



30<sup>th</sup> October 2025

Dr. Evgenii Glushkov Senior R&D Engineer

## MICRO- AND NANO-OPTICS FOR AUTOMOTIVE APPLICATIONS



## **CSEM AT A GLANCE**

#### **CSEM AT A GLANCE**

We are a public-private, non-profit Swiss technology innovation center

We enable competitiveness by developing and transferring world-class technologies to the industrial sector

We fuel the innovation of more than 200 industrial partners every year.





**1984** 



>600 SPECIALISTS



**107.6** M TURNOVER in 2023



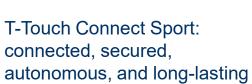
177
PATENT
FAMILIES



1100
INDUSTRIAL
CLIENTS SINCE
2018

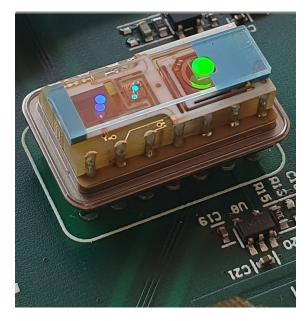
# IMPACT THROUGH INDUSTRY PROJECTS, WITH START-UPS, SMEs AND BIG COMPANIES







Al platform for diagnostic trains to determine and plan track maintenance



Miniaturized atomic clocks for precise time measurement with unparalleled low power consumption



Automated machine to bioengineer personalized skin

#### **WE ARE INDUSTRY-ORIENTED**



Staff with industry experience

Long-term support (80% of staff on permanent contracts)

Processes with builtin confidentiality

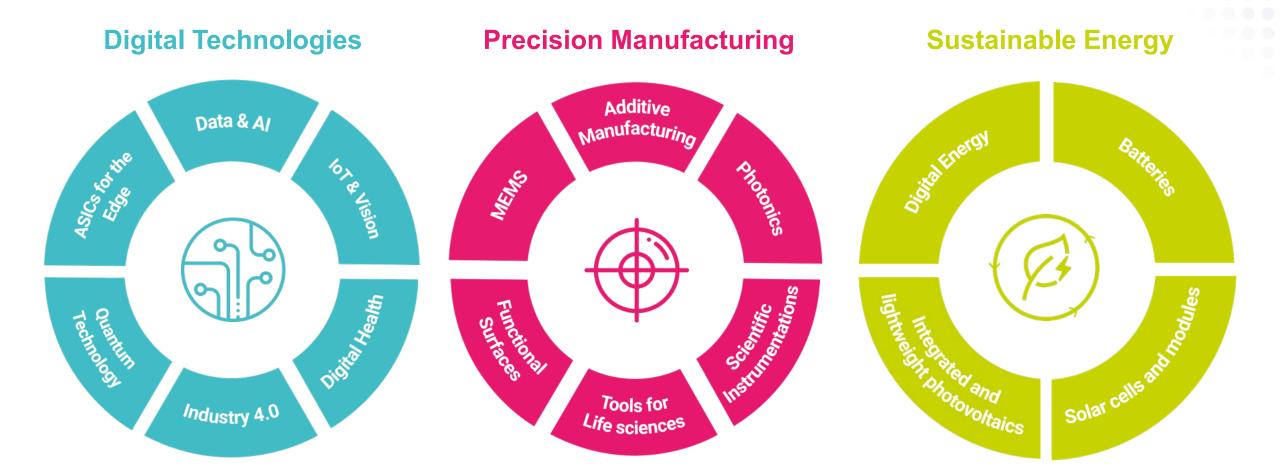


Industrial equipment (clean rooms, characterization labs)

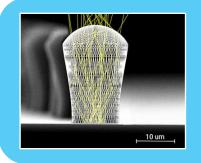
Proven project management methodology (300 projects/year)

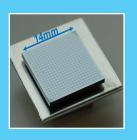
QMS & certifications
(ISO 9001 and 14001,
ISO 13485: Medical devices)

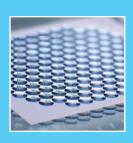
#### WE FOCUS ON THREE RESEARCH PRIORITIES



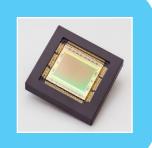
#### **CSEM EXPERTISE IN OPTICS AND PHOTONICS**





