heliotis

High-Speed 3D Sensor with Micrometer Resolution Ready for the Production Floor

Industrial VISION days 2011

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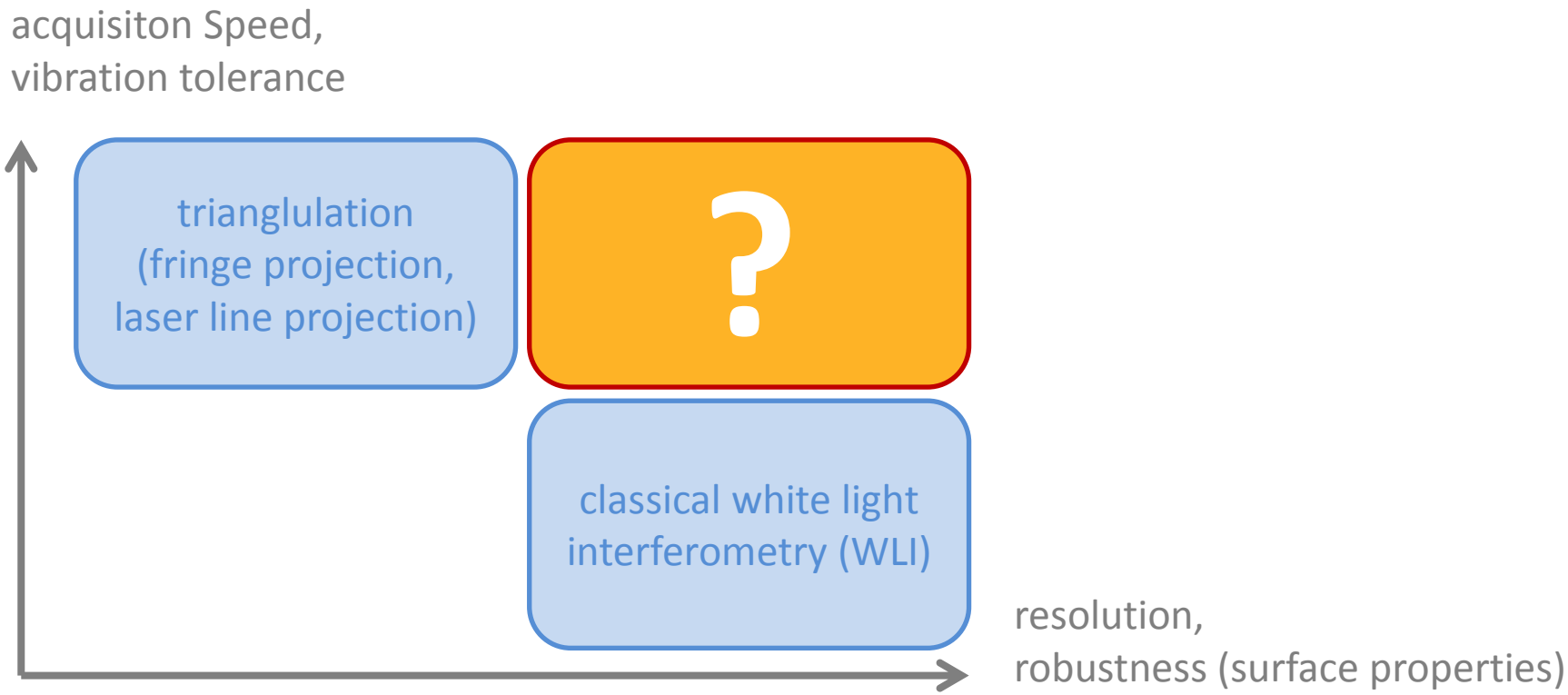
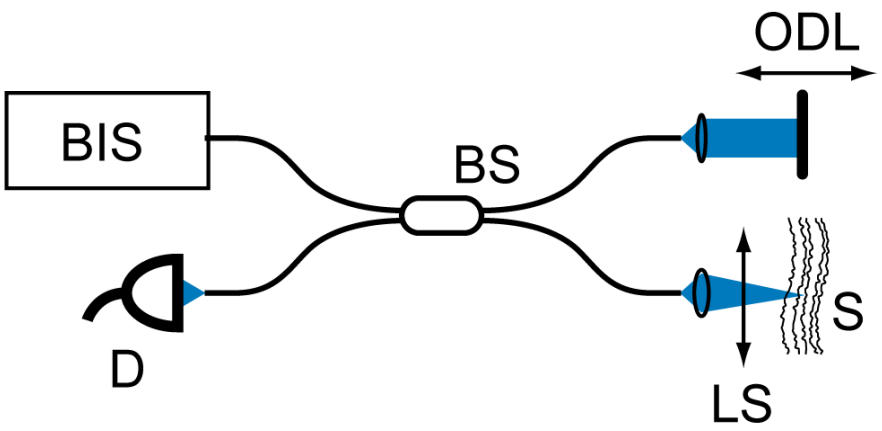
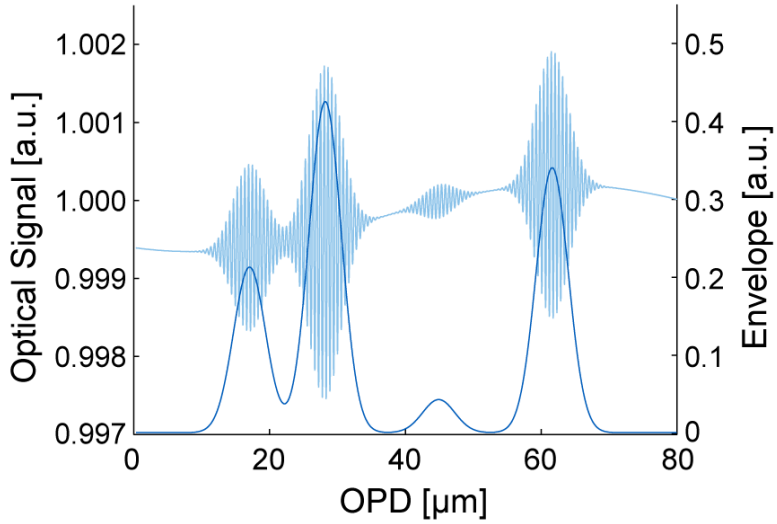
Challenge: High Precision on the Production Floor



