# COMPASS

a **FormFactor** users' group conference

# Multi Sensor Metrology Tools for Hybrid Metrology in Wafer Manufacturing

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CEO FRT GmbH

# Products

- Designed for full integration into automated production lines

MicroProf® MHU

MicroProf® FS

MicroProf® FE/AP

Fully automated systems with flexible sample handling

# Multi Sensor Metrology

- compact – multi-sensor – modular – standardized

point sensors

- extremely flexible
- any scan range
- fast on large areas

field of view sensors

- highest resolution
- large areas via stitching
- fast on small areas

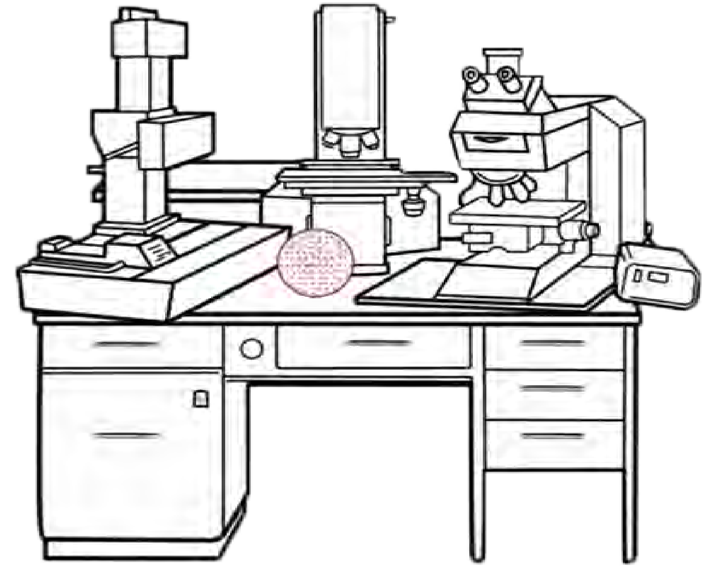
atomic force microscopy

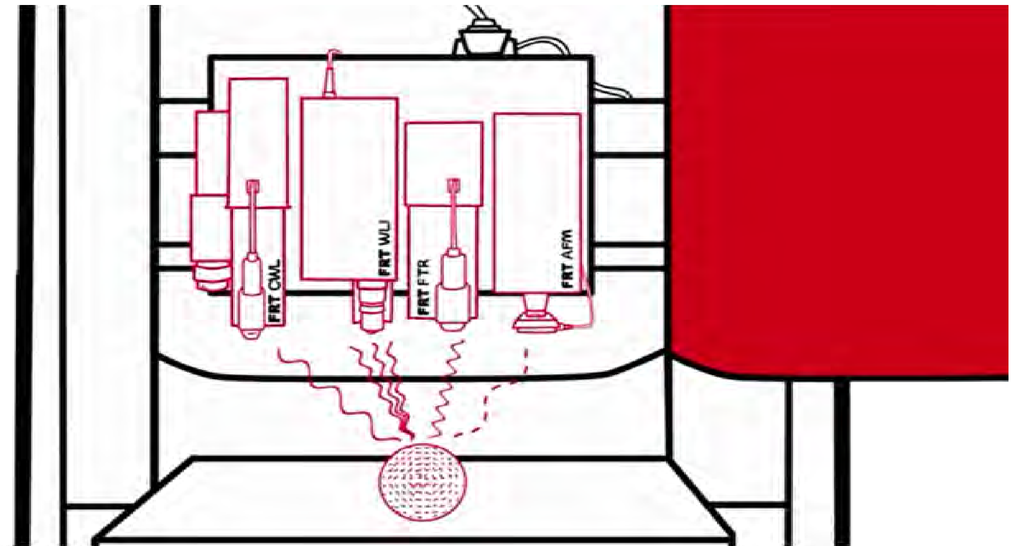
- nm resolution
- large scan area
- easy handling

film thickness sensors

- highest resolution
- large measurement range
- measurement of multi layers

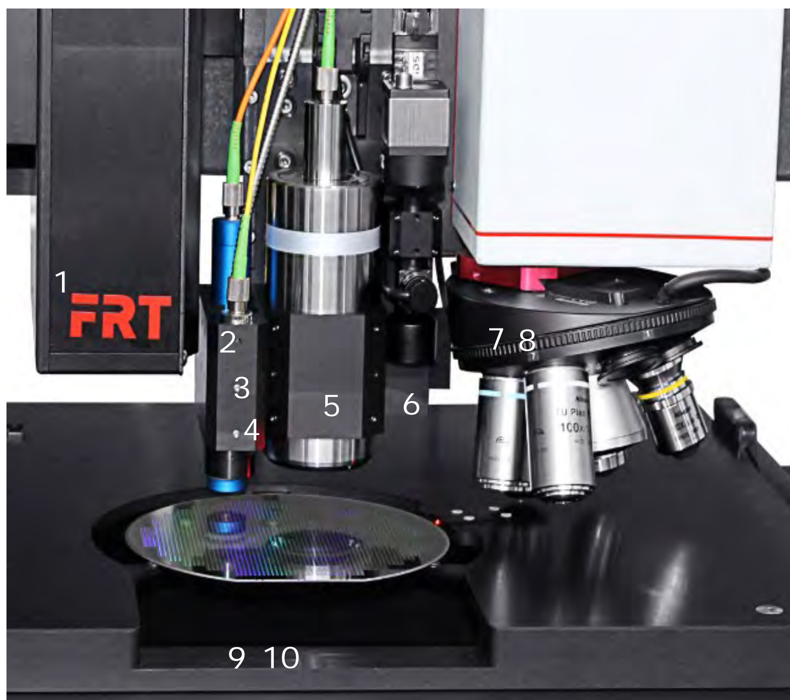
*topography*
*profile*
*roughness*
*film thickness*
...