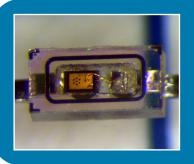


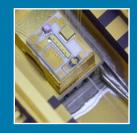


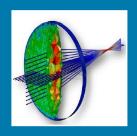


#### Components:

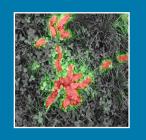
- MOEMS
- Micro- and Nano-Optics
- Photonics Integrated Circuits (PICs)
- Imaging sensors











#### Technologies:

- PICs design, testing, consulting
- Optical design: Zemax, Comsol, etc.
- Multi-spectral imaging
- ML & Al









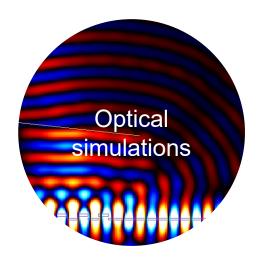


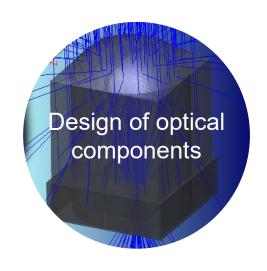
#### Systems:

- Lasers
- Cameras
- LIDARs
- Sensing systems & readout modules

## **MICRO- AND NANO-OPTICS**

### **TECHNOLOGY BLOCKS AND VALUE PROPOSITION**

















#### FROM LAB TO FAB

From concept development projects to small and medium series production

#### **CSEM Micro-Systems Cleanroom:**

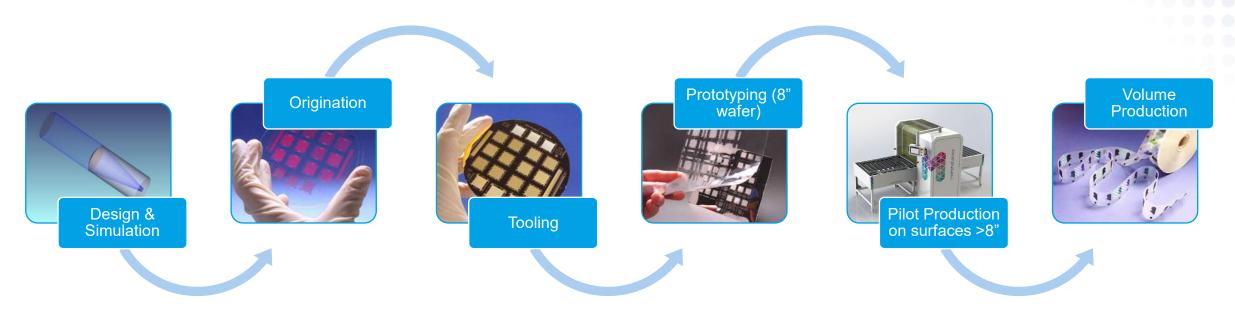
- 800 m<sup>2</sup> ISO5 to ISO6 areas (+300 m<sup>2</sup> in 2027)
- Wafers up to 8"
- Permanent staff of experienced engineers
- ISO9001 and 14001 certified

Preferential access to extended foundry network

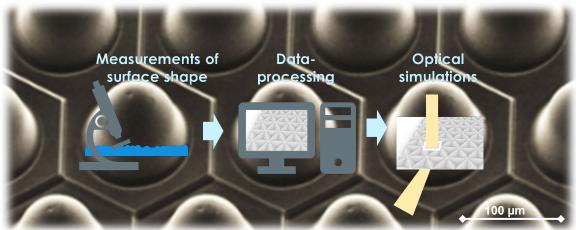


https://www.csem.ch/en/tailored-services/mla-foundry-services/

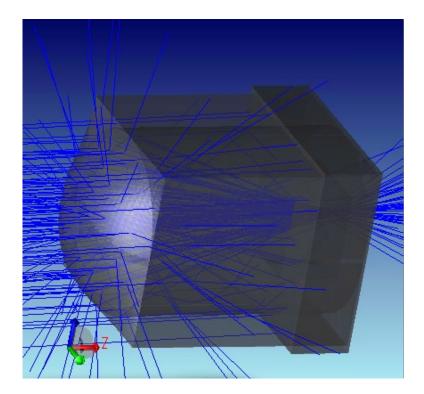
### **MICRO & NANO-OPTICS PROCESS FLOWS**



