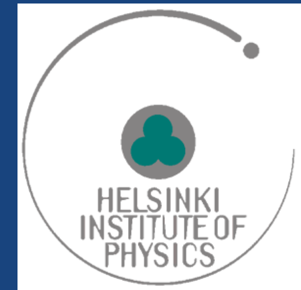


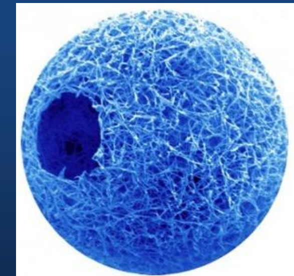
Characterization of Ni/SnPb - TiW/Pt Flip Chip Interconnections in Silicon Pixel Detector Modules

A. Karadzhinova, A. Nolvi, J. Härkönen, P. Luukka,
T. Mäenpää, E. Tuominen, E. Hæggström,
J. Kalliopuska, S. Vähänen, I. Kassamakov

Department of Physics, University of Helsinki, Finland;
Helsinki Institute of Physics, Finland;
Advacam Ltd, Finland

Outline

I. Background
   i. Silicon detectors
   ii. Flip-chip interconnects
II. Scanning White Light Interferometry (SWLI)
III. Results
IV. Conclusions



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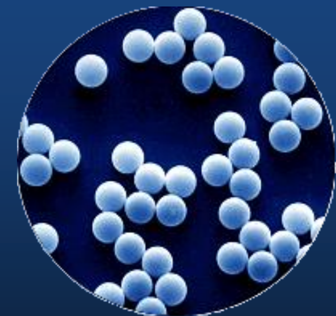

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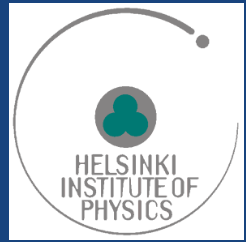
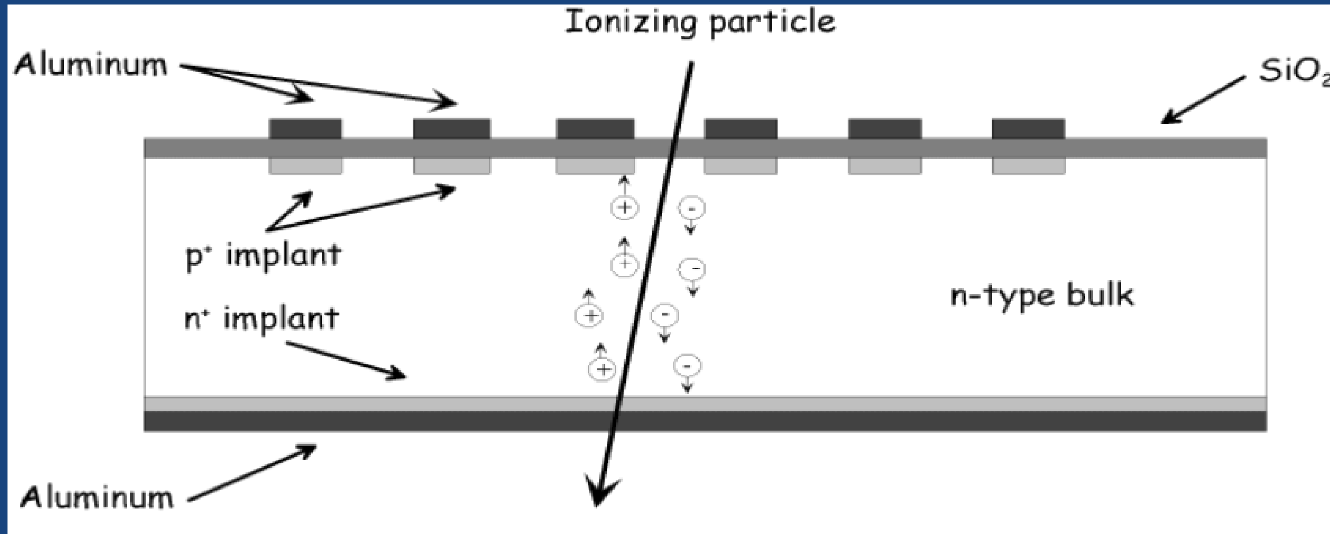
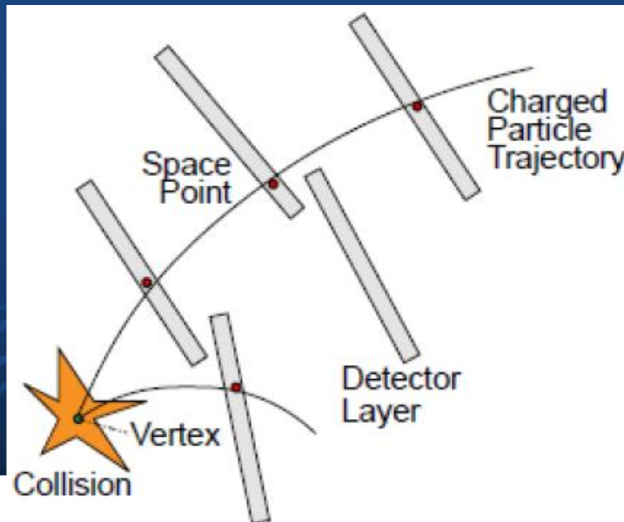
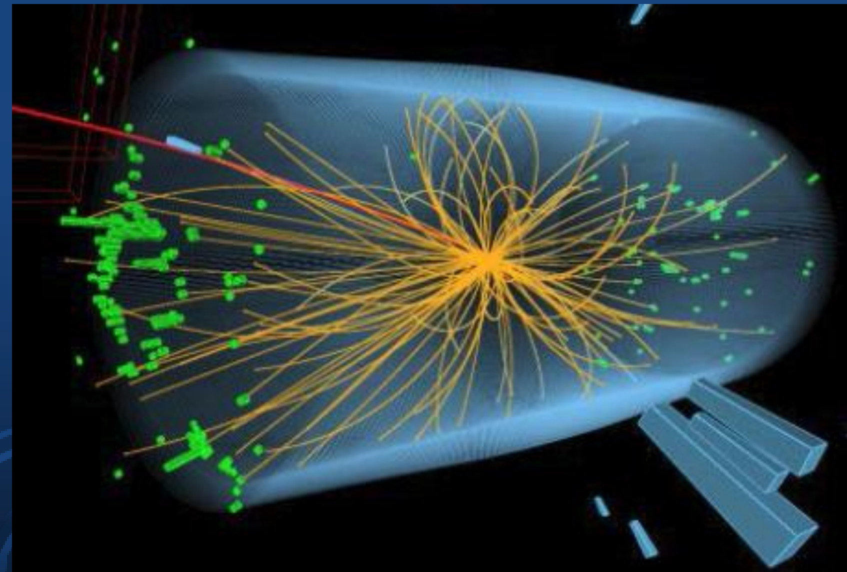
Silicon detectors