# Tool platform example

- All-in-one device due to unique multi sensor philosophy

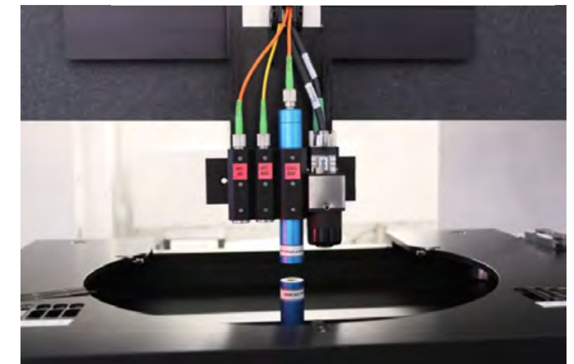



1. WLI PL (white light interferometer)
2. CWL 600 µm (point sensor)
3. FTR (reflectometer layer thickness)
4. CWL FT (layer thickness sensor)
5. CWL 1 mm (point sensor)
6. High-resolution camera with pattern recognition
7. CFM DT (combi-sensor white light interferometer with 7x turret)
8. CFM DT (combi-sensor confocal microscope with 7x turret)
9. CWL 600 µm (TTV point sensor), underside
10. FTR (reflectometer layer thickness), underside

Fully automated multi sensor and hybrid metrology arrangement – 10 sensors, 1 recipe

# MicroProf® Series - Wafer metrology tool for manufacturing

- 300 mm / 200 mm wafer stage
- multi sensor configuration
- hybrid metrology
- simultaneous measurement on both wafer sides
- multiple applications
- fully automated handling and integration
- fast and accurate measurement
- high repeatability and reproducibility
- fully SEMI compliant



# MicroProf® Series – Metrology for

die separation

bumps and pillars
vias and trenches

FOWLP

MEMS cavities

edge trimming

advanced packaging
2.5D / 3D IC

multilayer thickness
polymers - PR/PI/BCB
Oxides, Nitrides
Silicon, RST, SOI
Mold

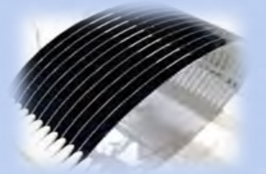
nanotopography

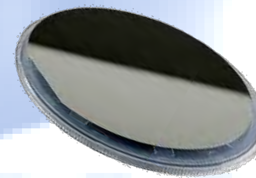
wafer thinning
TTV, bow and warp

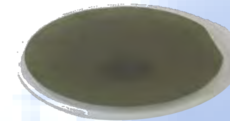
**solutions for many process steps**

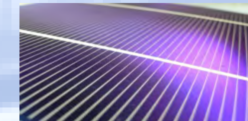
# MicroProf® Series – Measurement of

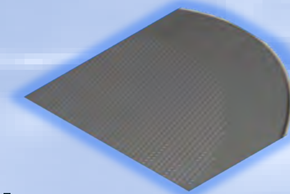
- semiconductors Si, Ge,…
- compound semiconductors GaAs, InP, SiC, GaN, ZnO…
- special substrates LiNbO3, DLC,…
- sapphire and glass wafer
- solar / PV mono-/poly-crystalline and amorphous Si
- lens wafers





