

## Space & Scientific CMOS Image Sensors

# Results of microlens testing on back-illuminated image sensors for space

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Toulouse, 27.11.2019

# CSEM: A public-private **partnership**

- A Swiss not-for-profit private company
- Flexible and professional
- Industry friendly IP approach
- About 470 employees
- 82 MCHF turnover

CSEM Brasil



CSEM Zürich

CSEM MuttENZ

CSEM  
Neuchâtel

CSEM  
Alpnach

CSEM  
Landquart

**14 %**

Swiss Government

**13 %**

Neuchâtel – City & Canton



**73 %**

Private Organizations

# Background

## Microlenses for improved space imagers

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<sup>1</sup>CSEM SA

<sup>2</sup>ESA-ESTEC

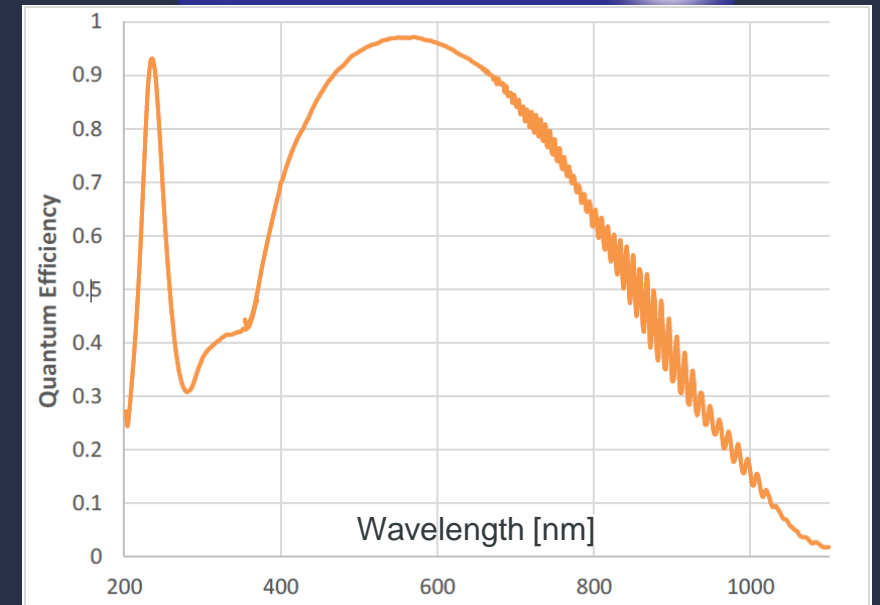
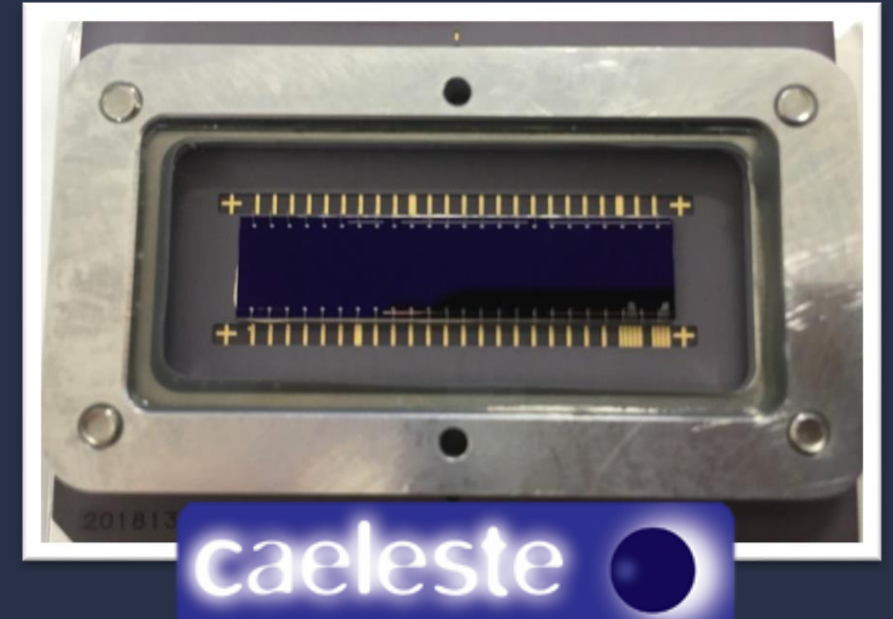
Toulouse, 21.11.2017

