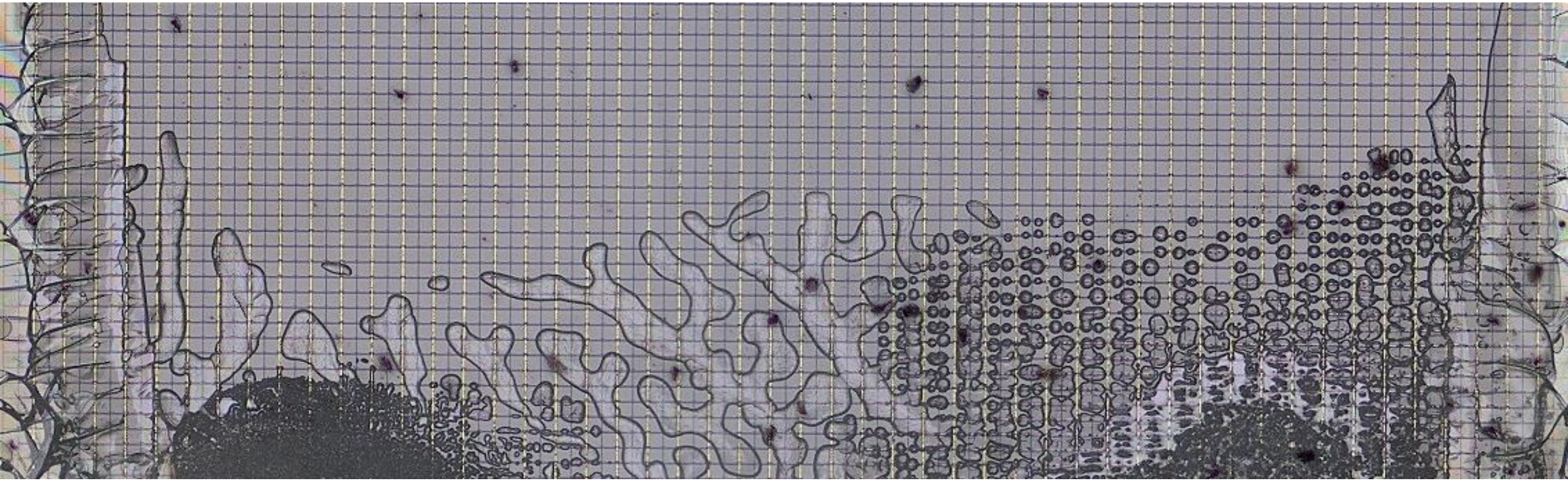


Investigation of physical damages on SiPM after annealing

•(dRICH) Preliminary results from studies of the SiPM array optical window after annealing were shown. A more detailed evaluation of the effect of high-temperature annealing on the shape integrity and optical properties of the resin layer is advised.

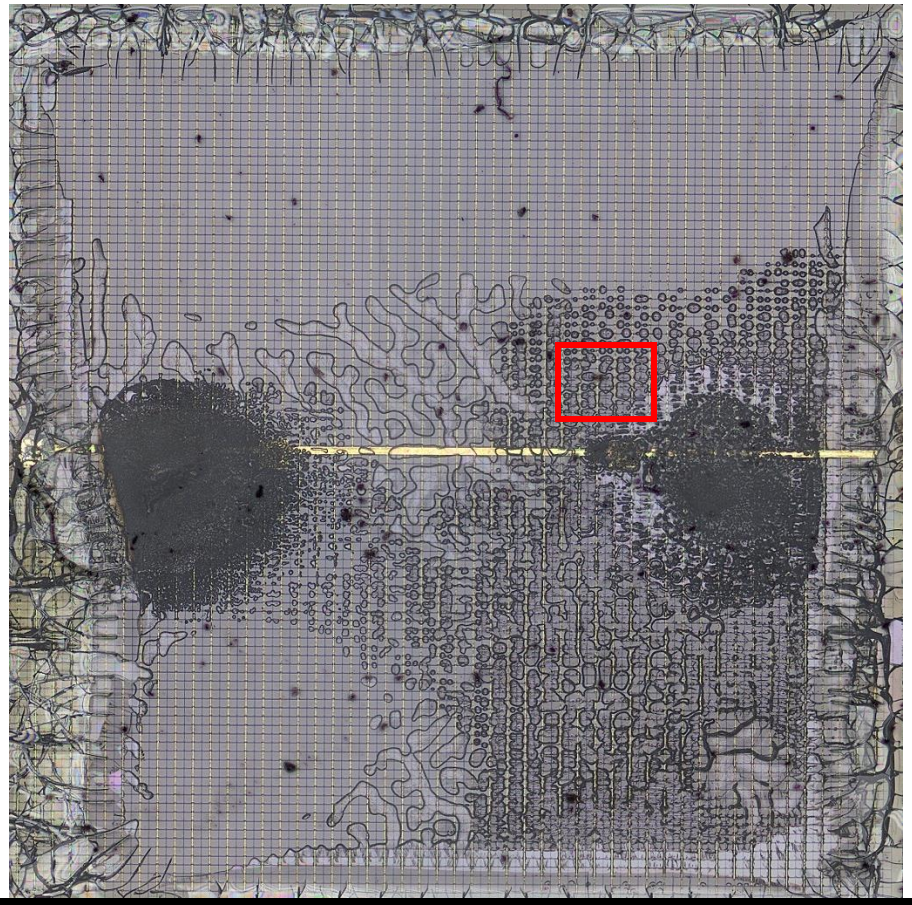
Incremental Preliminary Design and Safety Review of the pfRICH, dRICH, and hpDIRC, 1-2 Apr 2025

https://indico.bnl.gov/event/26574/

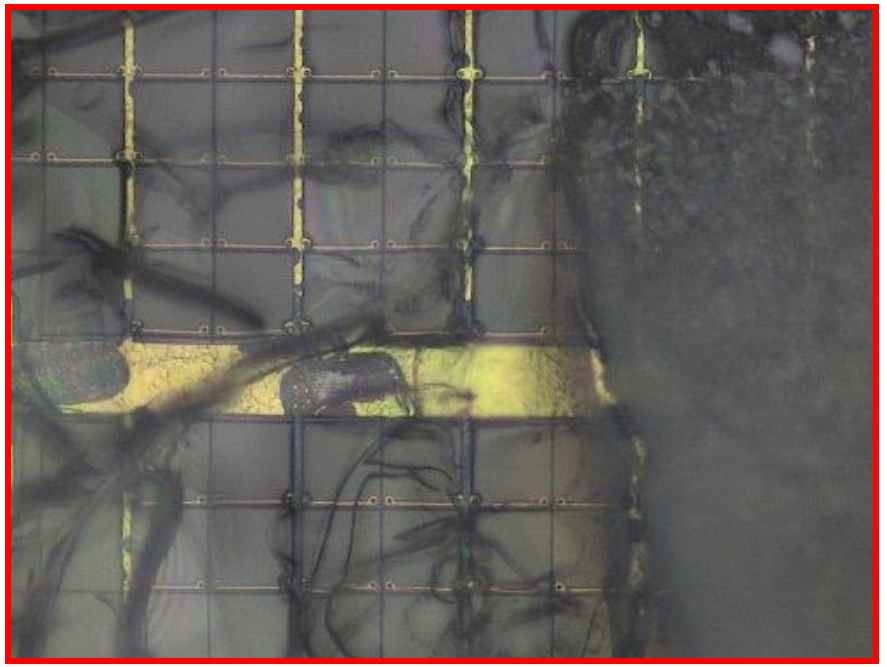
First tests in 2021/2022

During the initial tests of the forward and reverse current annealing procedure, multiple devices were evaluated at temperatures of up to 250 °C.