White Light Interferometry Principle





- Michelson interferometer
- finite temporal coherence / non-zero spectral bandwidth
- path length difference < coherence length → interference
- parallel measurement via 2D array of pixels

White Light Interferometry Advantages

- extreme precision
- widest range of surfaces and materials
  (diffusive, reflective, wide range of reflection coefficients)
- wide range of geometries
  (no shadow projection, discontinuous steps)
- tomographic measurement
  (multi surface in non-opaque media)

Limitations of Conventional White Light Interferometers: Acquisition Speed

huge amount of data:

- interference signal fringes at light's wavelength period
- vertical sampling at 50-100nm

data bottleneck:

- inside image sensor of the camera
- transmission from image sensor to camera electronics

⇨ **best case performance:**
scan speed 10-100 um/s; 10k surface points/s

Limitations of Conventional White Light Interferometers: Vibrations

vibration sensitivity:

- amplitude: fraction of optical wavelength
- frequency: in the range of scan speed/wavelength

low scan speed ⇨ sensitivity in low frequency range

best case: 100Hz-200Hz

⇨ **highest precautions, no use on production floor**

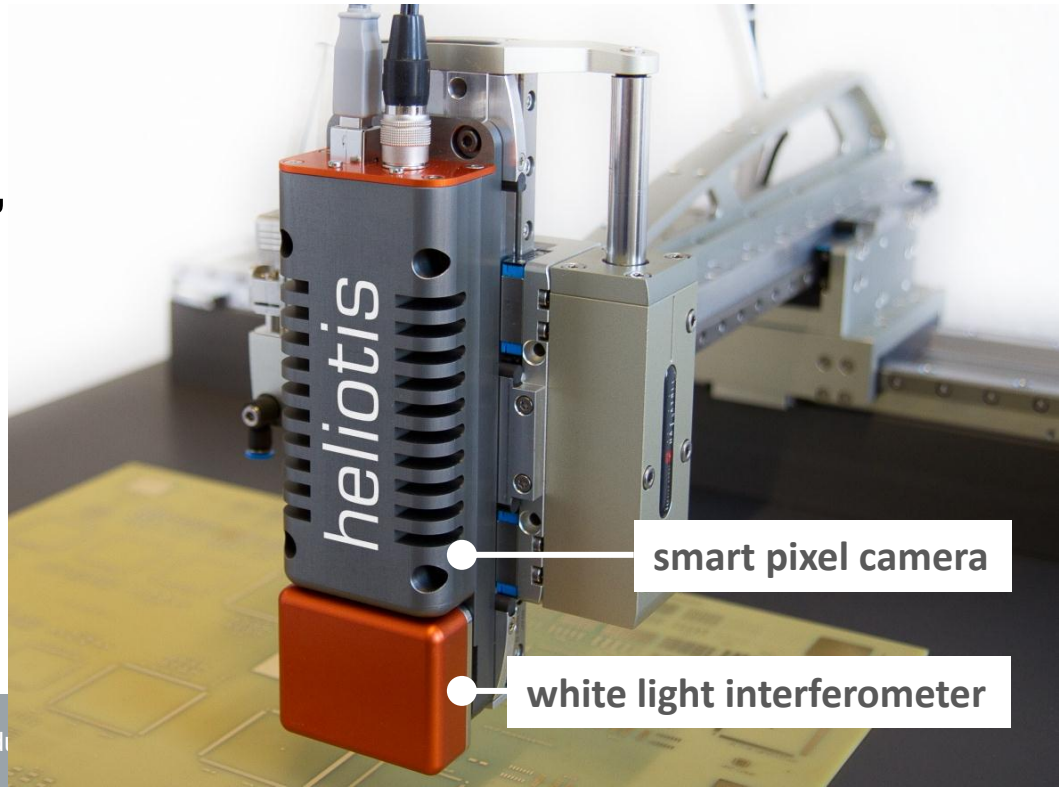
Heliotis H3 Measurement Module: WLI at Extremely High Speed

