

WAFER-LEVEL MANUFACTURING OF MICRO-OPTICS

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WAFER-LEVEL MANUFACTURING OF MICRO-OPTICS

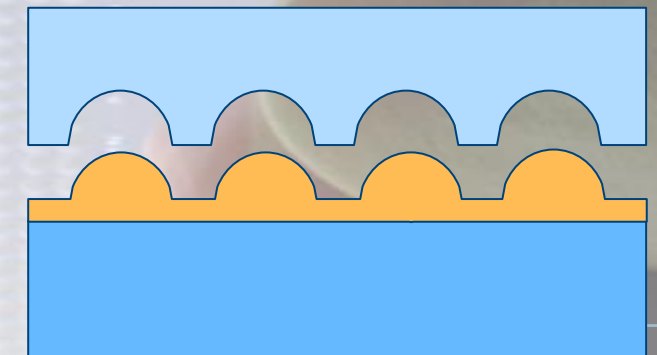
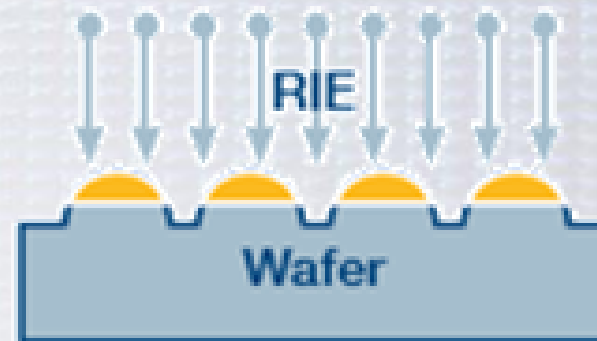
or ... *TO ETCH OR TO IMPRINT* MICRO-OPTICS ?

IS THIS REALLY THE QUESTION?

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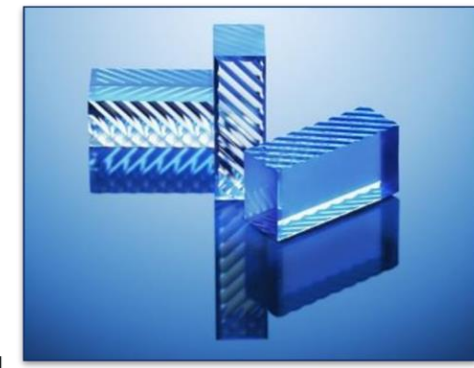
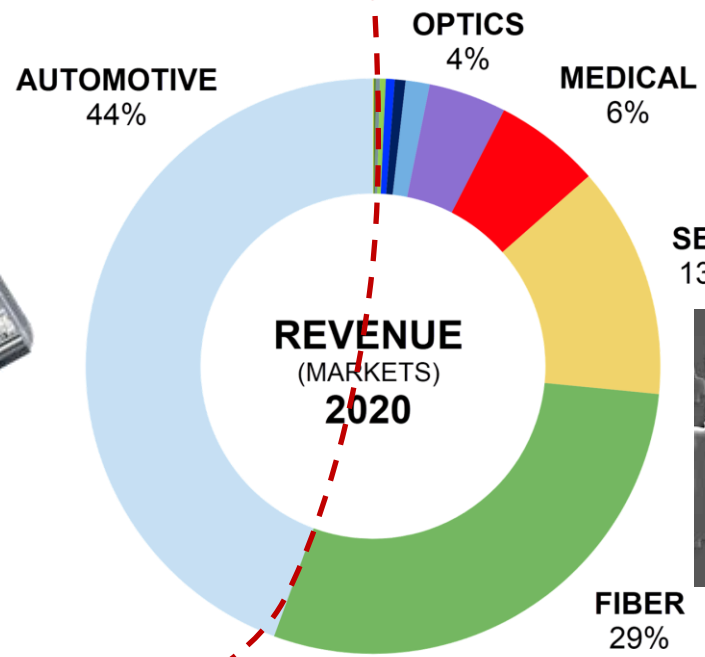
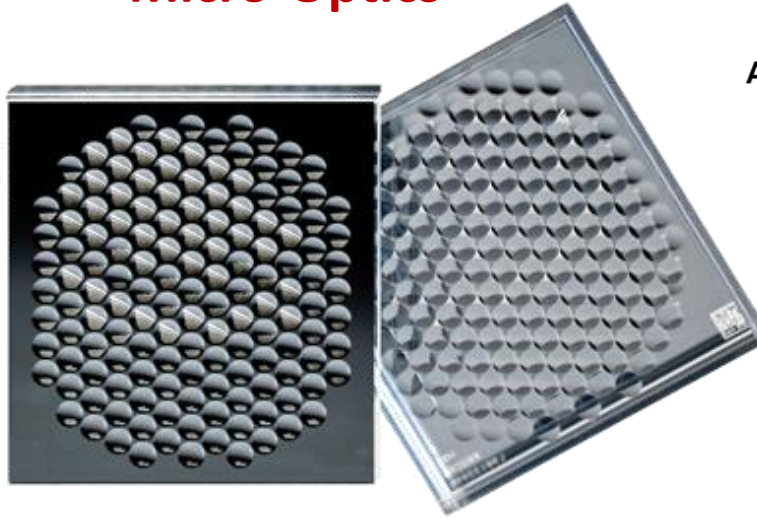
8" (200mm) Wafer Cleanroom Fab & Imprint Lithography Production

- + Founded 1998
- + Refractive microoptics
- + Diffractive microoptics
- + Worldwide client base in data/telecom, metrology, semiconductor, instruments
- + Part of the SUSS MicroTec Group

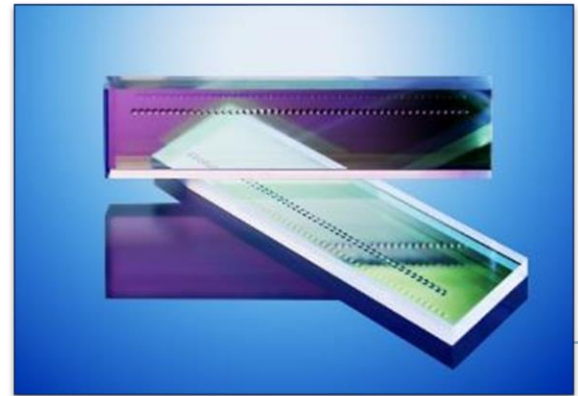
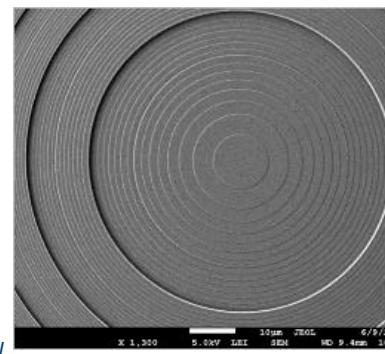
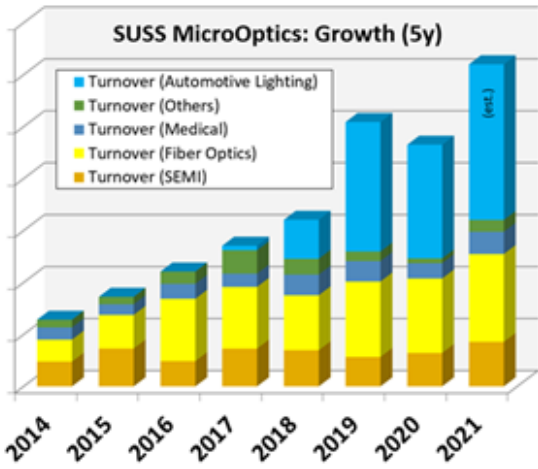
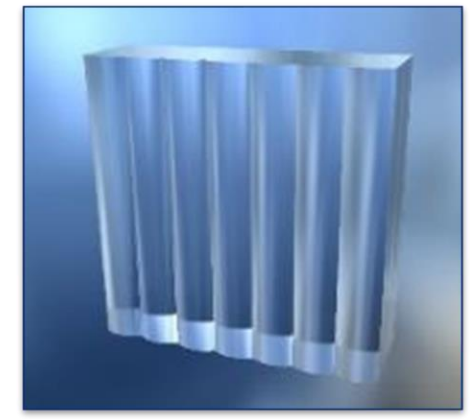
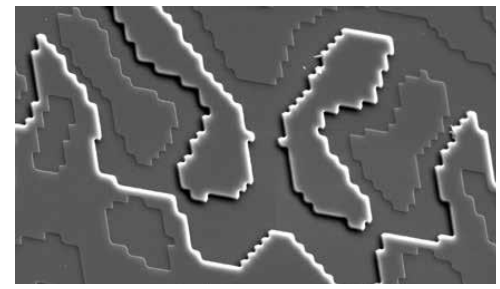
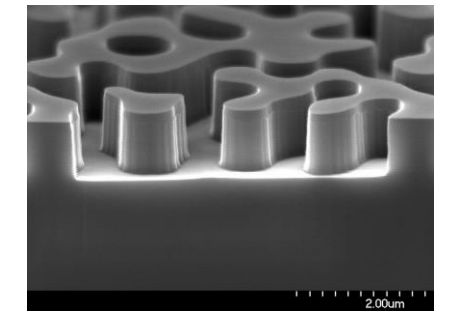
IATF 16949
Automotive Qualified Imprint Production

PRODUCTS & MARKTES

Imprinted Micro-Optics



Etched Micro-Optics



WAFER-LEVEL OPTICS – WHY?