**CMOS Image Sensors  
for High Performance  
Applications**

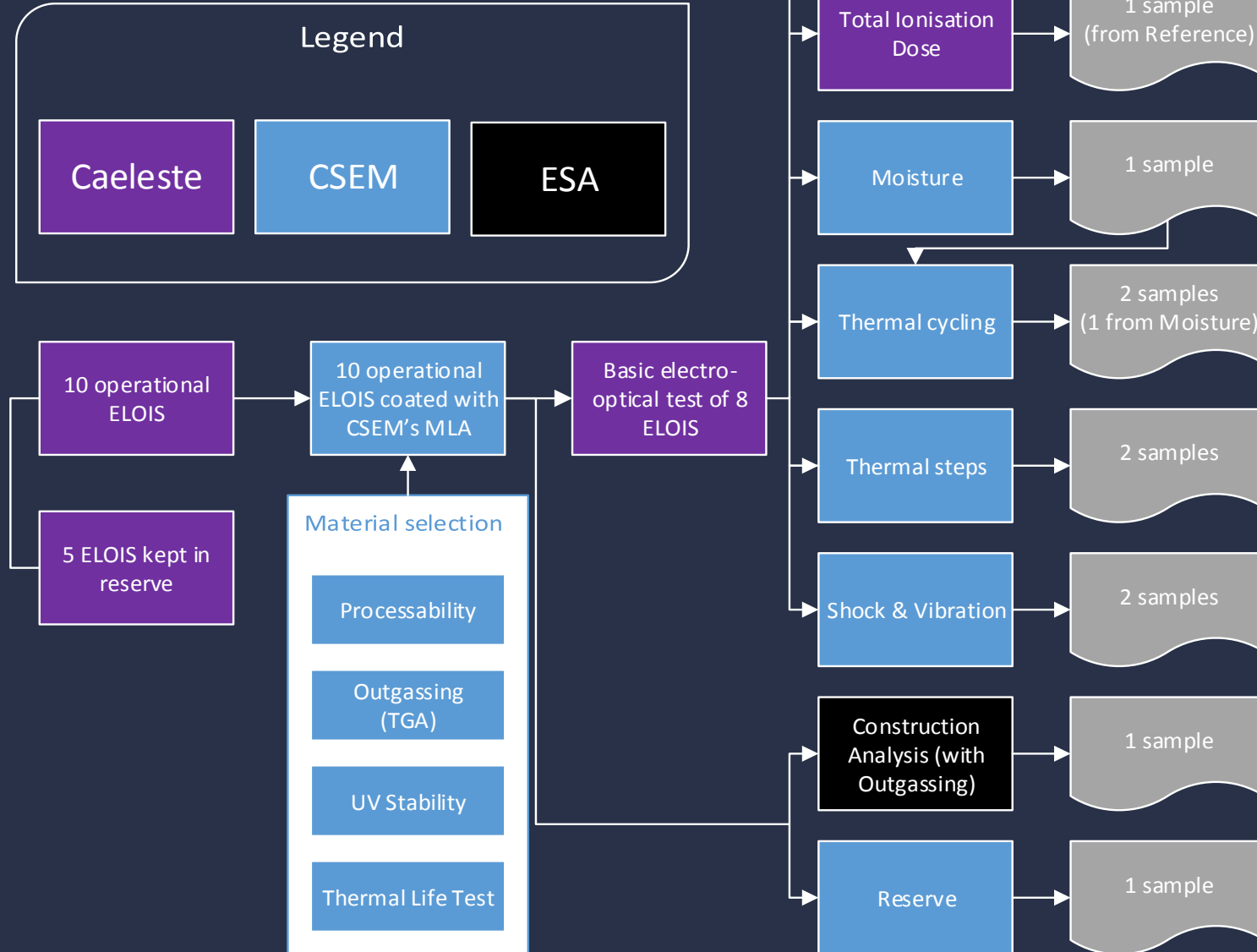
- CSEM's On-Chip Lenses: capabilities
- ESA's activity launched for back-illuminated imagers

# Back-illuminated CMOS imager: ELOIS from Caeleste

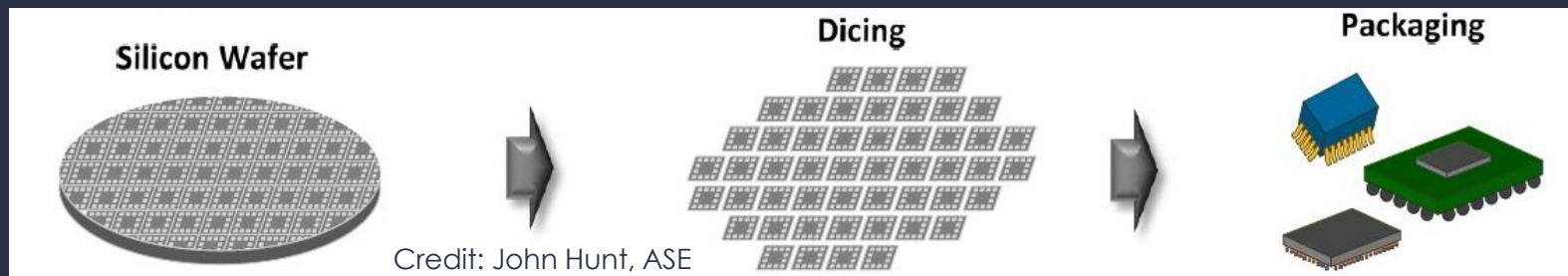
- 256 x 2048 pixels
- Pixel pitch: 15.5  $\mu\text{m}$
- Designed for use as hyperspectral imager: 350 – 900 nm
- QE > 90%
- MTF: 0.556 – 0.593