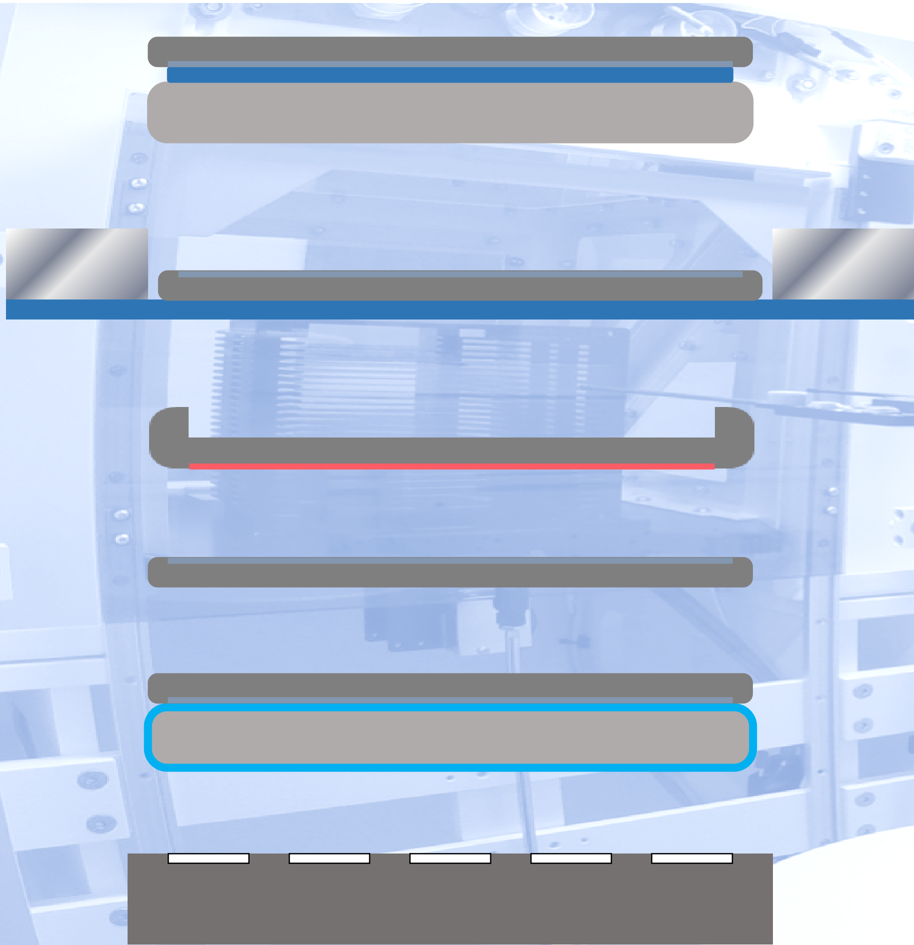






**solutions for all materials**

# MicroProf® Series - Automated handling of



bonded wafers /wafer stack

wafer on tape in frame

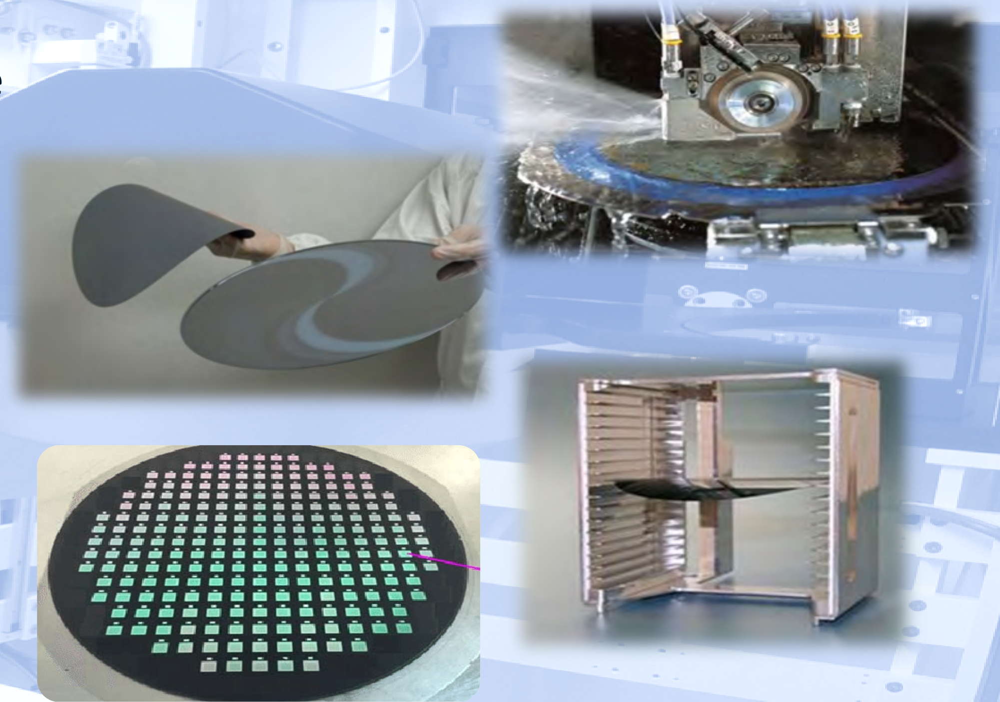
Taiko wafer

bare and
thinned wafer > 50 µm

SOI wafer

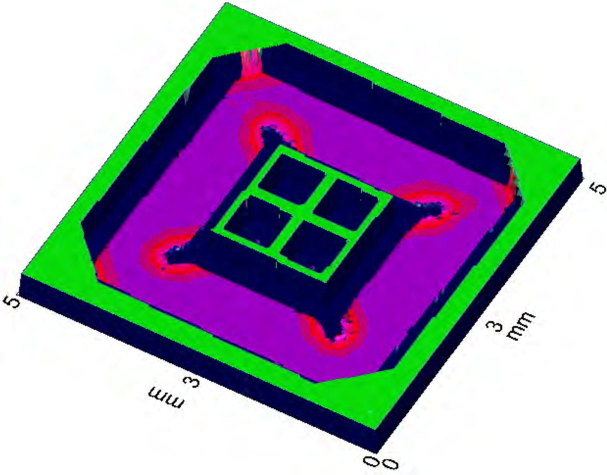
FO wafer

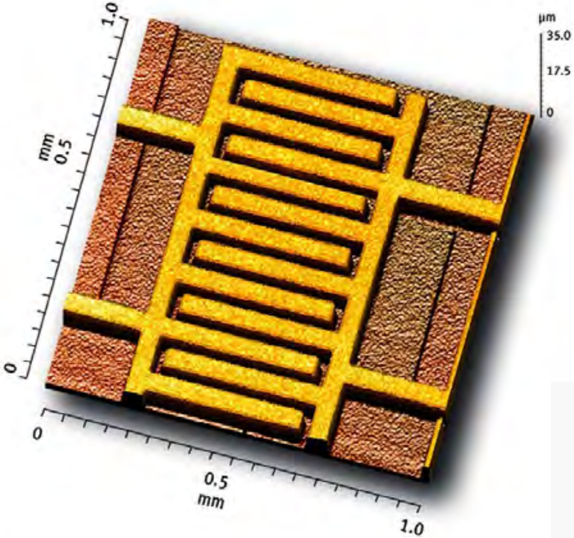
**solutions for all wafer types**

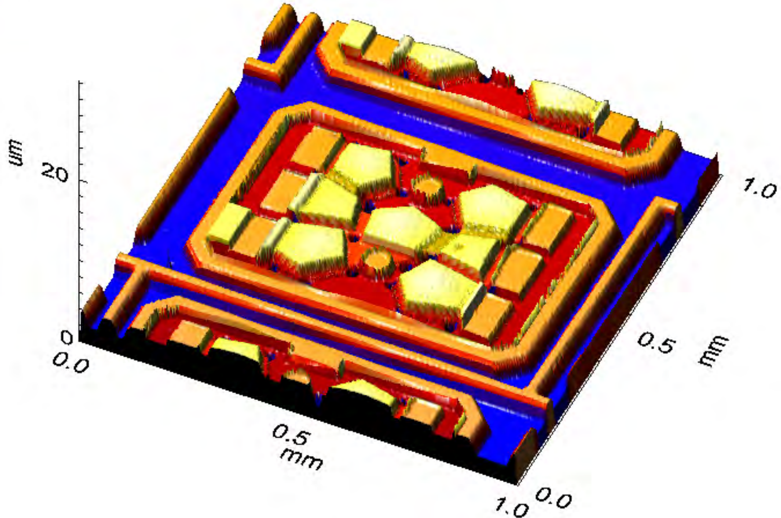


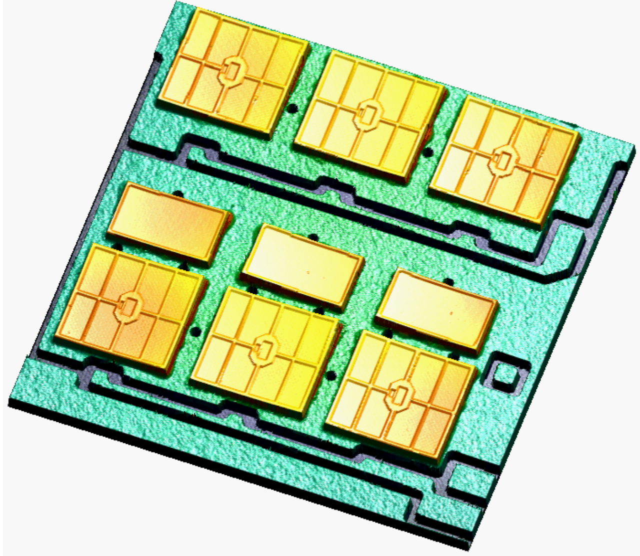
*photographs courtesy of DISCO HiTEC EUROPE GmbH, mechatronic systemtechnik gmbh and researchgate.net*