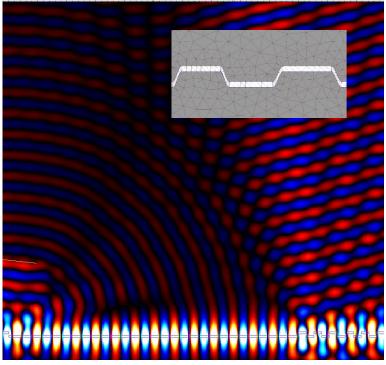
Continuous **metrology** and quick re-iterations at every step to ensure customer satisfaction



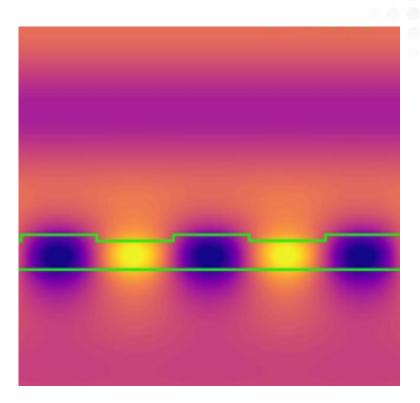
#### **OPTICAL SIMULATION TOOLS**



- Ray Tracing:
  - Tools: Zemax, LightTools with SolidWorks, in-house software
  - Applications: illumination, imaging



- Wave Optics:
  - Tools: FDTD, FEM
  - Applications: waveguides, resonant structures

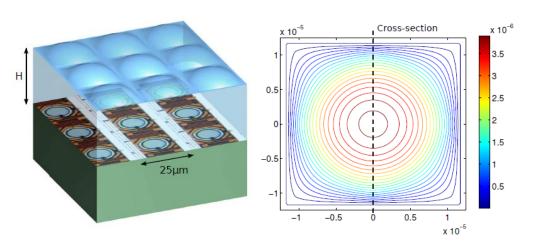


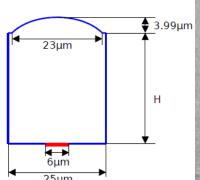
- NanoOptics:
  - Tools: Rigorous Coupled-Wave Analysis
  - Applications: photonic crystals, diffraction gratings, plasmonics

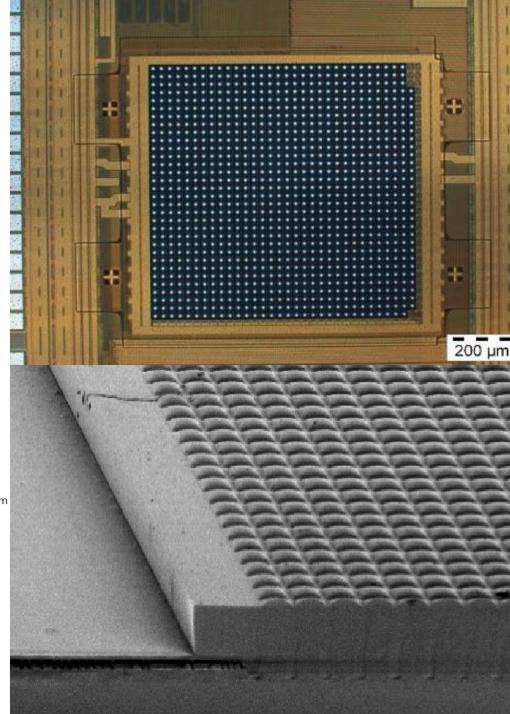
# APPLICATIONS OF MICRO- AND NANO-OPTICS

# INTEGRATED MICRO LENS ARRAY ON SPAD SENSOR IMAGER

- Direct creation of micro-lenses on a SPAD
- Increase of detector efficiency
- From design to fabrication