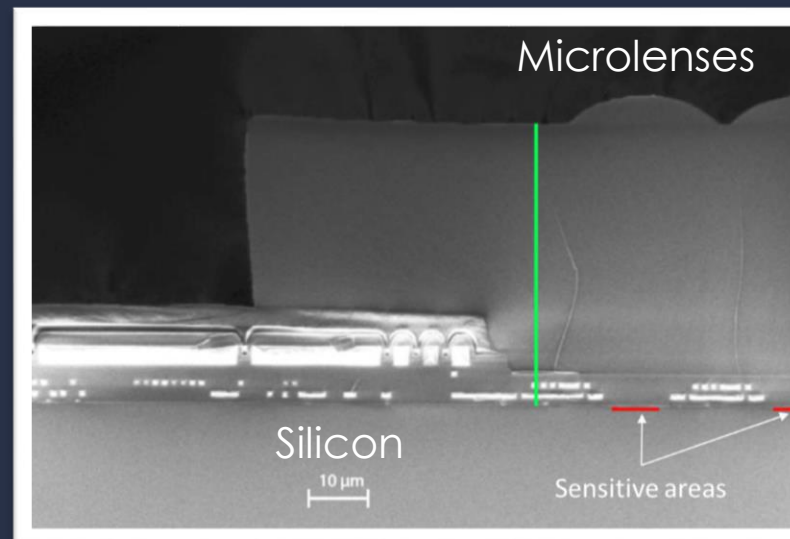
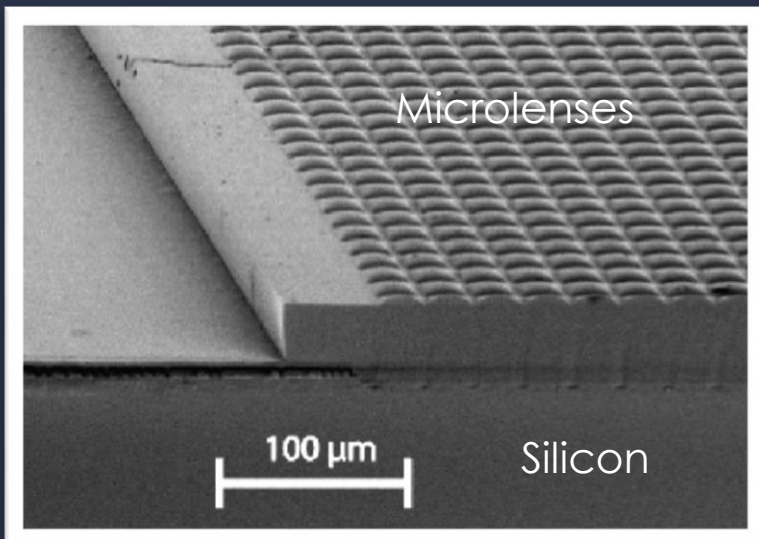
# Space evaluation campaign



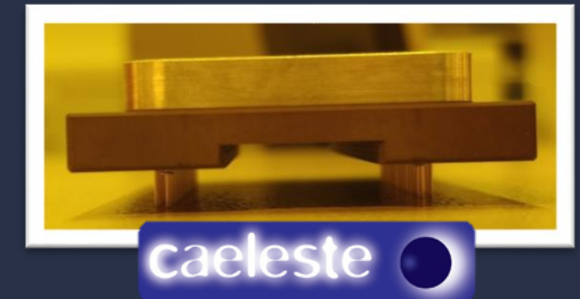
# Deposition of microlenses



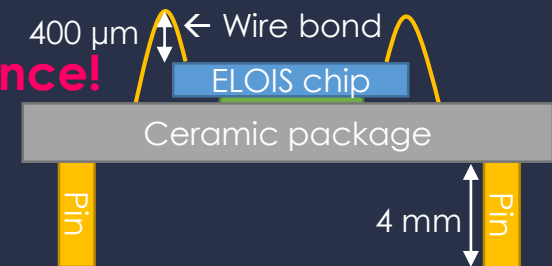
Microlenses deposition at CSEM (space TRL 4)



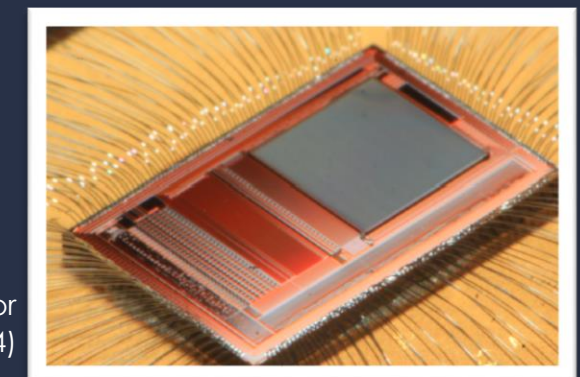
J. Mata Pavia et al., "Measurement and modeling of microlenses fabricated on single-photon avalanche diode arrays for fill factor recovery," Optics Express 22, 4202-4213 (2014)