general approach:

- exploit data redundancy
- reduce data amount at earliest possible stage

implementation:

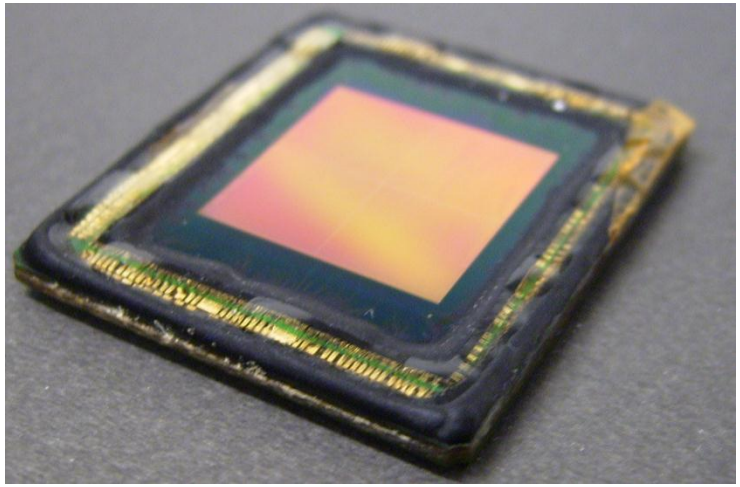
- proprietary “smart-pixel” image sensor



Heliotis Smart Pixel CMOS Image Sensor

principal features:

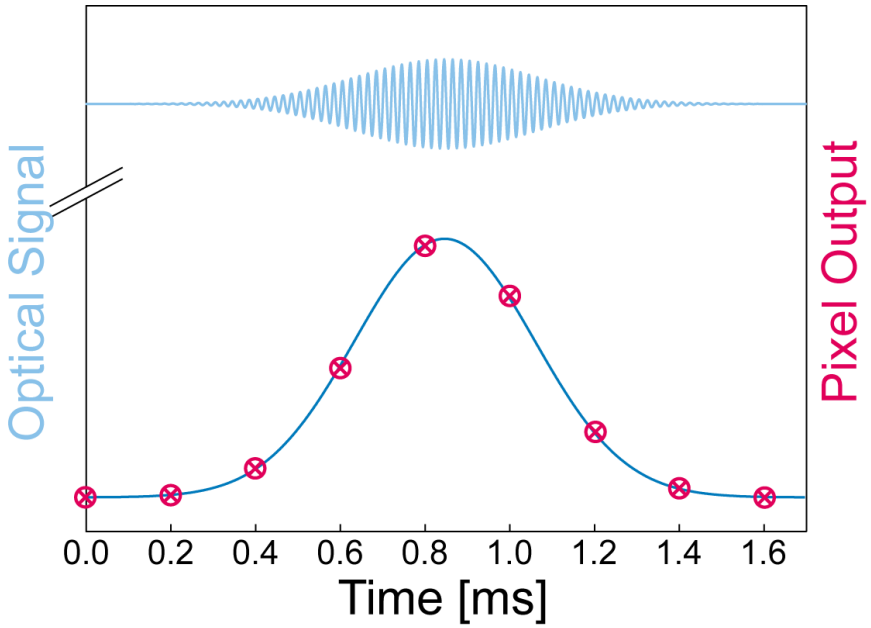
- pixel level suppression of dc component
- pixel level data rate reduction
- very high data output rate
  (5000fps 300x300 pixels/frame)



