

# High-Resolution 3D Line Confocal Imaging Technology in Real-Time R2R Measurement Applications

AIMCAL R2R Conference USA 2017 – Florida

# Introduction

- Company
- Line Confocal Imaging (LCI)
- Applications on web products
  - Surface roughness measurement
  - Thickness measurement
  - 3D feature measurement
- Other 3D web imaging ideas

# Company

# FocalSpec, Ltd

- Founded in 2009
- Spin-off from Technical Research Center of Finland (VTT)
- HQ in Oulu, Finland
- FocalSpec, Inc. (Atlanta, GA)
- Core technology:  
Line Confocal Imaging (LCI)
- Products
  - Sensors - for system integration
  - Scanners - off-line & online



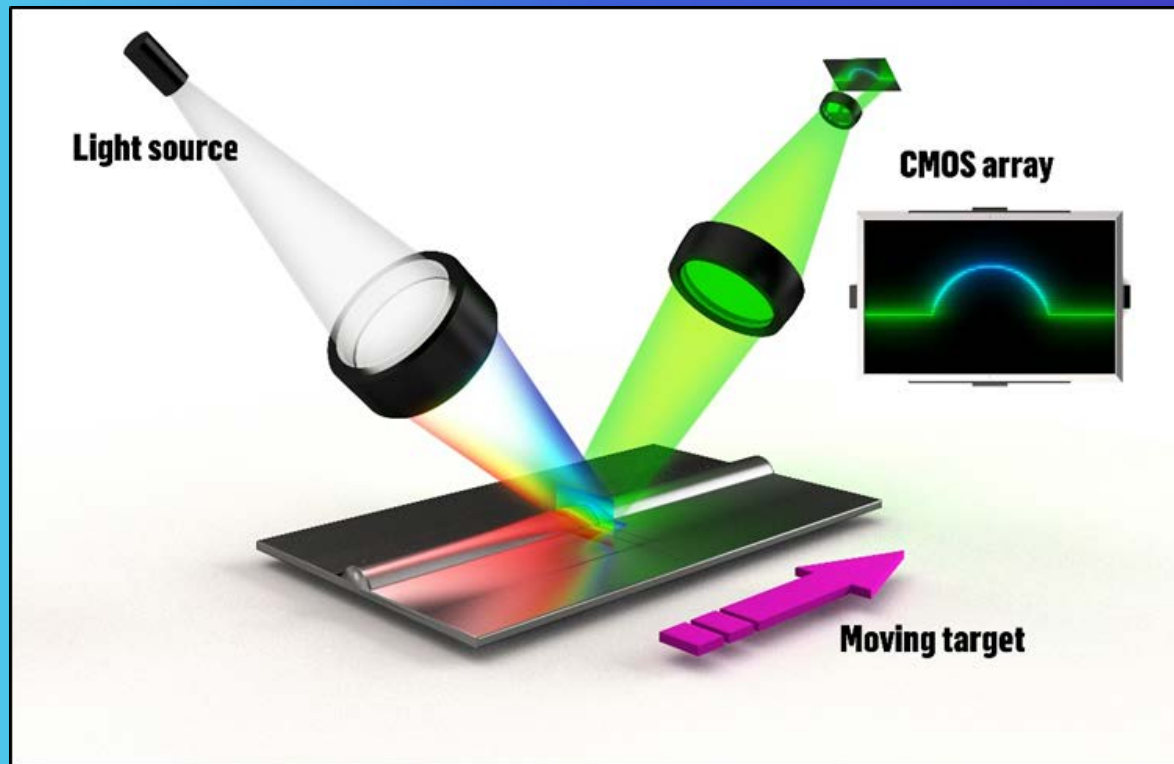
# Line Confocal Imaging (LCI)

# What is LCI

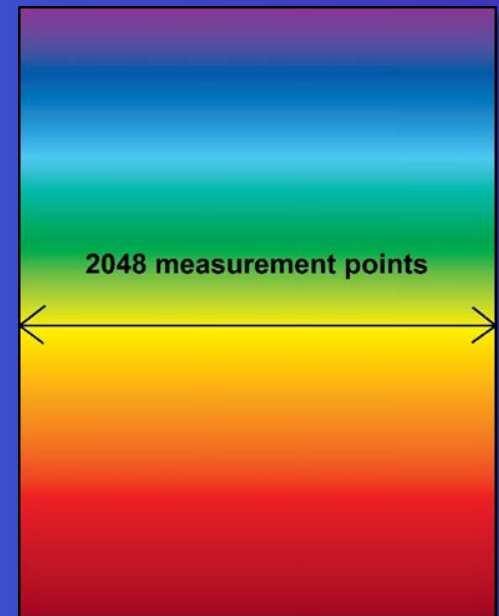
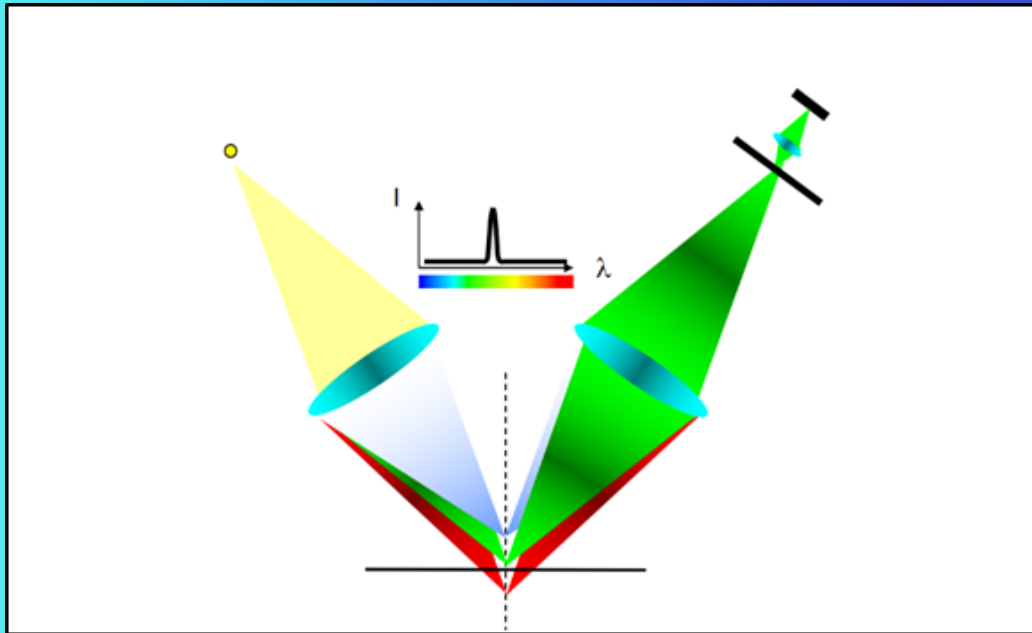
- Optical, non-contact metrology method
- High-speed, high-resolution 3D imaging technology for
  - Shapes
  - Profiles
  - Textures
  - Thickness
  - Dimensions
  - Roughness, etc.
- Unique, patented