# Applications - MEMS and electronic components



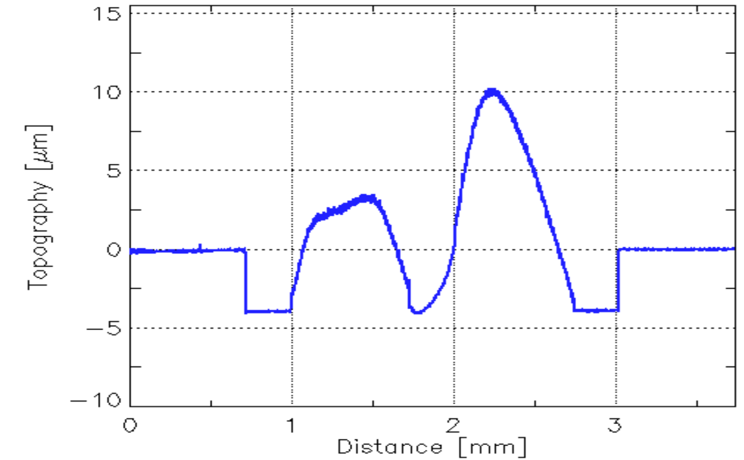



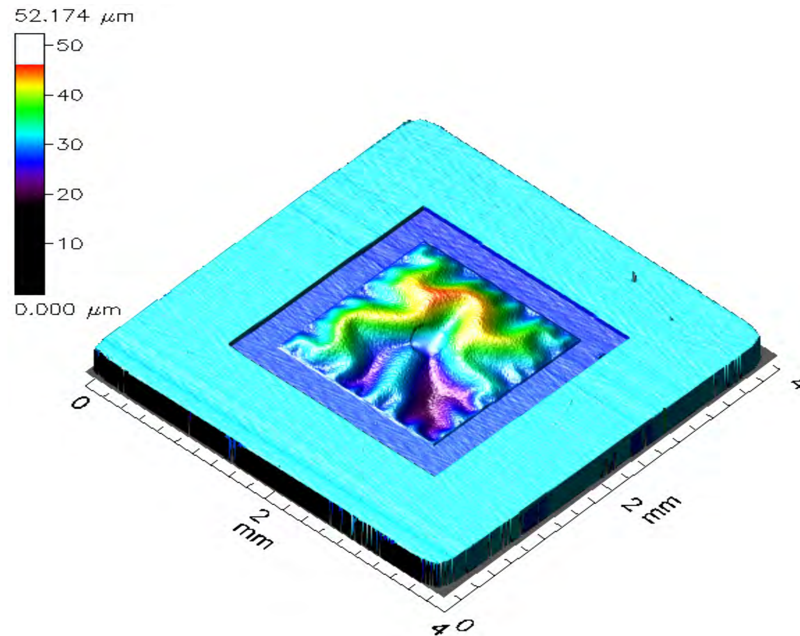



# Application - MEMS

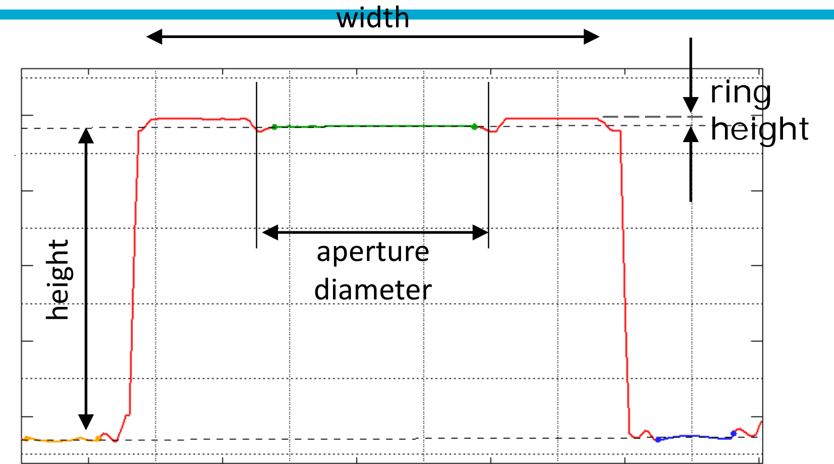
- evaluation of:
  - profile and shape of total structure
  - topography and radius

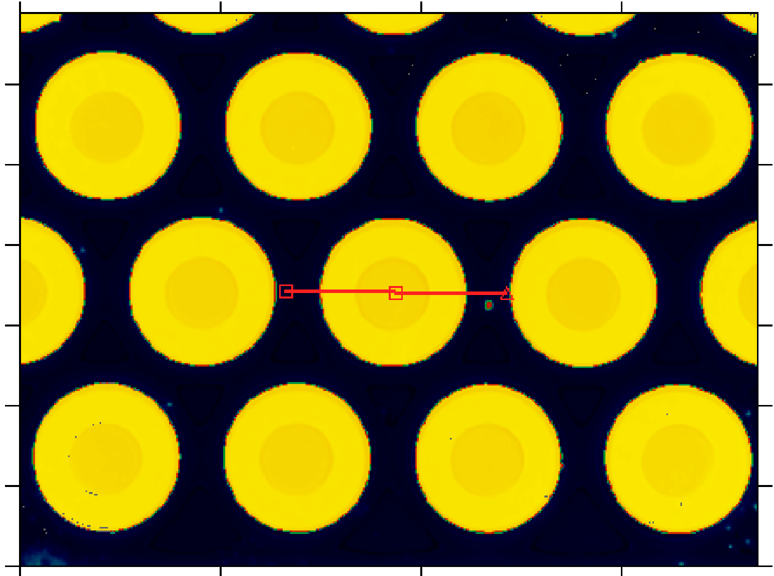


# Application - VCSELs

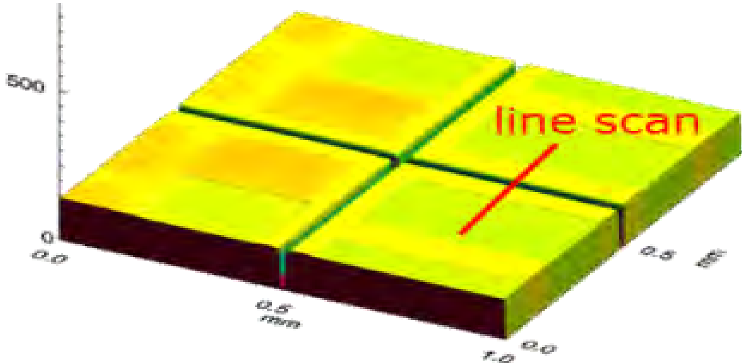
- evaluation of:
  - height and width of total structure
  - ring contact height to top of aperture
  - aperture diameter