Particle tracking









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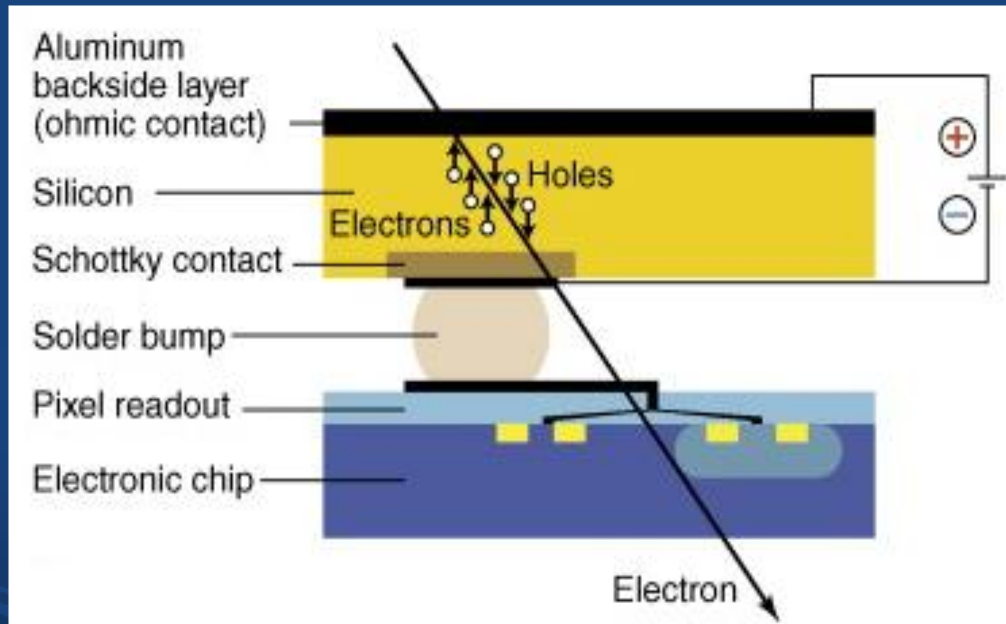
Flip – Chip Interconnects

Bump-bonding is the most common way of making interconnections to external electrical circuit with bumps that have been deposited on the surface of both the chips.



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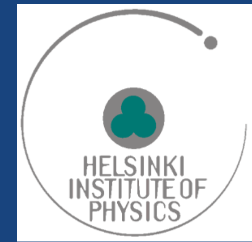
Bumping process flow



1

Contact pad metal (typically Al)

Pass

Substrate

2

Cu

TiW

Field metal deposition

3

Exposed & Developed Photoresist

4

Plated solder alloy (Eutectic Sn-Pb)

Under Bump Metallurgy (typically plated Ni)

5

After photoresist stripping

6

Wet etching of field metal Cu

7

Solder reflow

8

Wet etching of field metal TiW

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CMS bare pixel module

CMS Barrel Pixel Module

KIT
Karlsruhe Institute of Technology

Signalcable

Powercable

SMD–Components

Token bit manager

TBM

HDI
High density interconnect

Sensor
16×62 mm²
66,560 pixels

bump bonding:

ROCs
Read-out chips

SiN
Basestrips

[W. Erdmann]

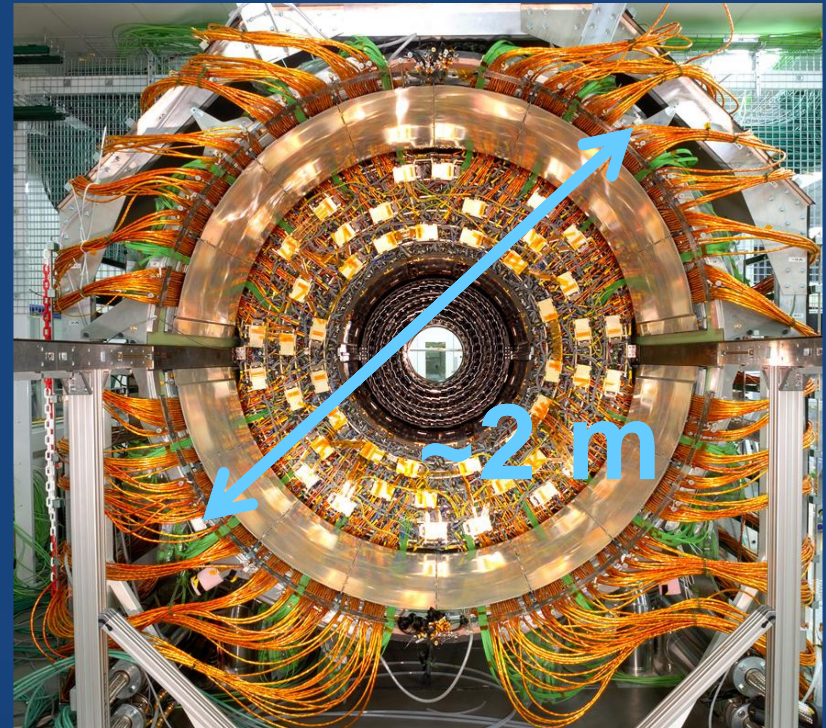
Module dimensions: 66.6 × 26.0 mm²

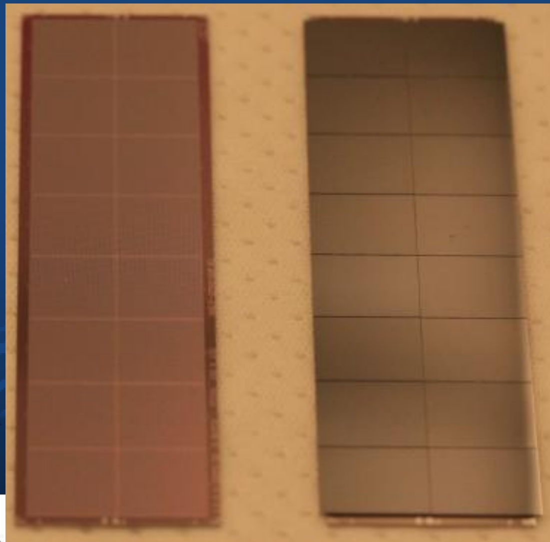
full–module ≙ 16 ROCs

Silicon detectors CMS bare pixel module

The CMS bare pixel module consist of a sensor and 16 Read Out Chips (ROC) bonded on sensor by Ni/SnPb solder bumps. Pt is used as Under Bump Metallization (UBM) on sensor chips.

Number of pixels in a module is 16 × 80 × 52 = 66560. <0.1% of dead channels is acceptable





The CMS Tracker implements 25000 silicon strip sensors covering an area of 210m2. Connected to 75000 APV chips, one has to control 9600000 electronic readout channels, needing about 26 million micro bonds.