# LCI Principle of Operation



# LCI Principle of Operation





# LCI Sensors



# LCI Sensors Key Specifications

- 3D points per line 2048
- Z (height) resolution 0.10 – 0.98  $\mu\text{m}$  (0.004 – 0.039 mil)
- Lateral resolution 2.2 – 36  $\mu\text{m}$  (0.087 – 1.417 mil)
- Z range 1.0 – 5.5 mm (0.04 – 0.22")
- Profile line length 4.50 – 16.40 mm (0.18 – 0.65")
- Measurement rate 300 – 4000 lines/second
- Data acquisition rate 0.6 – 8.2 million 3D pps

# LCI Strengths

- High speed → real-time online applications
- Sub-micron resolution
- LCI works well on
  - Matte, glossy and mirror-like surfaces
  - Opaque and transparent surfaces
  - High-contrast (matte/glossy, dark/light) surfaces
  - Soft, fragile, porous surfaces
  - All materials
  - All colors

# LCI Strengths

- Enables measurement of
  - Thickness of transparent layers and air gaps
  - Topography under transparent layers (tomography)
- Single-sided operation → simple scanners
- Acquires 2048 surface points simultaneously  
→ reduced error caused by target vibration
- Native 3-dimensional method
- Produces high-quality raw data
- No speckle effect
- Safe

# LCI Weaknesses

- Sensors are relatively
  - Large
  - Heavy
  - Costly to produce

# U.S. Dime Coin

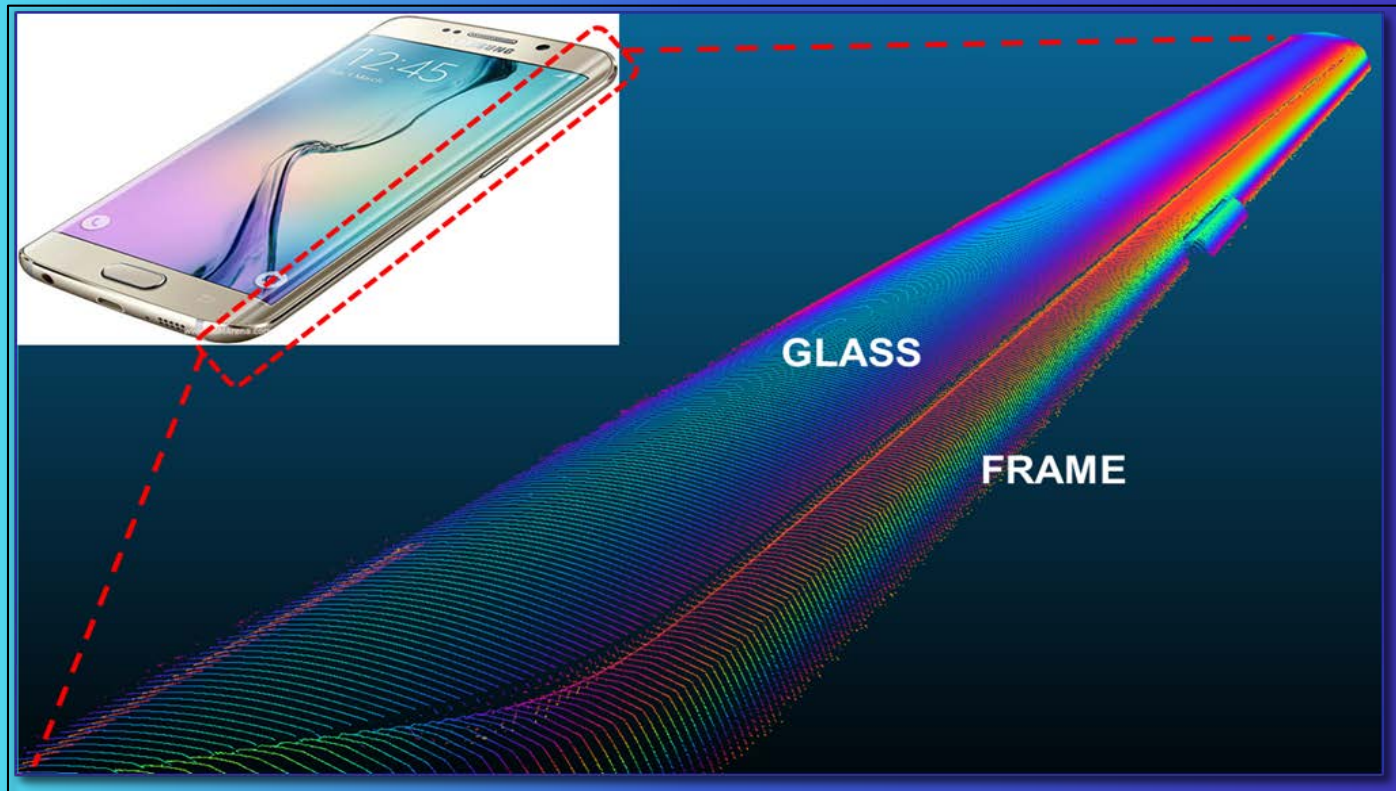
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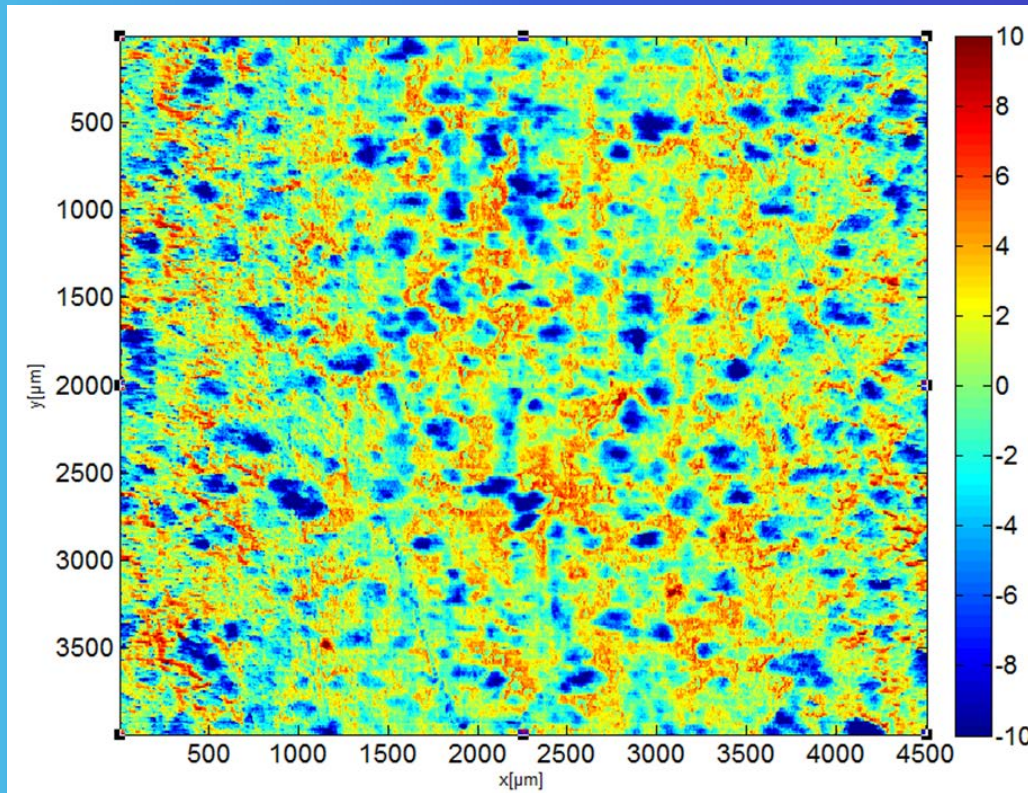
# Glossy Curved Glass Surface