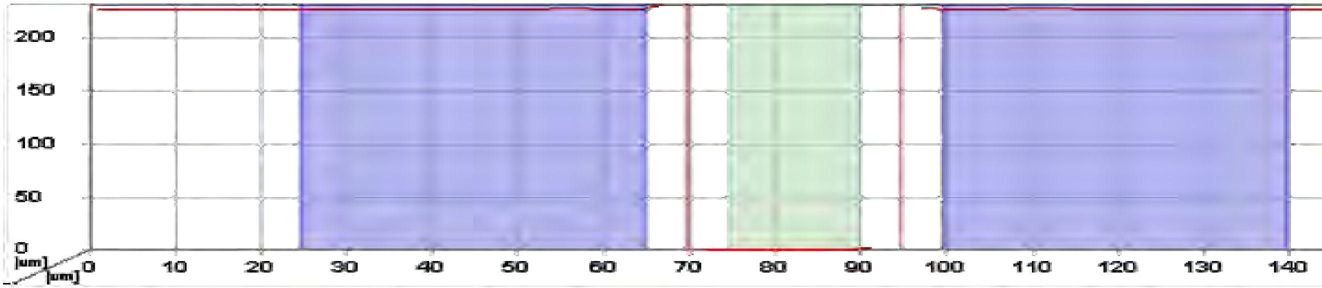



# Application - Trench ameasurement

- dynamic reproducability of trench depths

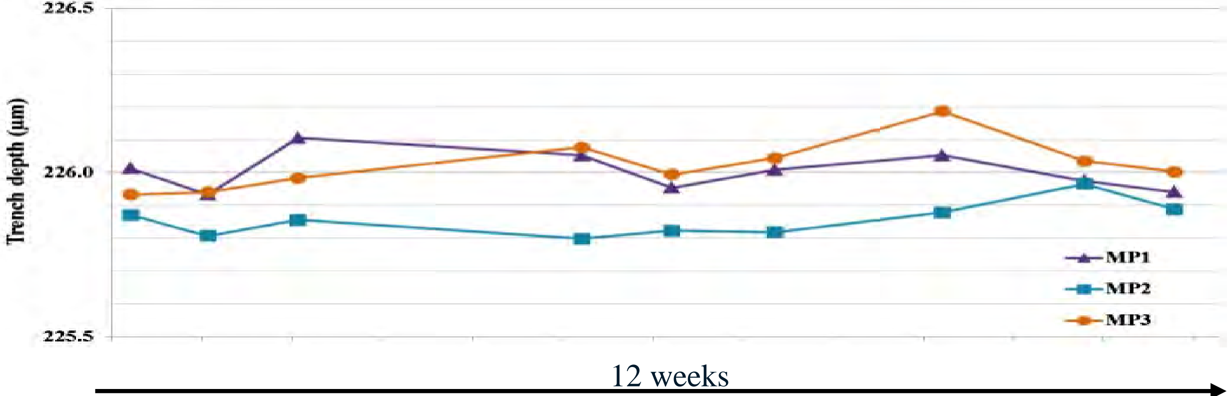



trench depth = 225.9 µm / trench width = 24.8 µm




dynamic repeatability tests for 12 weeks:

σ = 63 nm (0.03 %)




*ASMC2015: Optical step height and trench depth measurement , F.Heider et al. Infineon/FRT*

# Application - Cavity measurement

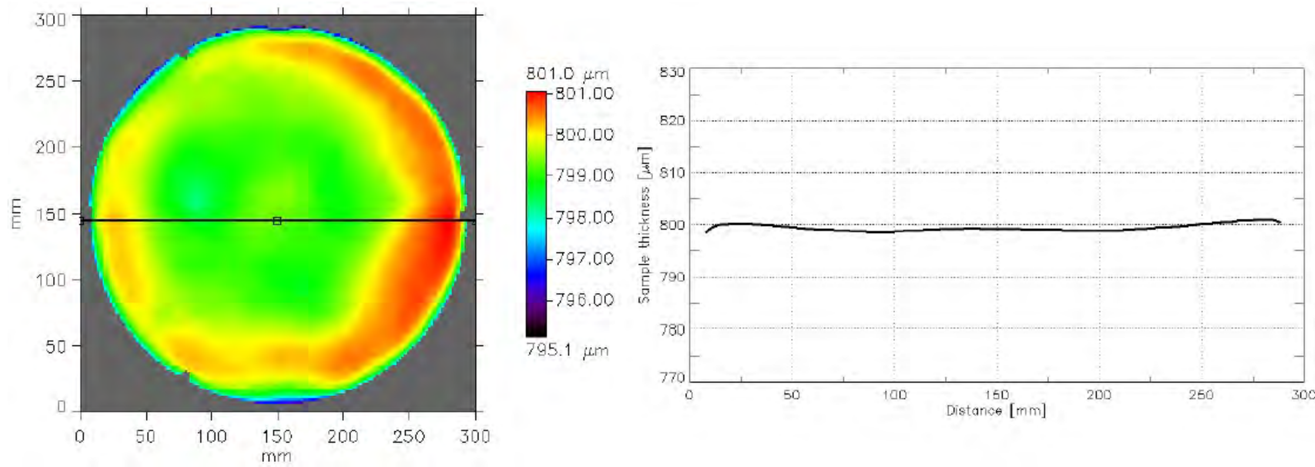
- evaluation of:

- photo resists thickness over cavity
  area to control film thickness uniformity (coating might be influenced by bending of device wafer)
- thickness of device wafer and cavity depth
- topography of cavity area

