

100th
Mitutoyo
Since 1934



Moving into the nano world with metrology

Fulco Verheul

1. Introduction

Welcome to Mitutoyo



Kawasaki Japan



Measurement museum in Japan



1st Micrometer by Mitutoyo Y1937







We measure everything, supporting manufacturing throughout the world

To respond to a wide range of manufacturing needs, Mitutoyo supplies more than 5,500 types of products including precision measurement instruments with accuracies of 1/100 mm to 1/1,000,000 mm (1 nanometer). These include micrometers, calipers, form measuring machines, microscopes, vision measuring machines, and coordinate measuring machines.



Over **5,500** Products

Mitutoyo's lineup

<u>First domestically produced</u>	<u>Automation of form measurement</u>	<u>Internally developed from the lens</u>	<u>Non-contact vision analysis</u>	<u>Supporting various hardness tests</u>	<u>Precision measurement of complex structures</u>
					
Measuring Length Micrometers and Calipers	Measuring Form Contour, Roundness and Roughness Measuring Machines	Measuring the Minute Optical Instruments	Image Measurement Vision Measuring Systems	Measuring Hardness Hardness testing machines	Measuring Coordinates Coordinate Measuring Machines

“Lifelines” Underlying Mitutoyo’s Manufacturing

The world’s leading R&D laboratories, our own plants with various advanced production equipment, and engineers who have a good knowledge and experience - all support Mitutoyo’s technological strength.



R&D Center Working on Core Metrology Contents from Length Standards to Advanced Measurement Technologies.

Research & Development Division is located in Kawasaki Headquarters.

In addition to measurement techniques and correction algorithms directly built into products, the laboratory has an important mission to develop technologies for measurement standards and calibration that will indirectly support products.

We are the only private company in the world that maintains and operates an "optical frequency comb*", an ultra-high precision standard instrument with the same performance as the national standard.

*Co-developed with the National Institute of Advanced Industrial Science and Technology.



• Research & Development Division



[Research of standard and calibration technologies]

Laser frequency calibration system with optical frequency comb



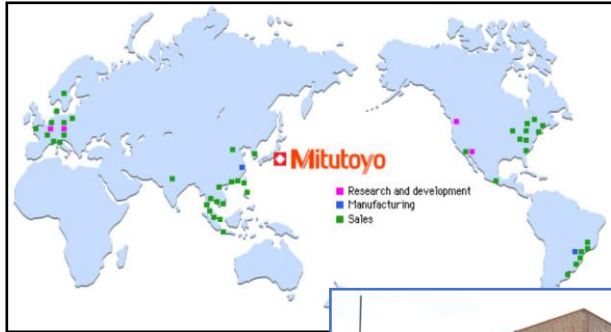
[Research of measurement and correction technologies]

System for measuring a gauge block with double-ended interferometer

Technology to evaluate uncertainty of coordinate measurements



Mitutoyo Research Center Europe (Eindhoven)