BCOM SiPM was tested at 250 °C



High current/temperature caused the metallic structures to fail and led to the fracturing of the glass window

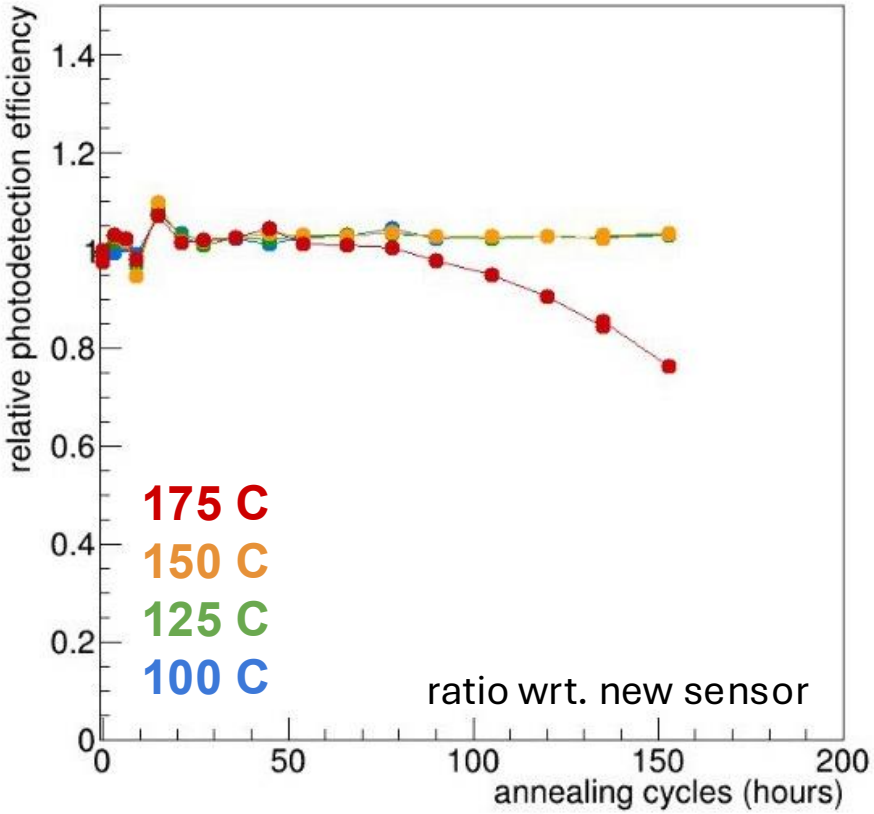


What did we learn?

- **Keep the temperature lower than 200 °C**
- **Glass is not suitable thus we have resin optical window**

Optical opacity of the resin window at high temperature

Late studies revealed that a combination of high temperatures and prolonged annealing time can lead to yellowing of the resin optical window, resulting in a loss of transparency.



While the **sensor** remained **functional**, we investigated whether the **resin** window **deformed** and whether any **structural defects** developed in the SiPM.

Microscope

Keyence VK-X3100 3D Surface Profiler: **laser confocal scanning** and focus variation measurement methods are used, high-accuracy measurement and analysis can be performed on any target. With a vertical resolution up to 0.1 nm and a scan area of 50 x 50 mm^2

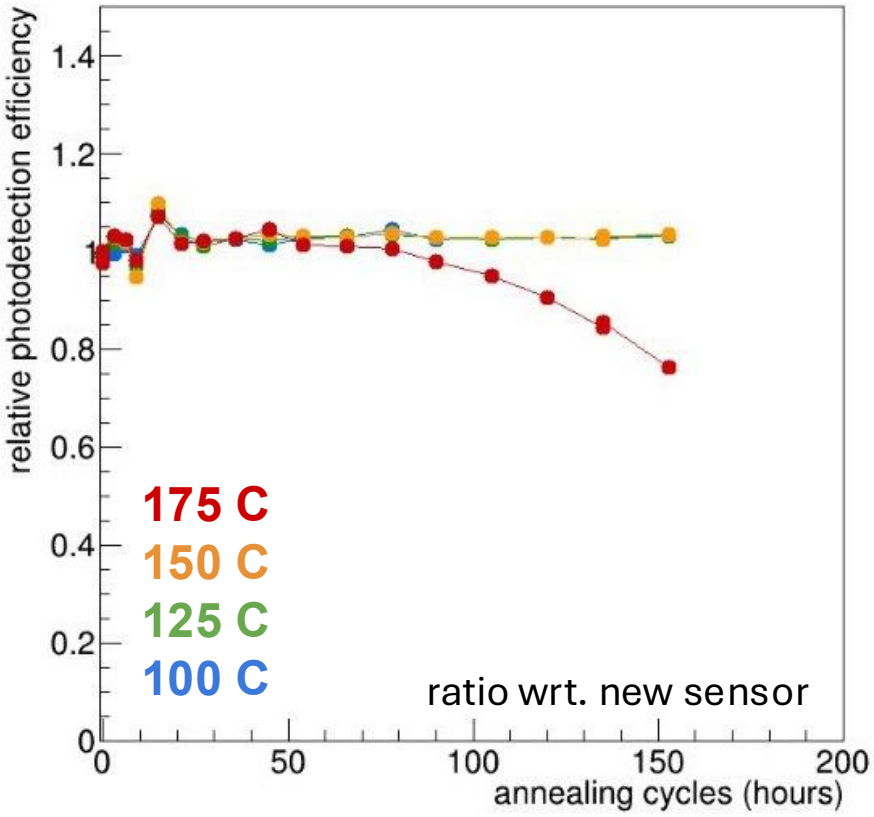
Two objectives used:

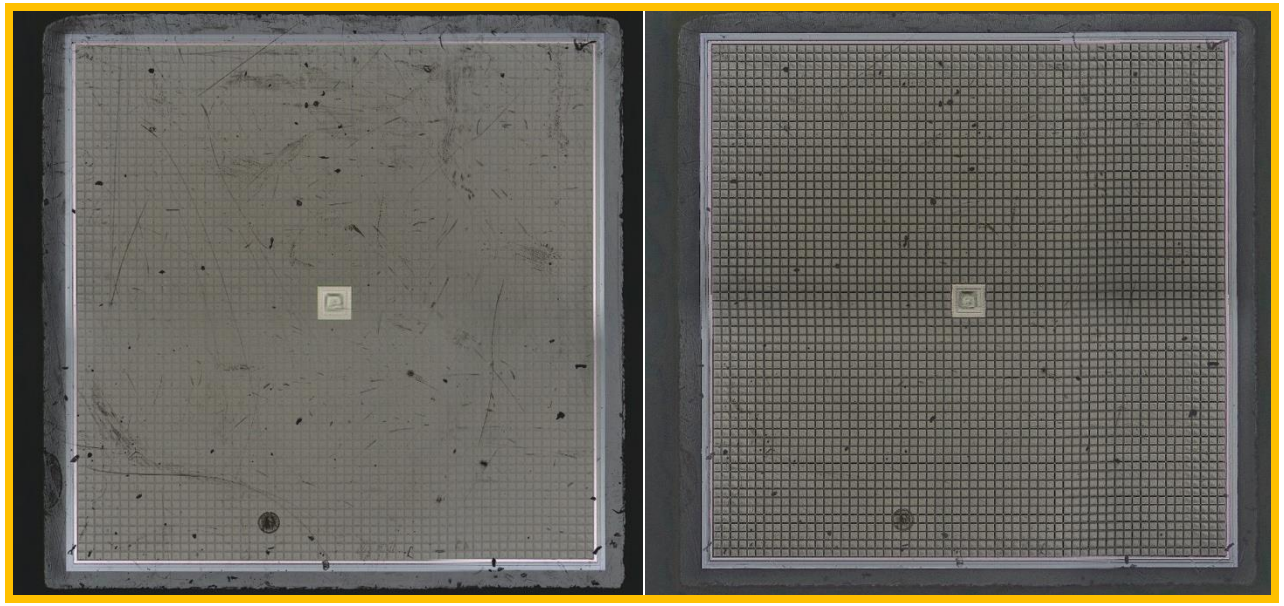
- **10×** with a vertical resolution of **2 µm**
- **50×** with a vertical resolution of **0.24 µm**