Jose's epic statement: *"The Micro-Optics Revolution in [everywhere]"*

The blessing: Everyone wants it. → New products, new markets, new tools & technologies

The curse: Everyone wants it. → New competitors, challenging markets, cheaper technologies

Why not injection molding, plastics, cool assembly features, million of pieces for pennies?

So Why wafer-level (micro-)optics?

Wafer-Level Technology for making the *perfect* micro-, nano-, meta- **OPTICAL SYSTEM**

... Conceived in CH & Europe, utilizing CH & European technology

Made in Europe ... or Asia.

WAFER-LEVEL OPTICS – MAKING IT BETTER & MORE COMPLEX

Ambitions & Challenges

- ams OSRAM
 - perfect sensors & cameras
- NIL Technology
 - perfect meta-optics and 3D sensors
- Ligentec
 - perfect SiN PICs
- Polariton
 - perfect plasmonic PICs
- Femtoprint
 - perfect 2P-technology in glass
- II-VI / Coherent
 - perfect lasers
- Axetris
 - perfect ... you know what ;-)
- IRIS
 - perfect NIR SPADs
- Alpes Lasers
 - perfect QCLs
- ALBIS
 - perfect PDs
- YALOSYS
 - perfect microglass
- perfect SWISS Technology

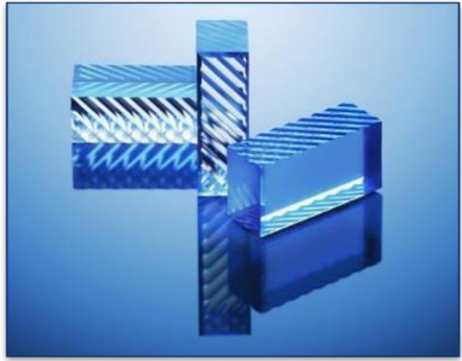
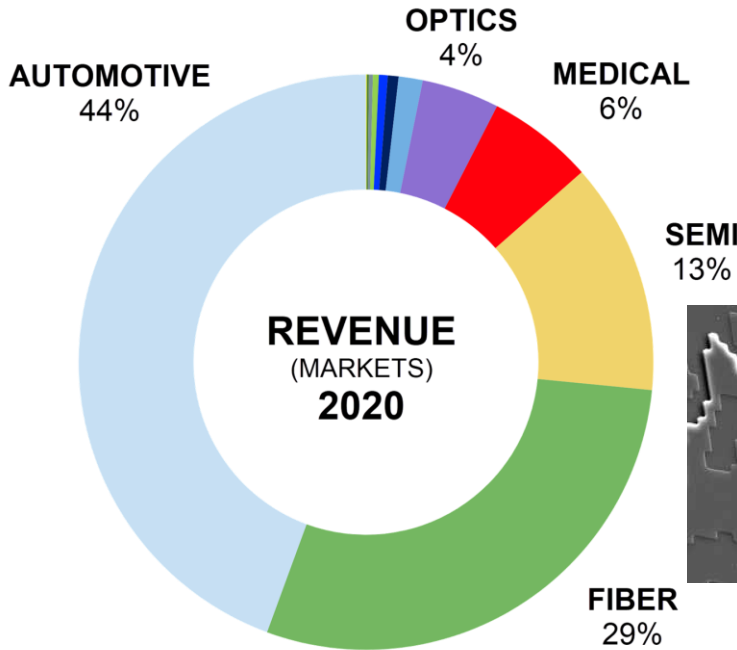
SUSS MicroOptics Talk and SIA Vision Paris - 2022



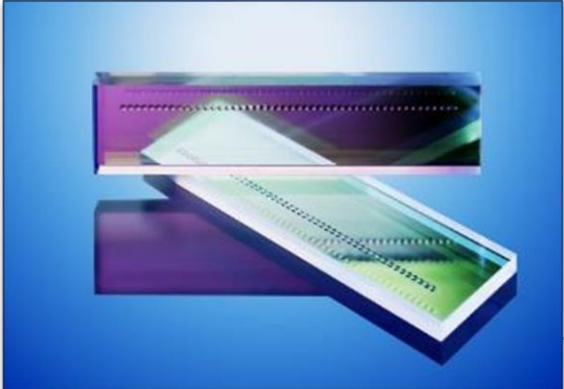
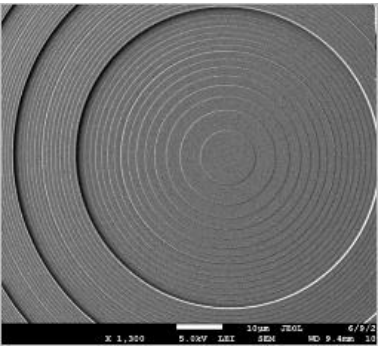
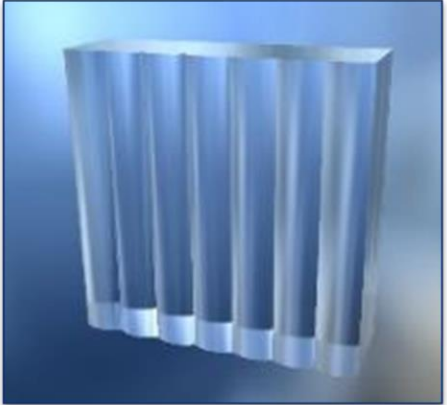
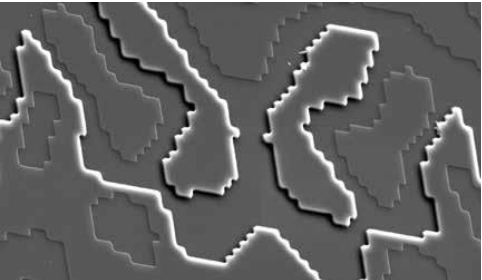
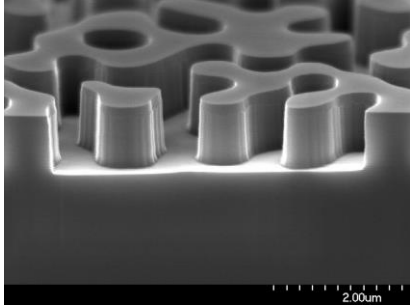
THE PERFECT MLA HEADLAMP

CHRISTOPHER BREMER

Paris, 2022

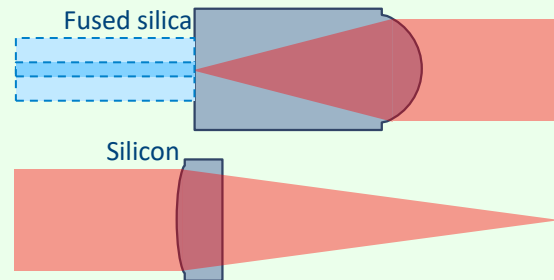


Etched Micro-Optics

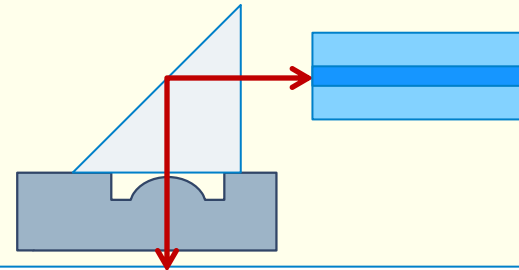
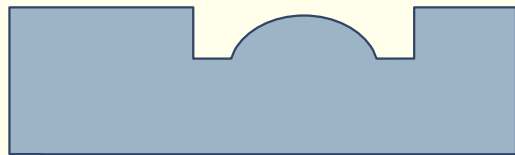


❖ Micro-Optics With Easy-Assembly Features

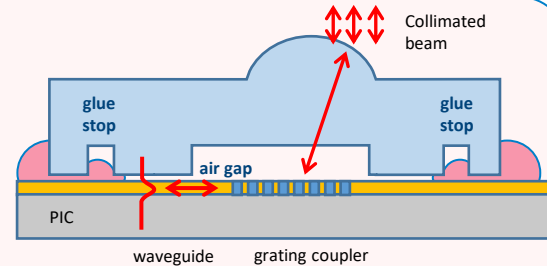
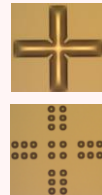
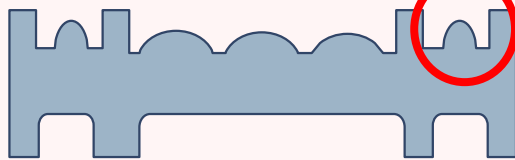
Protruding lenses for collimation