# Application

- Temporary carrier bonding

topography and TTV

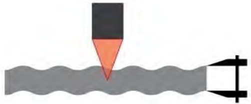



dedicated sensors:
2× CWL 600 µm
(TTV setup)

fast and reliable wafer thickness measurement

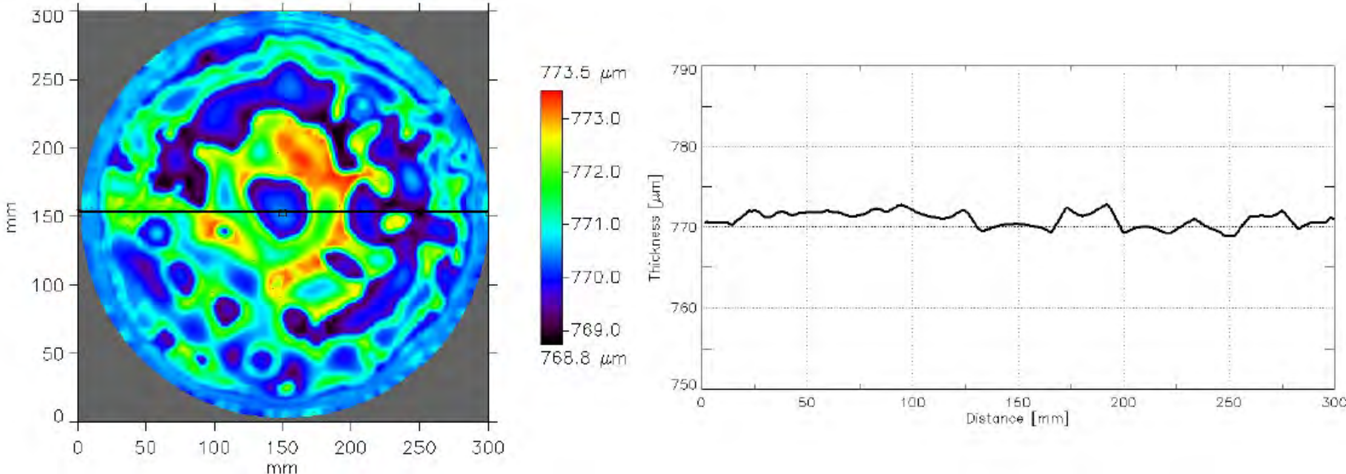
# Application

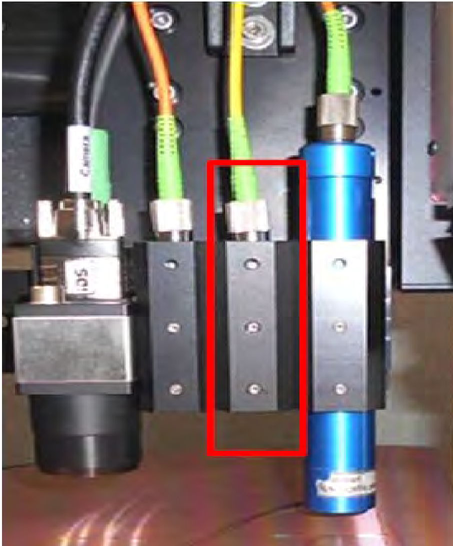
- Temporary carrier bonding



dedicated sensor:
IRT 800

carrier wafer

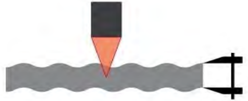


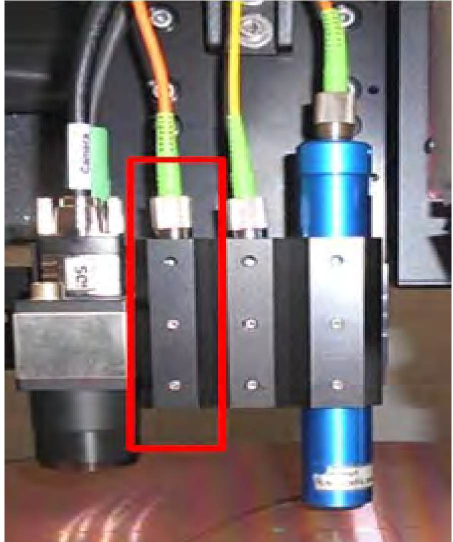
fast and reliable bonded carrier wafers thickness measurement