Profile measurements were employed to investigate **resin deformation**, while a combination of **optical** and **laser-based manual inspection** was used to assess **potential damage** to the **SiPM structure**.

Analyzed sensor

Hamamatsu S13360-3050 **>150 h @ 150 °C. No PDE degradation observed**





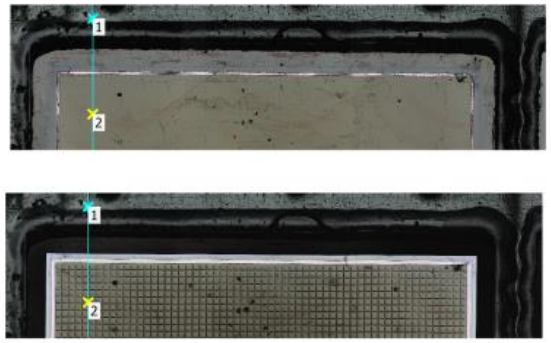
Resin focused

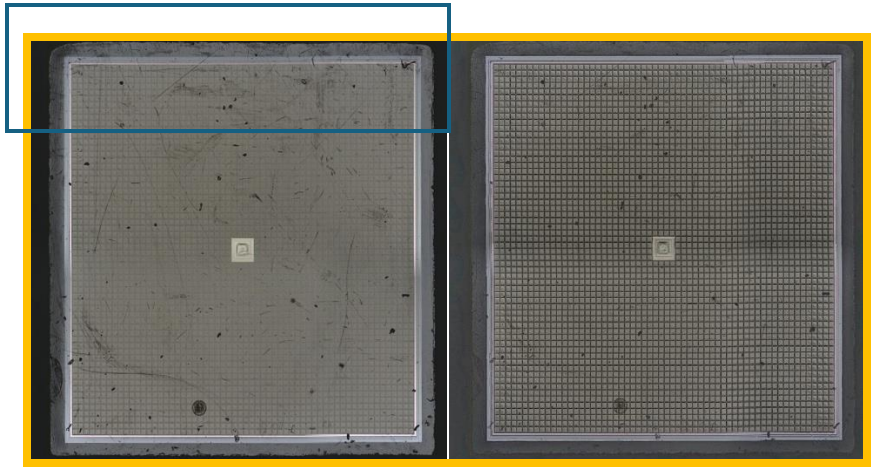
Silicon focused

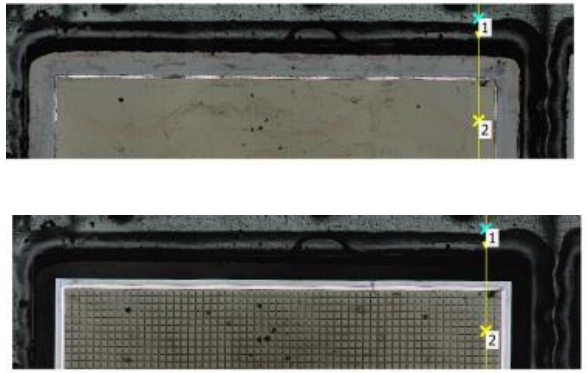
Scratches and particles on the surface

Resin deformation (I)

Film-top (PCB normalization)

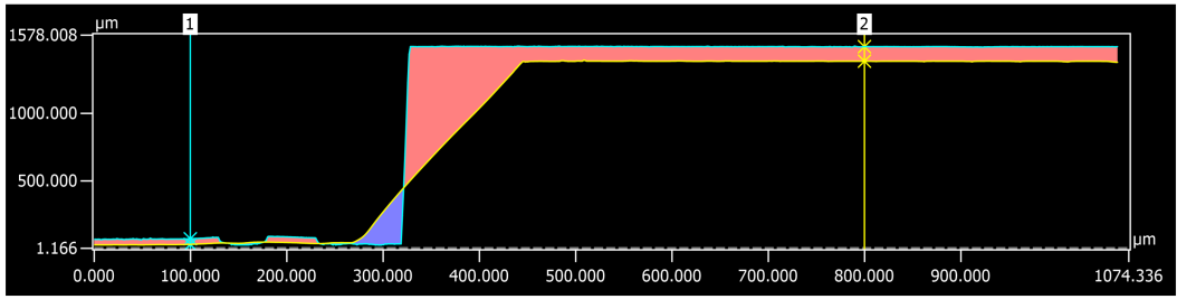






10× with a vertical resolution of **2 µm**

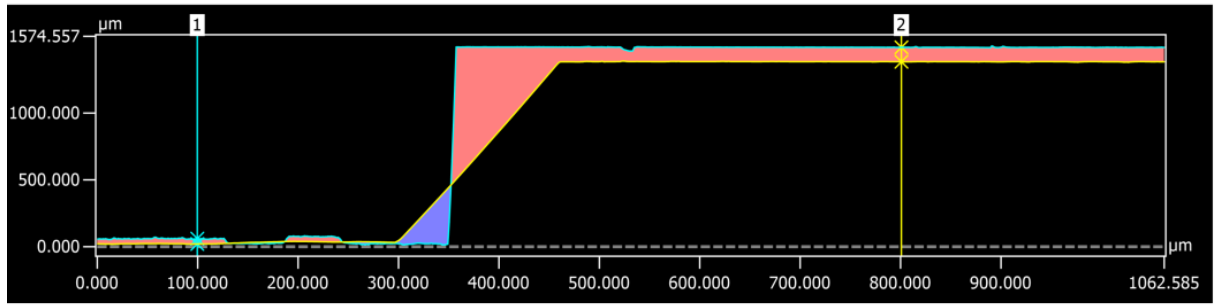
Comparative profile



No.	Measurement name	Measured value	Unit
1	1 point difference(Z axis)1	41.539	µm
2	1 point difference(Z axis)2	107.553	µm