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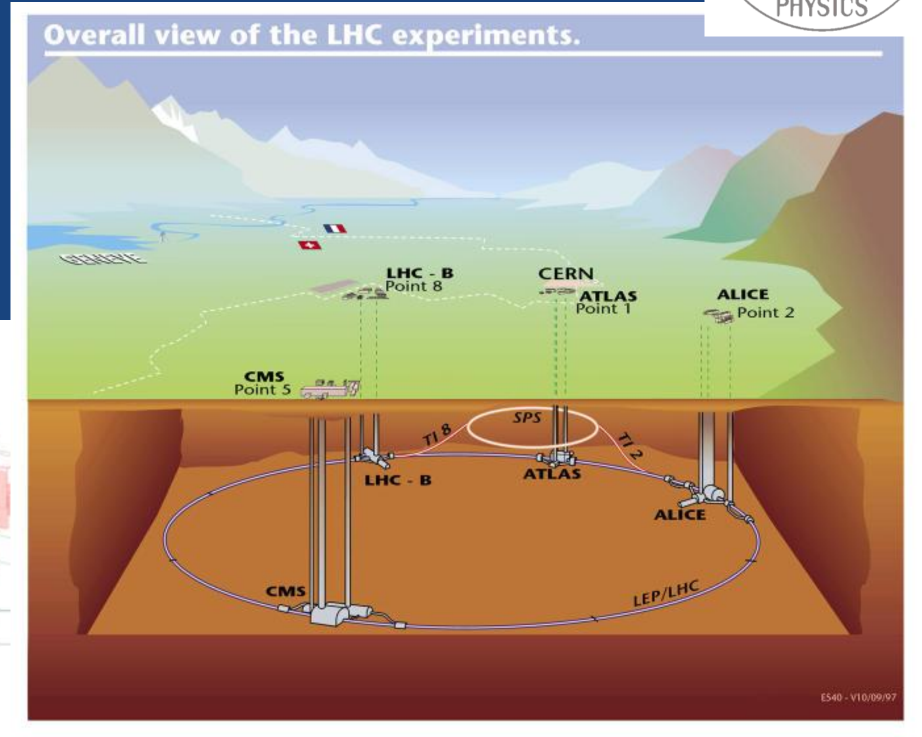
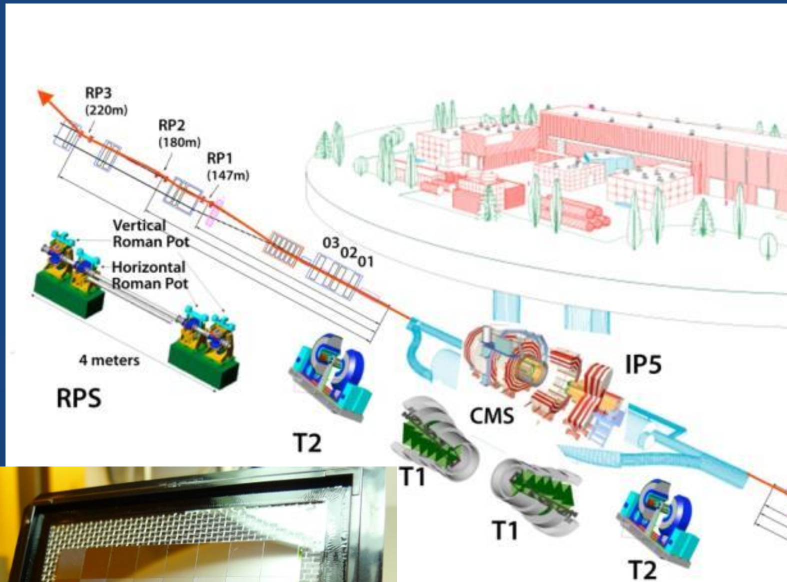
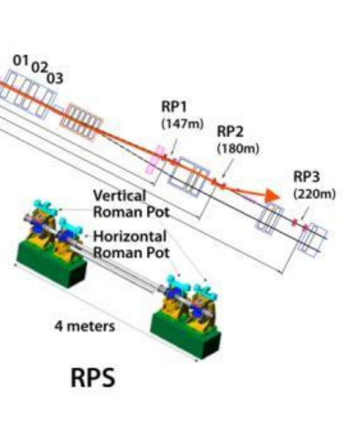
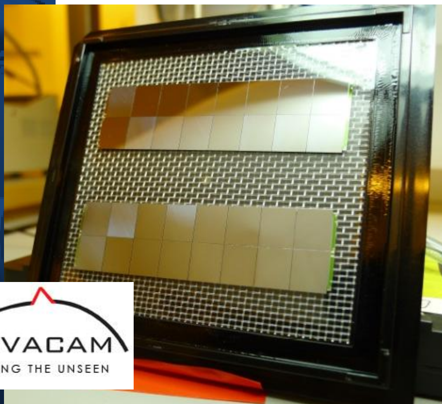
CMS Upgrade Project