#### SURFACE NANO-STRUCTURING FOR OPTICAL PURPOSES

- Surface nano-structuring is a costeffective technology to transfer optical patterns on almost any material
- Materials:
  - Metals
  - Glasses
  - Thin foils
  - Silicon
  - Ceramics
  - Polymers





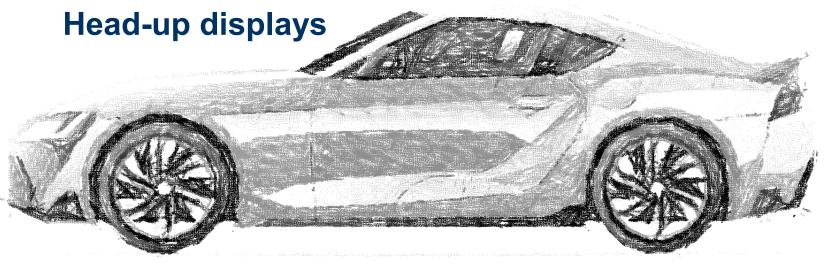




#### **USING MICRO-OPTICS FOR AUTOMOTIVE APPLICATIONS**

Navigation/LiDAR

**Optical sensors** 



**Taillights** 

Signal/decorative lighting

**Headlights** 

#### **ADVANTAGES OF MICRO-OPTICS FOR AUTOMOTIVE**





- Miniaturization: Enables compact designs and reduced packaging space & weight.
- **Styling:** Supports invisible or integrated optics for sleek vehicle aesthetics.
- Functionality: Enhances light control, sensing accuracy, and display capabilities.
- **Efficiency:** Improves light distribution and energy usage.

#### **SIGNAL & DECORATIVE LIGHTING WITH MICRO-OPTICS**

New advanced functionalities enabled by compact, lightweight and energy-efficient micro-optical systems:

- Light carpets
- Reverse warnings
- Turn signals

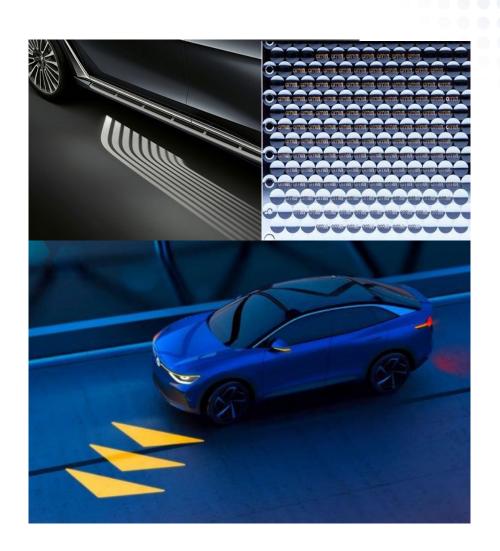




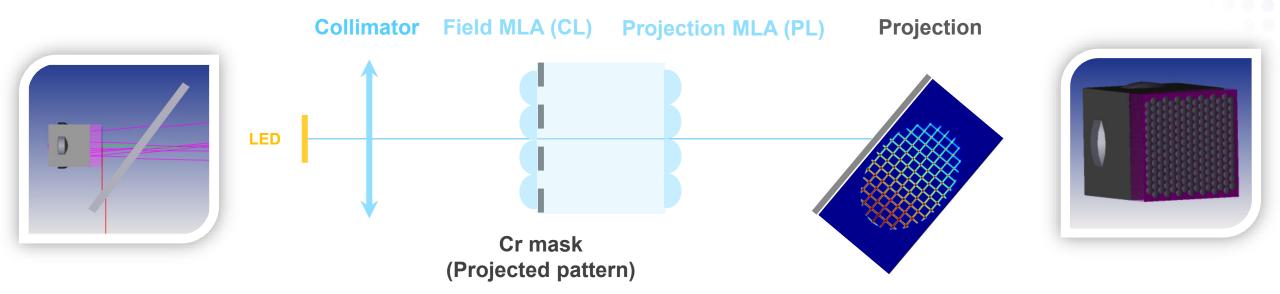
Source: DVN

#### **MICRO-LENS ARRAYS FOR AUTOMOTIVE LIGHTING**

- Microlenses from 2 to 900 microns
- Arbitrary microlens shape design: square, rectangle, round, cylindrical, etc.
- From wafer scale to large area format
- Full cycle development: design & simulations, fabrication, metrology, upscaling