Delta = 66 um

Comparative profile

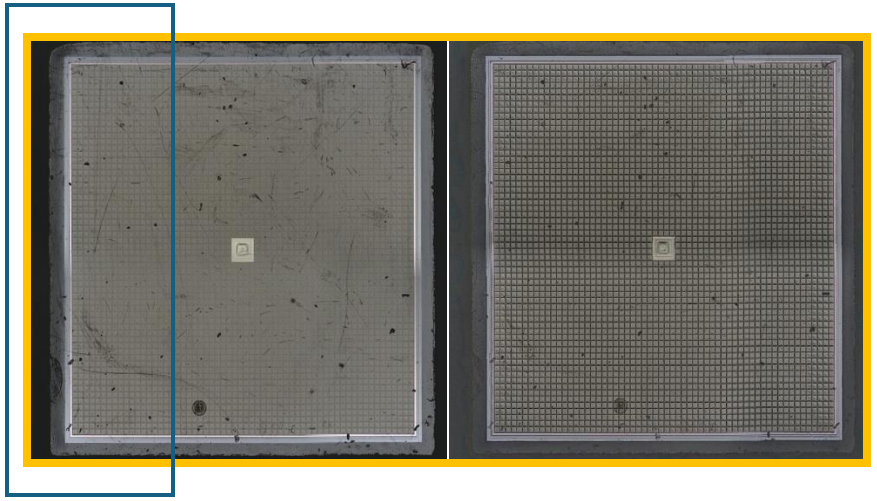


No.	Measurement name	Measured value	Unit
1	1 point difference(Z axis)1	40.405	µm
2	1 point difference(Z axis)2	108.389	µm

Delta = 68 um

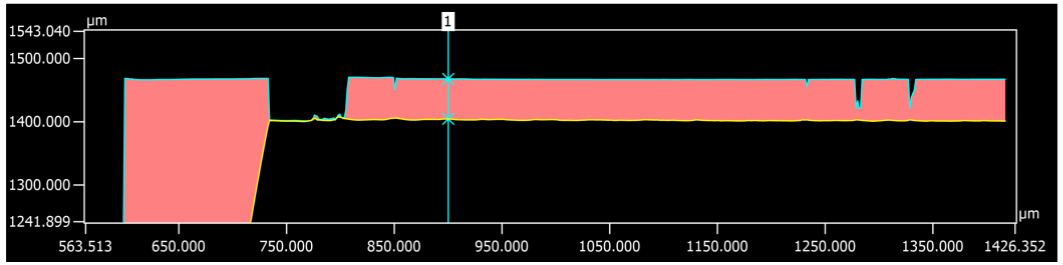
Resin deformation (II)





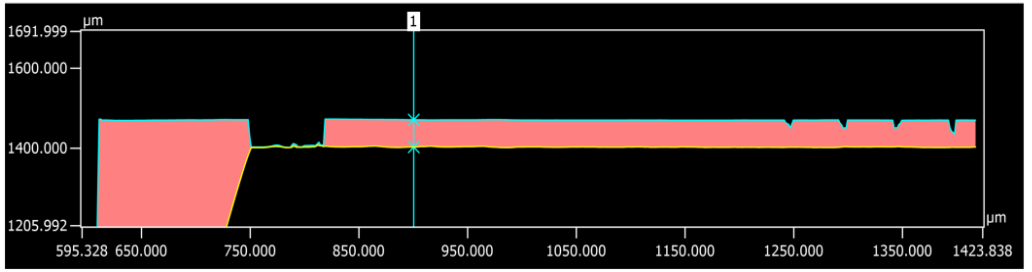
10× with a vertical resolution of **2 µm**