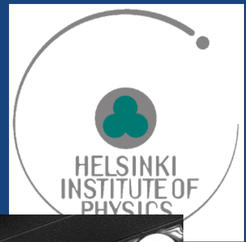


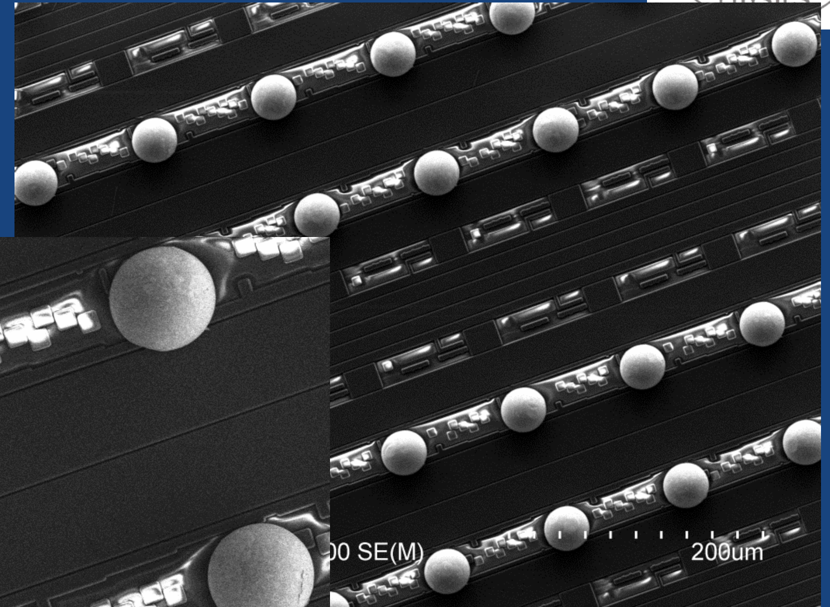


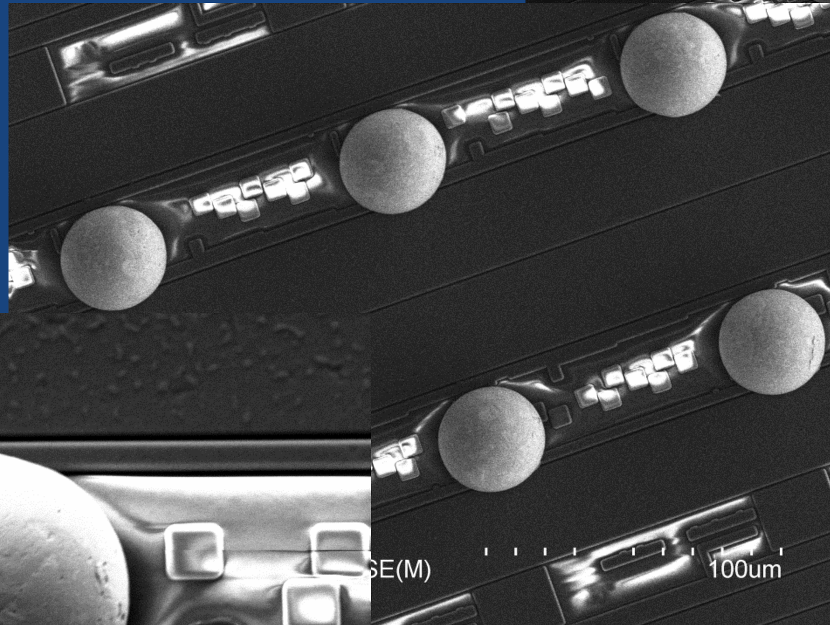


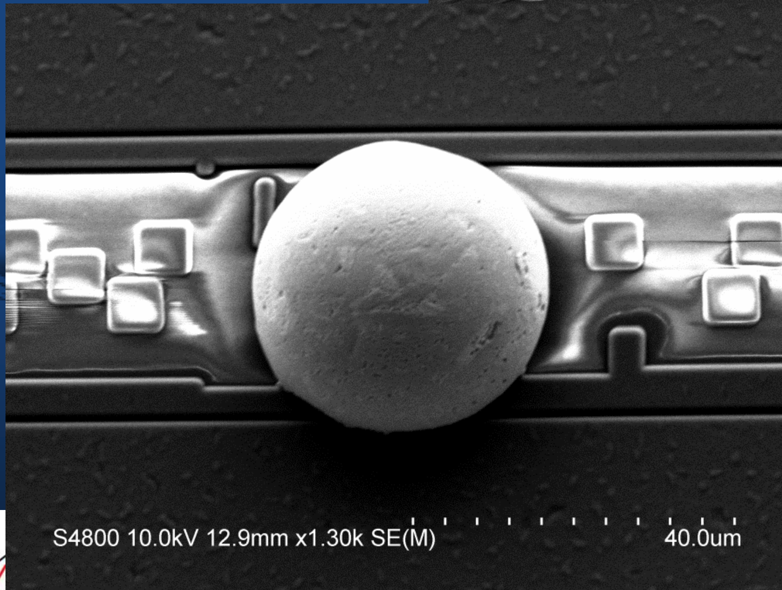


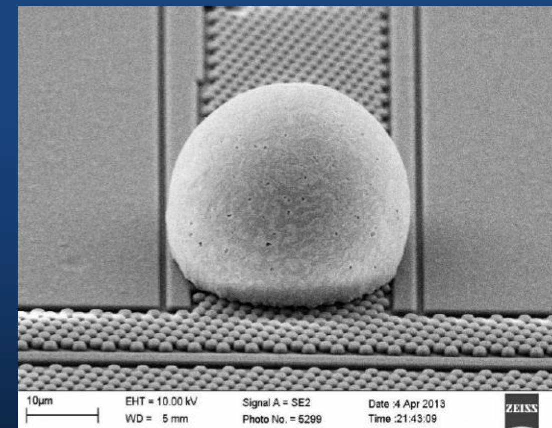
SnPb solder bumps











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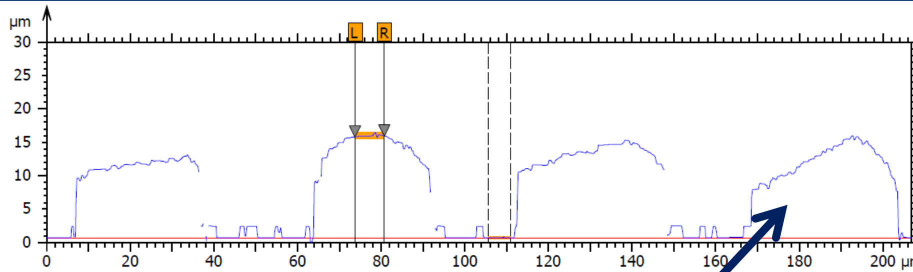
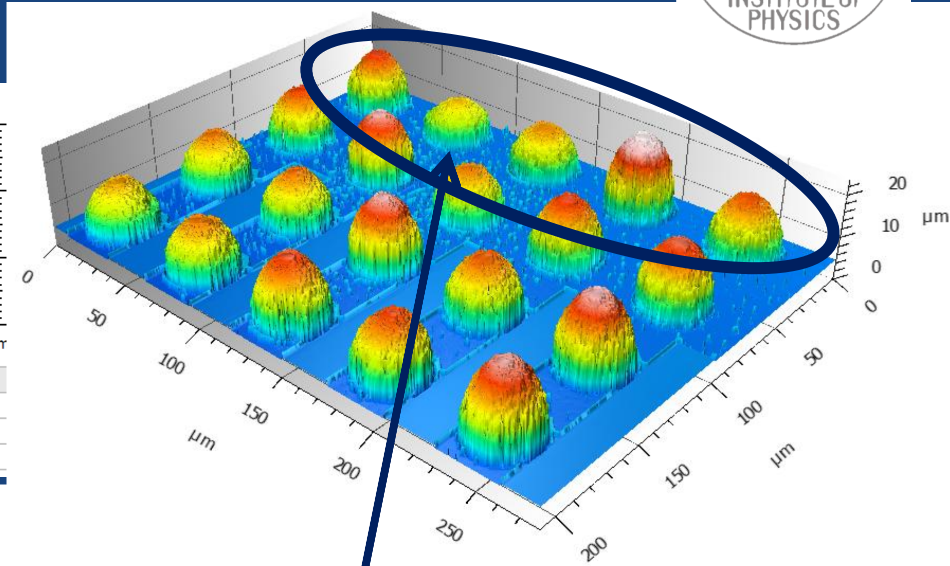
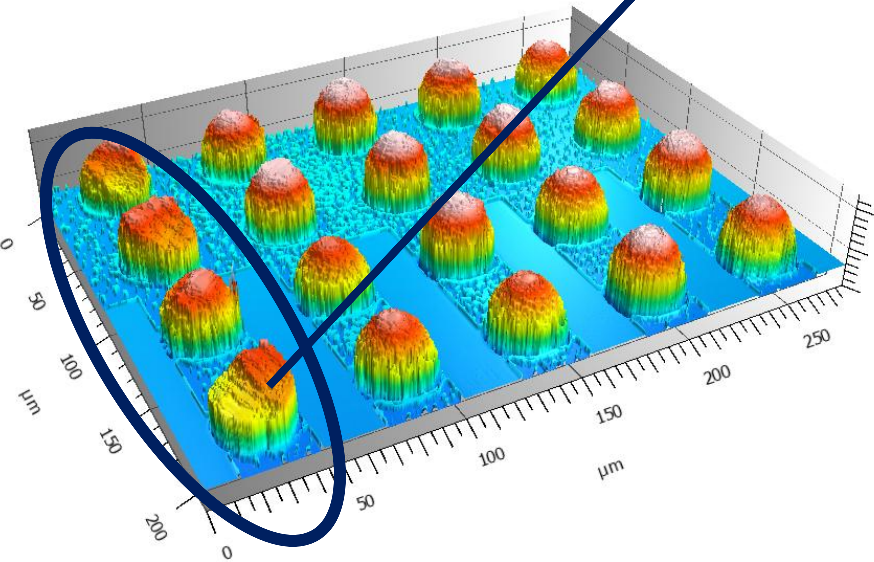
Bump - bonds Challenges

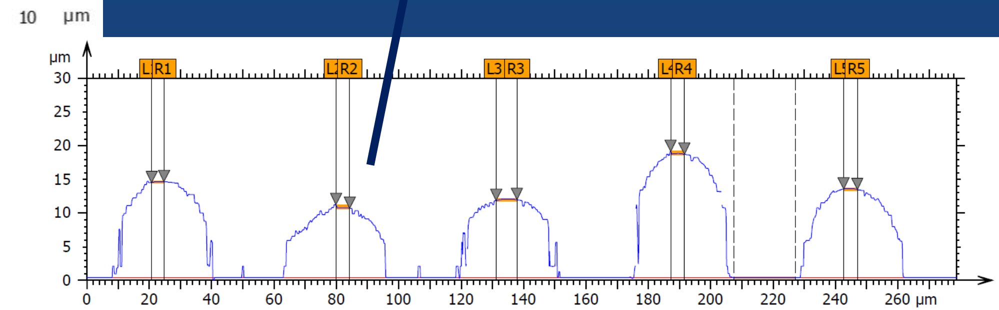


Parameters	Step 1	Unit
Width	7.06	µm
Maximum height	15.7	µm
Mean height	15.2	µm





Maximum height measurement of the bump - bonds.