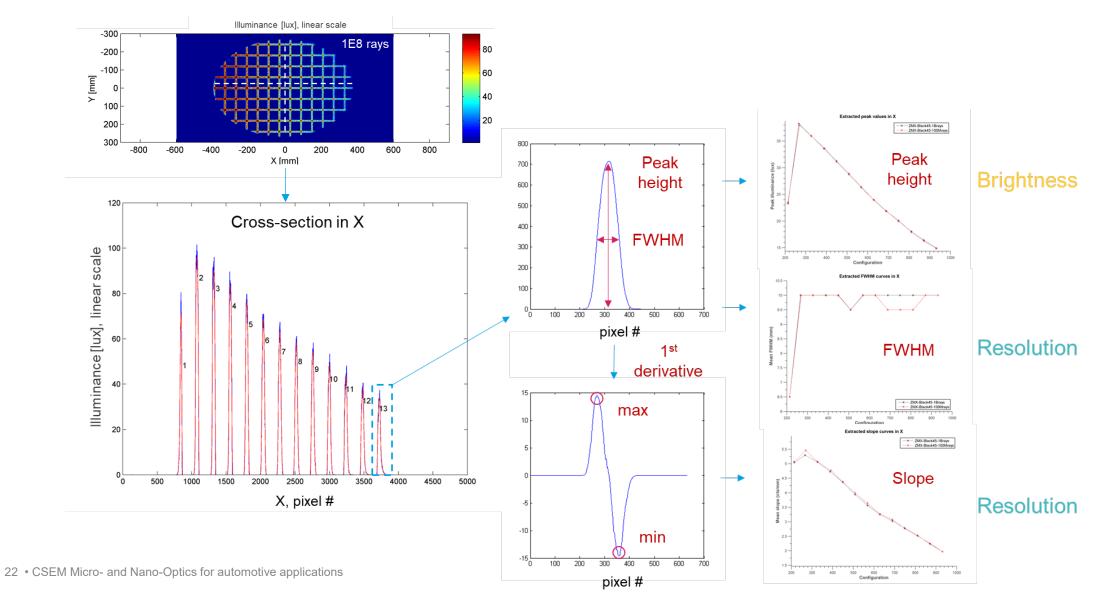


#### **MICRO-LENS ARRAYS: DESIGN & SIMULATION**



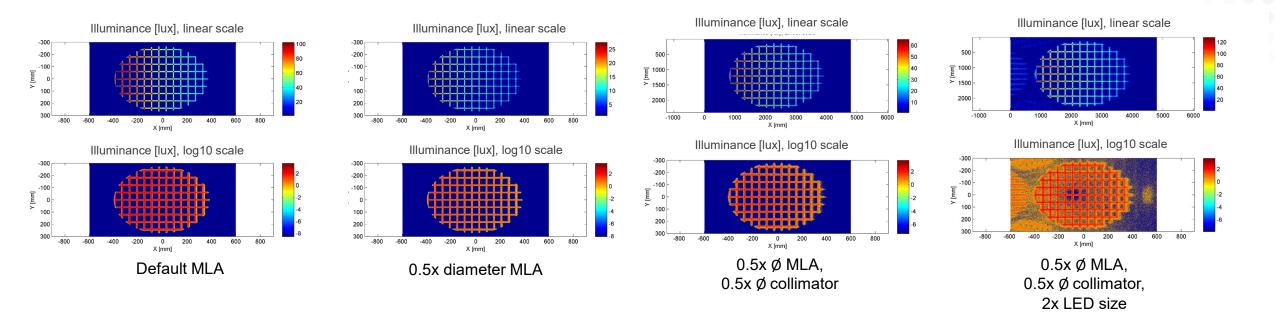
- Using leading design & simulation tools (Zemax, LightTools, etc.)
- Analyzing & optimizing performance metrics (brightness, resolution, homogeneity)