# Application

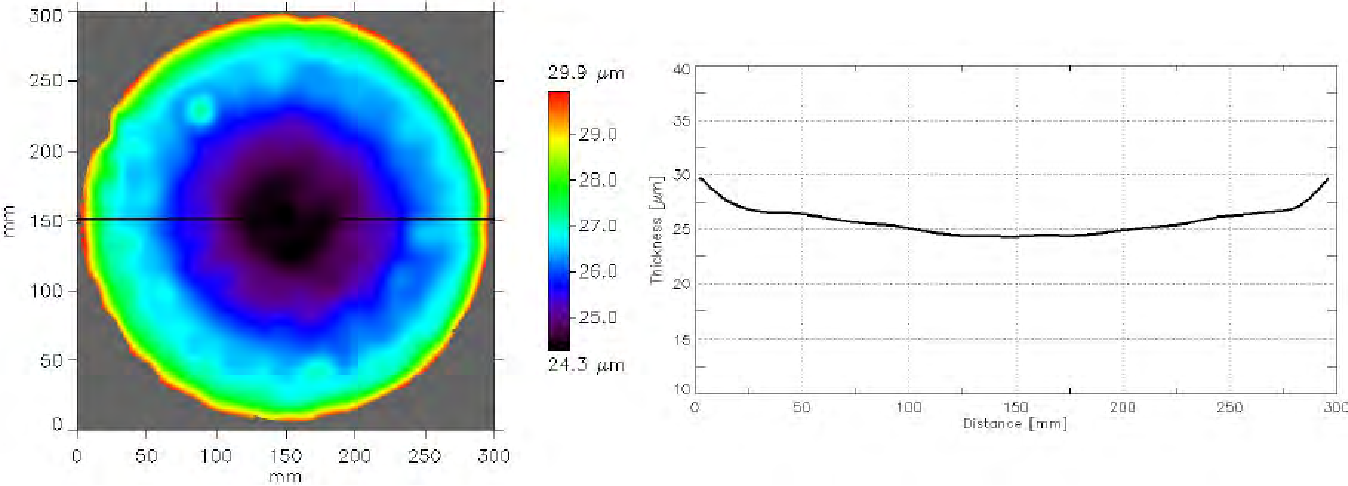
- Temporary carrier bonding



dedicated sensor:
IRT 80



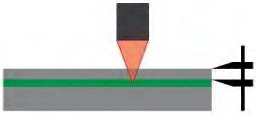
device wafer




fast and reliable bonded device wafers thickness measurement

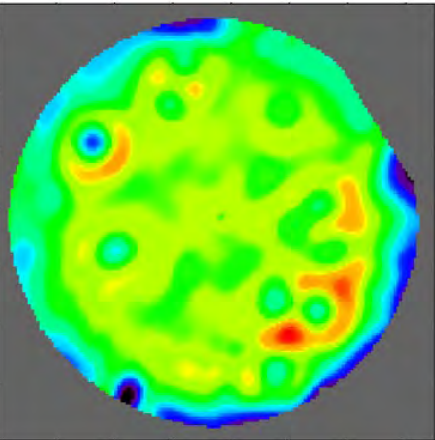
# Application

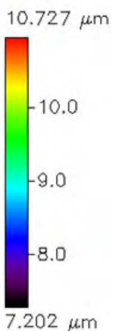
- thickness measurement of buried glue



Temporary carrier bonding

Glue thickness





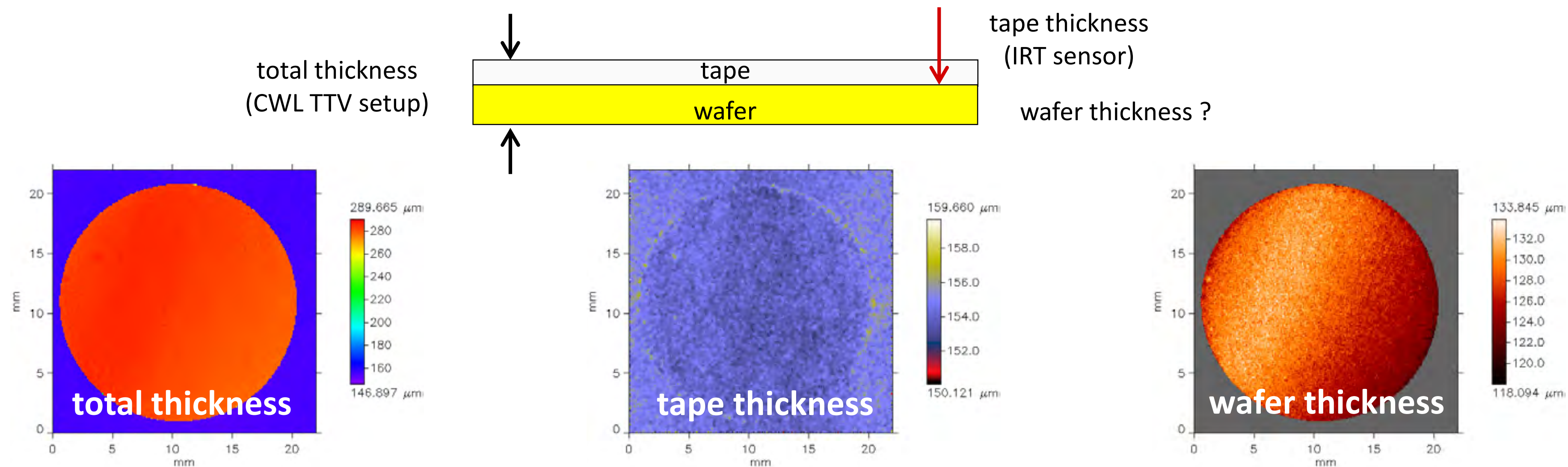

| average thickness[um] | min. thickness [um] | max. thickness [um] |
| --- | --- | --- |
| 9.48 | 7.2 | 10.73 |

glue thickness measurement over full wafer possible

# Hybrid metrology - Wafer + tape thickness

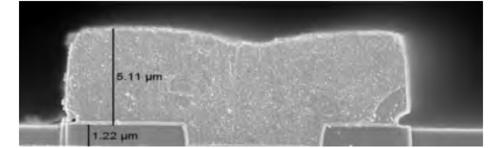
- total thickness measurement: wafer+tape (CWL TTV setup)
- measurement of tape thickness (IRT sensor)
- evaluation of wafer thickness