Comparative profile



No.	Measurement name	Measured value	Unit
1	1 point difference(Z axis)1	63.211	µm

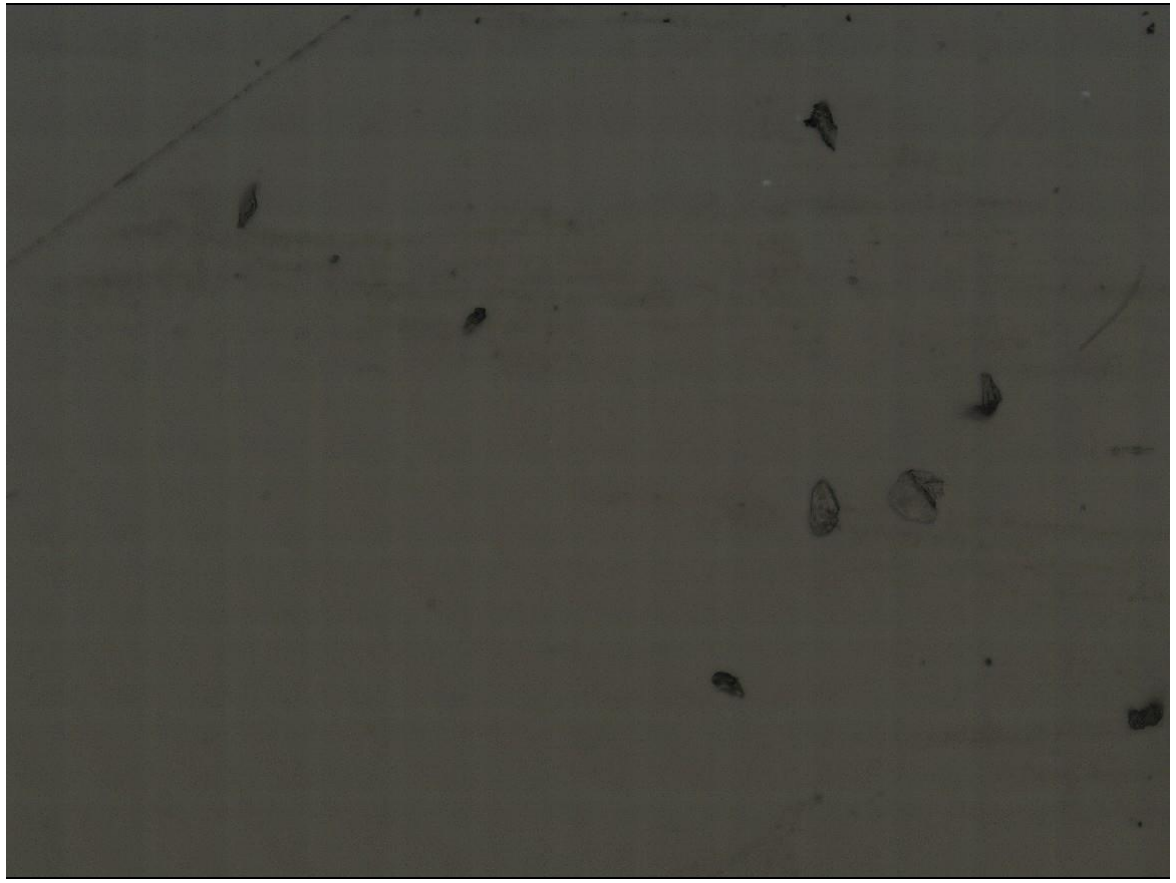
Comparative profile

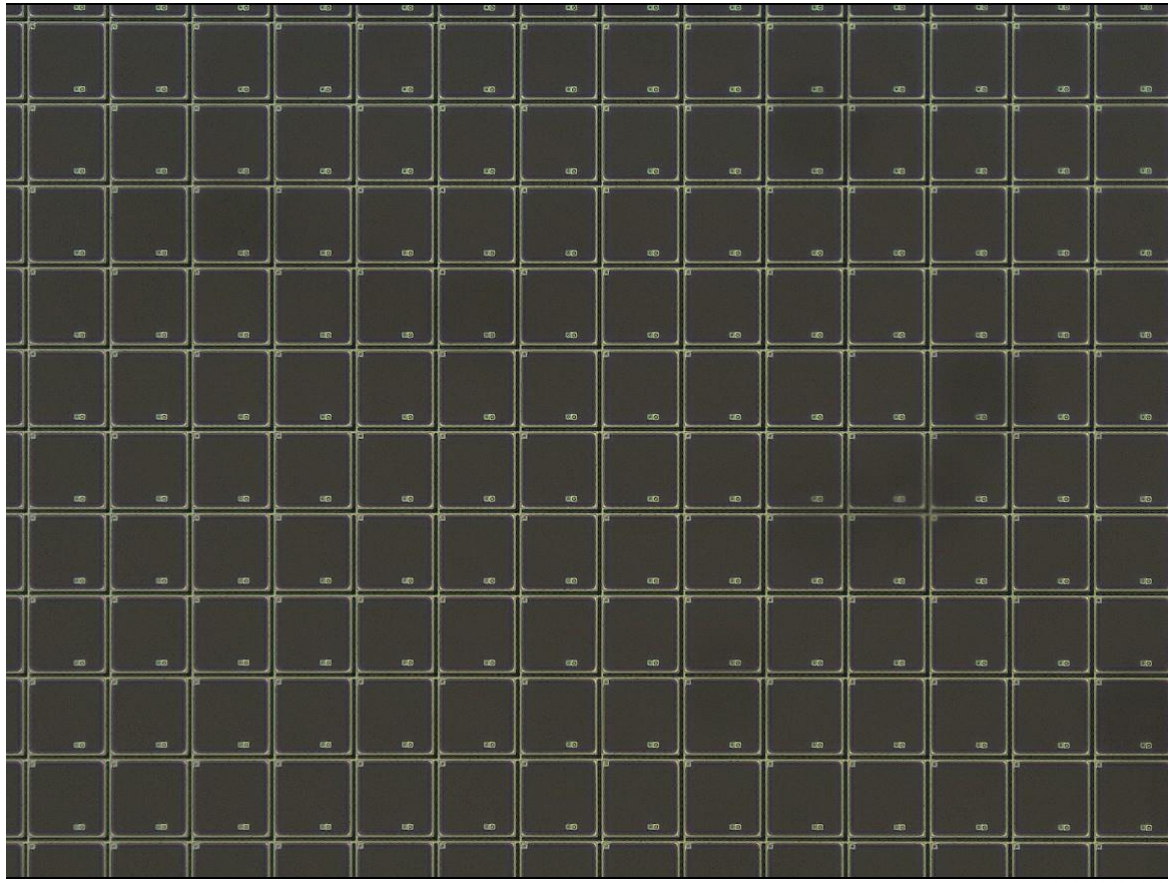


No.	Measurement name	Measured value	Unit
1	1 point difference(Z axis)1	68.128	µm

Silicon defects search (I)

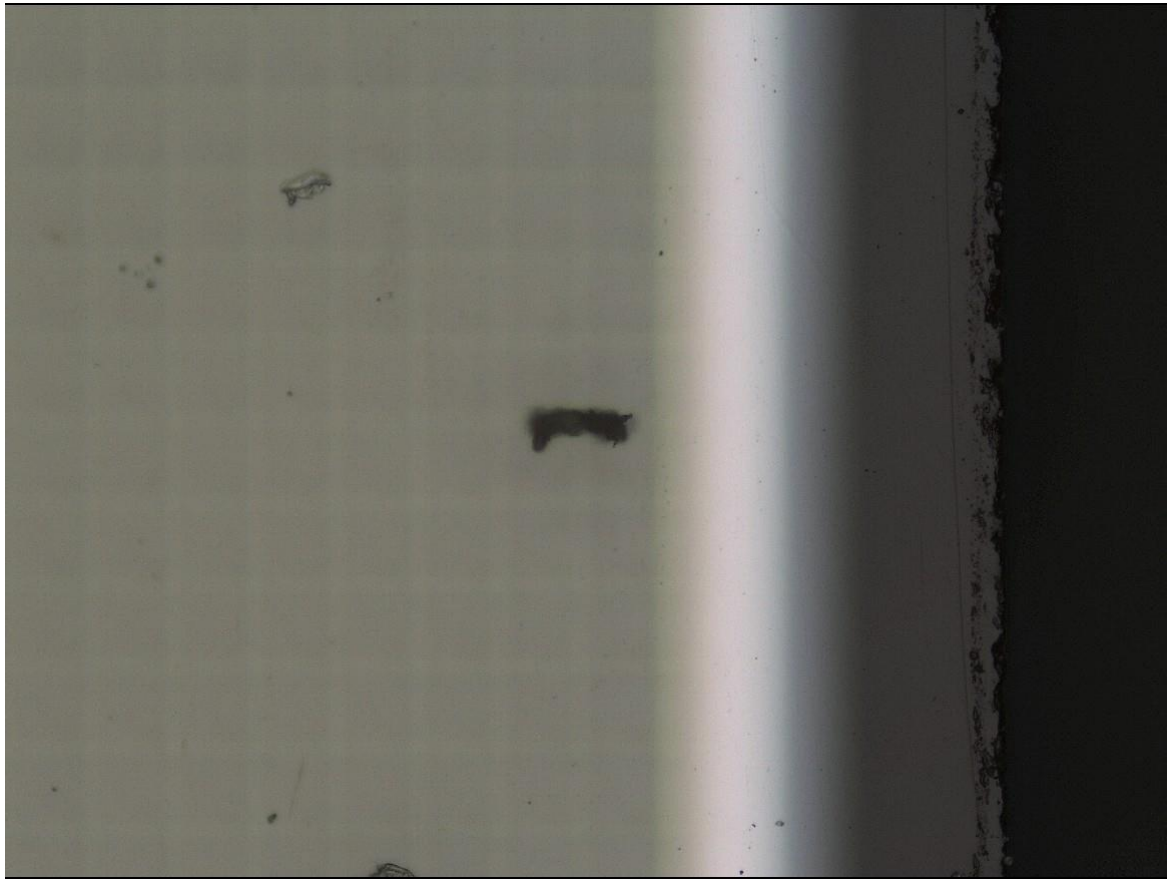
Manual search of possible defects at the silicon level