Parameters	Unit	Step 1	Step 2	Step 3	Step 4	Step 5
Width	µm	4.07	4.65	6.82	4.50	4.50
Maximum height	µm	14.2	10.9	11.6	18.7	13.2
Mean height	µm	14.2	10.4	11.6	18.4	13.2

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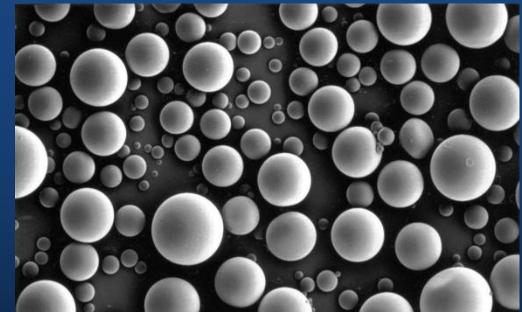

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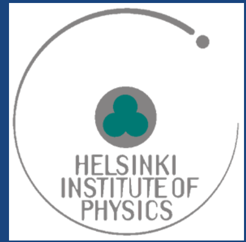
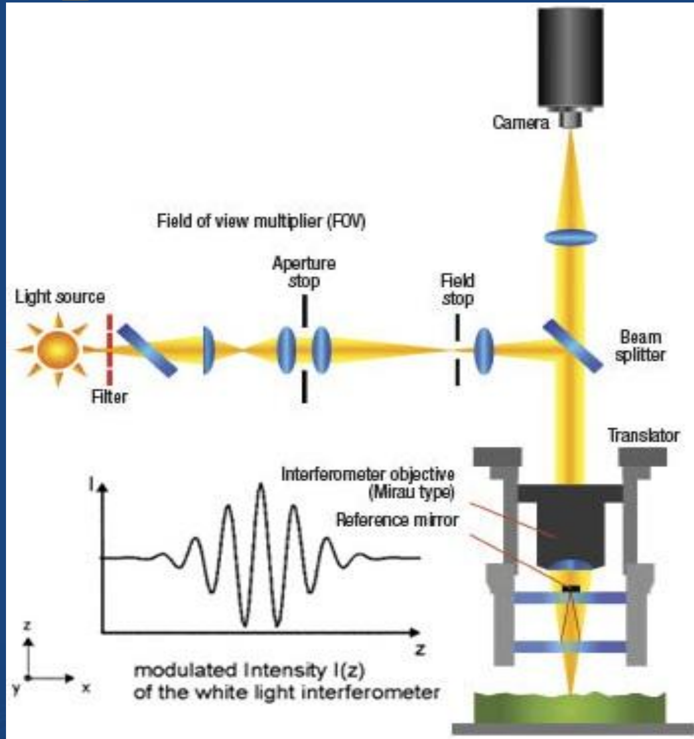
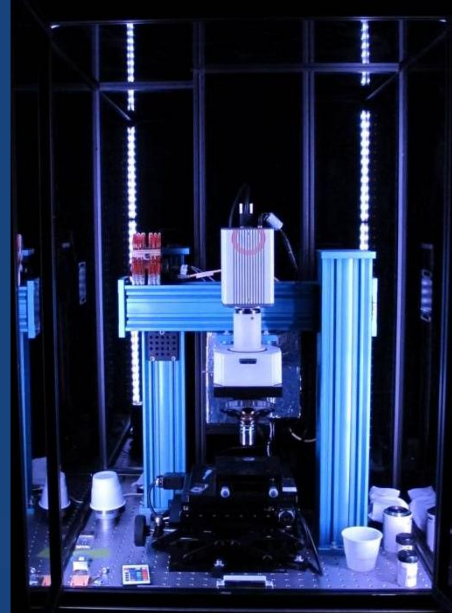
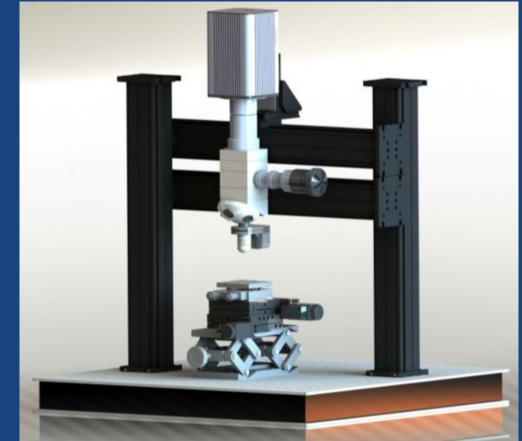
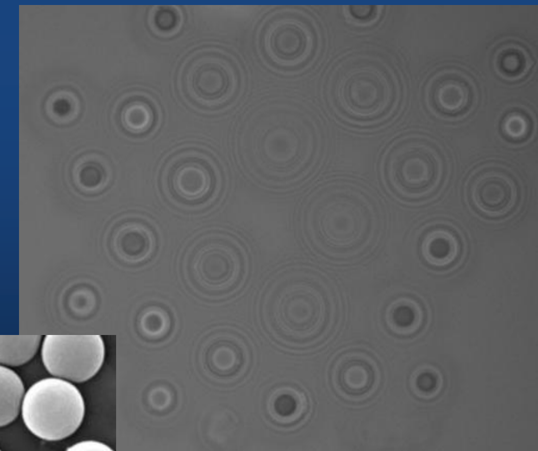
Scanning White Light Interferometry (SWLI)





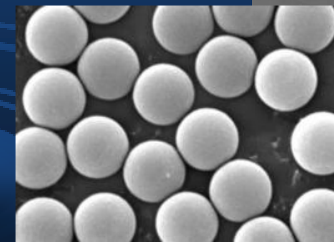






Objective: NIKON CF IC Epi Plan DI 50x 0,55NA
Total magnification: 25x (0,5x tubelens NIKON)

Camera: HAMAMTSU Orca Flash 2.8
Light source: halogen bulb



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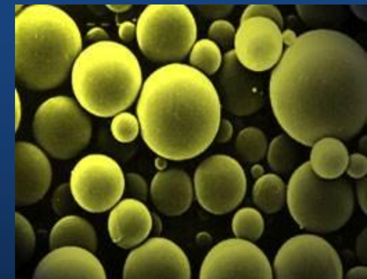

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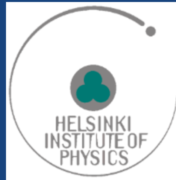
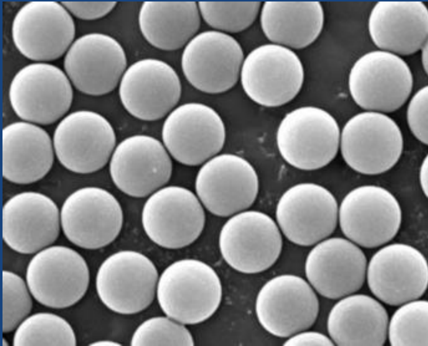
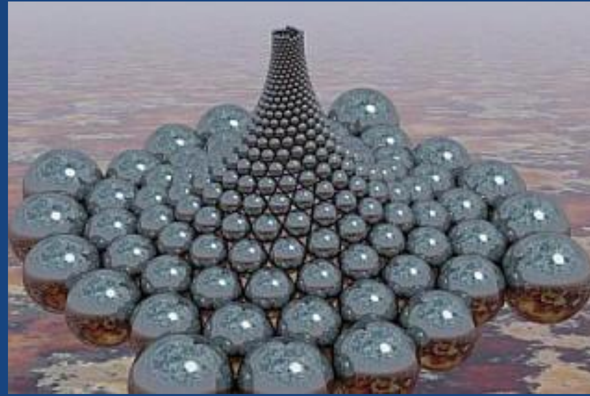
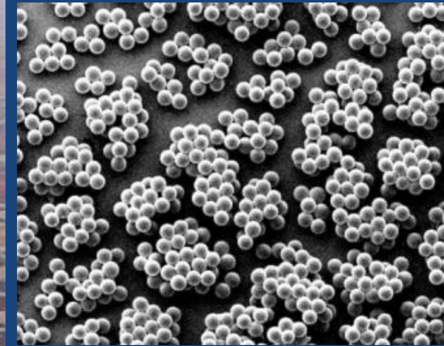
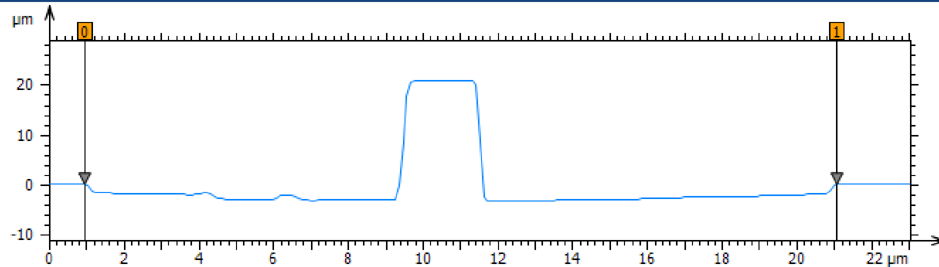
SWLI Measurements of NIST Calibrated SiO_2 Spheres