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# Stainless Steel Surface

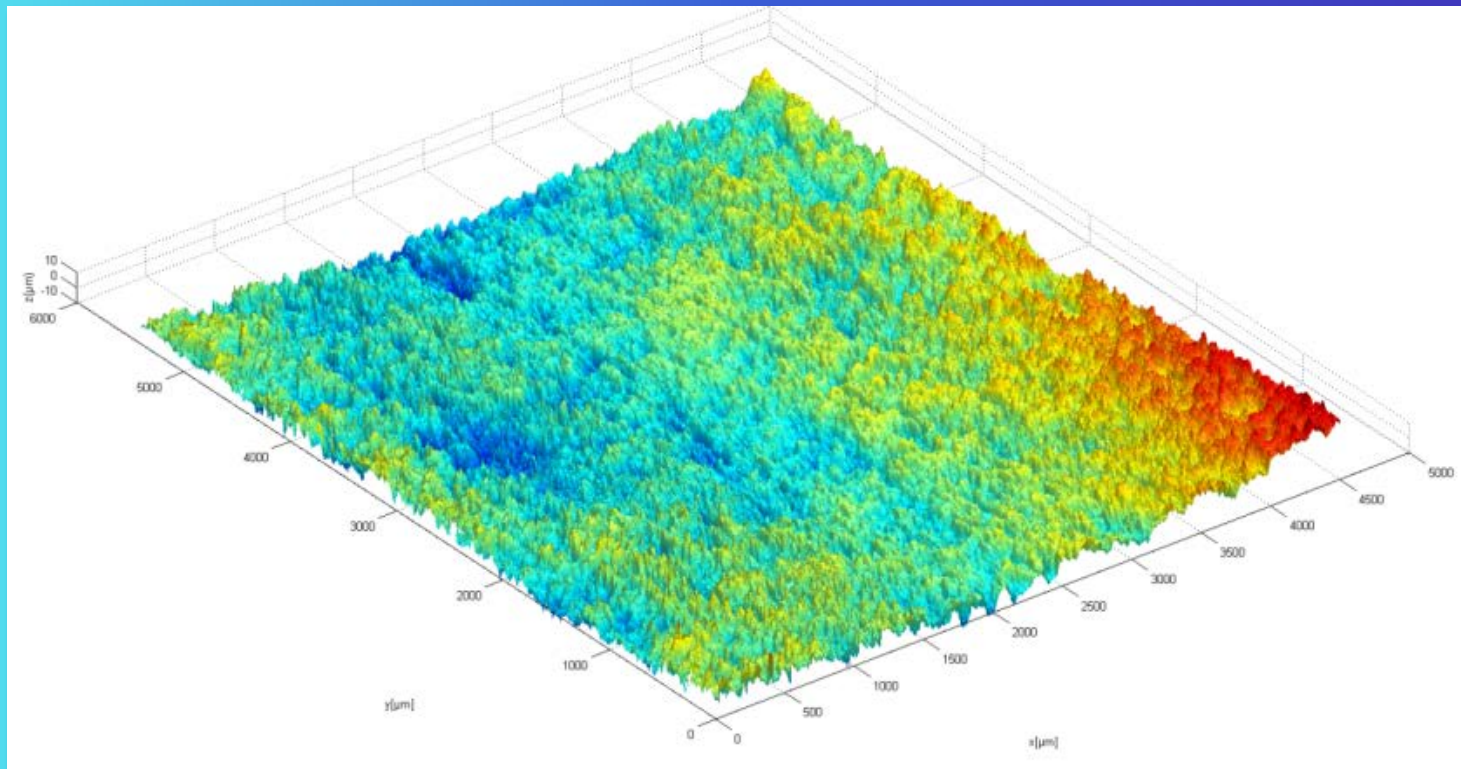
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# Paper Surface Microtopography

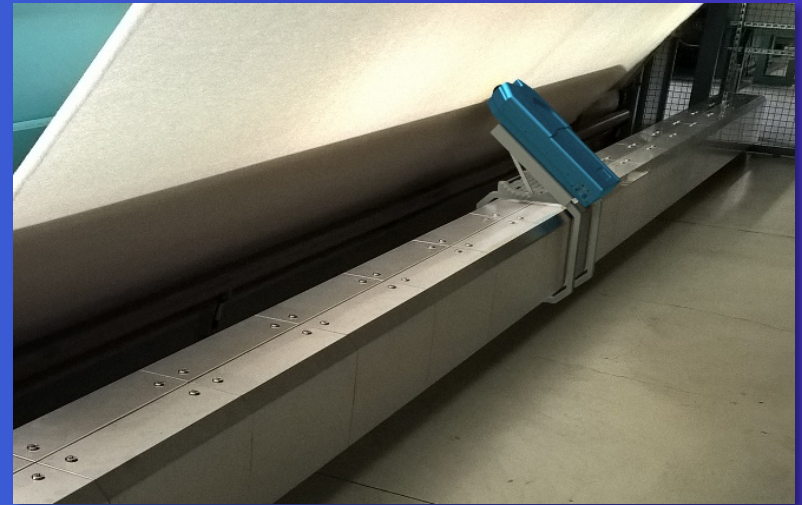
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# **LCI Web Application: Inline Surface Roughness Measurement**