Recessed microlenses for stacking



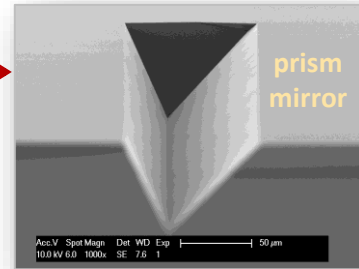
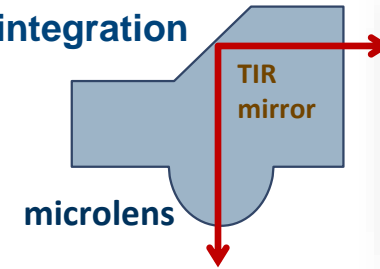
Microlenses with “adhesive management”, air gap, fiducials and trenches



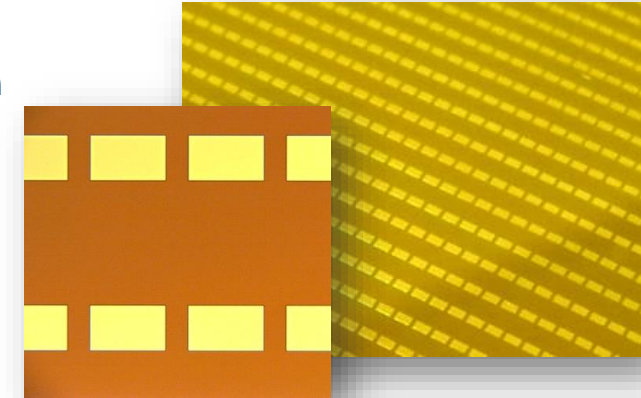
Microoptics costs lower

❖ Special Features

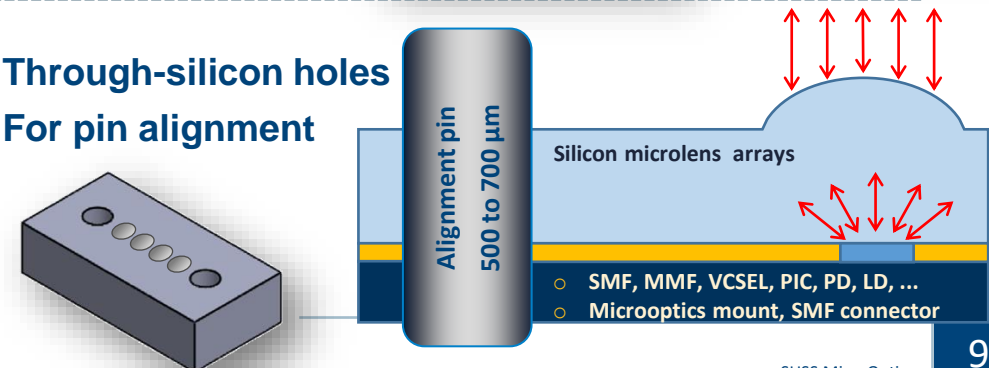
- + Integrated prisms
- + For high level integration



- + AuSn solder pads
- + Less than 3 µm thin
- + For reflow process

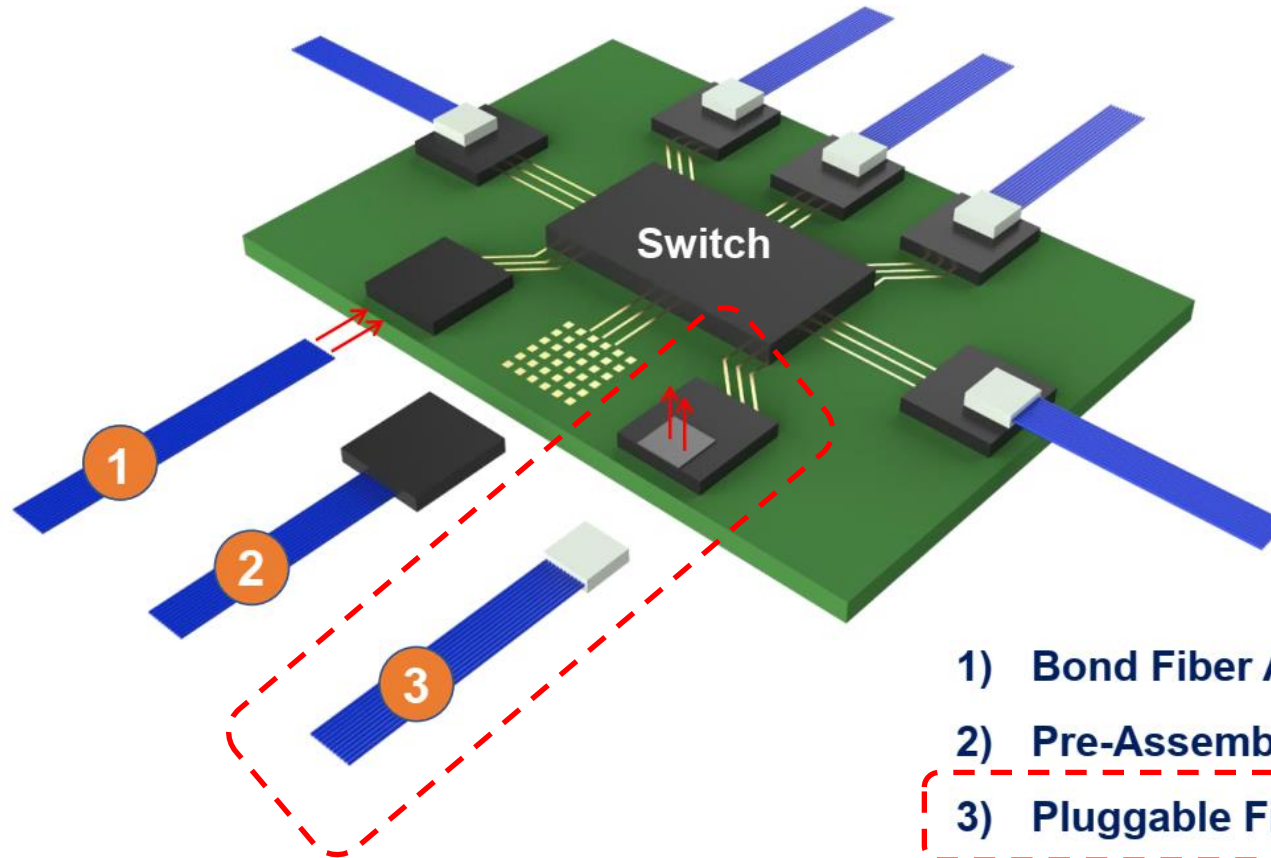


- + Through-silicon holes
- + For pin alignment



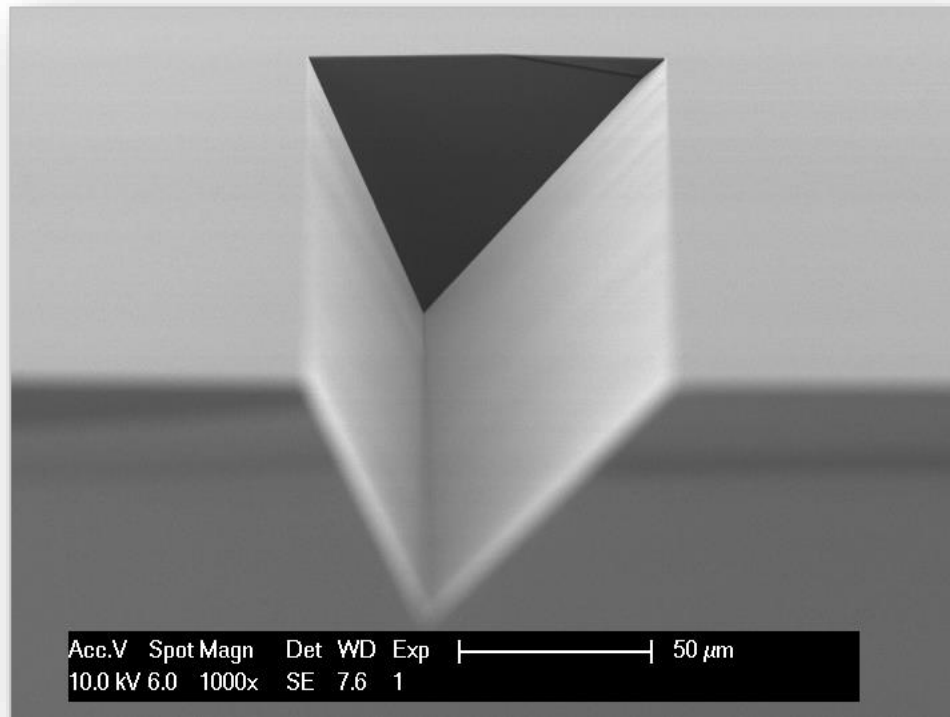
IATF 16949

Co-Packaging (Optical Packaging)