PHILIPS



TriNano 3D CMM

*Nanometer uncertainty
for a micro price*

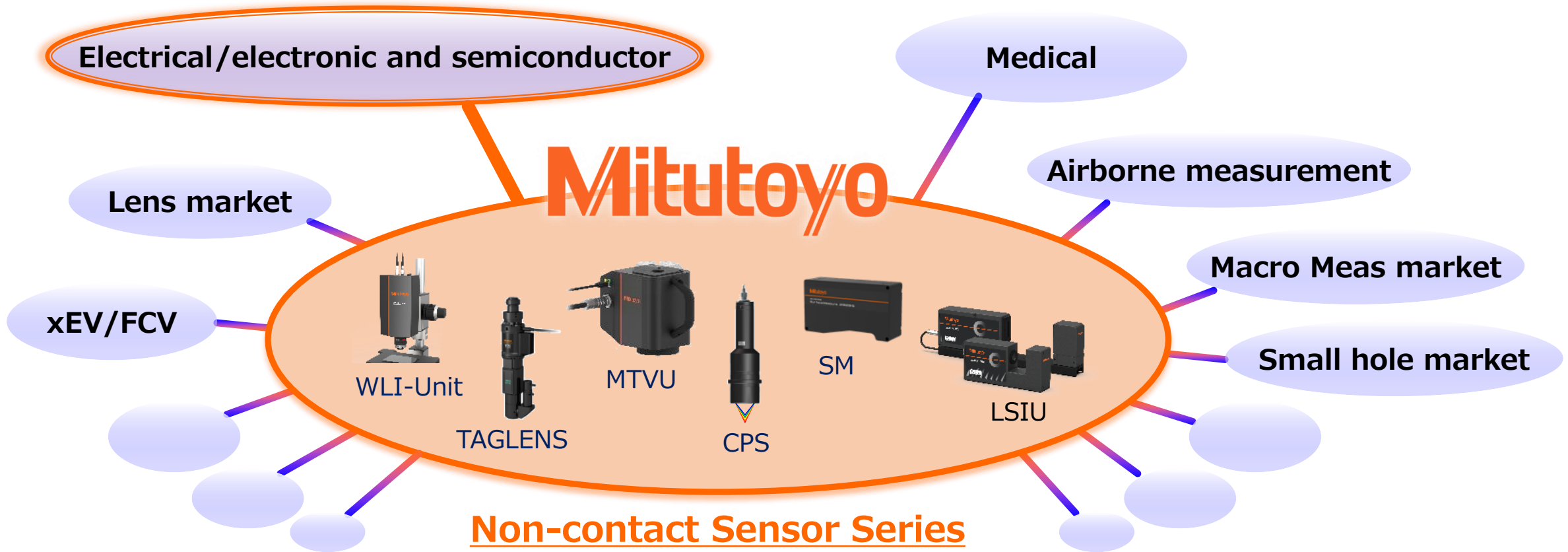
TU/e EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

Organization Profile

- ~ 15 researchers and engineers
- Core Expertise: Optical Sensing Technology (Algorithm, HW)
- Example Technology:
 - Digital Holography
 - Coherence Scanning Interferometry

Mission of Mitutoyo RCE

1. Development of new sensing technologies in focused domain (e.g., Semiconductor)
2. Catch-up the state-of-the-art metrology needs especially focus on the activity in Europe
3. Collaborating with European partners (High tech suppliers, NMIs) representing the whole Mitutoyo R&D



❑ The semiconductor industry in Japan surrounding Mitutoyo

- Participate in 'JOINT3', a co-creation evaluation platform that promotes the development of materials, equipment, and design tools suitable for panel-level organic interposers, utilizing a trial production line for panel-level organic interposers with a size of 515 x 510 mm.







 **The only measuring instrument manufacturer participating in 'Joint3'**

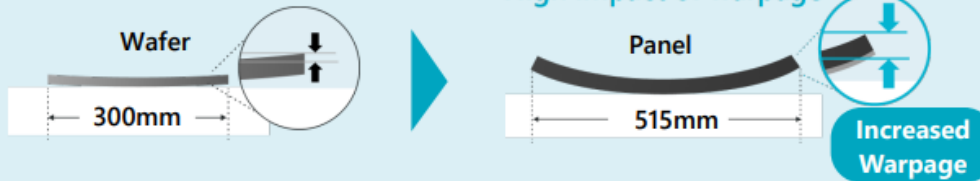
<https://www.resonac.com/sites/default/files/2025-09/JOINT3irHPE.pdf>

New sensors (under Development)

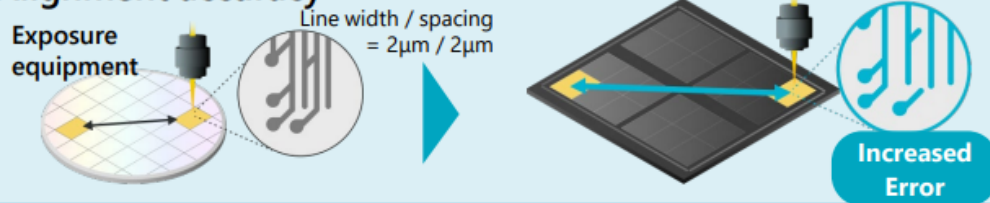
Mitutoyo is currently developing new sensors driven by semiconductor market trends.