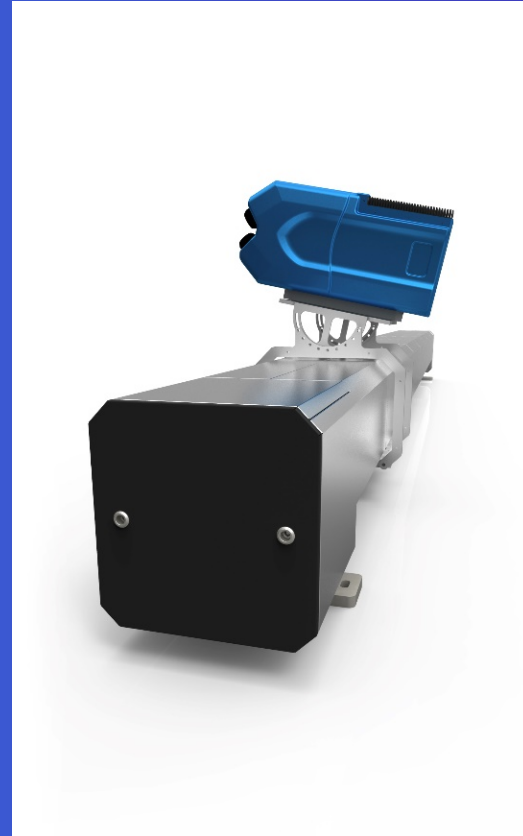
# On-line Roughness Measurement for Web Products

- MicroProfiler MP 9000
- European launch at K 2016
- North American introduction at ICE USA 2017

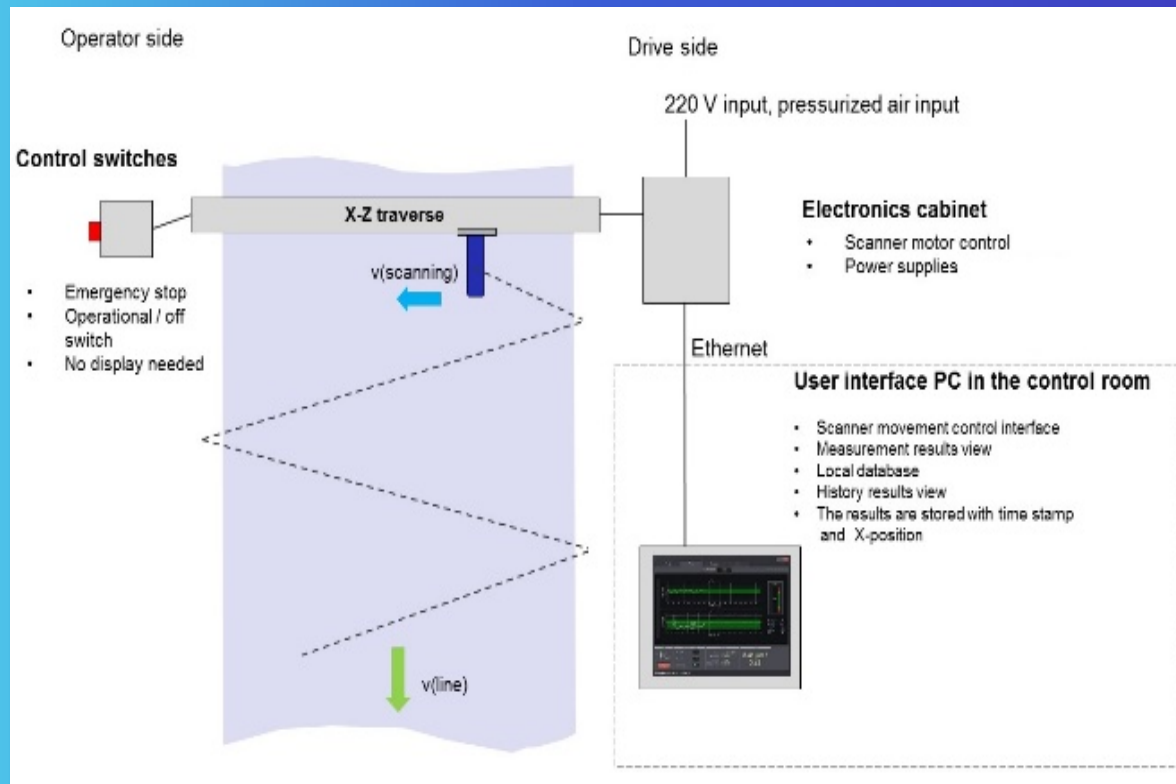


# MP 9000 Applications

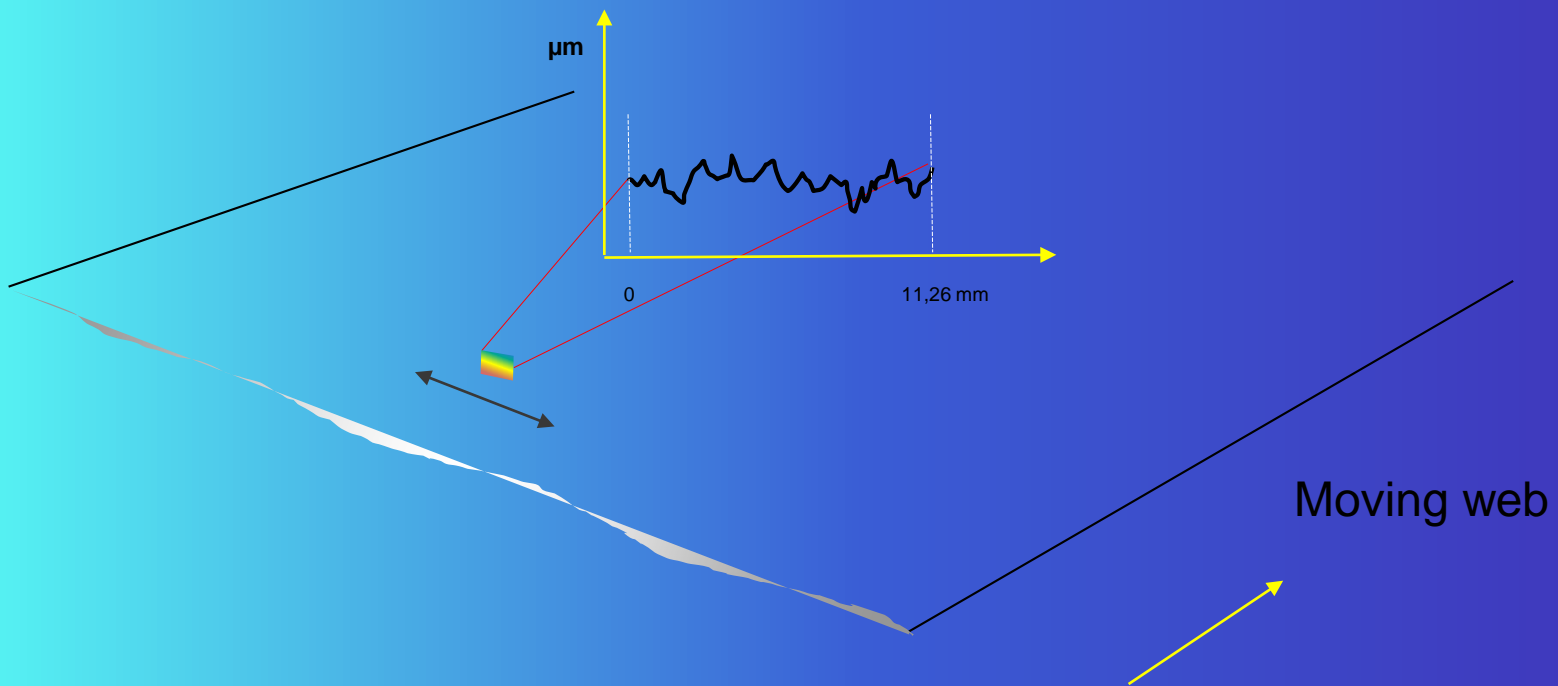
- Films (PVB etc.)
- Sheets
- Coatings
- Paper
- Foils
- Laminates
- Glass
- Composites
- Metals