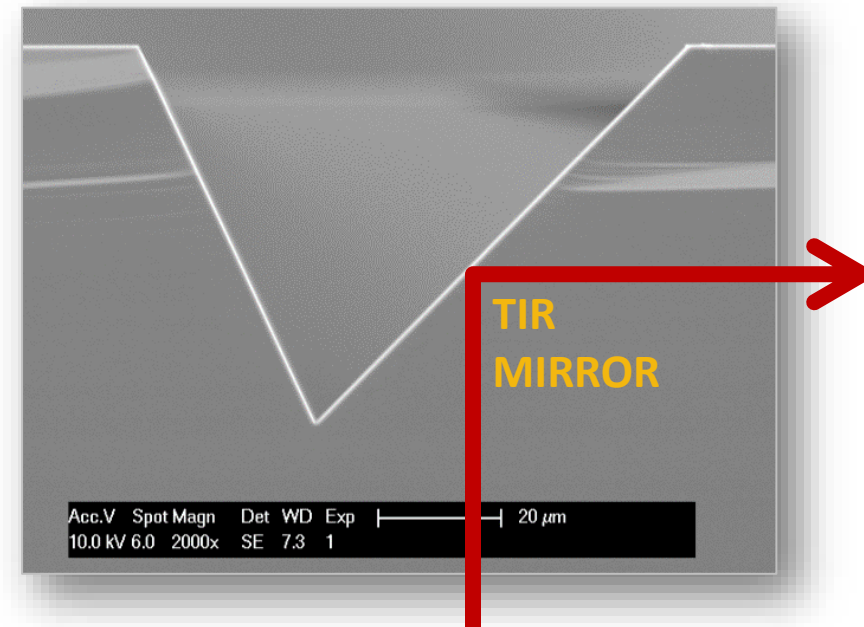
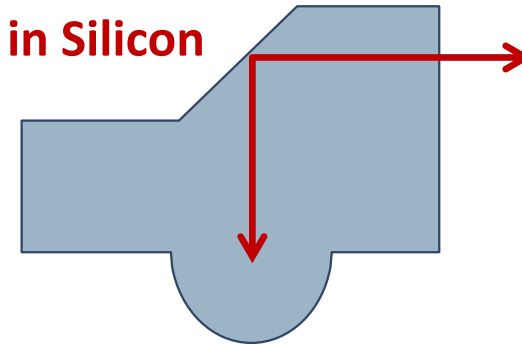


45° PRISM WITH INTEGRATED 90° MIRROR (Silicon) – 1ST GEN.

- + Highly integrated
- + TIR prism/mirror combine with lens
- + V-Grooves for passive fiber alignment



90°-Turn
Prism in Silicon



INTEGRATED 90° PRISM WITH MICROLENS ARRAY – NEXT GEN.

+ Materials

- Silicon or fused silica

+ Optical function

- 90° bent
- Re-Focusing
- Collimating

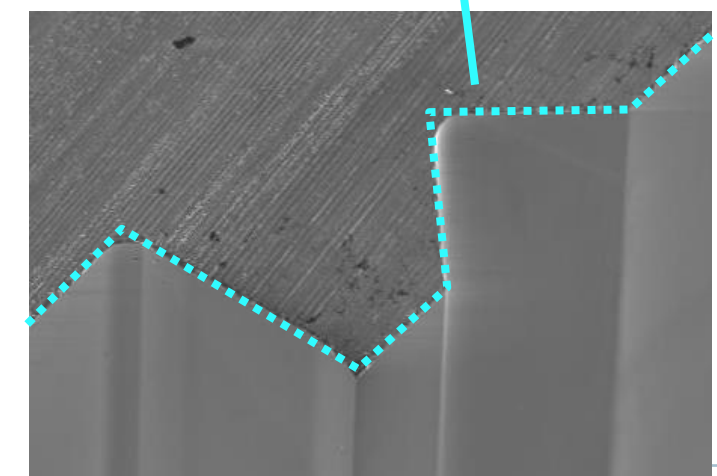
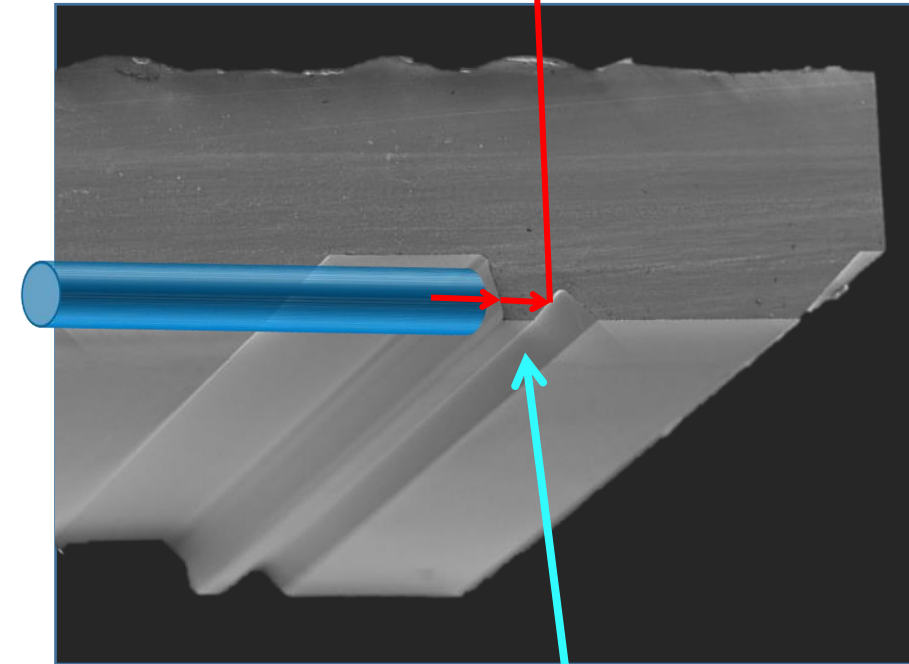
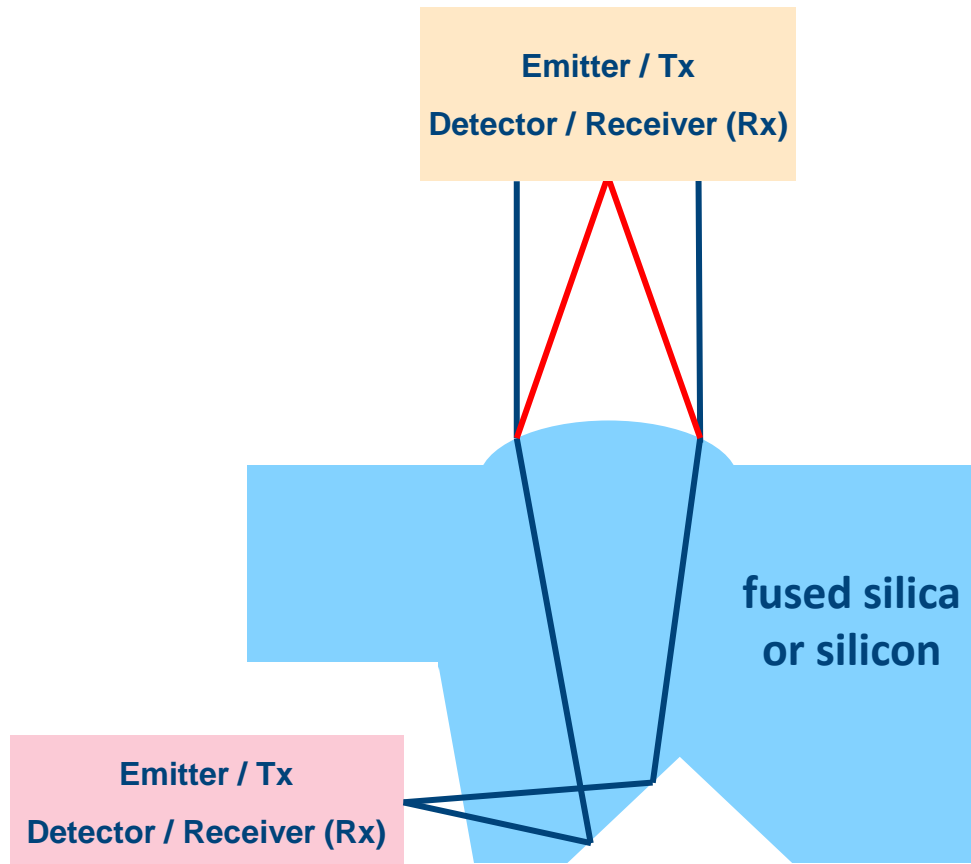
+ Emitting devices