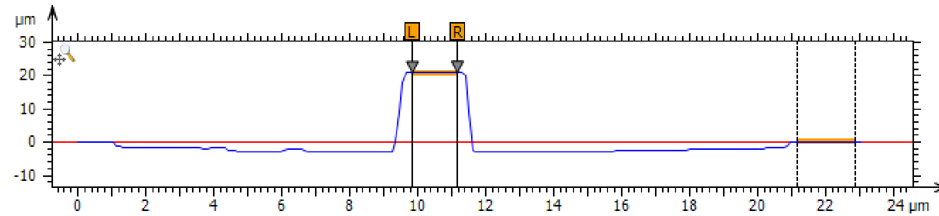






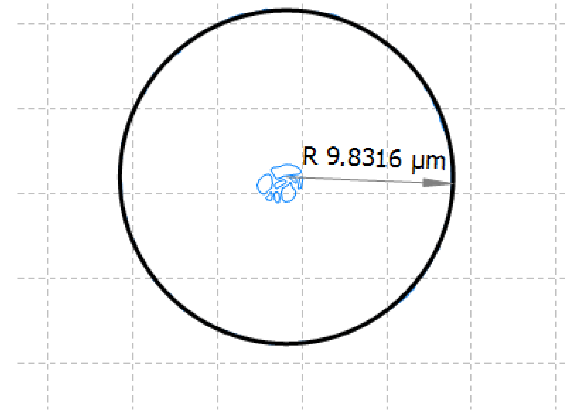


Parameters	0-1	Unit
Horizontal distance	20.1	µm
Height difference	0.00707	µm



Parameters	Step 1	Unit
Width	1.44	µm
Maximum height	20.7	µm
Mean height	20.6	µm

Width, Maximum height and Radius measurement of the spheres



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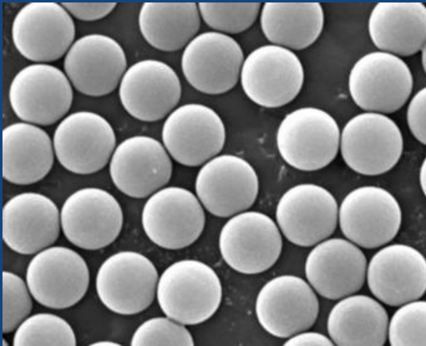
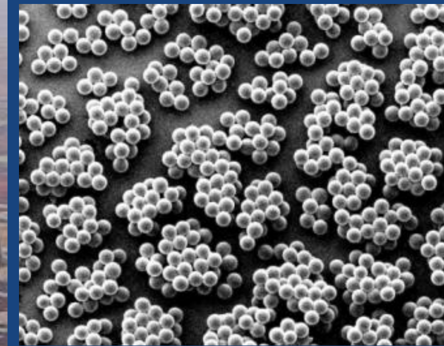
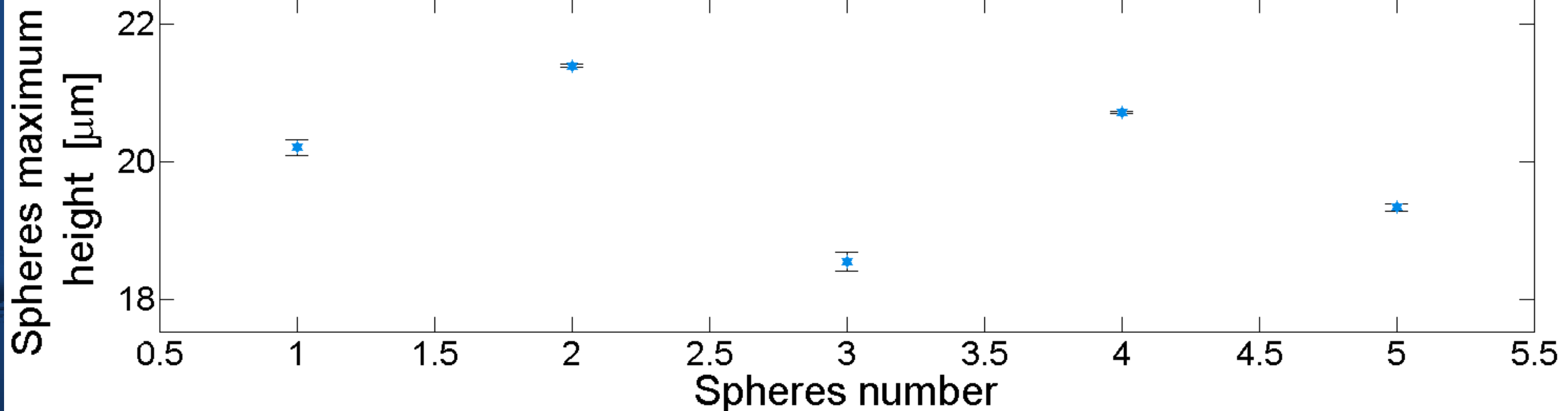
SWLI Measurements of NIST Calibrated SiO_2 Spheres