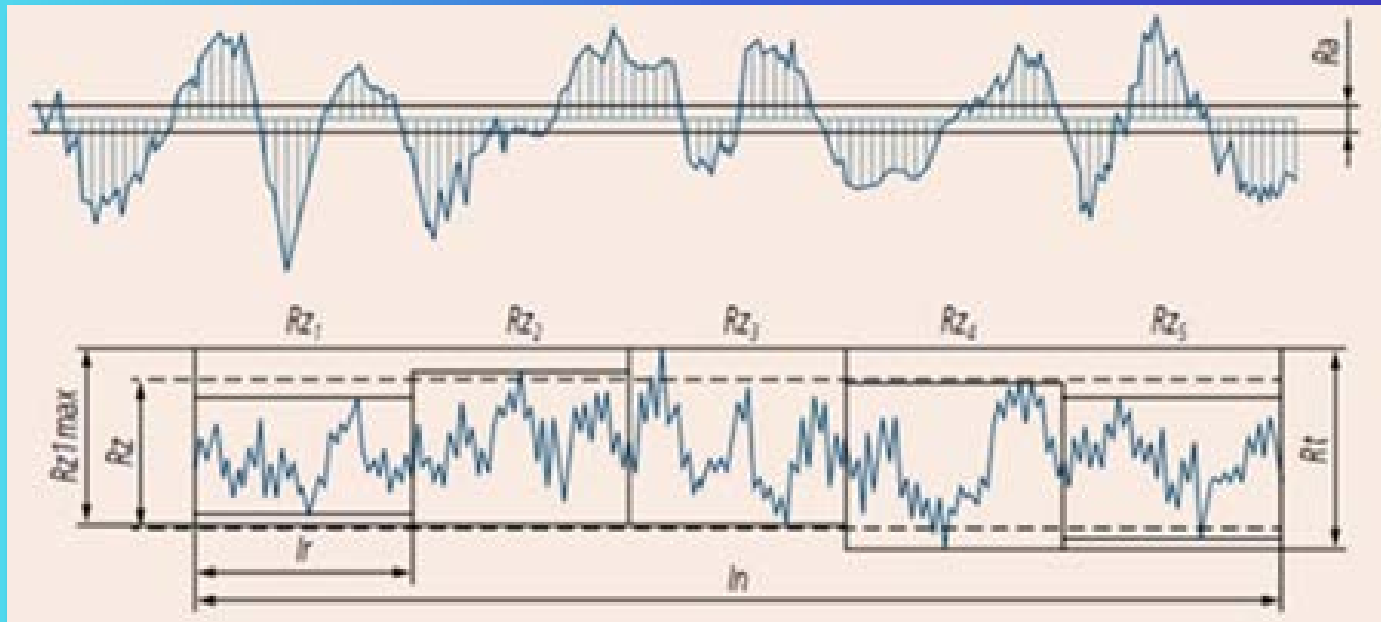
# MP 9000 System Components



# Web Surface Micro Profile



# Ra and Rz Calculation Methods



# Reporting

## Real-time single-profile display





# Reporting

Real-time cross direction & machine direction roughness charts



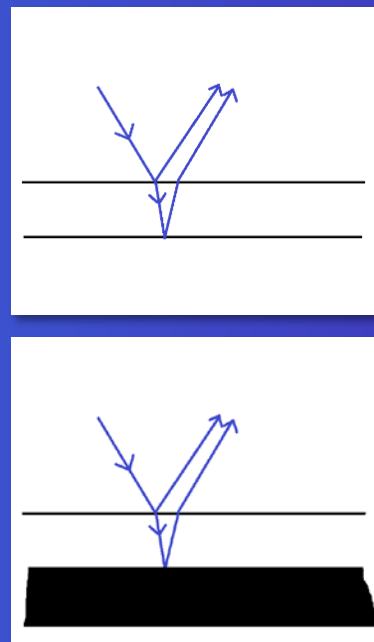
# MP 9000 Specifications

- Material Any
- Color Any
- Parameters Ra, Rz, RSm
- Ra range 0.5 to 20  $\mu\text{m}$
- Ra precision Better than 0.03  $\mu\text{m}$
- Line speed 150 m/min (max)
- Web width No practical limits

# **LCI Web Application: Inline Thickness Measurement**

# Direct Measurement

- For transparent and translucent layers
- Single or multi-layer structures
- Applications
  - Polymer films
  - Glass sheets
  - Coatings and inks on non-transparent substrates
  - Air gaps, etc.



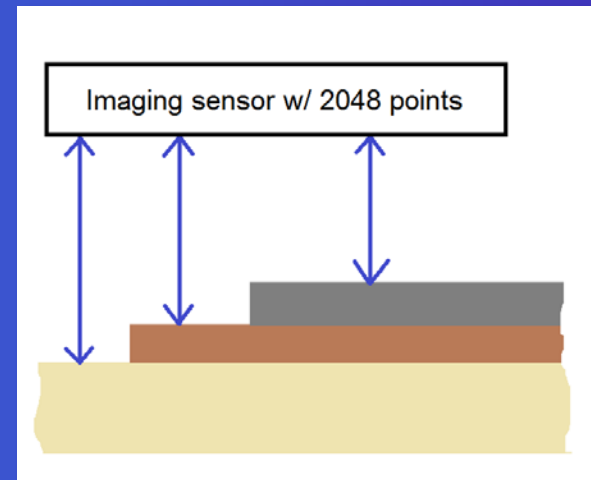
# Direct Measurement

- Thickness range 30 – 5500  $\mu\text{m}$
- Resolution up to 50 nm
- LCI Sensor
  - Thickness + 3D characteristics
  - Transparent layers only
- MCP 100 Sensor
  - IR reflection-based dual point sensor
  - Thickness only
  - Transparent + translucent layers



