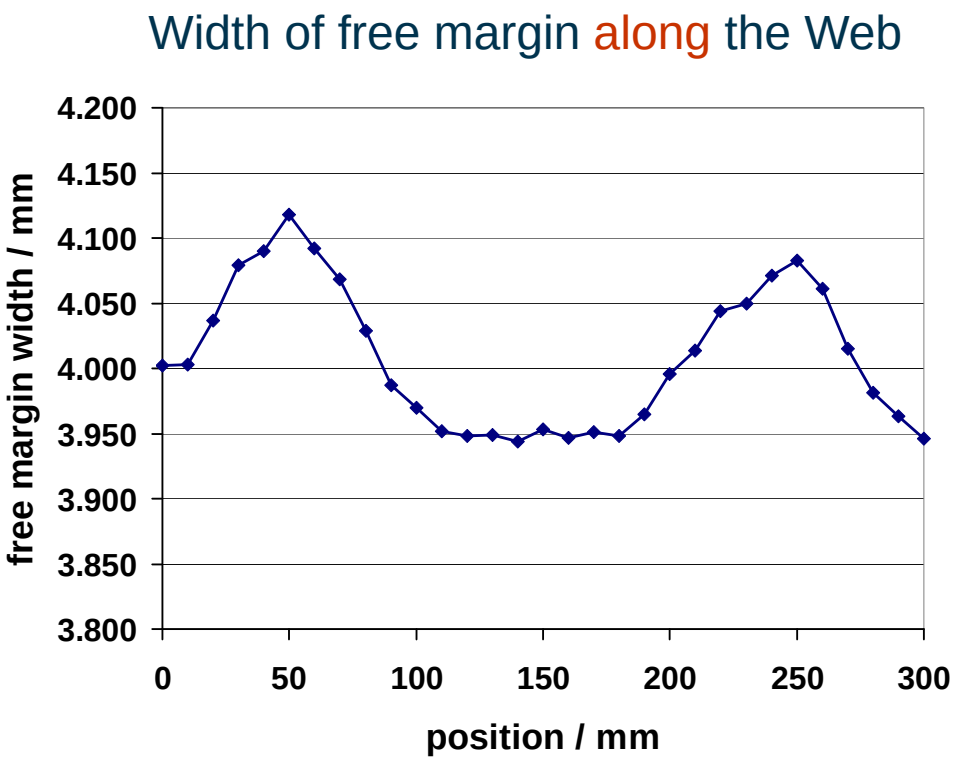


LEYBOLD OPTICS

Example: Free margin uniformity

Oscillating free margins

- Resolution of free margin measurement 20 to 200 m of web between readings
- Free margin oscillations go unnoticed
- Required is a resolution < 0.2 m to detect free margin oscillations
- DISS supplies resolution of 0.003 m



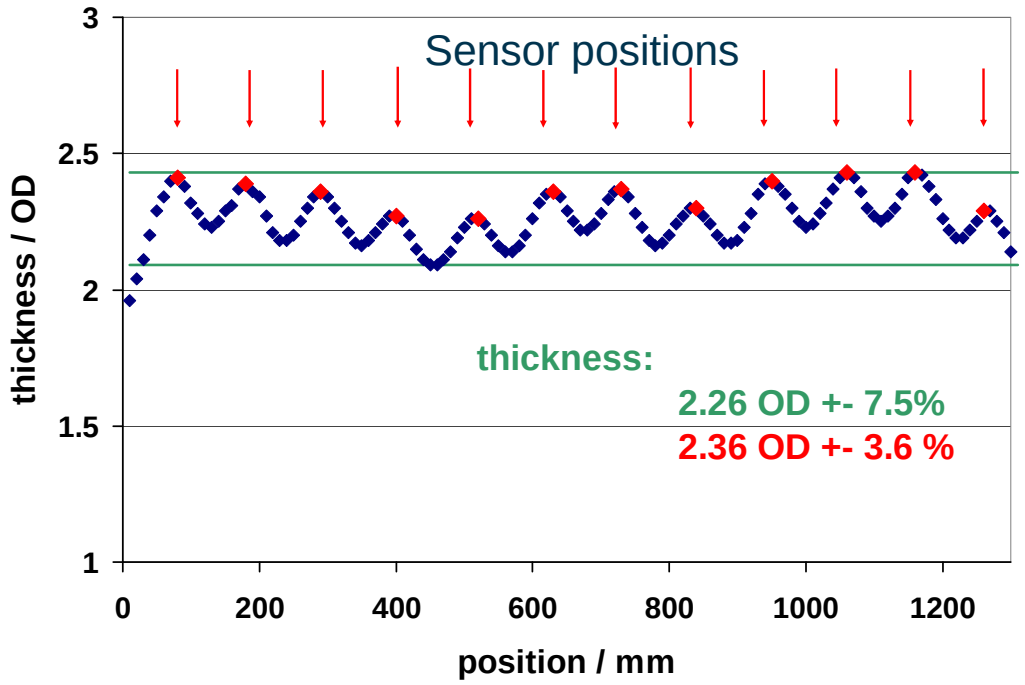
LEYBOLD OPTICS

Example: Uniformity across Web

Banding:

- Present equipment measures only few positions
- Ignores variations between measurement points
- Resulting uniformity information too tolerant
- Higher spatial resolution of sensors needed: Nyquist theorem
- DISS supplies spatial resolution of < 3 mm

Layer thickness across the Web



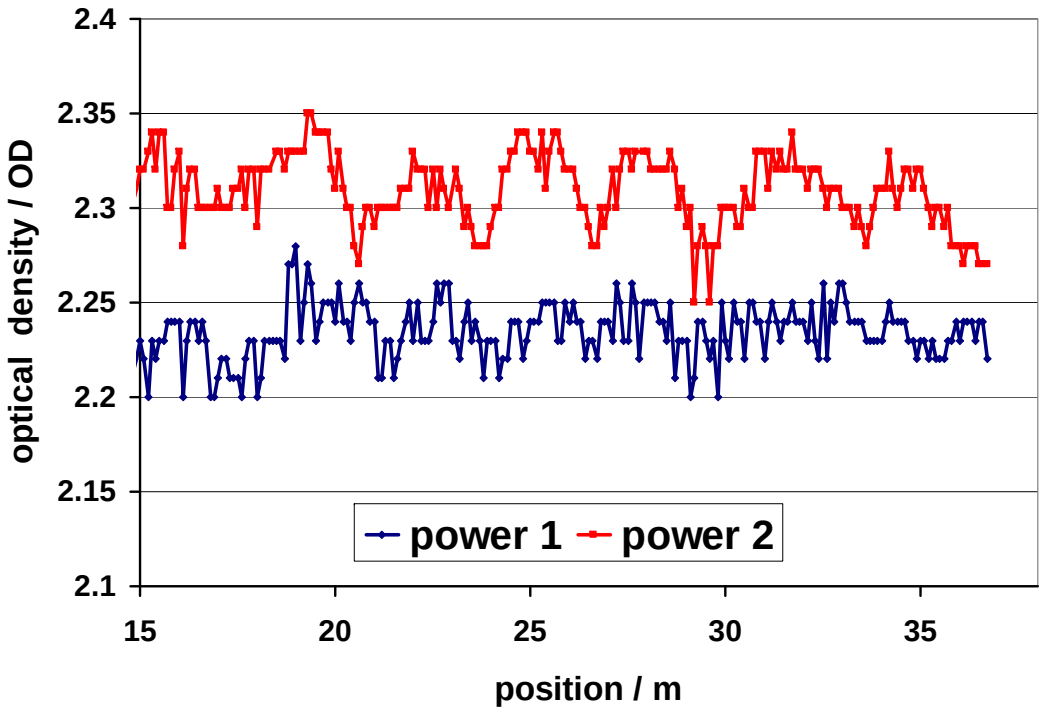
LEYBOLD OPTICS

Example: Uniformity along Web

Al-Dripping:

- Present equipment measures every ~ 100 m web length
- Cannot detect variations between measurement points
- Resulting Nonuniformity is “Noise”
- Higher measurement frequency needed
- DISS supplies frequency of 20 kHz corresponding to 1 mm @ 20 m/sec