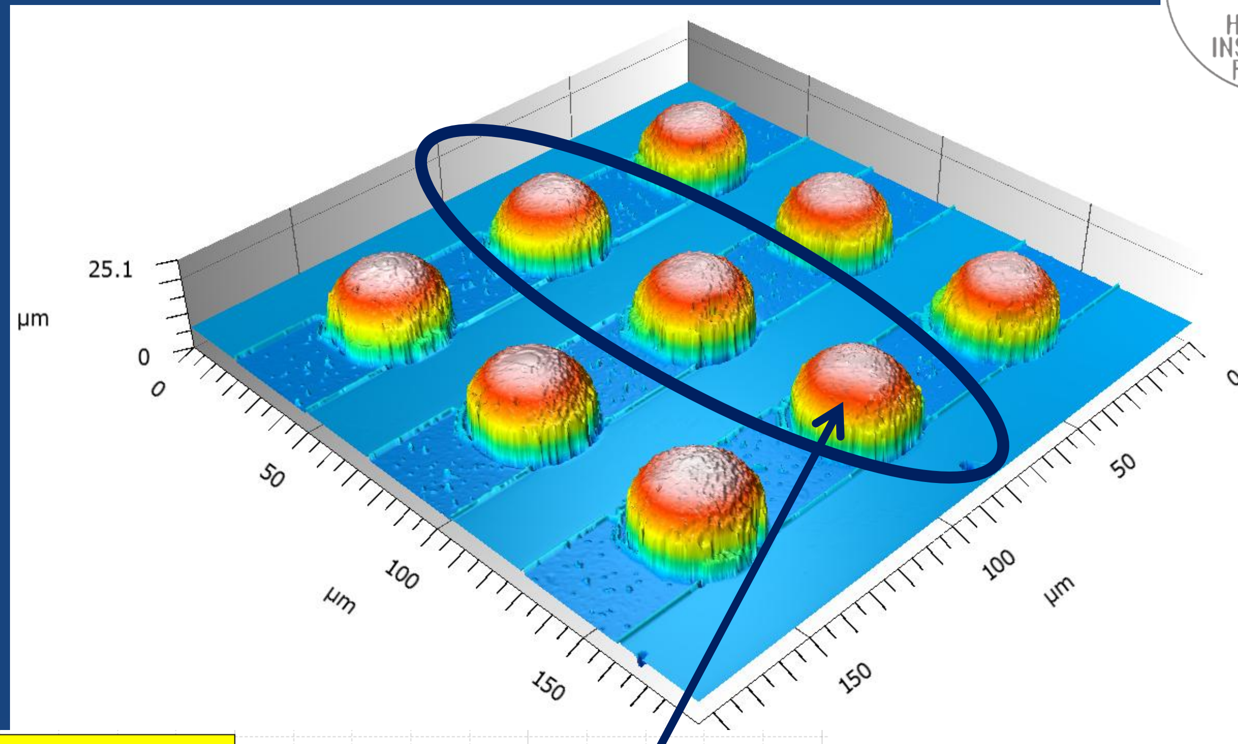


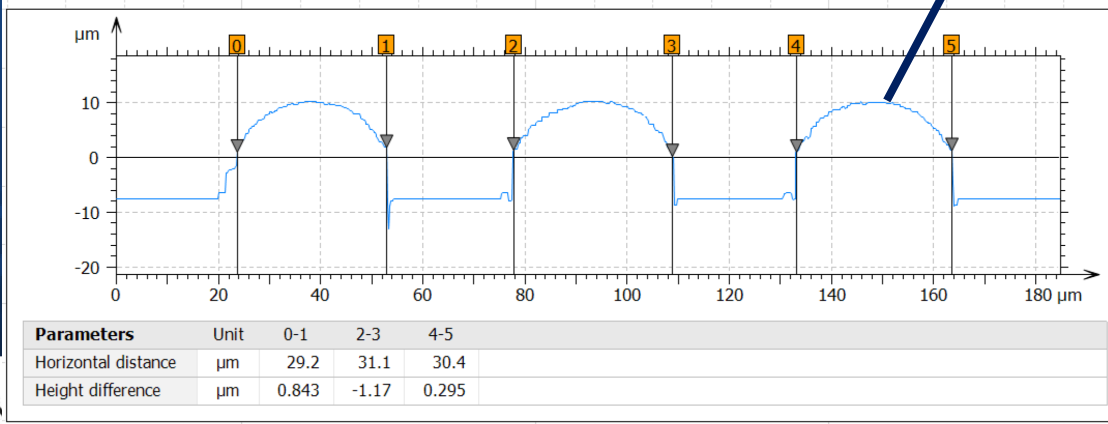




The uncertainty of the SWLI measurement at a coverage factor $k = 2$, for a 95% confidence level was ± 0.0076 µm.

SWLI Results – Bump bonds





Parameters	Unit	0-1	2-3	4-5
Horizontal distance	µm	29.2	31.1	30.4
Height difference	µm	0.843	-1.17	0.295

Width measurement of the bump - bonds.

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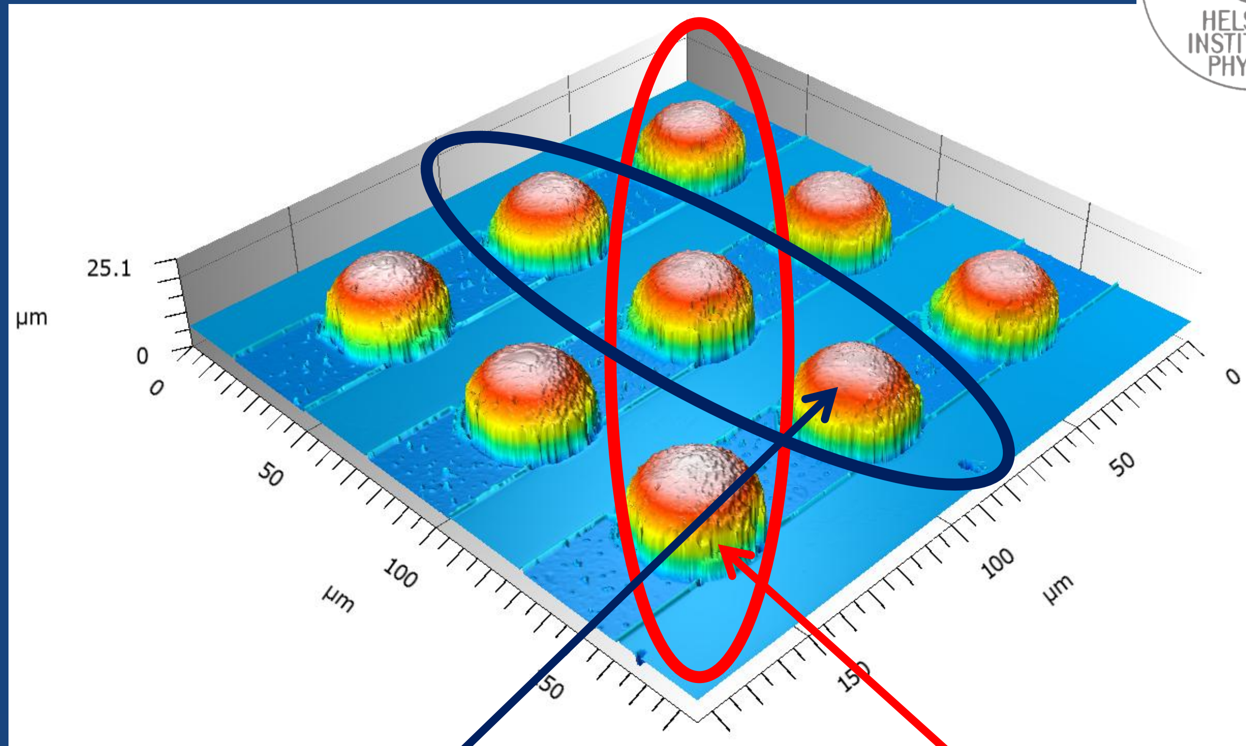
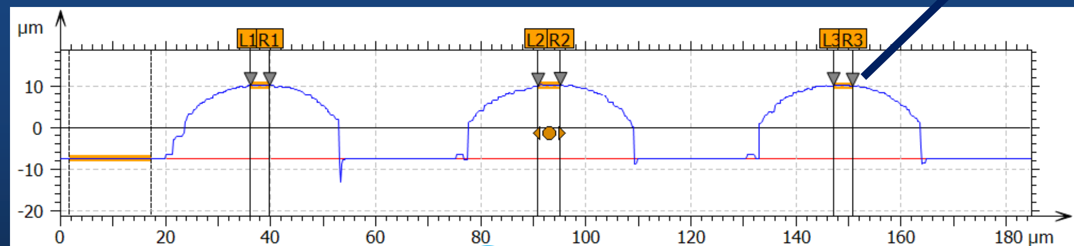
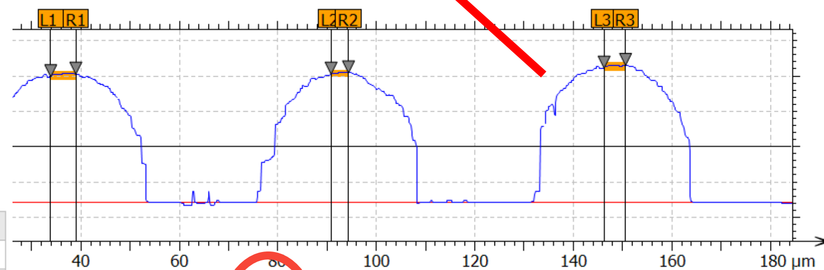
SWLI Results – Bump bonds



Maximum height measurement of the bump - bonds.