# Step Height Measurement

- For non-transparent and transparent layers
- Single and multi-layer structures
- Applications
  - Coatings
  - Inks, etc.
- LCI Sensors
- Thickness range  
~ 0.5 – 5500  $\mu\text{m}$
- Resolution up to 100 nm



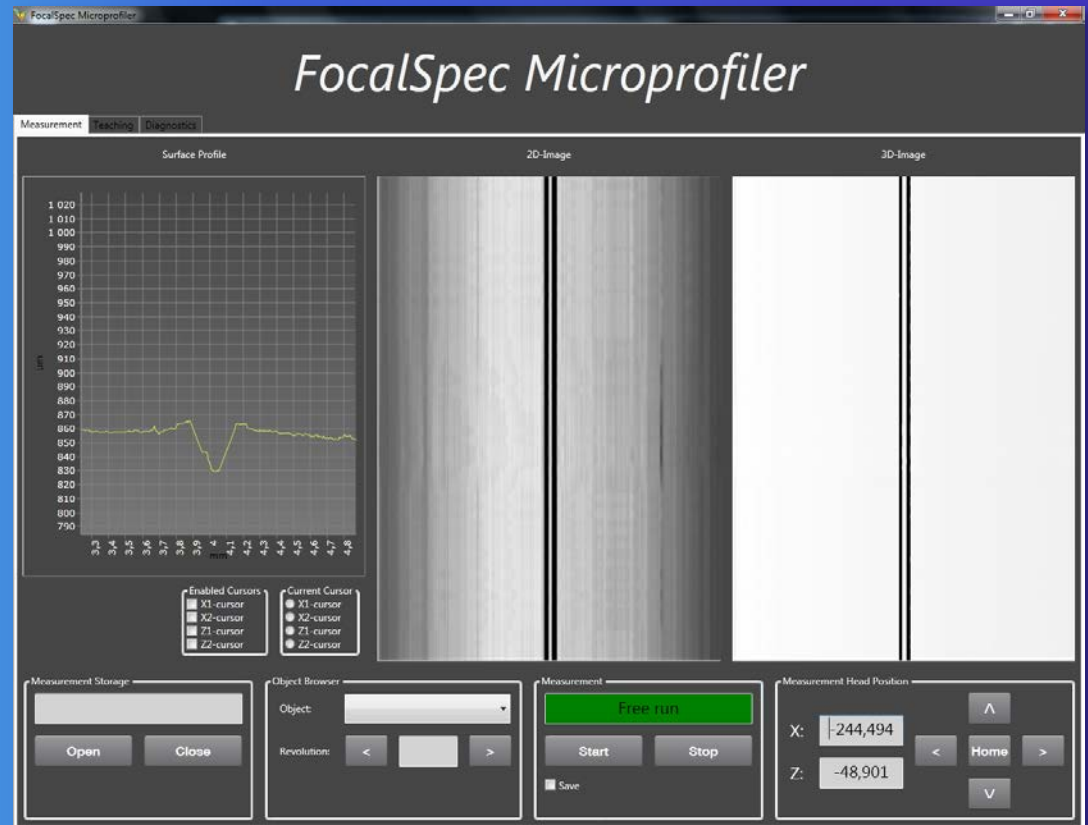
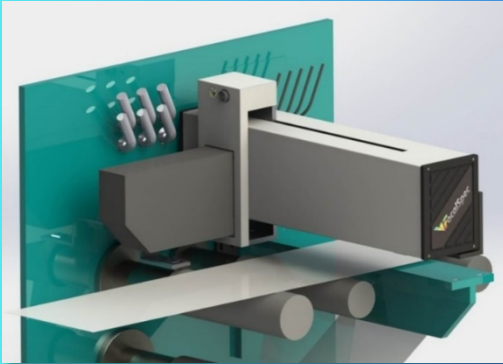
# **LCI Web Application: Inline 3D Feature Measurement**

# 3D Web Measurement

- For narrow and wide webs
- Applications
  - Embossed 3D features
  - Printed 3D features
  - “Tomography” – 3D features under transparent layer (micro fluidic devices etc.)
- LCI sensor w/ stationary or traverse mounting
- Up to 0.1  $\mu\text{m}$  height resolution
- Up to 2.2  $\mu\text{m}$  lateral resolution