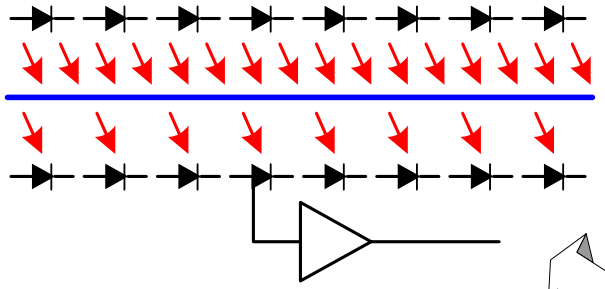
Layer thickness along the WEB



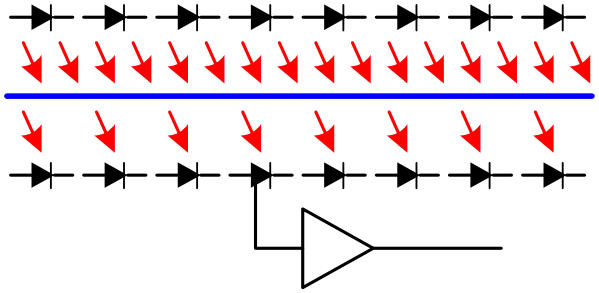
LEYBOLD OPTICS

DISS, Principle

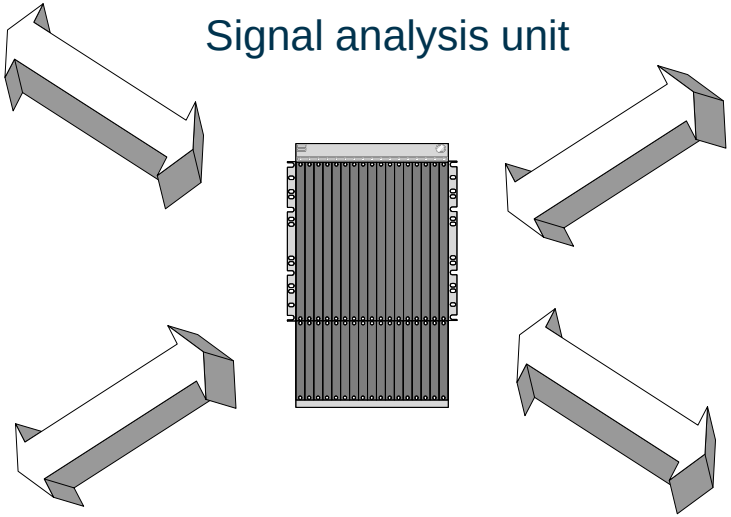
Free margin sensor



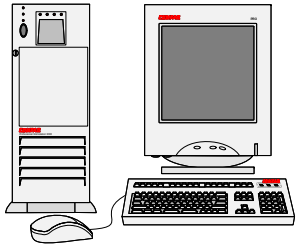
Optical density sensor



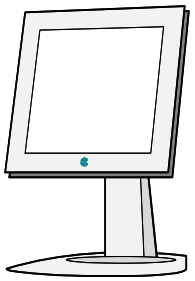
Signal analysis unit



Host



Display:



- raw data
- mean values
- variances
- trend

DISS, the bare FACTS

Optical Density Sensor

Parameter	Unit	DISS-Spec
Optical density	OD	O - 4
Wavelength	nm	645
Geometrical resolution across web	mm	3
Geometrical resolution along web @ 20m/s	mm	3
Probe Frequency	kHz	20

Free Margin Sensor

Parameter	Unit	DISS-Spec
Optical resolution across web	µm	< 50
Geometrical resolution along web @ 20 m/s	mm	3
Probe Frequency	kHz	20