Advanced packaging technologies roadmap

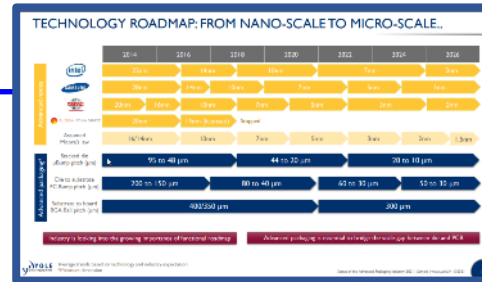
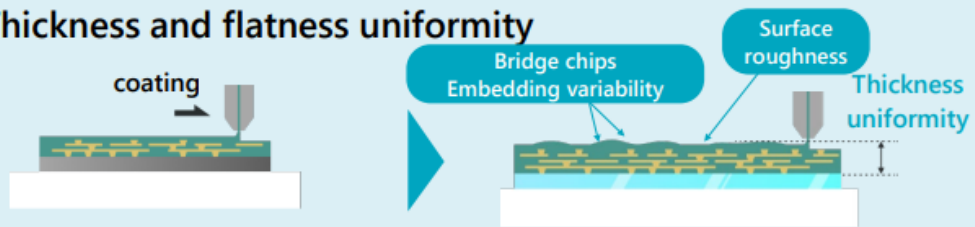
1. Warpage



2. Alignment accuracy



3. Thickness and flatness uniformity



Metrology

Non-contact

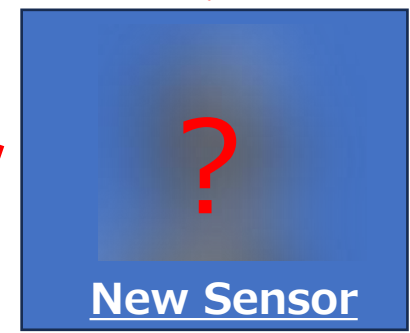
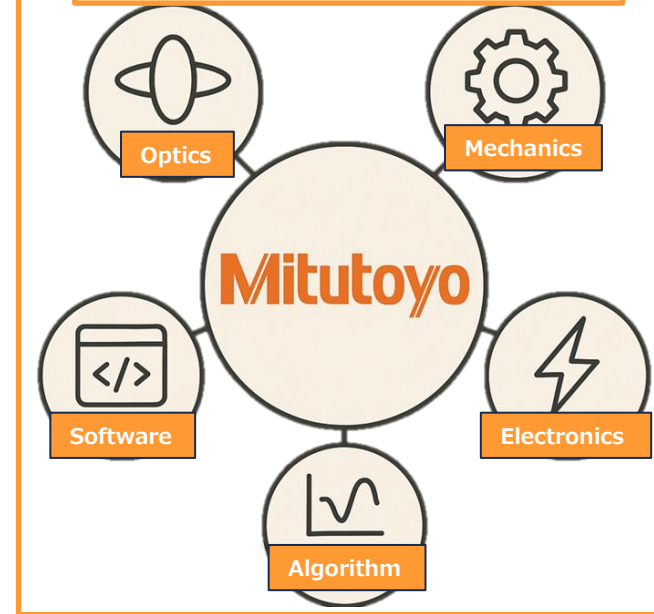
High Resolution

low noise

3D



Mitutoyo Technology



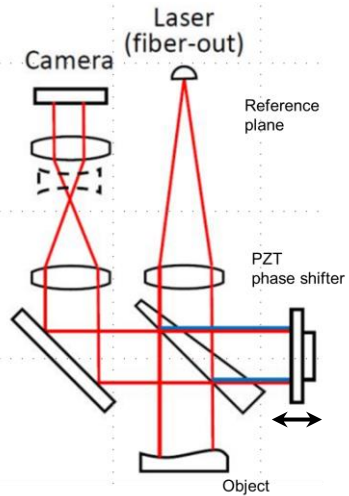
Addressing challenges of new sensors in an industrial environment