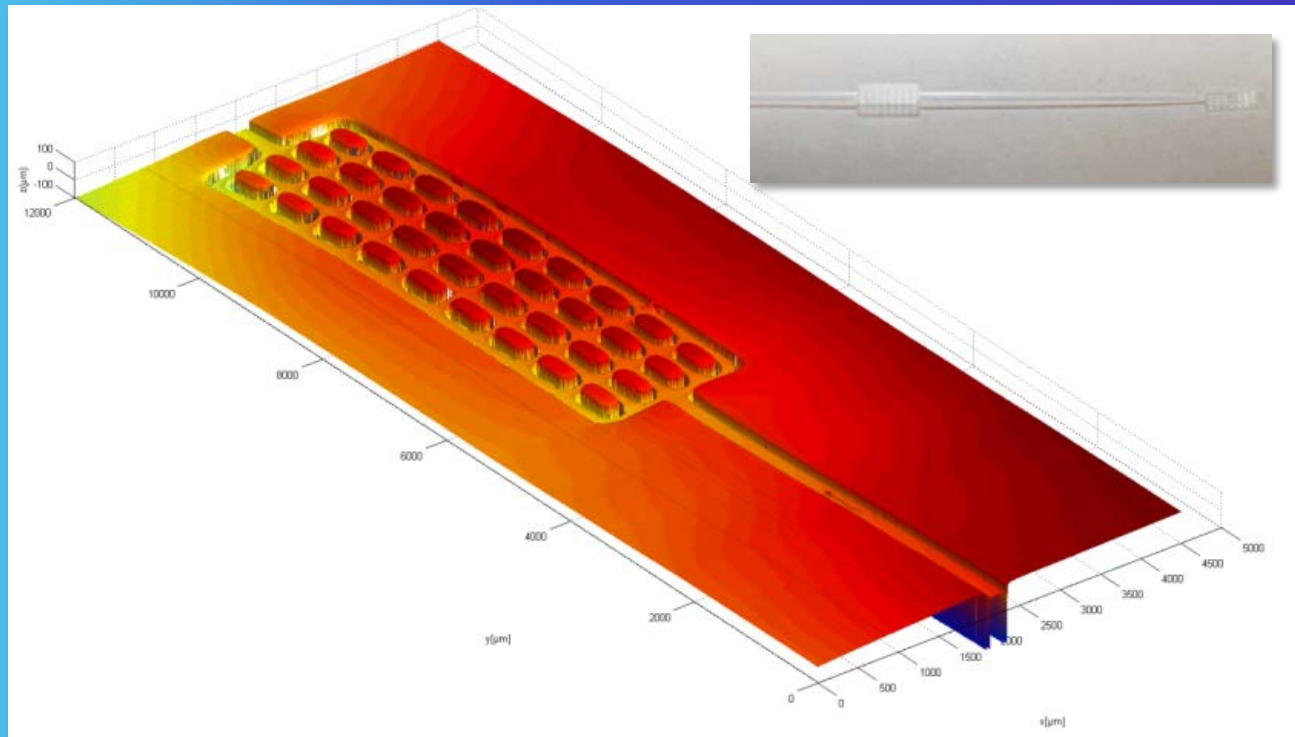


# MicroProfiler MP 400



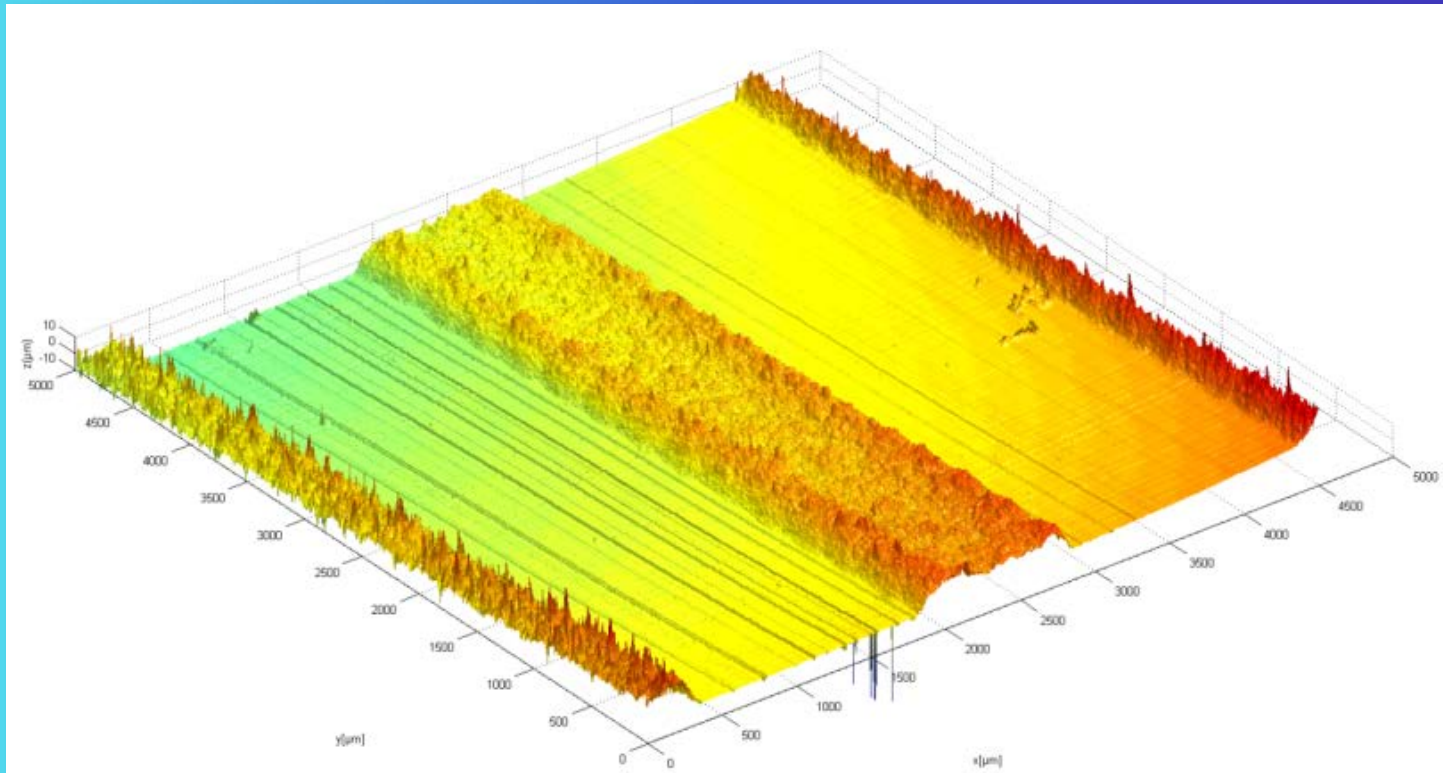
# Hot Embossed Microfluidic Device

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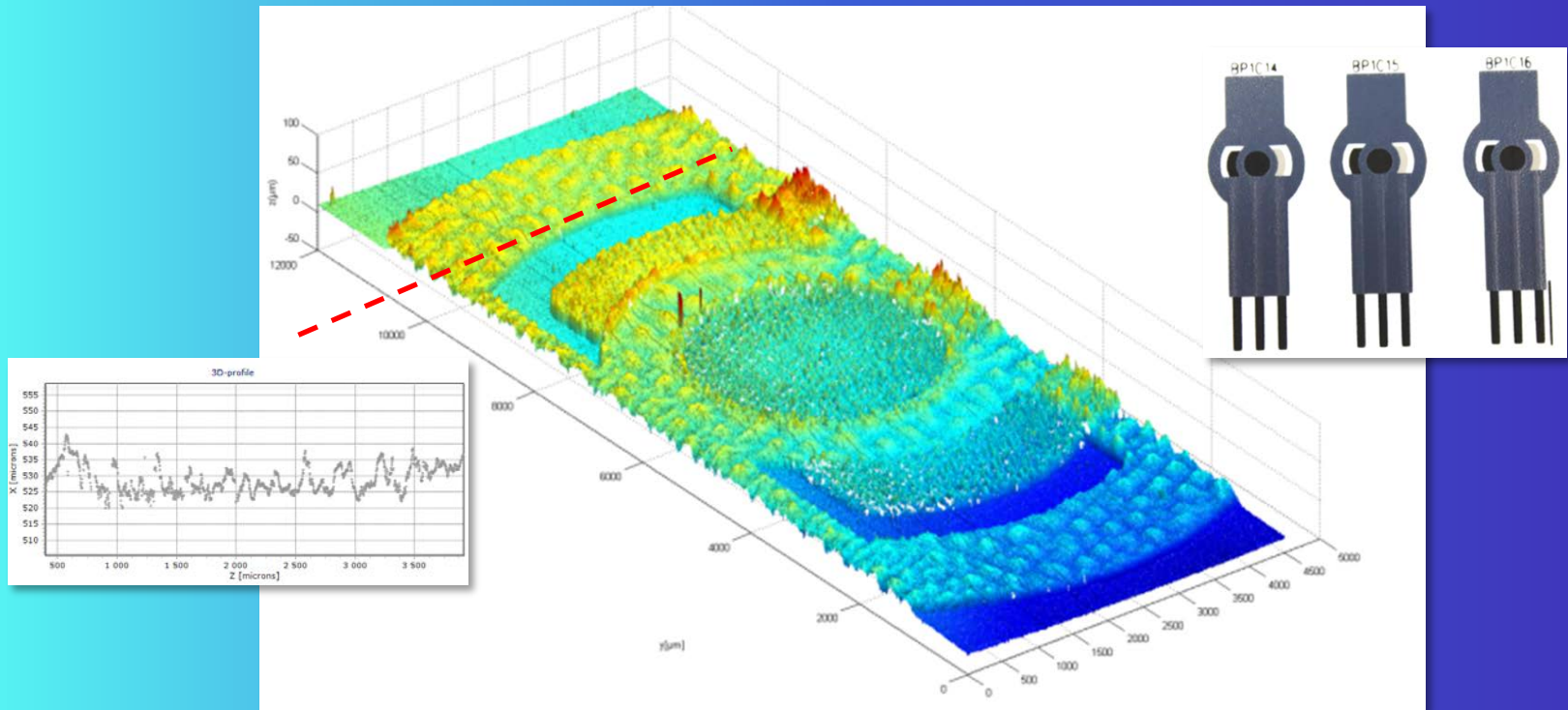
# Printed Conductor on PET Film