Pixel-Level Data Rate Reduction (I)

data content and redundancy:

- ***carrier frequency:***
  no interesting information
- ***envelope (amplitude):***
  surface z-location
- ***phase:***
  additional high-resolution relative surface z-location information

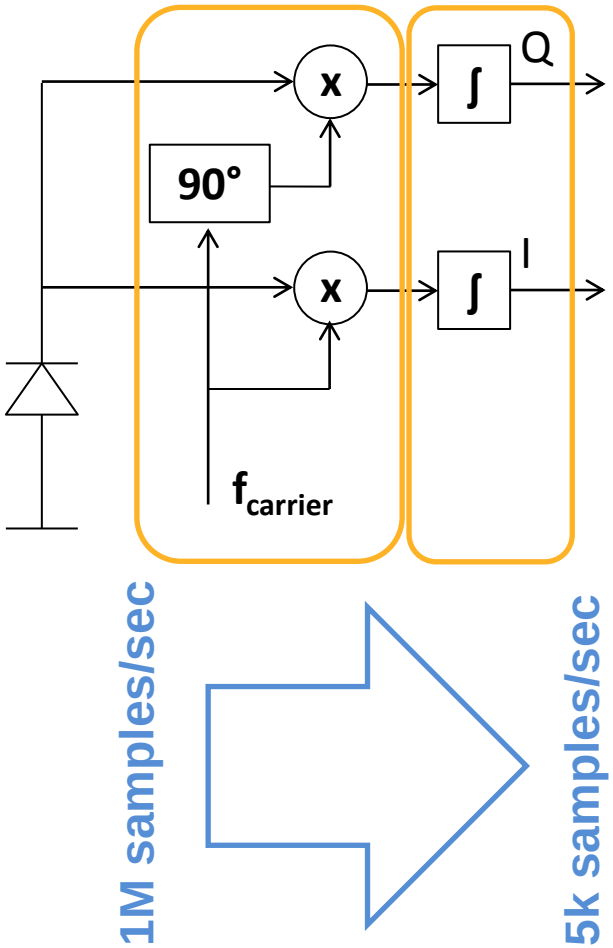


Pixel-Level Data Rate Reduction (II)

Functional hardware blocks:

- pixel level envelope extraction
- pixel level low-pass filtering and down-sampling

full quadrature demodulation conserves phase information



Pixel-Level DC Suppression

challenge:

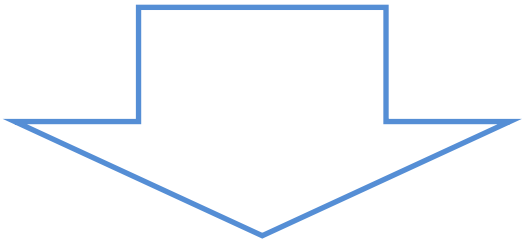
- intra-scene mixture of materials, surface quality and angles → high intra-scene variation of modulation index
- very stringent dynamic range specification

two-stage pixel-level DC suppression approach :

- coarse swing DC removal from each sample
- fine DC removal by difference computation for demodulation
- overall DC rejection ratio of 60dB

H3 Acquisition Speed Example

- 300x300 surface points/frame at 25 fps = 2.2 Mpoints/s
- 100 raw volume elements (voxels, envelope samples) per surface point (e.g. 1mm scan range at 1voxel/10µm)
- Interpolation factor = 10 (e.g. 1µm vertical resolution)



220 MVoxels/s (conventional camera would need 22 GS/sec)

interference signal carrier frequency of 29.4kHz

H3 Features

- surface topography
- volume tomography
- robust and fast
- sub-micrometer vertical resolution
- modular interferometer optics for scalable lateral resolution (2um to 20um)
- measures any surface
- small form factor
- software modules for rapid integration (windows, mac, linux)
- modular systems of linear motors (portal robots)

H3 Application Examples:

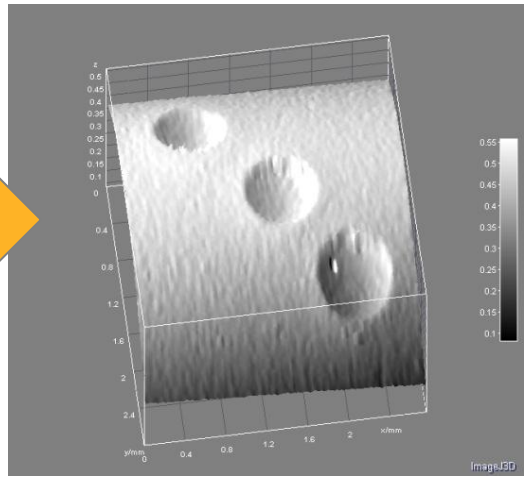
- in-line quality inspection
- statistical process control
- lab automation
- surface quality (roughness)
- geometrical feature verification
- OEM integration