New optical sensor for Precision Metrology

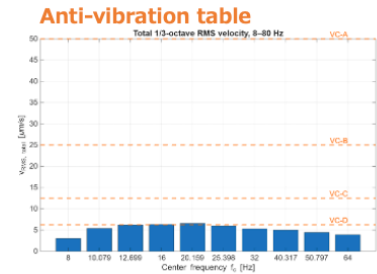
- Reliable dimensional accuracy (flatness, z-scale accuracy)

Challenges:

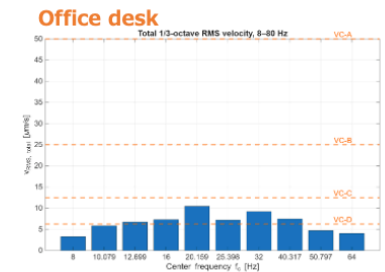
- Laser Wavelength Drift**
→ On the fly wavelength compensation algorithm
- Coherent Noise in the imaging system**
→ High-speed modulation & unique optical design
- Vibration Sensitivity**
→ Vibration robust Algorithm



Vibration robust algorithm

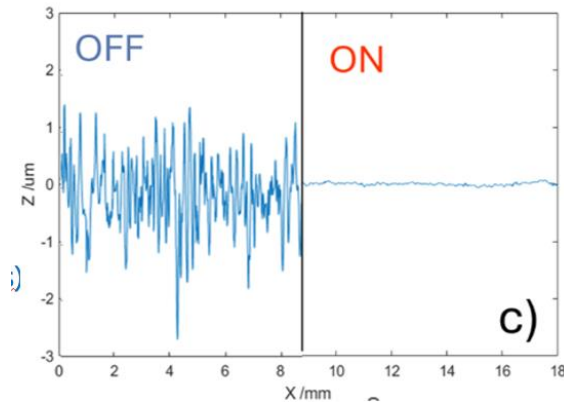


Noise floor ($\sim 6 \mu\text{m/s}$, VC-D)

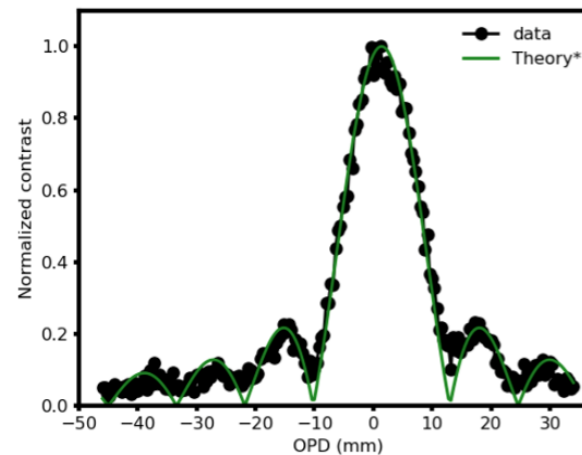


Environmental vibrations ($\sim 10 \mu\text{m/s}$, VC-D)

Coherence Reduction Hardware



Coherence control of Laser



CONFIDENTIAL

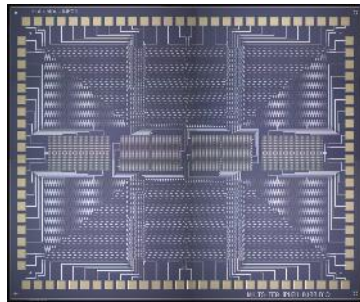
New sensors (under Development)

Functional model sensor box – a recent example of collaboration with a local NL system integrator partner