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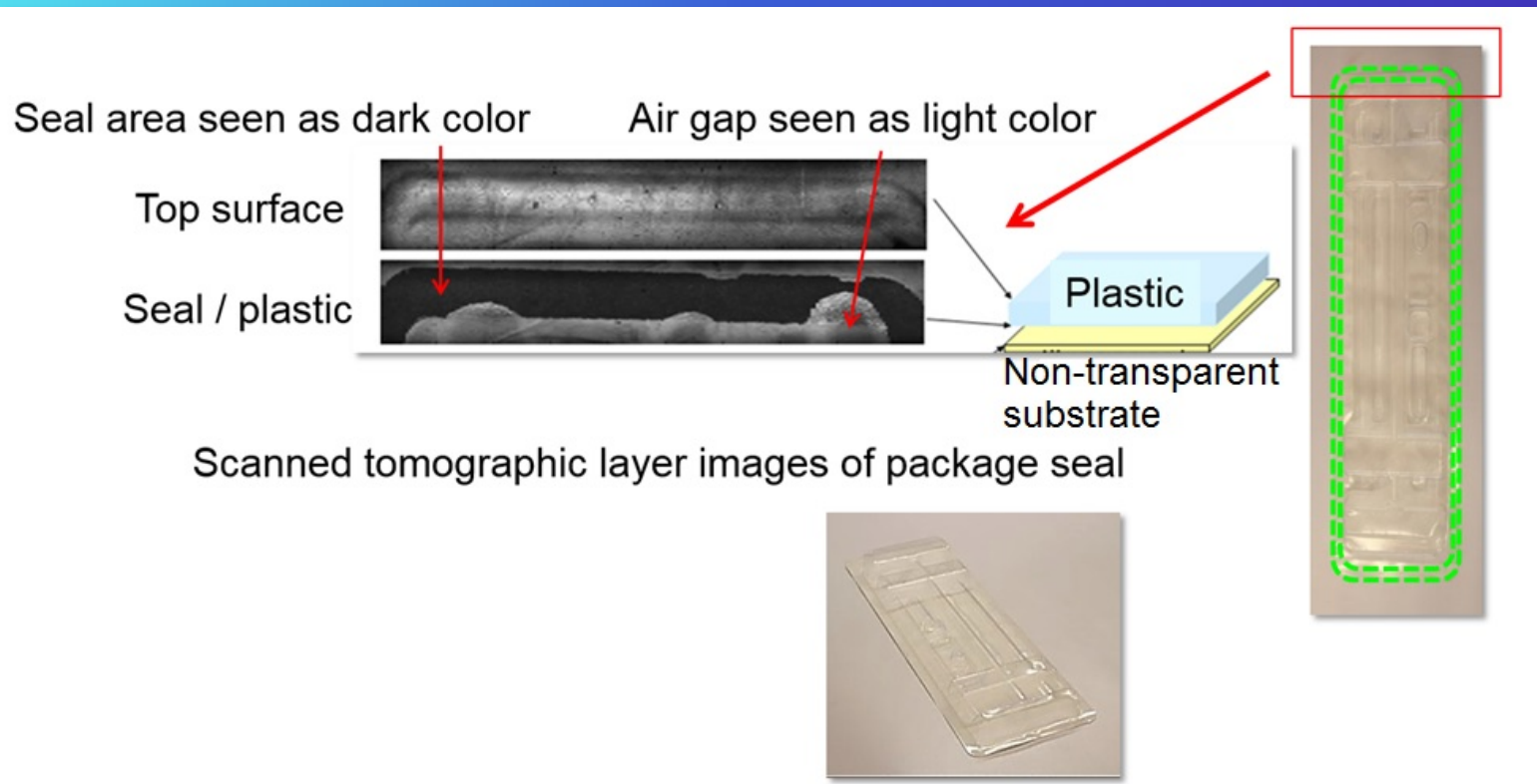
# Printed Bio Sensor

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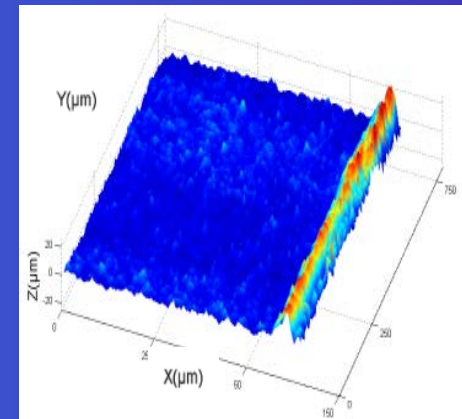
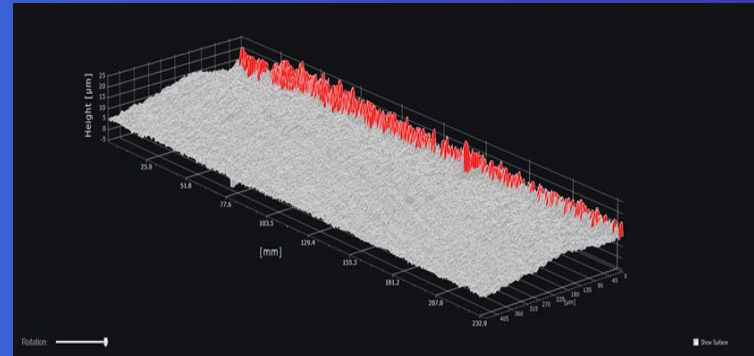
# Heat Seal Tomography in Medical Packaging

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# Other Potential LCI 3D Web Imaging Applications

- 3D edge height/burr height measurement
- 3D fold/wrinkle detection/measurement





# Thank you!

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