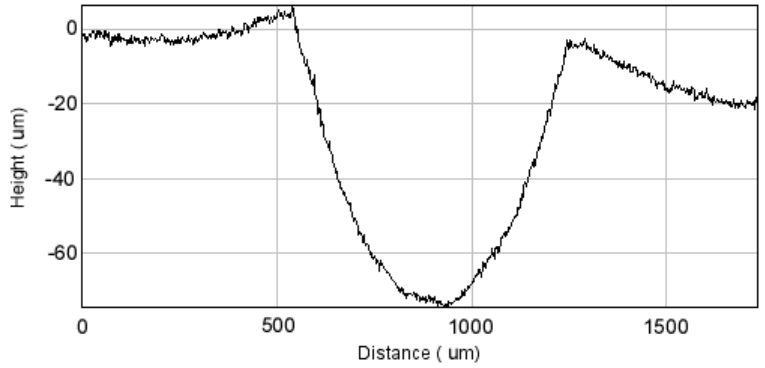
Defect Analysis (Aerospace)

2D-AOI is used
to identify potential defects

3D

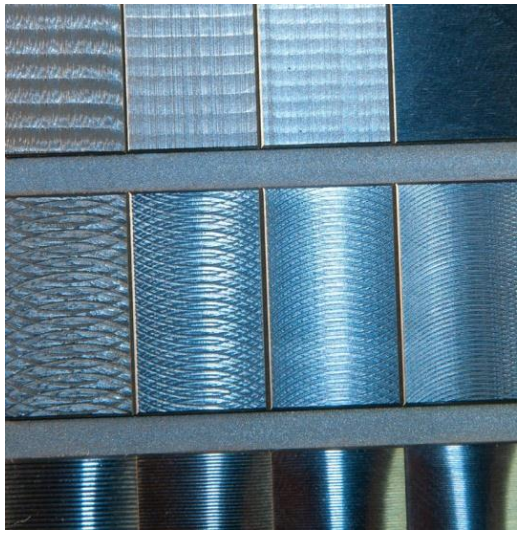
3D-AOI is used
to characterise defects quantitatively