Parameters	Unit	Step 1	Step 2	Step 3
Width	µm	3.78	4.36	3.78
Maximum height	µm	17.7	17.8	17.6
Mean height	µm	17.7	17.7	17.6



	Unit	Step 1	Step 2	Step 3
	µm	5.23	3.63	4.50
Maximum height	µm	18.2	18.4	19.4
Mean height	µm	18.1	18.3	19.3

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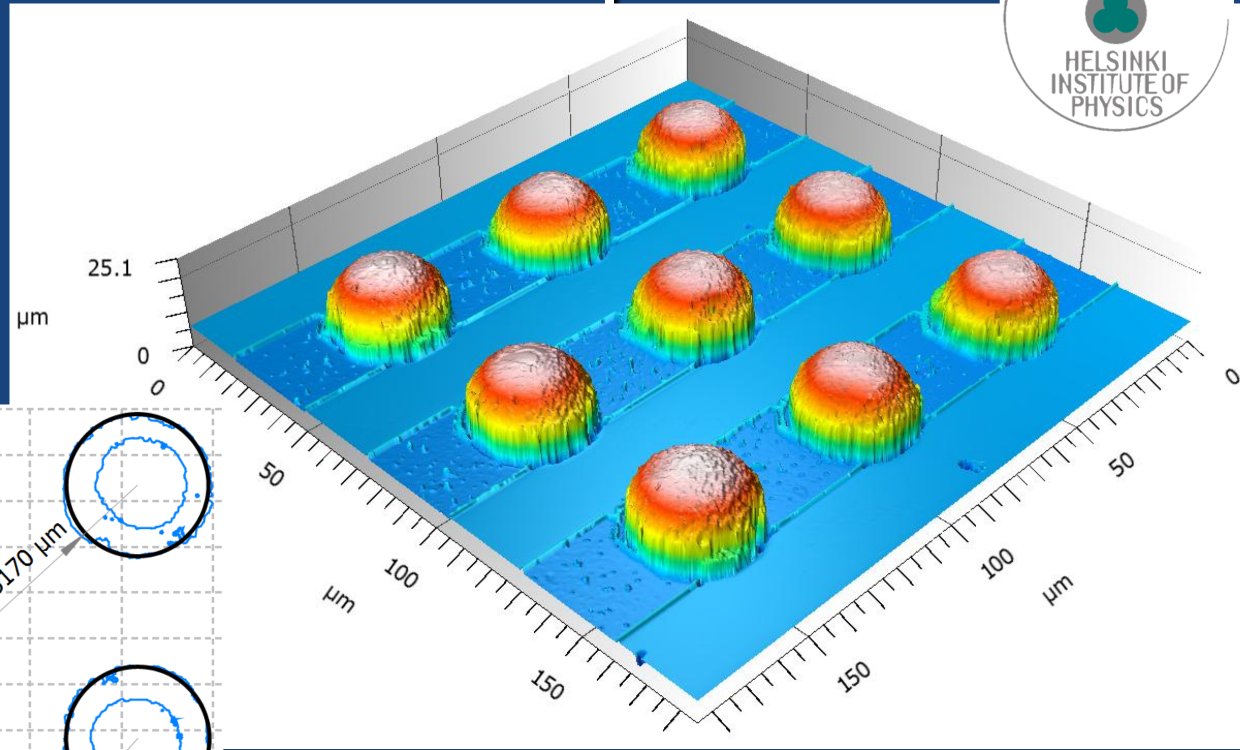
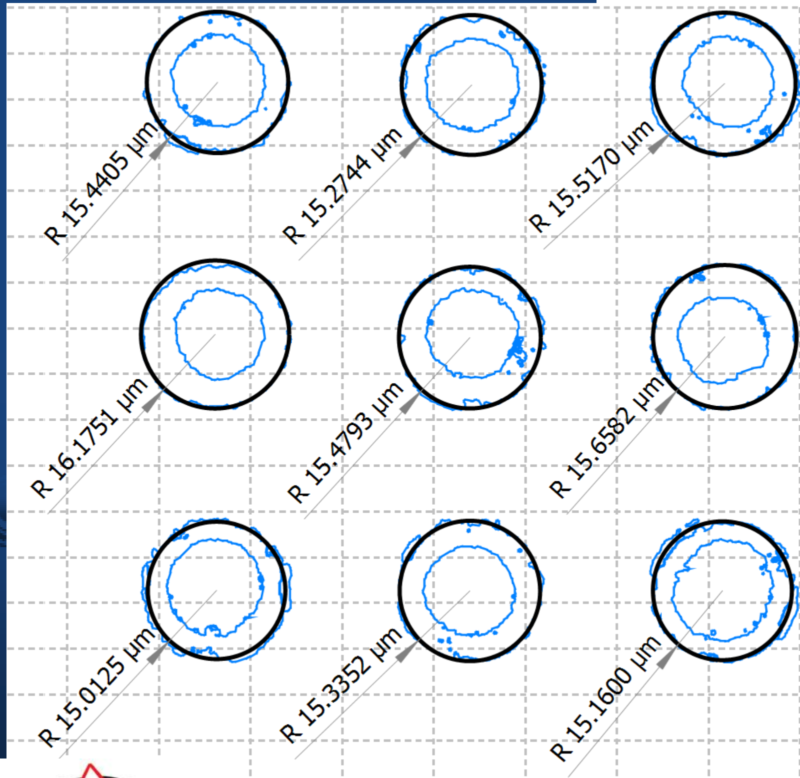
SWLI Results – Bump bonds





Radius measurement of the bump - bonds.

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Results – Multiple bonds comparison

Maximum height measurement of the bump - bonds.

Bump - bonds maximum height [μm]

20
19
18
17

0 1 2 3 4 5 6 7 8 9 10

Bump - bonds number

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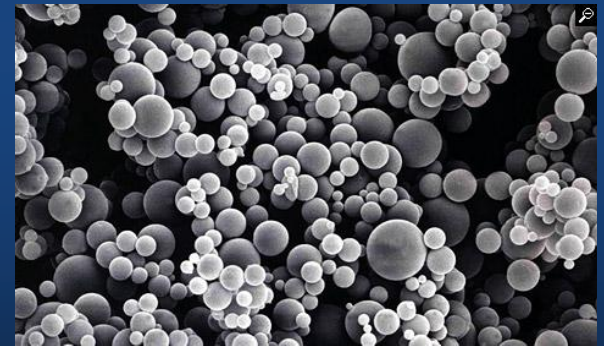

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Conclusions

- The SWLI measurements of NIST calibrated SiO_2 Spheres was successfully made.
- The uncertainty of the SWLI measurement at a coverage factor k = 2, for a 95% confidence level was ± 0.0076 µm.
- The Bump - bonds heights are in the range of 18.03 – 19.18 µm and corrections were calculated according to the UKAS M3003 requirement.

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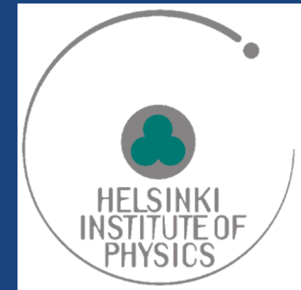
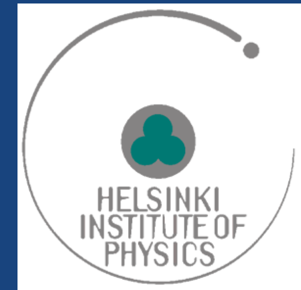


Acknowledgements

This work was partly supported by EMRP NEW08 MetNEMS project and associate research excellence grant NEW08-REG3. The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.



Thank you for your Attention