- PIC waveguide
- SMF or MMF

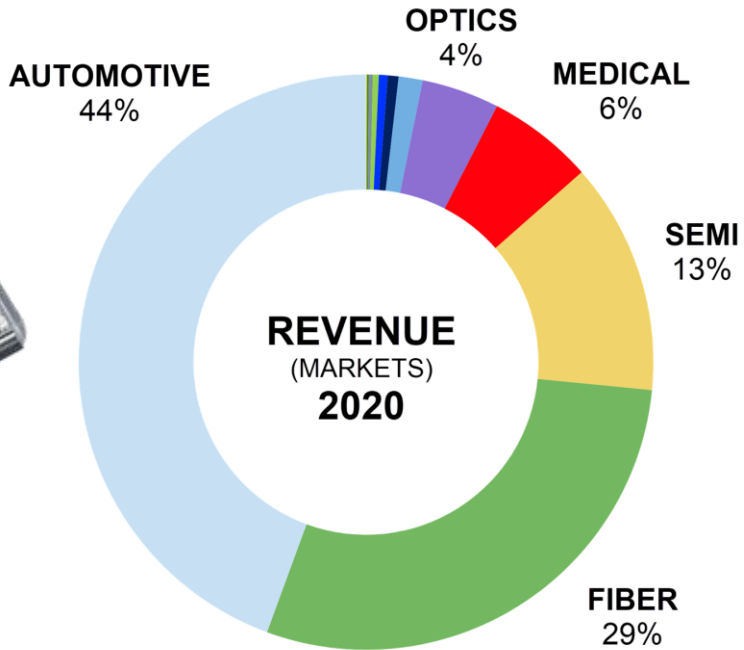
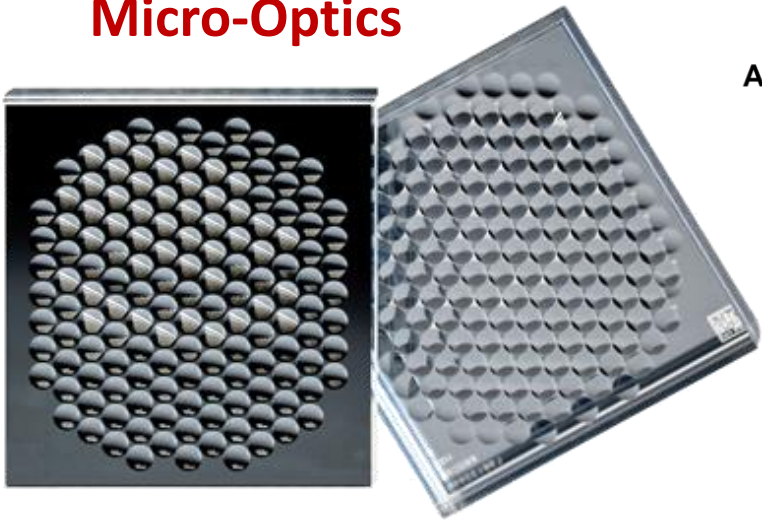
+ Detection devices

- SMF or MMF
- APD

+ Angles and depths can be customized



**Imprinted
Micro-Optics**



LIGHT CARPETS FOR DESIGN AND SAFETY

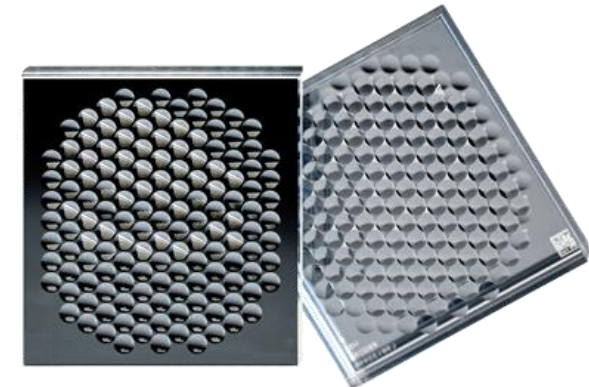
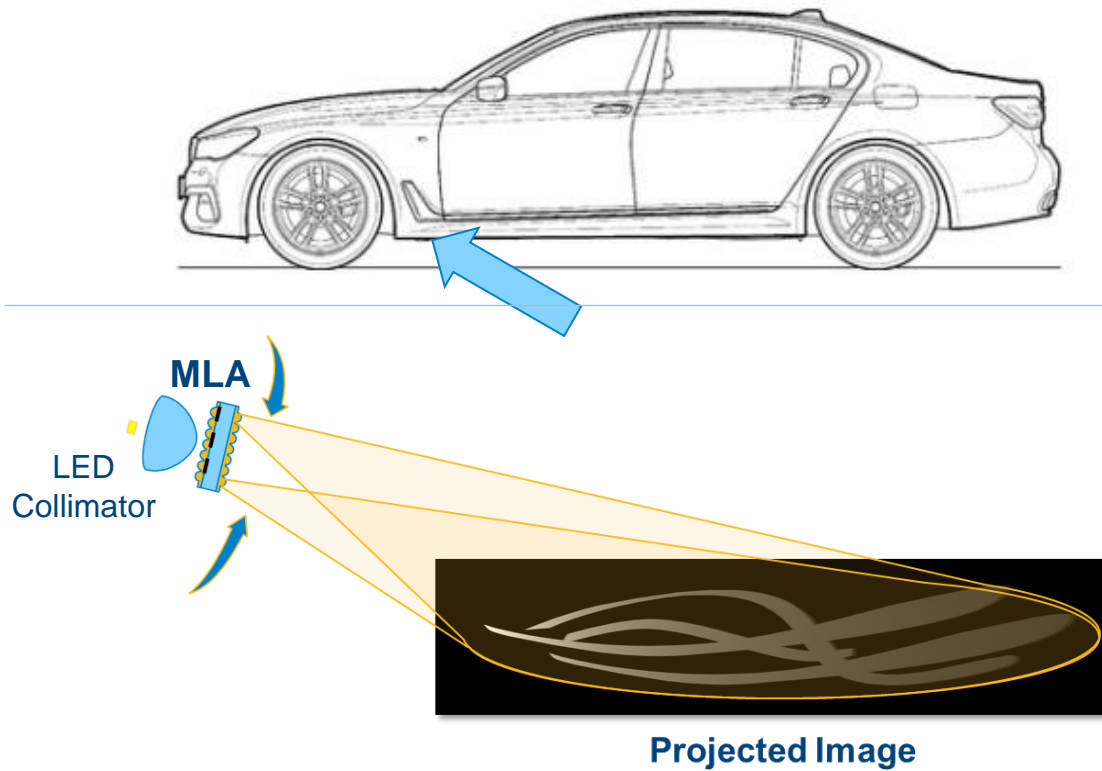
Future



Sources: BMW, www.glowwing.com

LIGHT CARPETS FOR AUTOMOTIVE

+ Development by Fraunhofer IOF (Jena), started in 2014

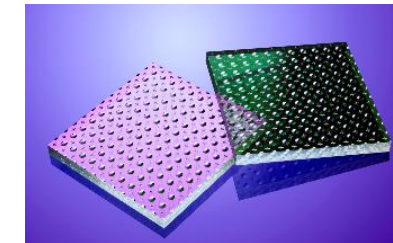
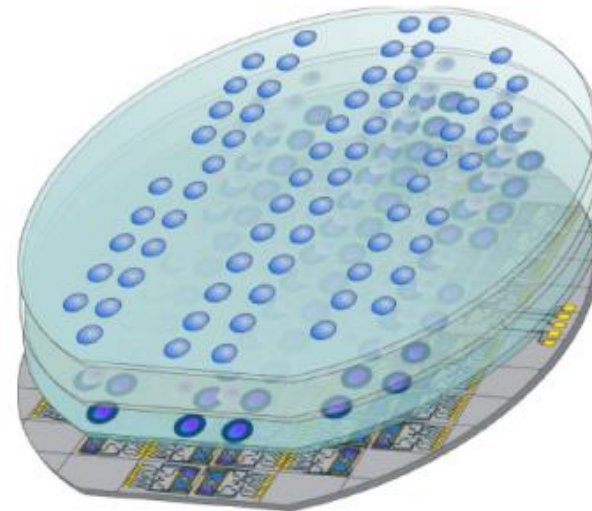
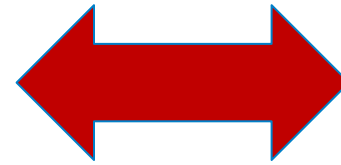


SUSS MicroTec SE

- + Global company (210 M€ revenue, 780 people)
- + Lithography **tools**
- + Wafer-level processing **machines**

SUSS MicroOptics SA

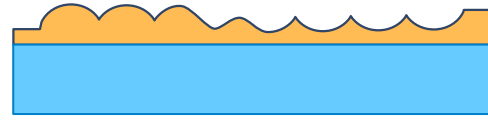
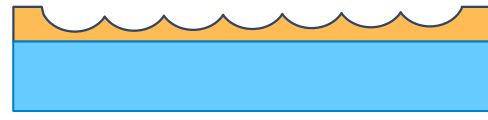
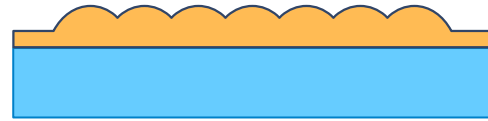
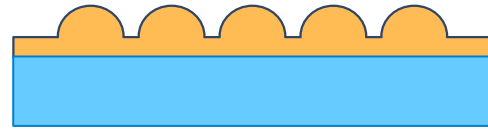
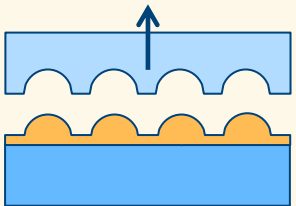
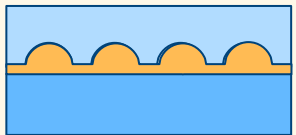
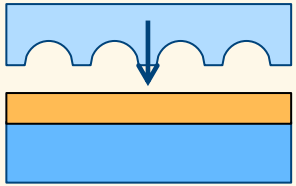
- + Swiss company (90 people)
- + Micro-Optics **chips & wafers**
- + Wafer-level **processes & optics**



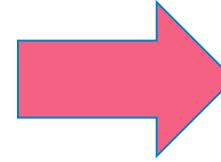
60 years in microstructuring process equipment for the semiconductor industry