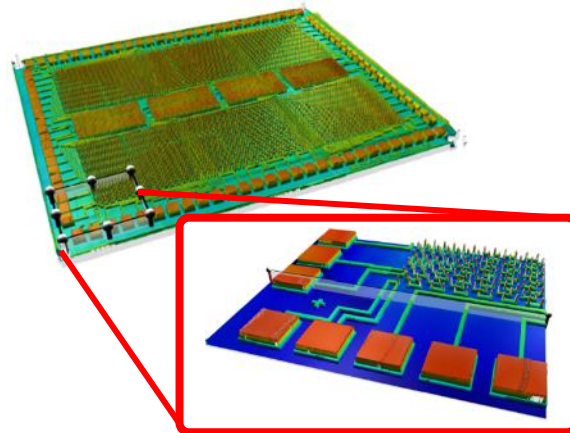
- opto-mechanical design by Mitutoyo. RCE NL in the lead supported by R&D in HQ Japan
- Design for Assembly by a local system integrator in the Netherlands
- < 1 year lead time from concept to functional model for dimensional metrology measurements in real- world conditions:
 - Semiconductor packaging
 - Defect / particle detection
 - Highest grade cleanliness surface measurement

HBM-TEG

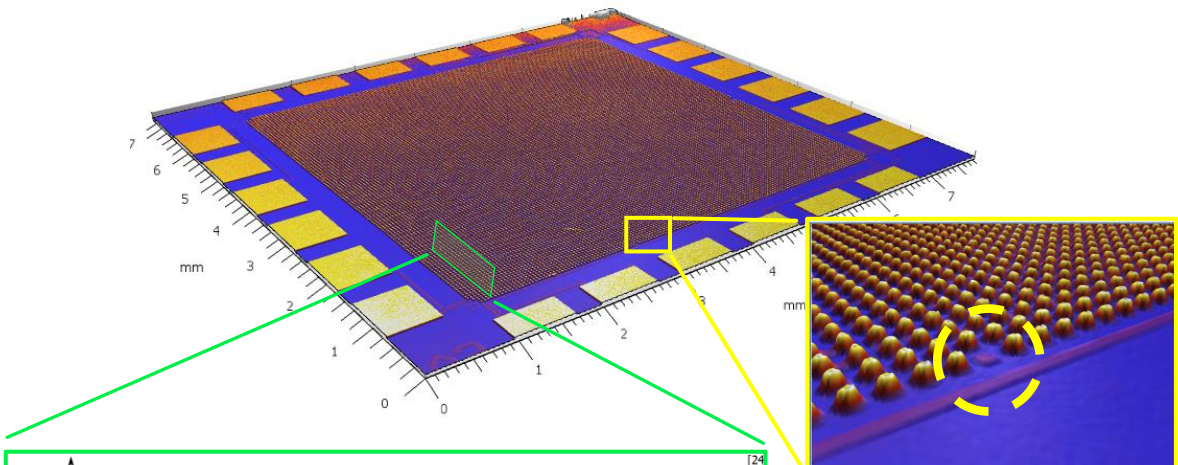
(High Bandwidth Memory Test Element Group)



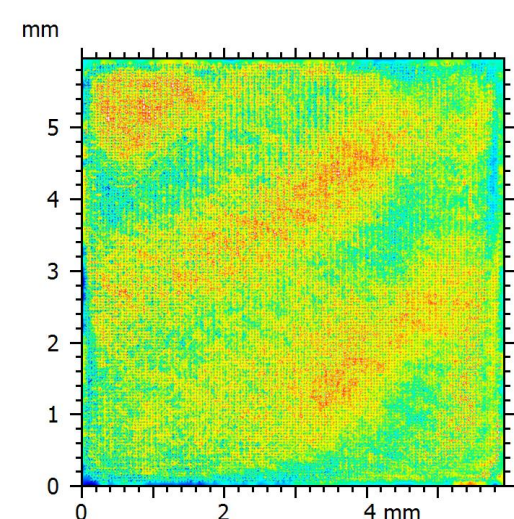
Provided by WALTERS CO., LTD / ASKINDEX CO., LTD