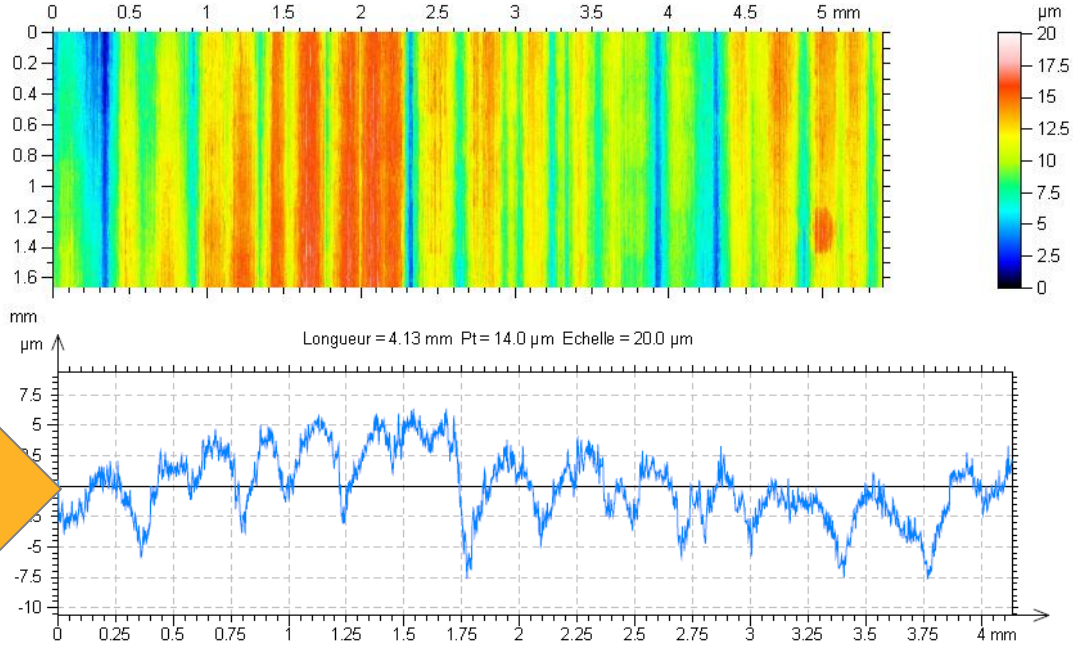


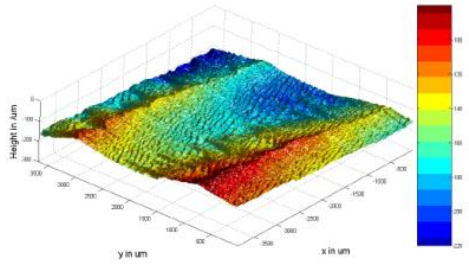
Surface Characterization (ISO 4287)

2D Image
of technical surfaces



3D

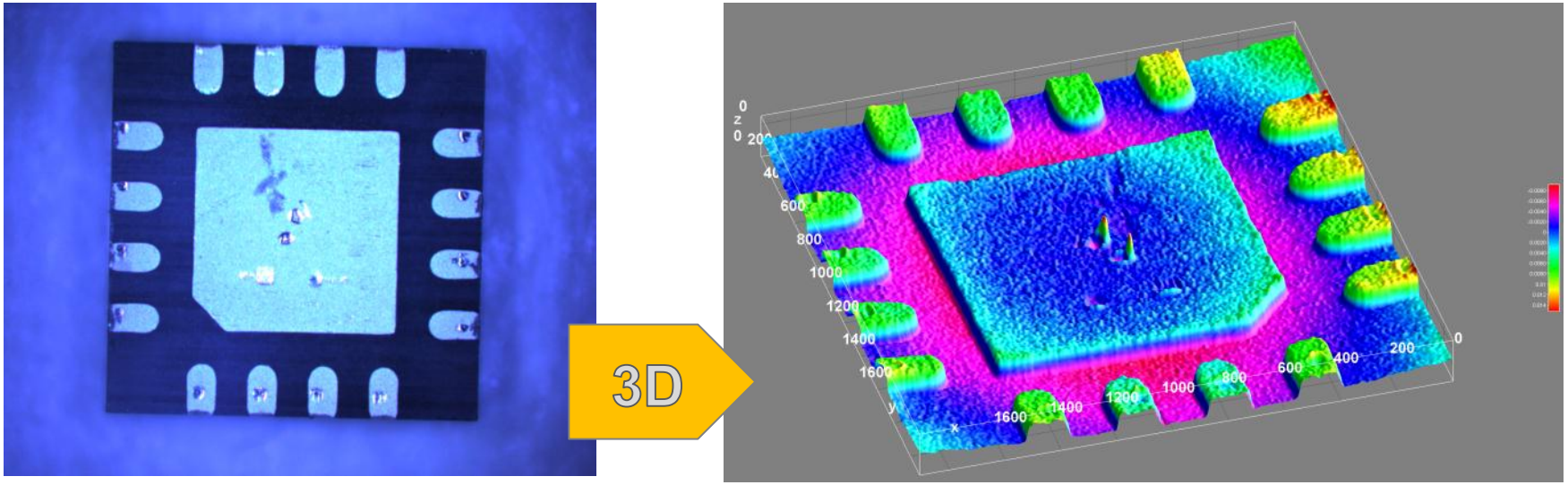




ISO 4287						
		Contexte	Mean	Std dev	Min	Max
Paramètres d'amplitude - Profil de rugosité						
Ra	µm	*Filtre gaussien, 0.8 mm*	1.56	0.0201	1.50	1.62
Rz	µm	*Filtre gaussien, 0.8 mm*	9.46	0.253	8.79	10.3
Rt	µm	*Filtre gaussien, 0.8 mm*	12.5	0.555	10.9	14.2
Rq	µm	*Filtre gaussien, 0.8 mm*	1.93	0.0206	1.87	1.98