Comparison

What DISS can see for YOU

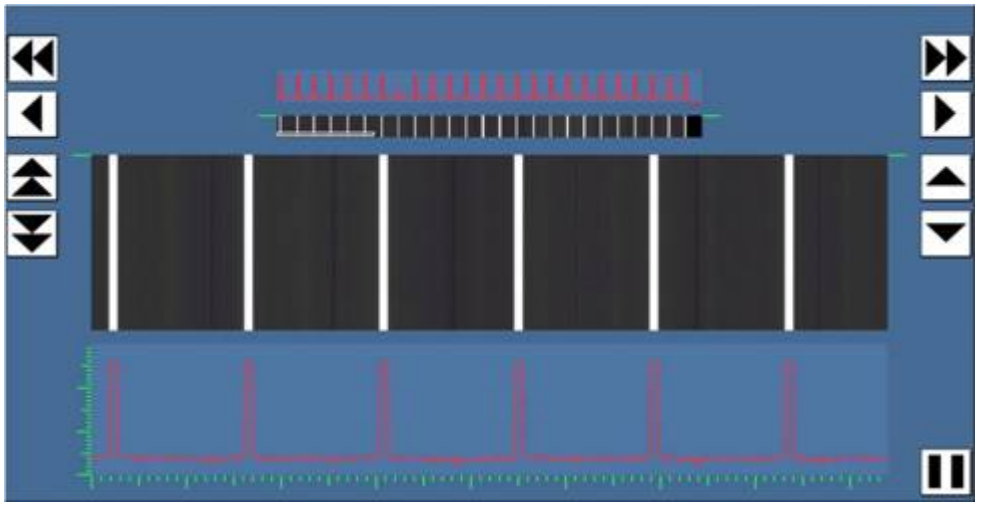
Conventional

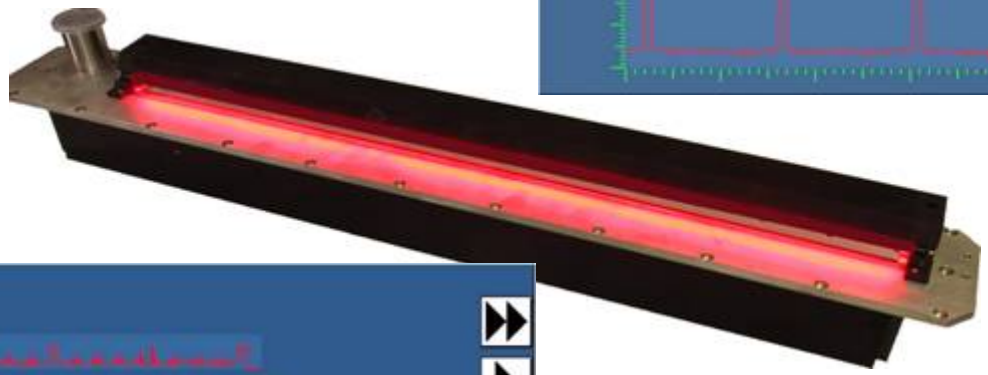
Parameter	Capability	Real Time	Capability	Real Time
Average Layer Thickness in Active Area and Heavy Edge	yes	yes	yes	no
Uniformity of Layer Thickness across Web	yes	yes	yes	no
Uniformity of Layer Thickness along Web	yes	yes	no	no
Width of Free Margins	yes	yes	yes	no
Uniformity of Free Margins across Web	yes	yes	yes	no
Uniformity of Free Margins along Web	yes	yes	no	no
Alignment of Heavy Edges and Free Margins	yes	yes	no	no

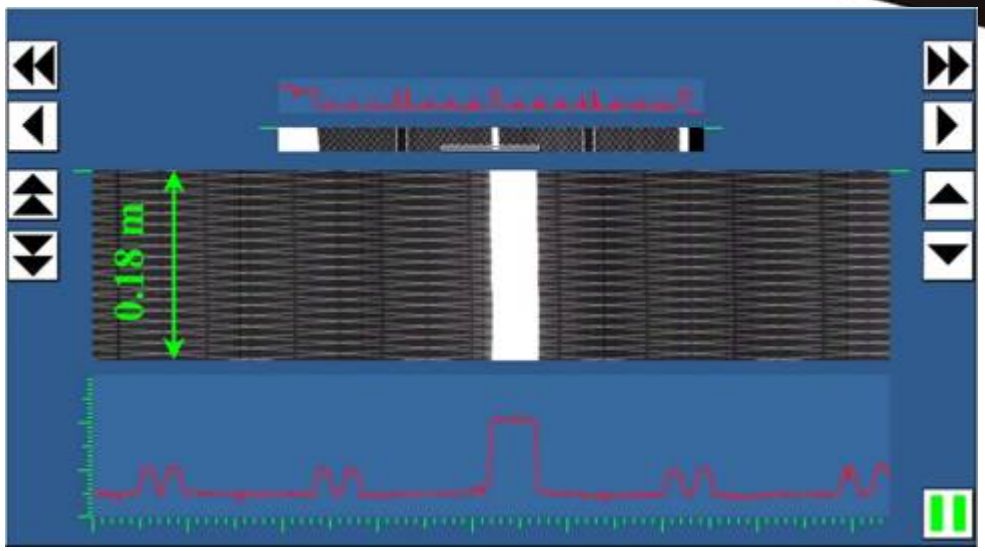
DISS: Experimental Results

Free margin measurement:

free margin: 0.5 mm
pitch: 9 mm







Free margin measurement:
free margin: 4.0 mm
pattern: 8 x 8 mm²
winding speed: ~ 18 m/s

LEYBOLD OPTICS

Summary

- Scrap reduction by true real time process control
- All free margins are measured simultaneously
- Real time control of layer uniformity across and along the web
- ‘100%’ quality control of the film
- Online control of the alignment of free margin, active area/heavy edge and pattern (for capacitor applications)
- Online control of layer thickness for patterned capacitor films
- DISS is the basic prerequisite for improvements in automatic layer control and the automatic uniformity control
- No moving parts, simple adjustment, auto calibration for thickness measurement

Thank you for your kind attention !