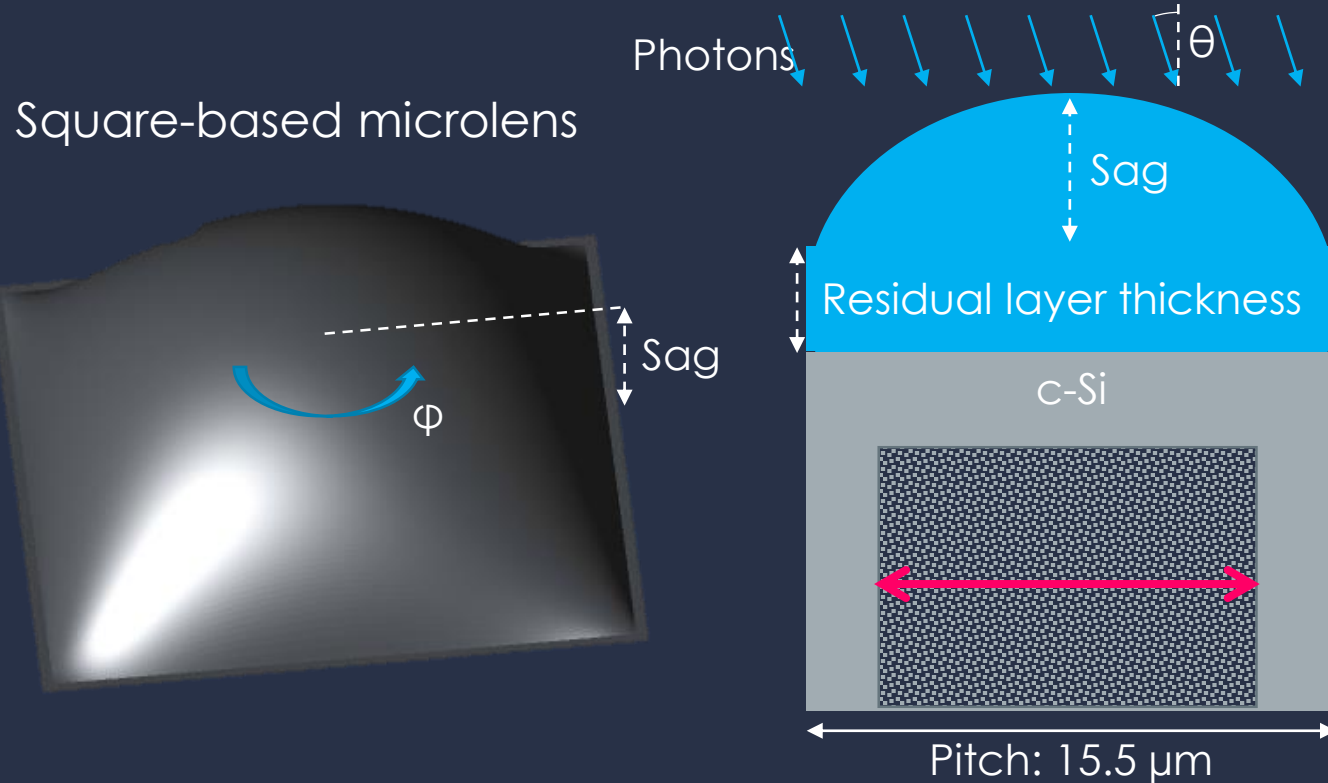
No experience!