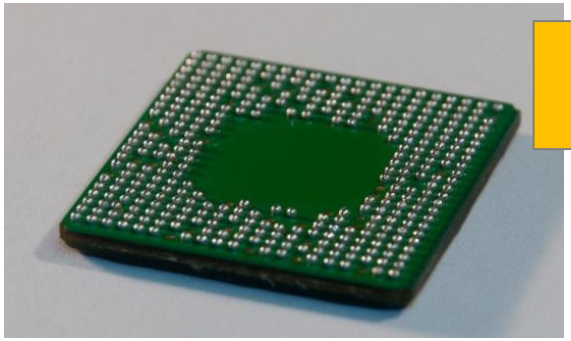
Electronics: Pads of IC

- highly reflective surfaces
- high dynamic range
- short test cycle times

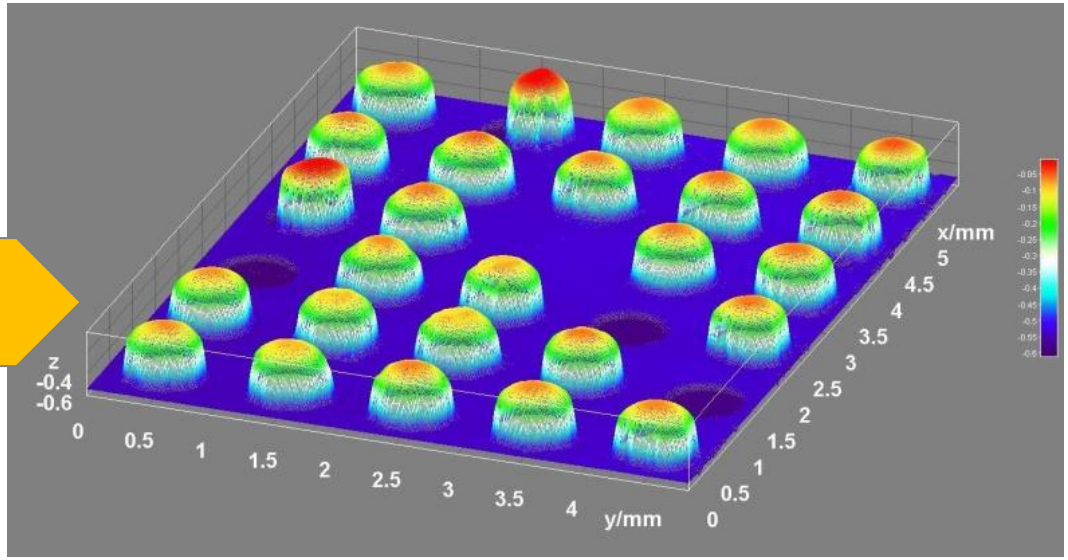


Electronics (II): Solder Balls (BGA)