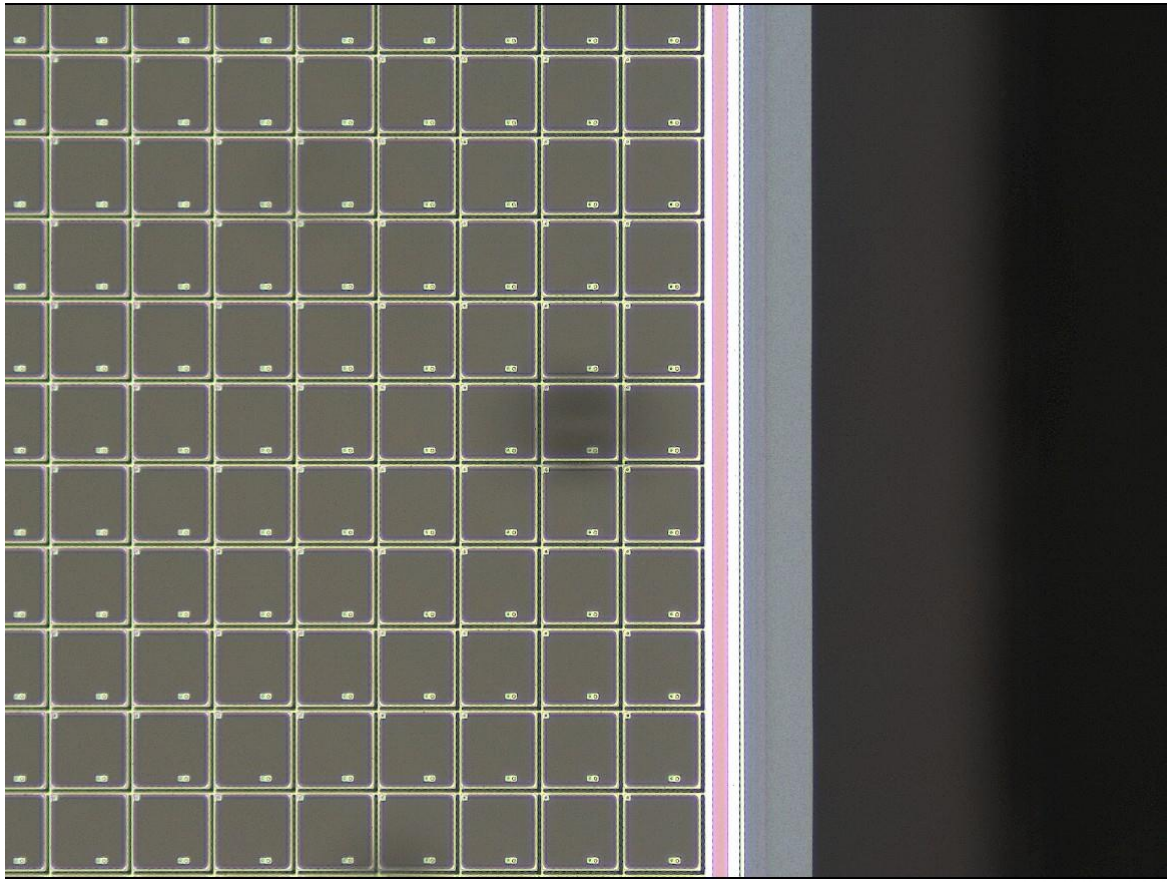




Silicon defects search (I)

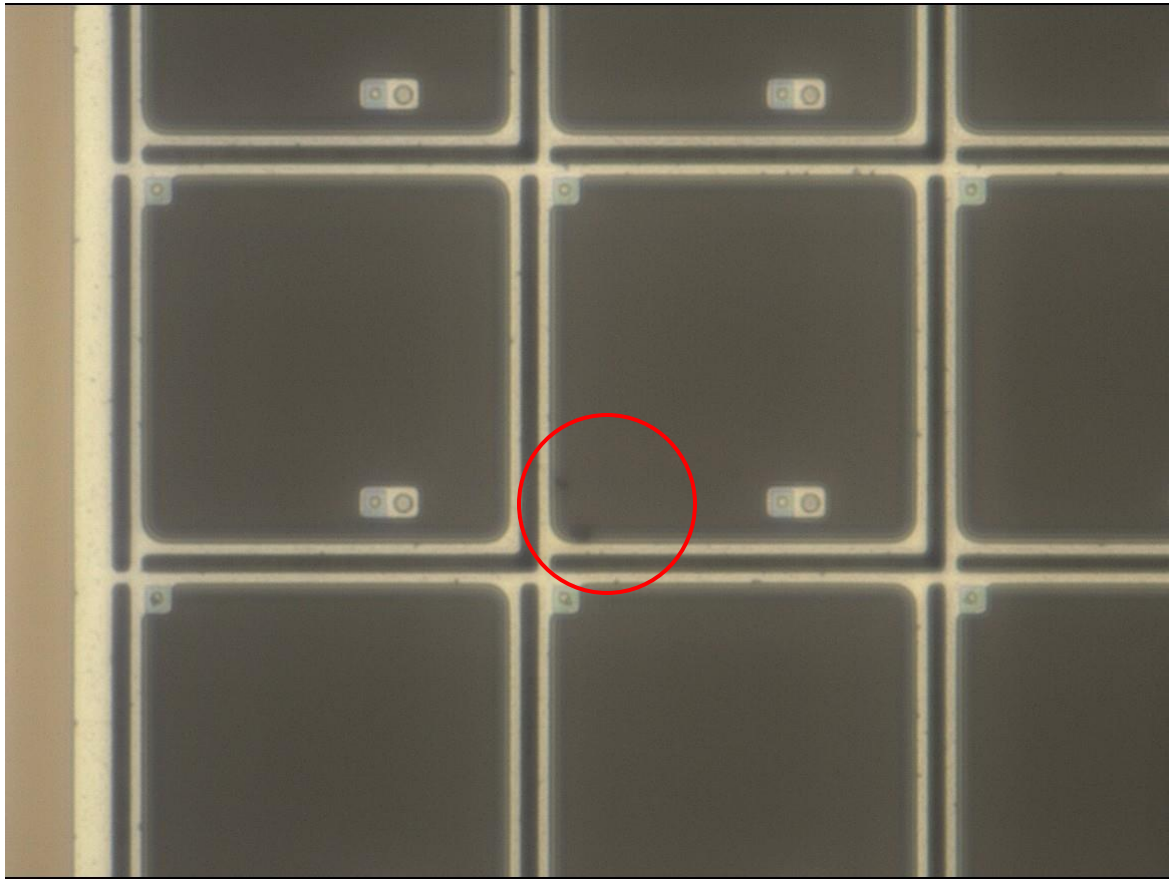
Manual search of possible defects at the silicon level



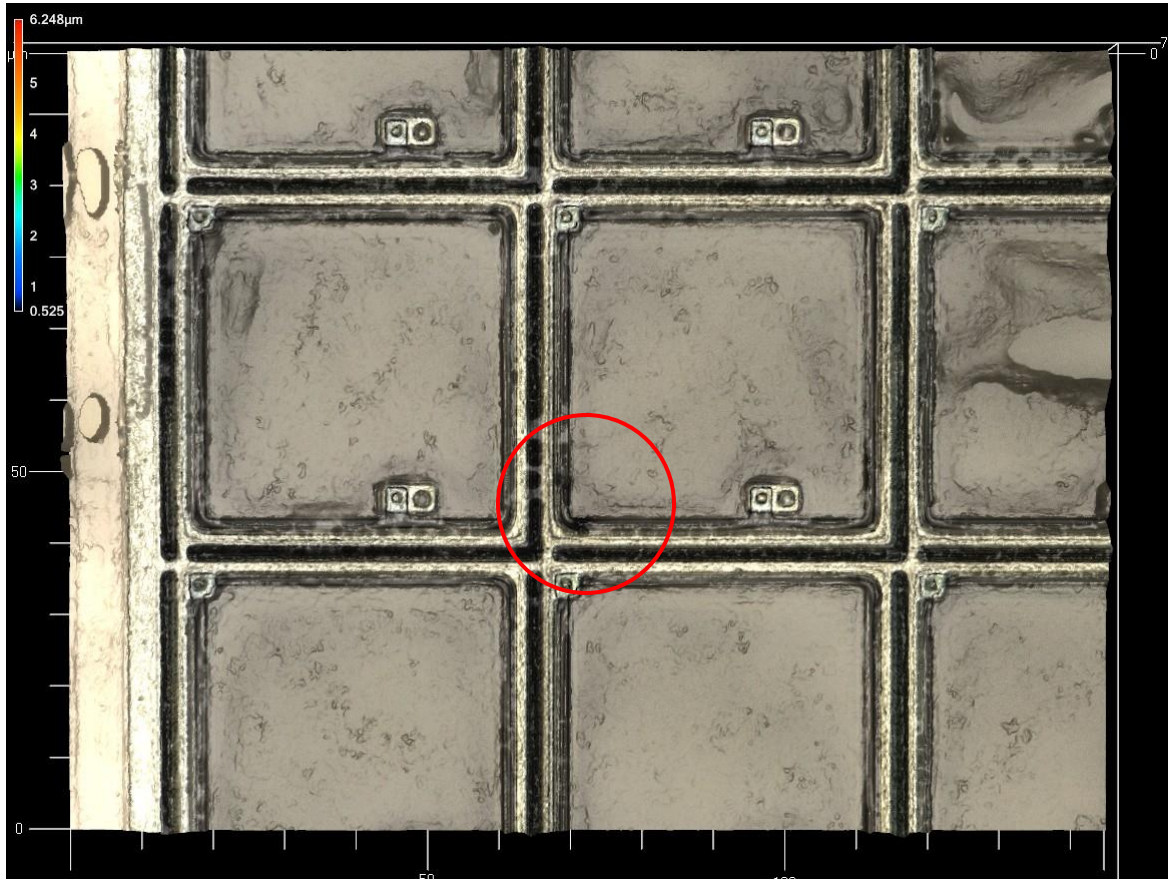


Silicon defects search (II)