F. Zanella et al., Paper submitted

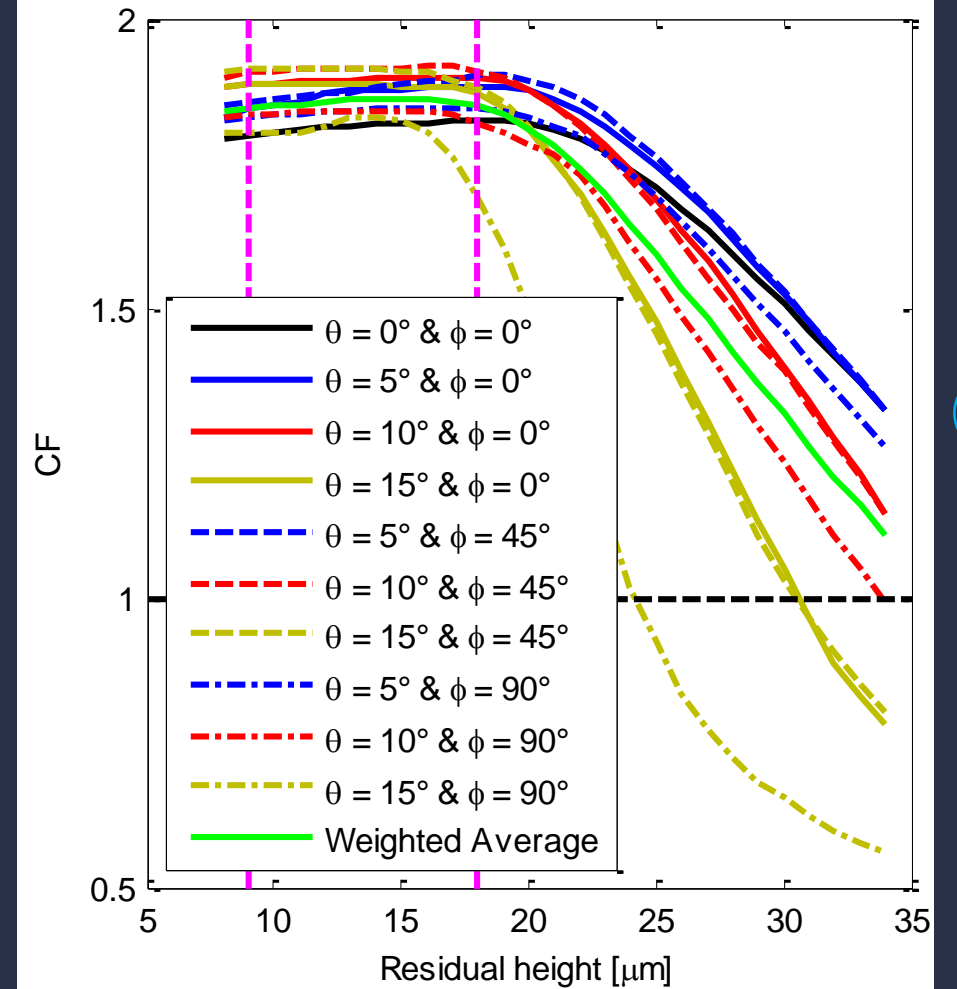


# Microlens design



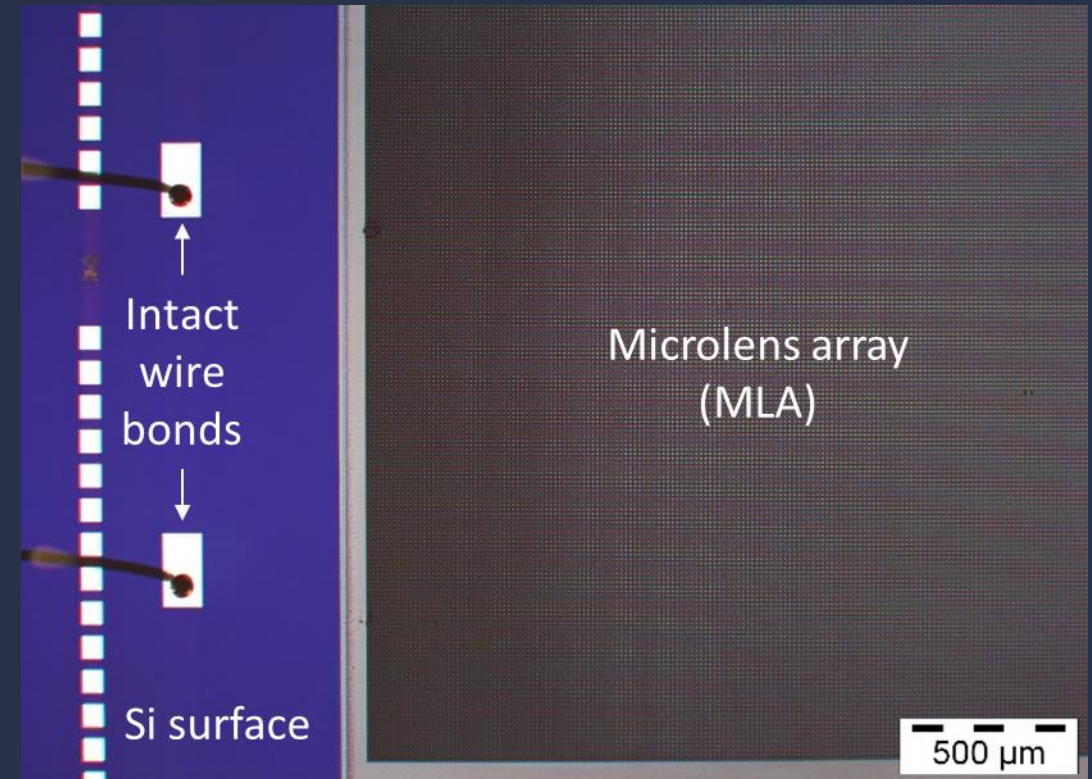
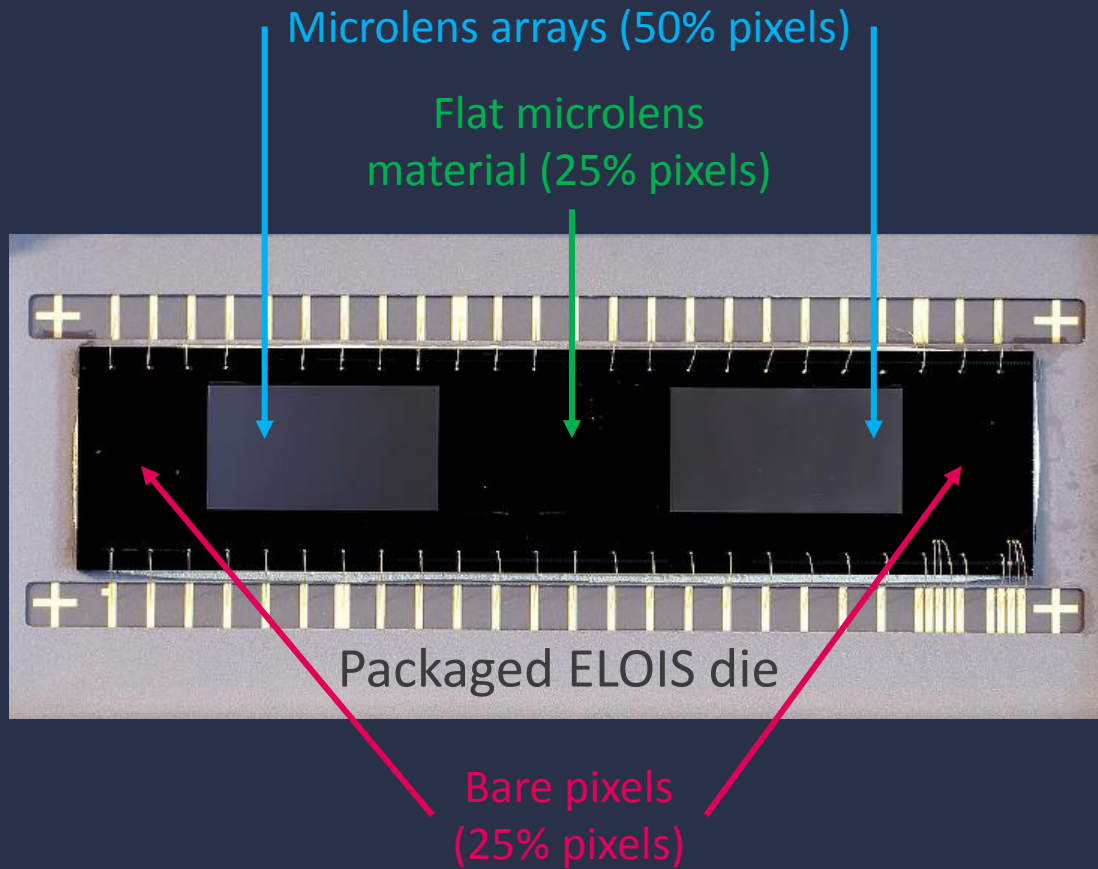
F. Zanella et al., Paper submitted