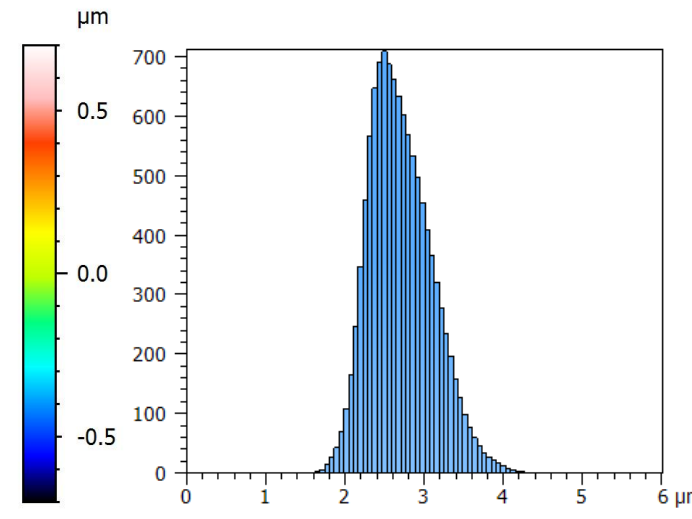
Application example (Copper pillar μ -Bumps)



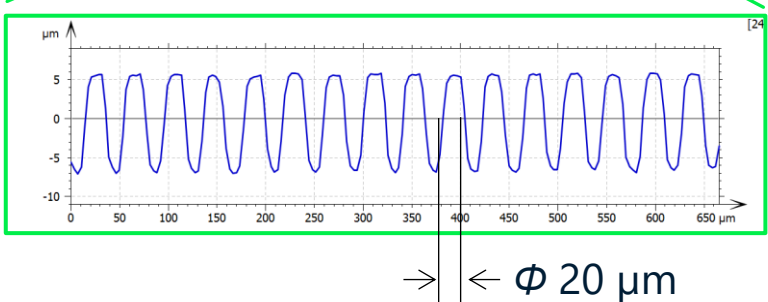
Missing Bump



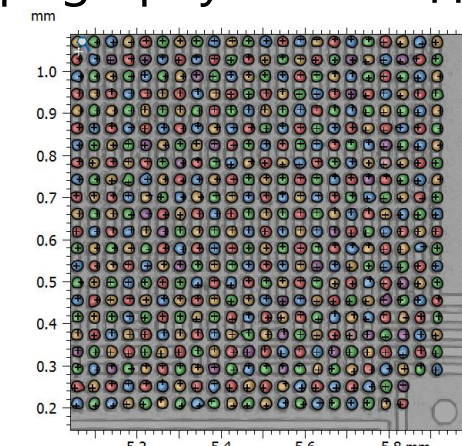
Bump-top topography



Height Distribution



$\Rightarrow \leftarrow \Phi 20 \mu\text{m}$



Bump number, locations

- **Bump top coplanarity** $< 0.6 \mu\text{m}$ (WID 12%)
- **Number of the bumps** $> 20,000$

Digital Holography for Quality Assurance in Advanced Packaging

Summary

- Mitutoyo Developed a new optical sensor in collaboration with partner
- Unique opto-mechanical design and algorithm enable metrology-grade dimensional measurement in real-world conditions
- New sensor offers advanced capabilities for industrial quality assurance

Application

- Dimensional Measurement in semiconductor packaging
- Inline Defect/Particle detection
- Highest grade mechanical surface (e.g., vacuum flanges)

... and more opportunities?



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Mitutoyo Europe –Semicon Center in Netherlands (Veenendaal)



We support Customers with **Optical technology** that Mitutoyo has established over many years.

We will hold a solo exhibition at the Semicon Center in December (3rd and 4th). Let me know if you are interested.

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Mitutoyo

URL: <http://www.mitutoyo.co.jp>