IMPRINTED MICROLENSSES – WAFER-LEVEL – DOUBLE-SIDED

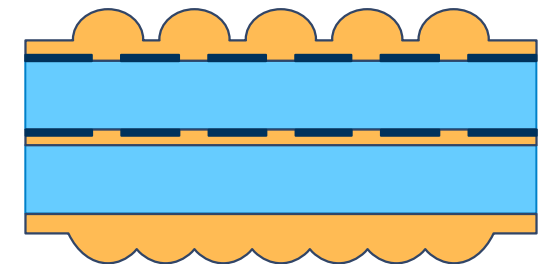
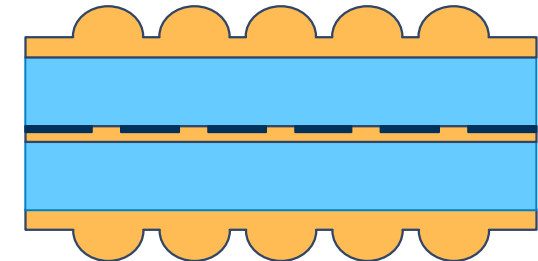
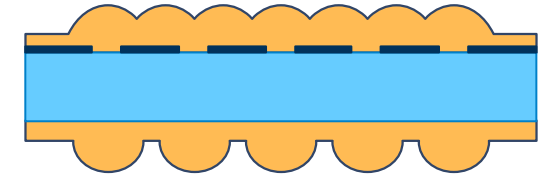
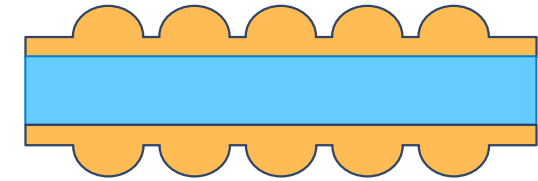
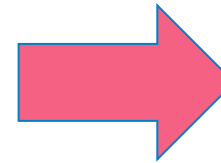
UV imprint of a liquid polymer layer on a glass substrate



Front- and Backside Optics



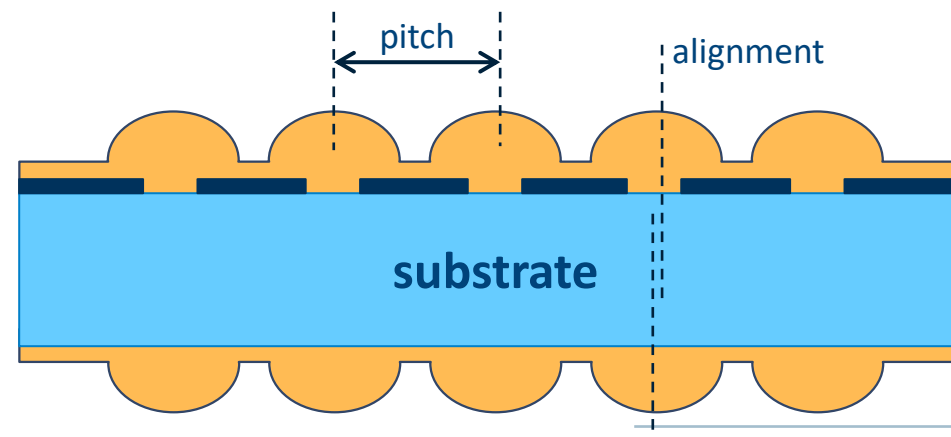
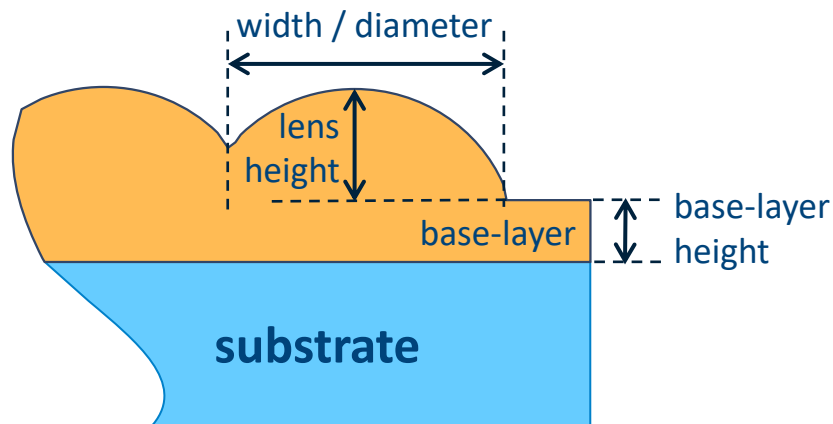
- ❖ Double-sided MLAs
- ❖ Precisely aligned
- ❖ Embedded apertures



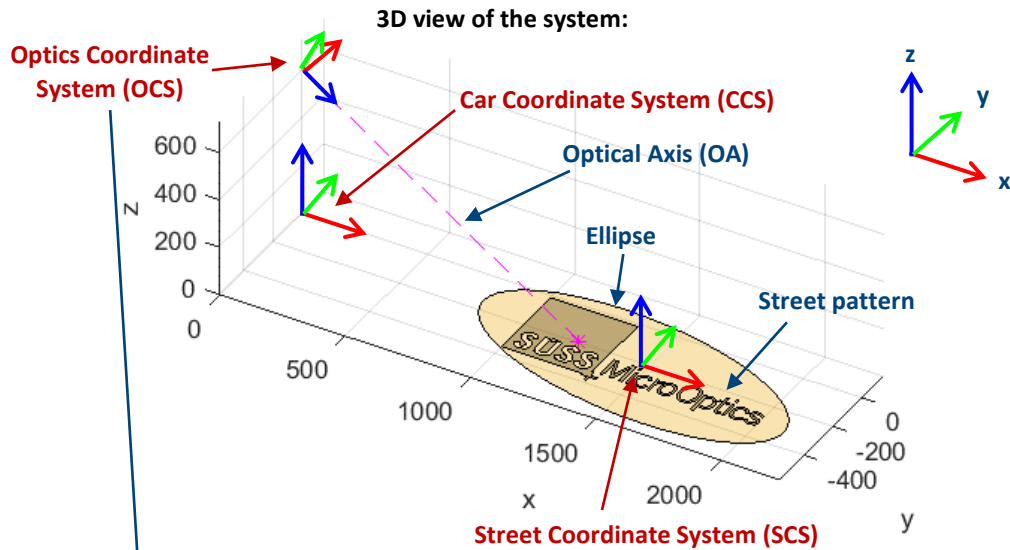
IMPRINTED MICROLENSES – DESIGN RULES

- ❖ Lens pitch / diameter: 10 μm to 2 mm
- ❖ Lens height (sag): 2 to $\sim 500 \mu\text{m}$
- ❖ Base layer thickness (BL): $< 200 \mu\text{m}$, ideally 20 to 50 μm , $\pm 20 \mu\text{m}$
- ❖ Total lens height (BL + sag): $< 500 \mu\text{m}$

- ❖ **Alignment accuracy** (standard values, better values feasible, depending on constrains)
 - ❖ Lens to aperture (same side): $\leq 5 \mu\text{m}$
 - ❖ Lens to aperture (opposite side): $\leq 5 \mu\text{m}$
 - ❖ Lens to lens (opposite side): $\leq 5 \mu\text{m}$
 - ❖ Lens to CMOS (same side): $\leq 5 \mu\text{m}$
 - ❖ Lens wafer to lens wafer (stack): $\leq 5 \mu\text{m}$



GEOMETRIC RELATIONS

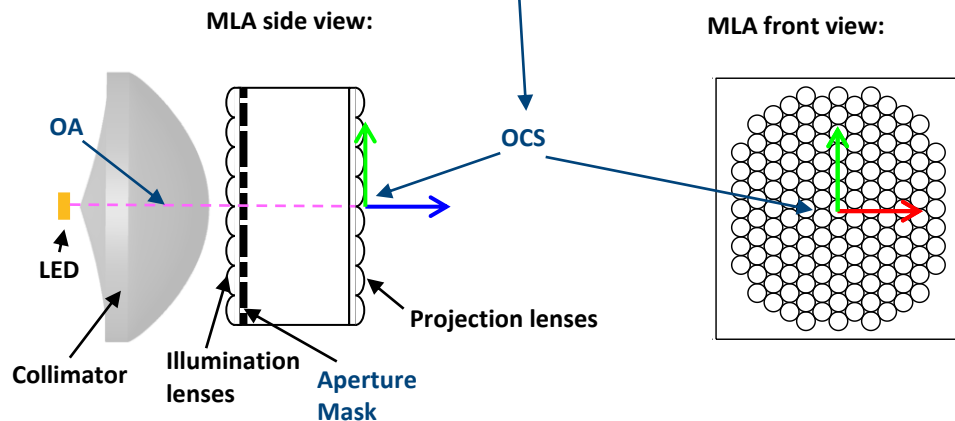


	X-center	Y-center	Z-center	Tilt about X	Tilt about Y	Tilt about Z
CCS	0 mm	0 mm	0 mm	0°	0°	0°
OCS	0 mm	600 mm	0 mm	152.826°	6.234°	-176.809°
SCS	200 mm	0 mm	-1300 mm	-90°	0°	-90°



Geometrical description compatible with Zemax notation!