→ hybrid metrology: total thickness – tape thickness = wafer thickness

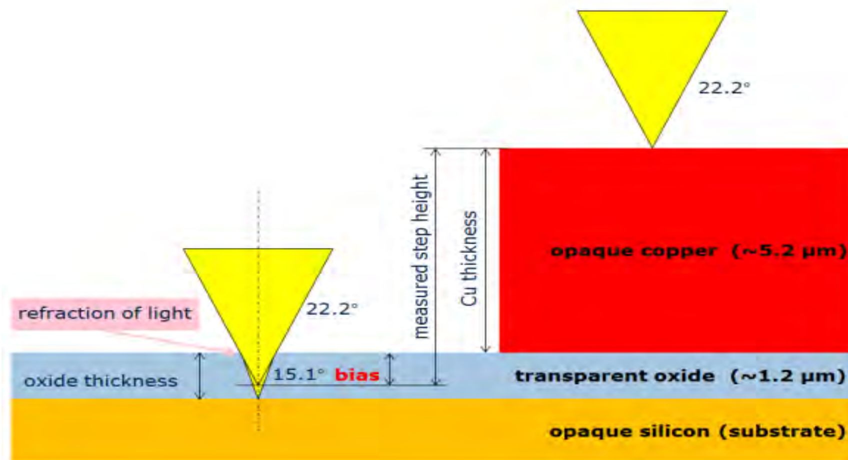


# Hybrid metrology

- Step height of metal pads on transparent layer

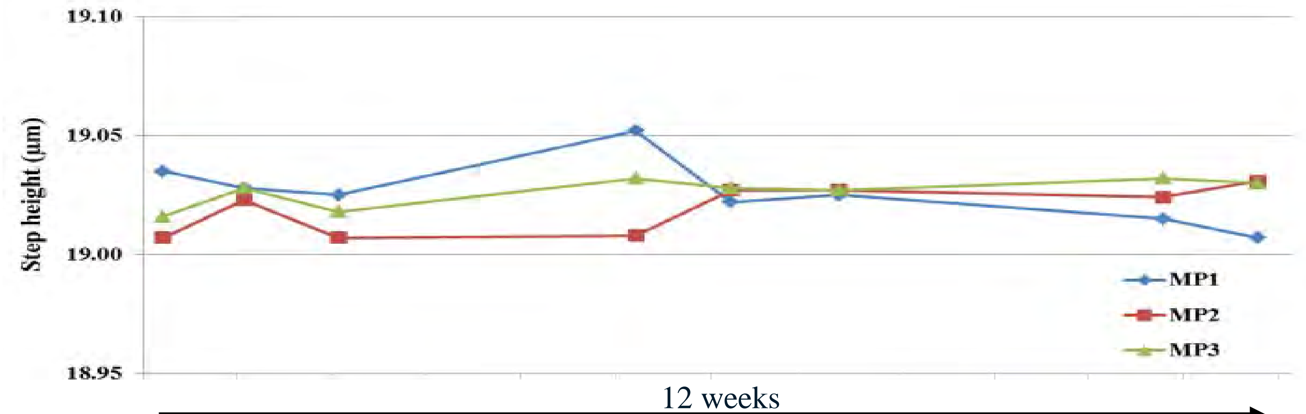



evaluation of step height and oxide thickness



dynamic repeatability tests for 12 weeks:

$\sigma$ = 9 nm (0.17 %)




*ASMC2015: Optical step height and trench depth measurement, F.Heider et al. Infineon/FRT*

# Hybrid metrology

- Topography and thickness measurement of transparent layers

➢ combination of various measurement tasks using different sensors to run fully automated in one task

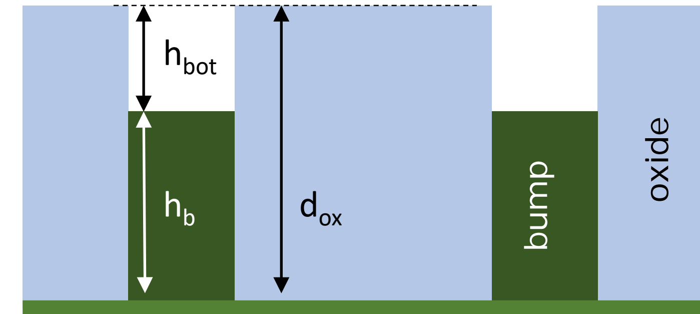
➢ measurements

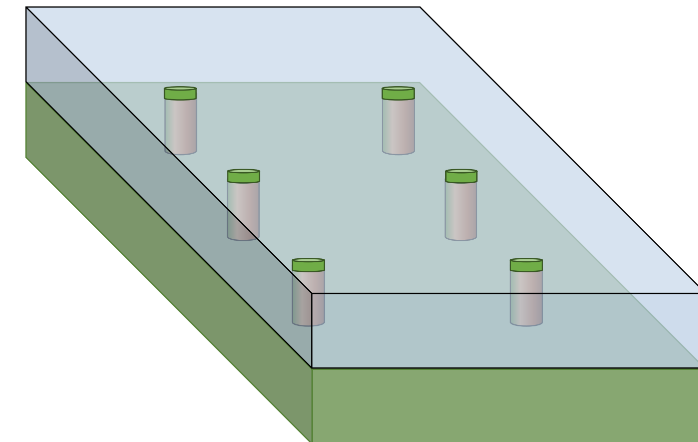
CFM → bump to oxide recess: $h_{bot}$

FTR → film thickness: $d_{ox}$

➢ hybrid metrology

$$\text{bump height: } h_b = d_{ox} - h_{bot}$$



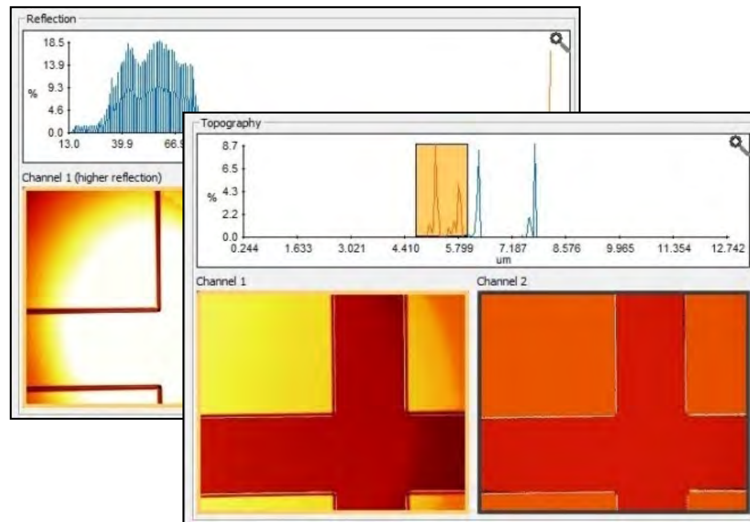
# Hybrid metrology

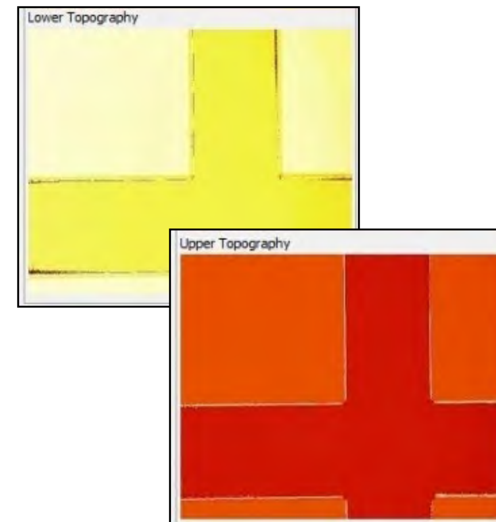
- Topography and thickness measurement of transparent layers

➢ distinguishing reflections coming from different surface layers

  ➢ topography measurement of a poorly reflective transparent layer, ignoring the signal of the underlying highly reflective substrate

  ➢ direct thickness determination of a transparent layer with known refractive index



# Thank you for your attention

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a FormFactor company

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