Manual scan of 120x120 um (100x), ≈4 spads at the time of the 3600



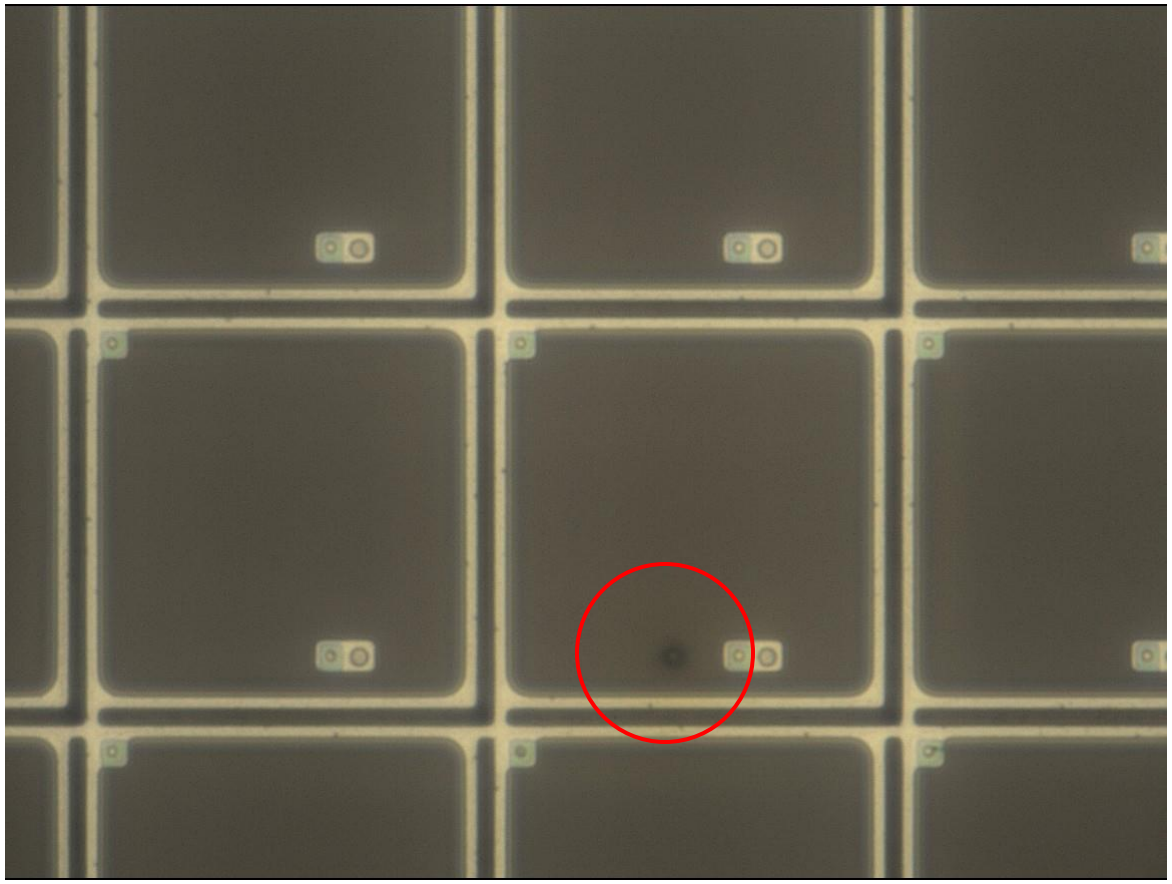
optical



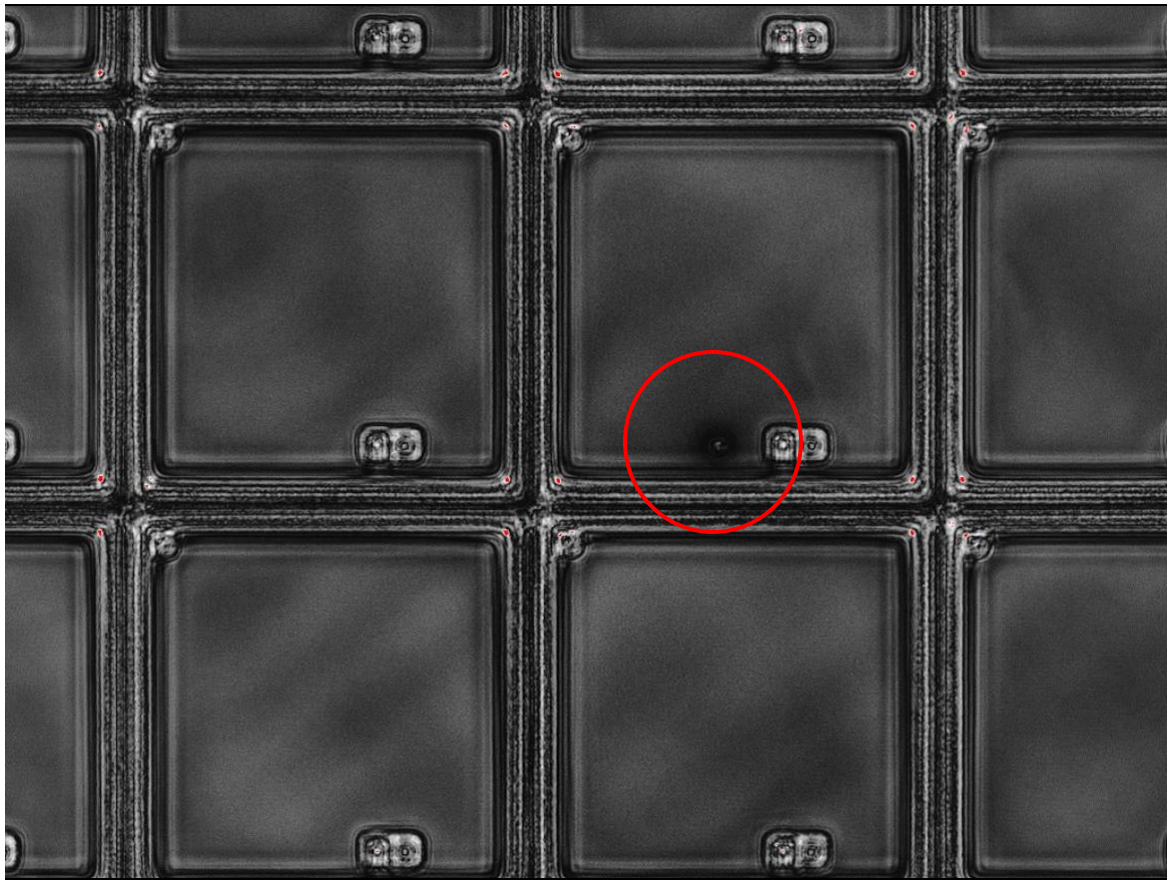
Laser scan

Silicon defects search (II)