- highly reflective surfaces
- high dynamic range
- short test cycle times

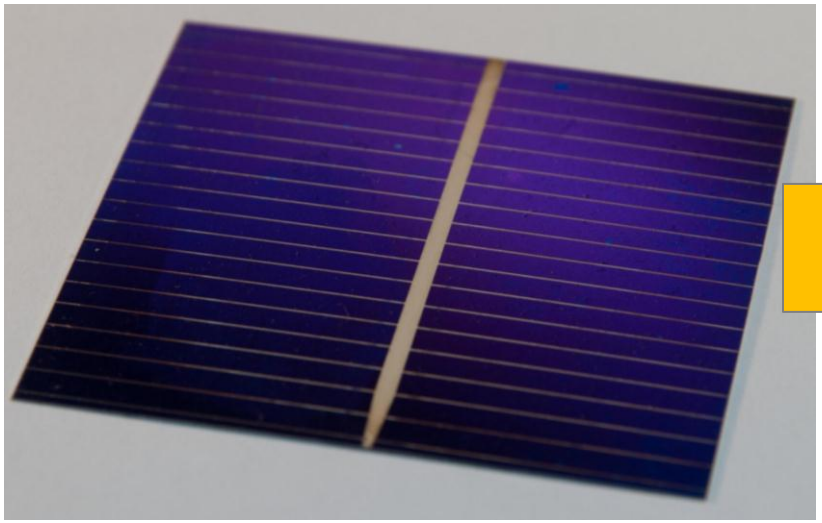


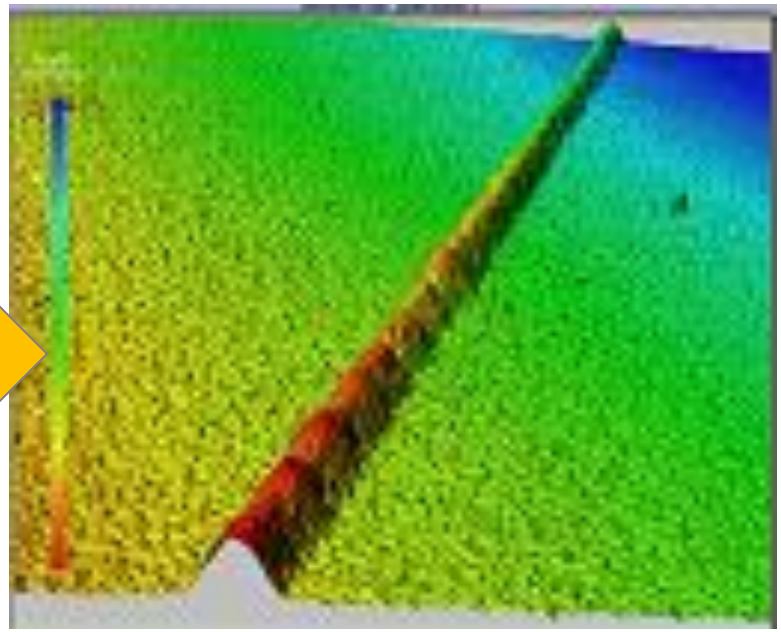
3D



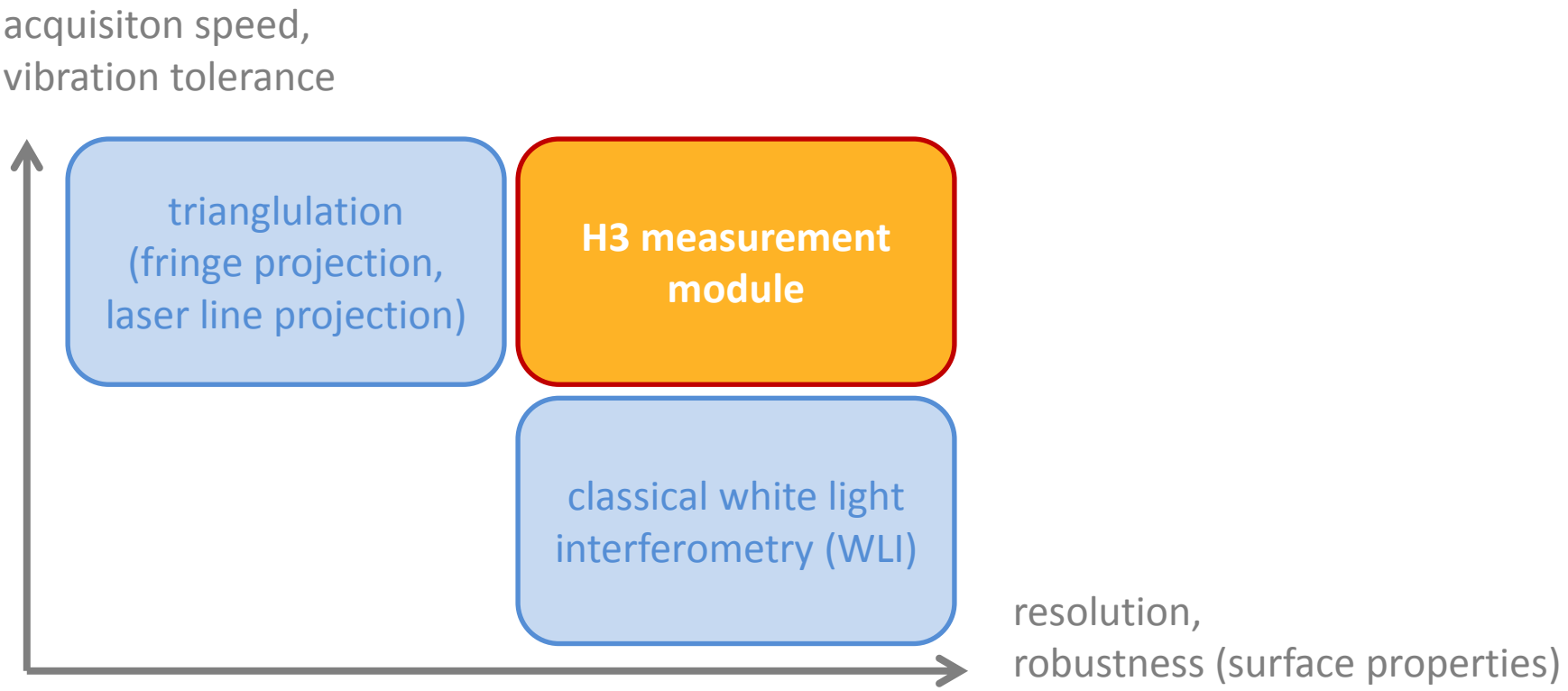
Electronics (III): Solar Cell Fingers

- highly reflective surfaces
- high dynamic range
- short test cycle times





Conclusions



advantages and performance of WLI ready for your production floor

Thank you for your attention!