# FULL QUANTITATIVE EVALUATION PIPELINE FOR COMPLEX PROJECTION OPTICS



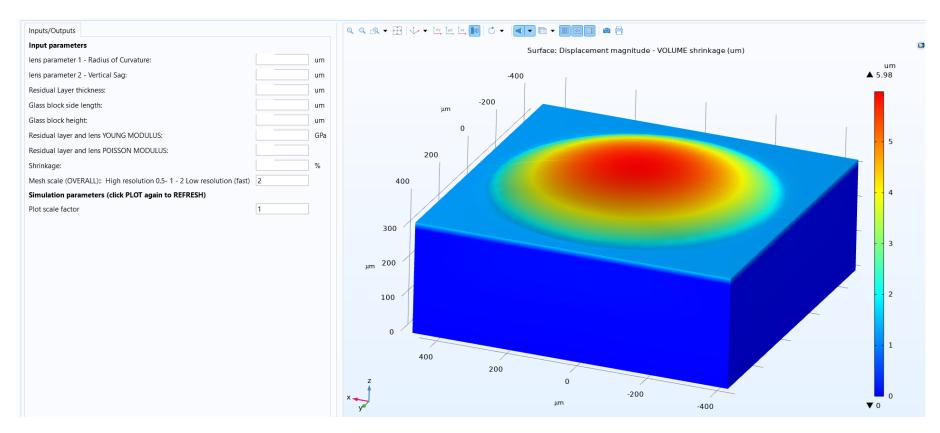
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#### **MICRO-LENS ARRAYS: DESIGN & SIMULATION**



- Analyzing the influence of the MLA, collimator & LED size on the projection
- Various combination of components can be used for the assembly

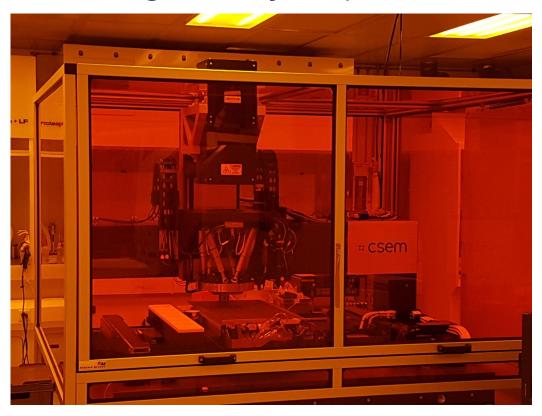
#### **MICRO-LENS ARRAYS: SHRINKAGE COMPENSATION**

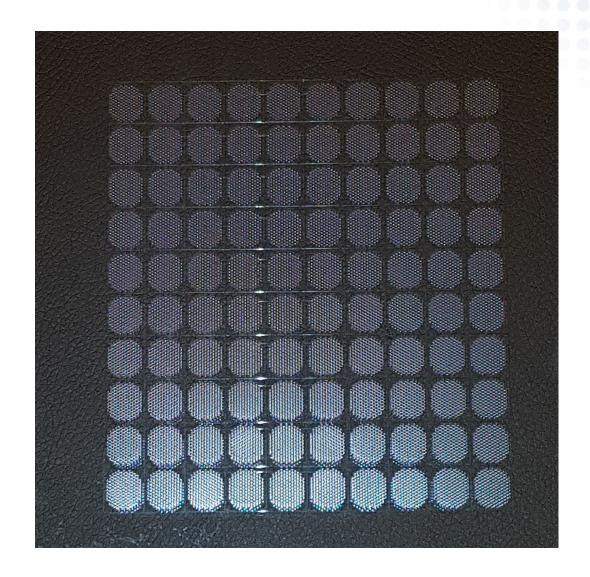


- Simulation results validated using imprint metrology data
- Shrinkage compensation can be applied to design specs
- Multiphysics simulation available to evaluate performance across various environmental influences and material options

### **MICRO-LENS ARRAYS: UPSCALING USING STEP&REPEAT**

- Step&Repeat process developed internally
- Substrate size: up to 35 cm x 60 cm
- Stamp size: up to 8 cm x 8 cm
- Positioning accuracy: < 2 μm in X/Y/Z





### **QUESTIONS? LET'S DISCUSS!**

**CSEM** keeps enhancing micro-optics for >30 years

Facing a challenge? Let's tackle it together!

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