Manual scan of 120x120 um (100x), ≈4 spads at the time of the 3600



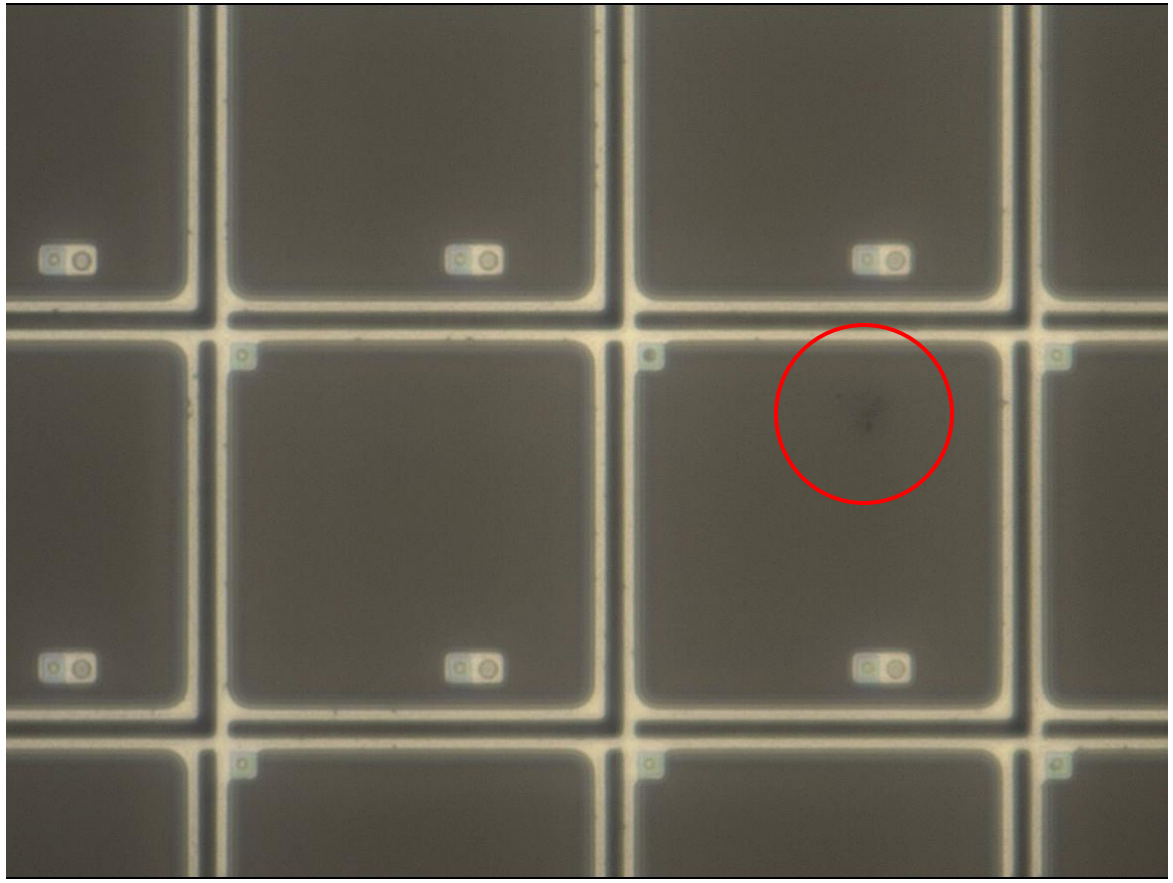
optical



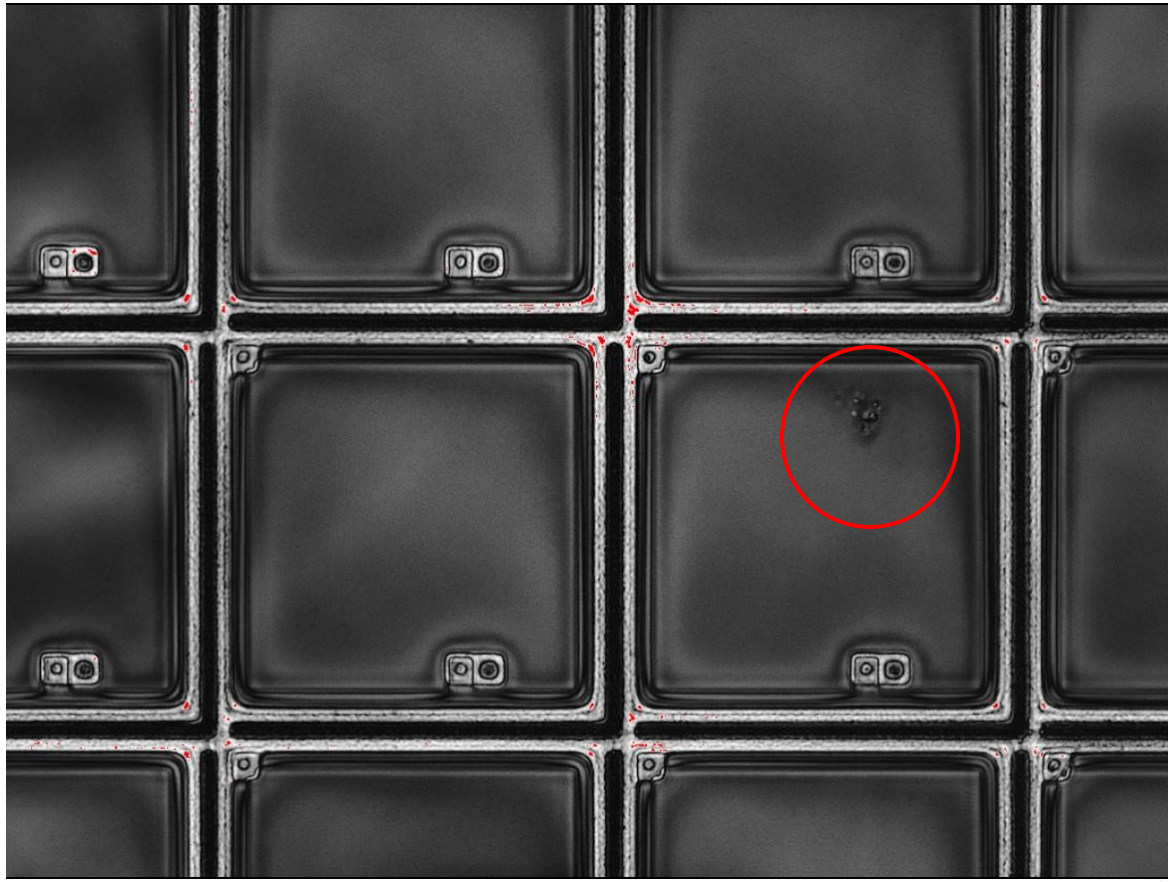
laser

Silicon defects search (II)

Manual scan of 120x120 um (100x), ≈4 spads at the time of the 3600



optical



laser

Summary and conclusion

- Negligible or no distortion was observed in the resin optical window.
- No defects were found in the electrical interconnections
- Minor inclusions were detected at the silicon level, with three inclusions identified within a 3 × 3 mm^2 sensor that probaly don’t affect the sensor itself. We don’t know if these «defects» were there before the irradiation and annealing