Object Type	Comment	Ref Object	Inside Of	X Position	Y Position	Z Position	Tilt About X	Tilt About Y	Tilt About Z
1	Null Object ▾ CCS: Car Coordinates Origin	0	0	0.000	0.000	0.000	0.000	0.000	0.000
2	Null Object ▾ OCS: Optics Coordinates Origin	1	0	0.000	600.000	0.000	152.826	6.234	-176.809
3	Null Object ▾ SCS: Street Coordinate Origin	1	0	200.000	0.000	-1300.000	-90.000	0.000	-90.000



MICRO-OPTICS HEADLIGHTS



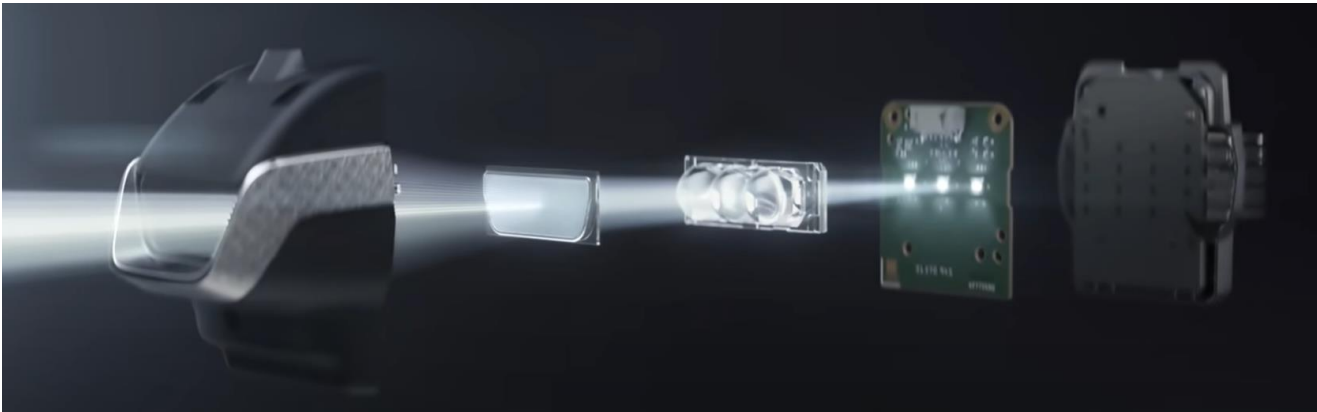
Lucid Air, top view



Headlight

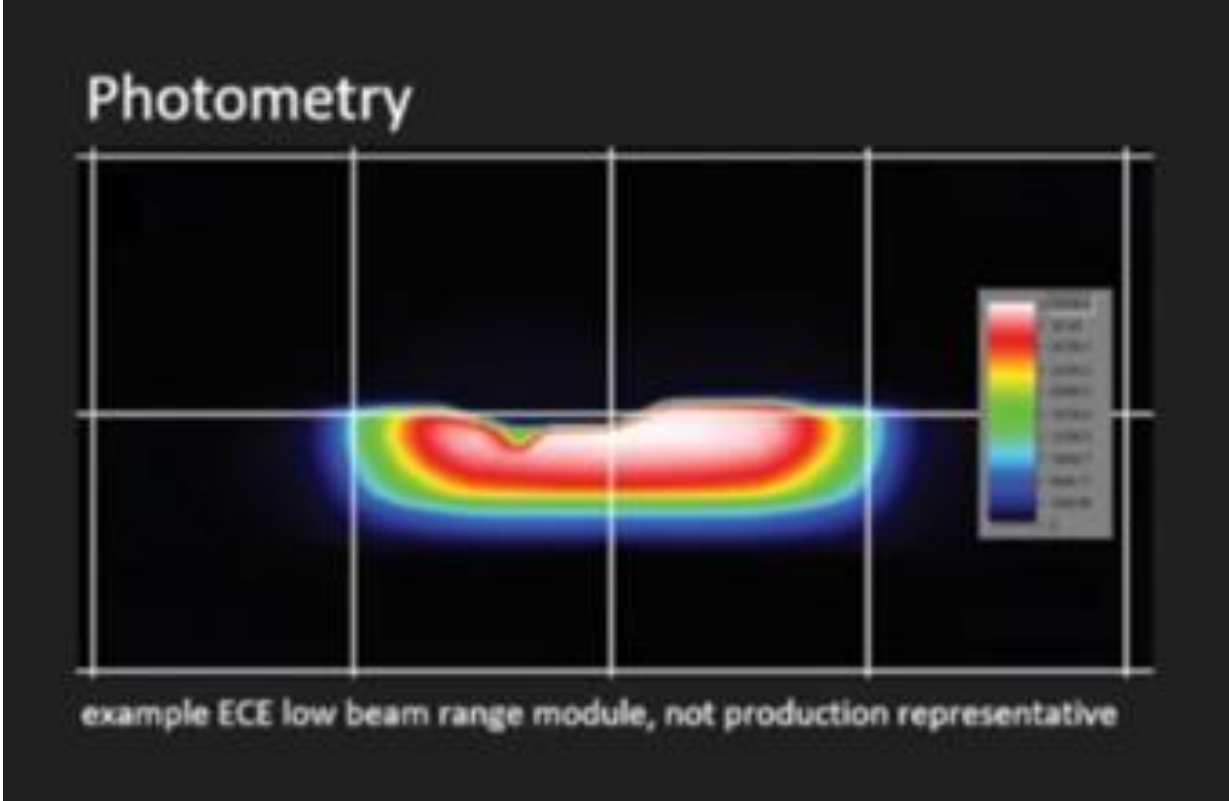
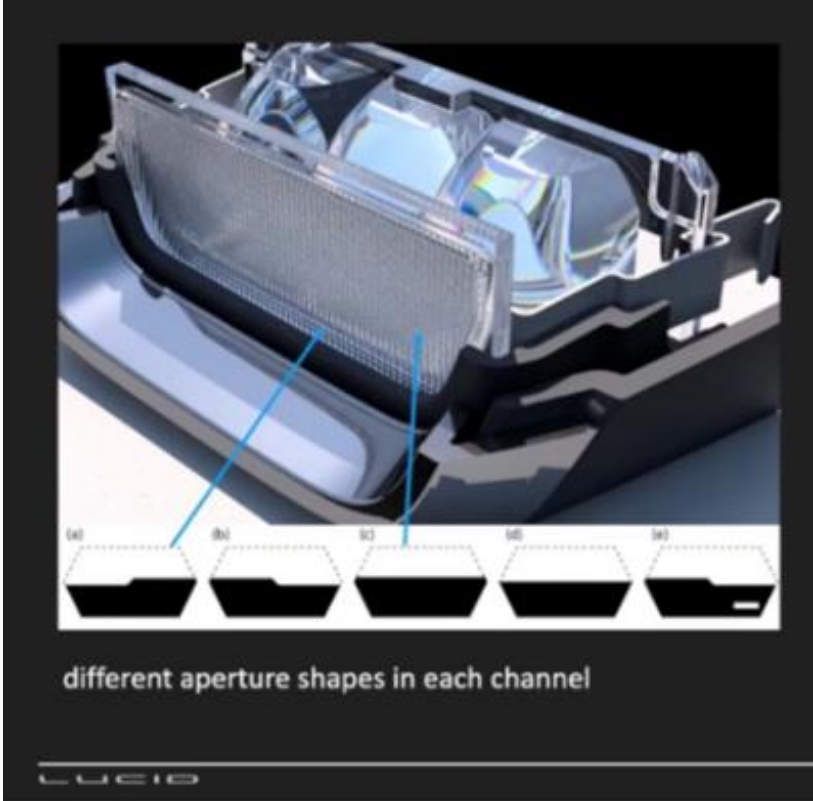


Module



Module, exploded view

Lucid Motors



The Opportunity

- + Headlamps integrated and hidden in the design
- + Not many concepts out there for miniaturization
- + Micro-Optics is by far the most-promising approach for the next generations of automotive lighting solutions.