Sag =  $5\ \mu\text{m}$ , Pitch =  $15.5\ \mu\text{m}$ , Gap =  $0.5\ \mu\text{m}$





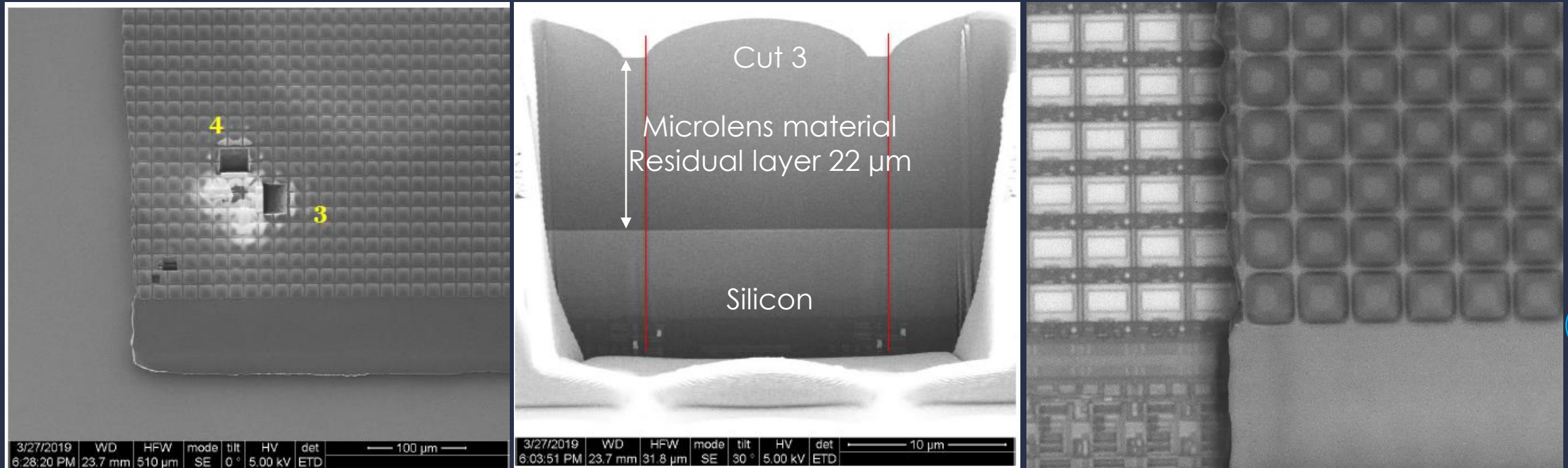
# Deposition of microlenses on packaged imagers: results



✓ Successful deposition of microlenses on packaged imagers!



# Deposition of microlenses on back-illuminated imagers: results

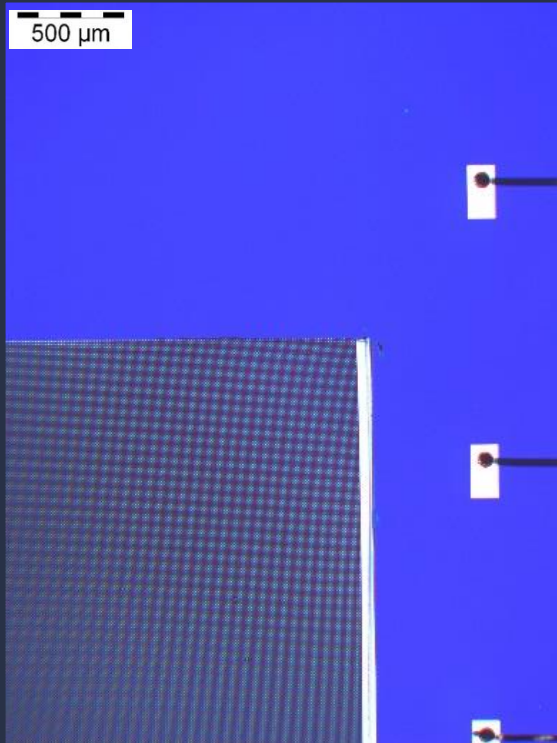
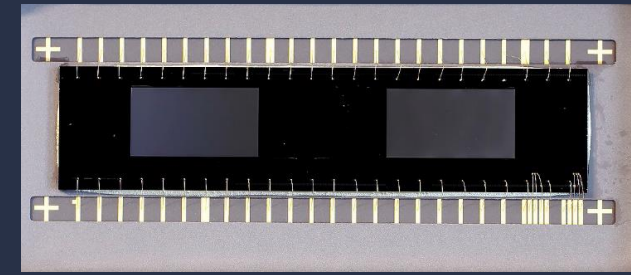


→ Microlenses are well aligned to the pixels (not visible directly for a back-illuminated imager)

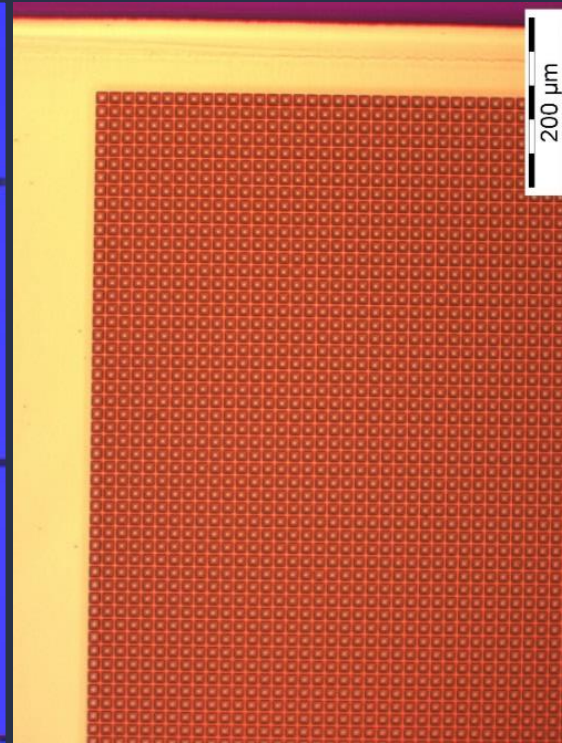
	MTF	QE	1/PLS
<b>Pixels covered with flat microlens material</b>	0.577	83.1%	565
<b>Pixels covered with microlens</b>	0.594	85.7%	1043
<b>Improvement</b>	<b>+0.017</b>	<b>+2.6%</b>	<b>×1.8</b>

F. Zanella et al., Paper submitted

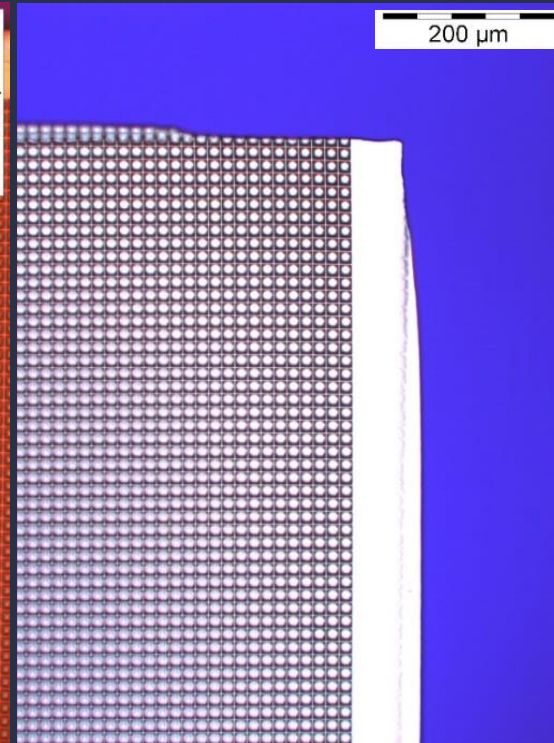
Some pictures of MLA corners taken after...



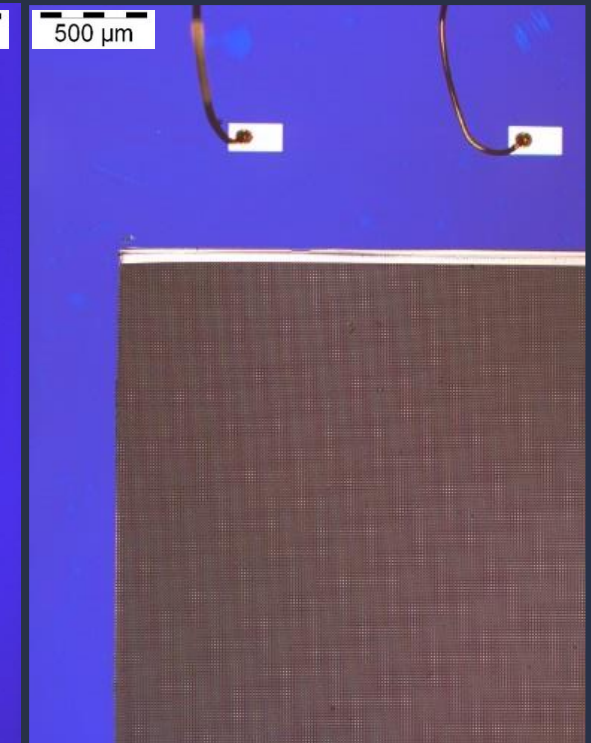
TID



Moisture → Thermal cycling  
(under yellow light)

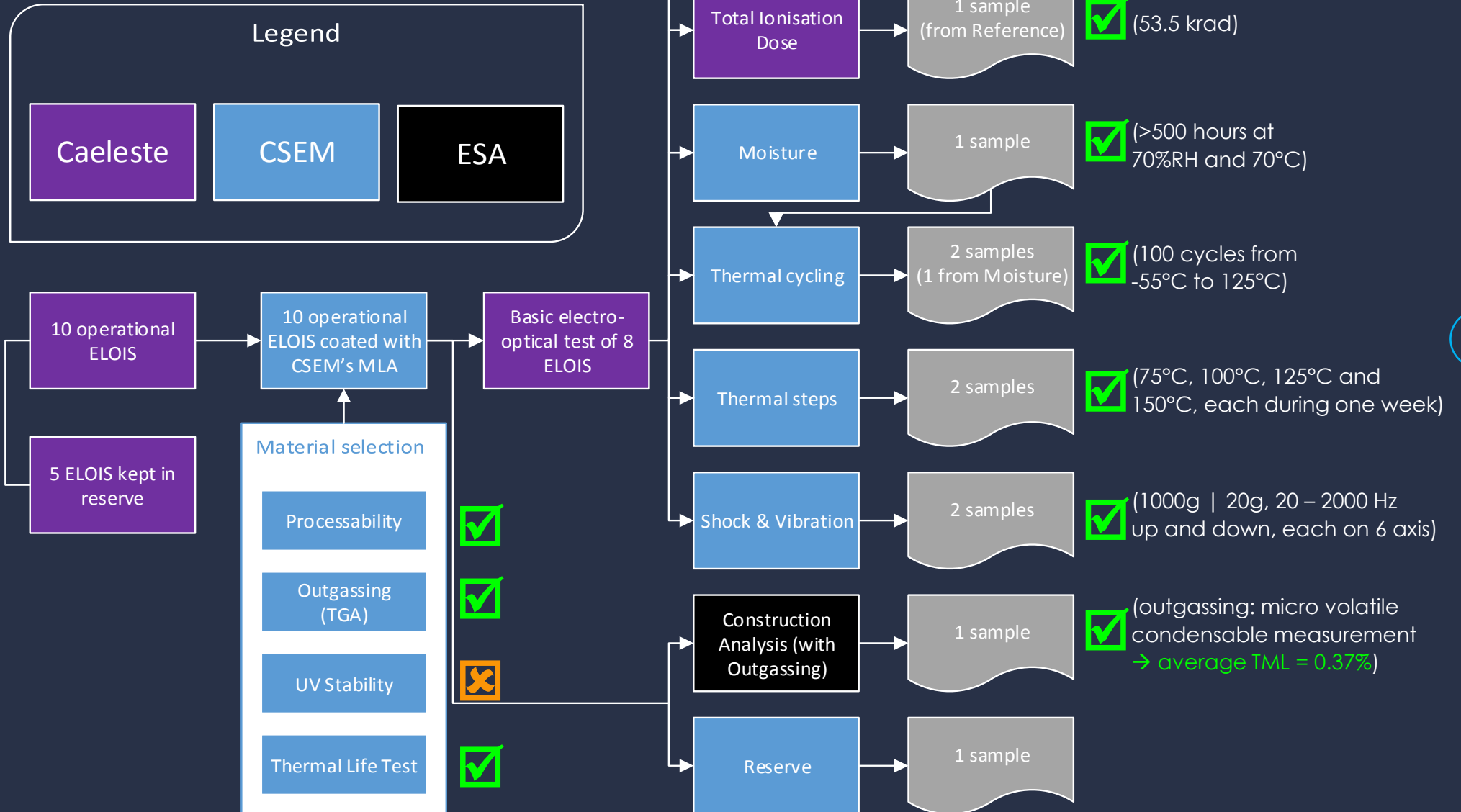


1 week at 150°C



Vibrations → Shocks

# Space evaluation campaign: Results



# Conclusions and next steps

- ✓ Successful deposition of microlenses on packaged imagers
  - Process was further optimized within a currently running industrial project
- ✓ Performance improvement of back-illuminated imagers
  - Larger improvement for front-illuminated imagers
- ✓ Space evaluation campaign completed
  - ✓ Available for Visible and NIR imaging
  - ✗ For UV or broadband imaging – Long term UV stability (yellowing)
    - CSEM keeps screening microlens materials in order to improve the UV stability while keeping a good adhesion of the microlenses → TRL increase
    - Standard wafer processing provides a higher TRL.



Interested in microlenses capabilities?

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TID: ESTEC  $^{60}\text{Co}$  facility

CA: ESA Materials and Electrical Components Laboratory