Challenges and Key Developments

- + Design flexibility
 - Size, weight and power consumption
- + Higher efficiency
 - Lower energy consumption (EV)
- + Visible innovation and uniqueness
 - Premium cars, individualization
- + Cost reduction



BMW Laser Light (ZKW)

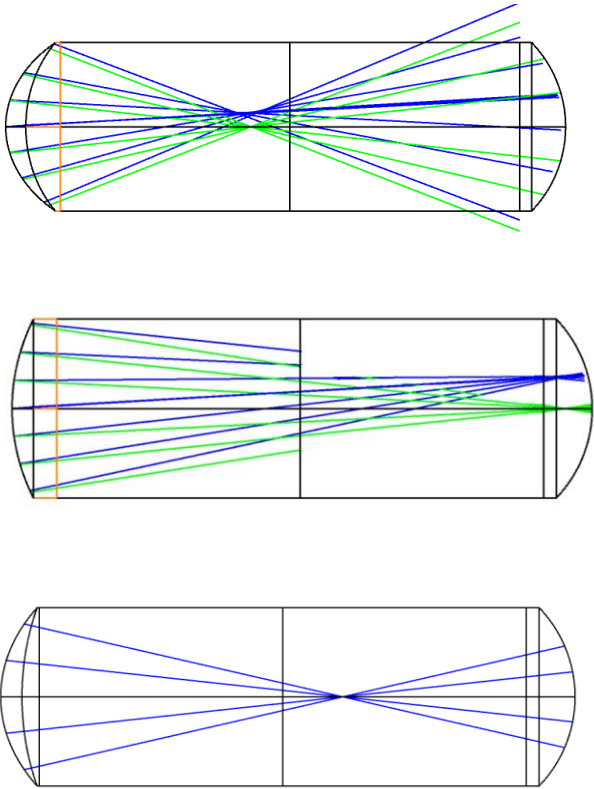


Lucid Air – Microlens Head Lights

OPTIMIZATION OF PERFECT HEADLAMP

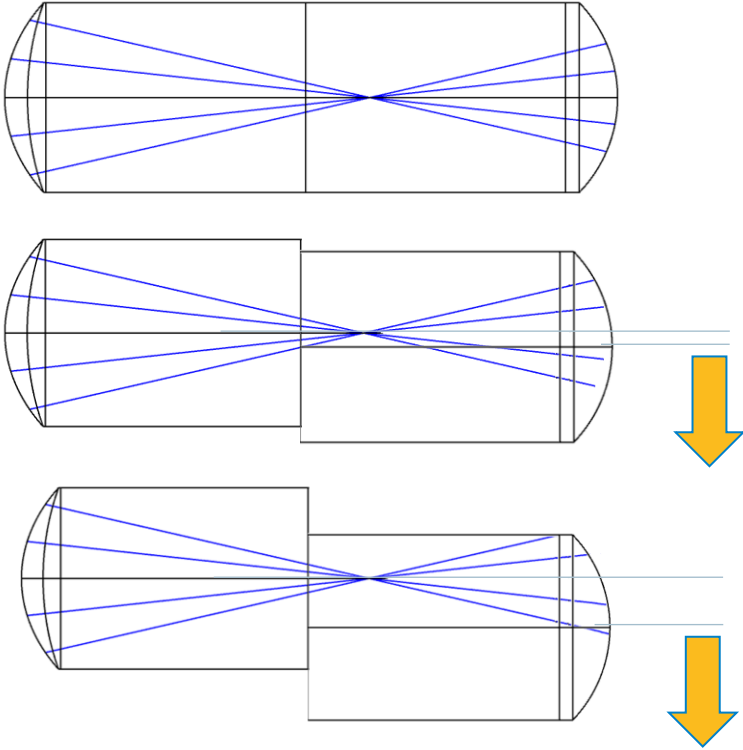
+ Optimization I

+ Change of focal length for x and y



+ Optimization II

+ Introduce Offset between illumination lens and projection lens

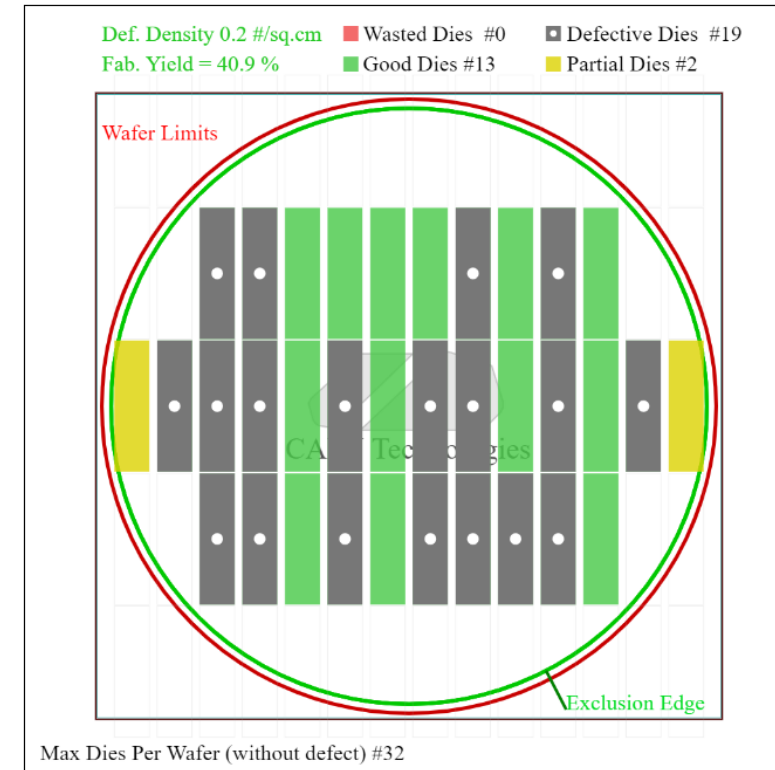
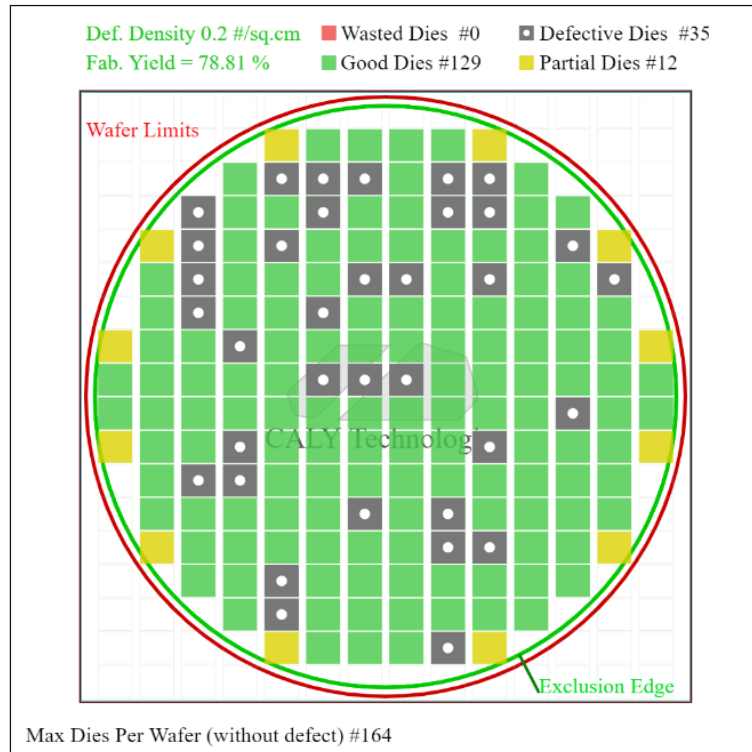


THE PERFECT MLA HEADLAMP

CHRISTOPHER BREMER

Paris, 2022

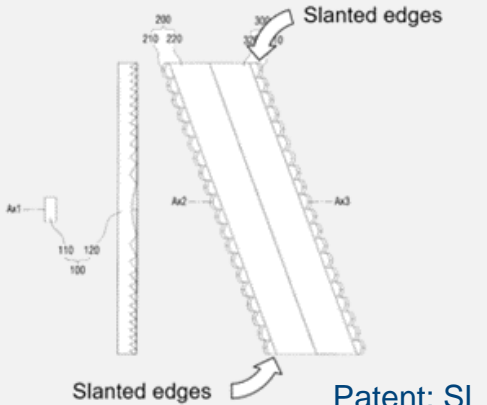
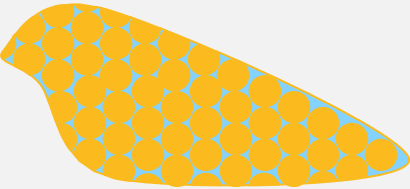
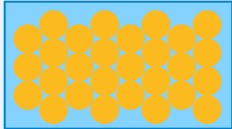
SIZE OF ELEMENT



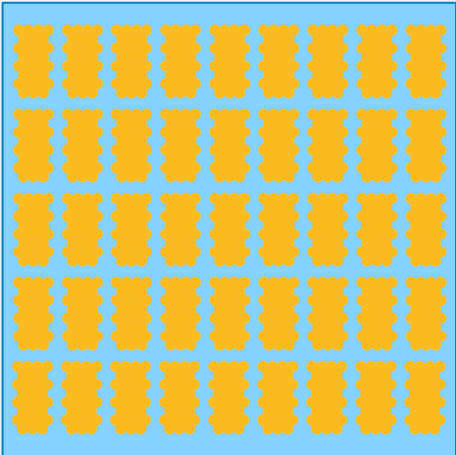
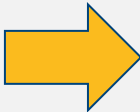
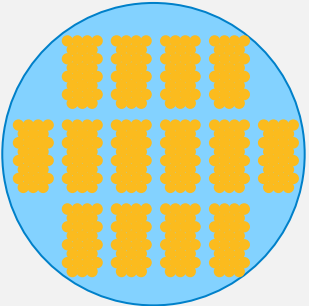
- + Number of good parts decreases even with constant defect density
- + Preferred size is < 20 mm x 20 mm but bigger elements can be manufactured

LARGER SUBSTRATES & SPECIAL DIES

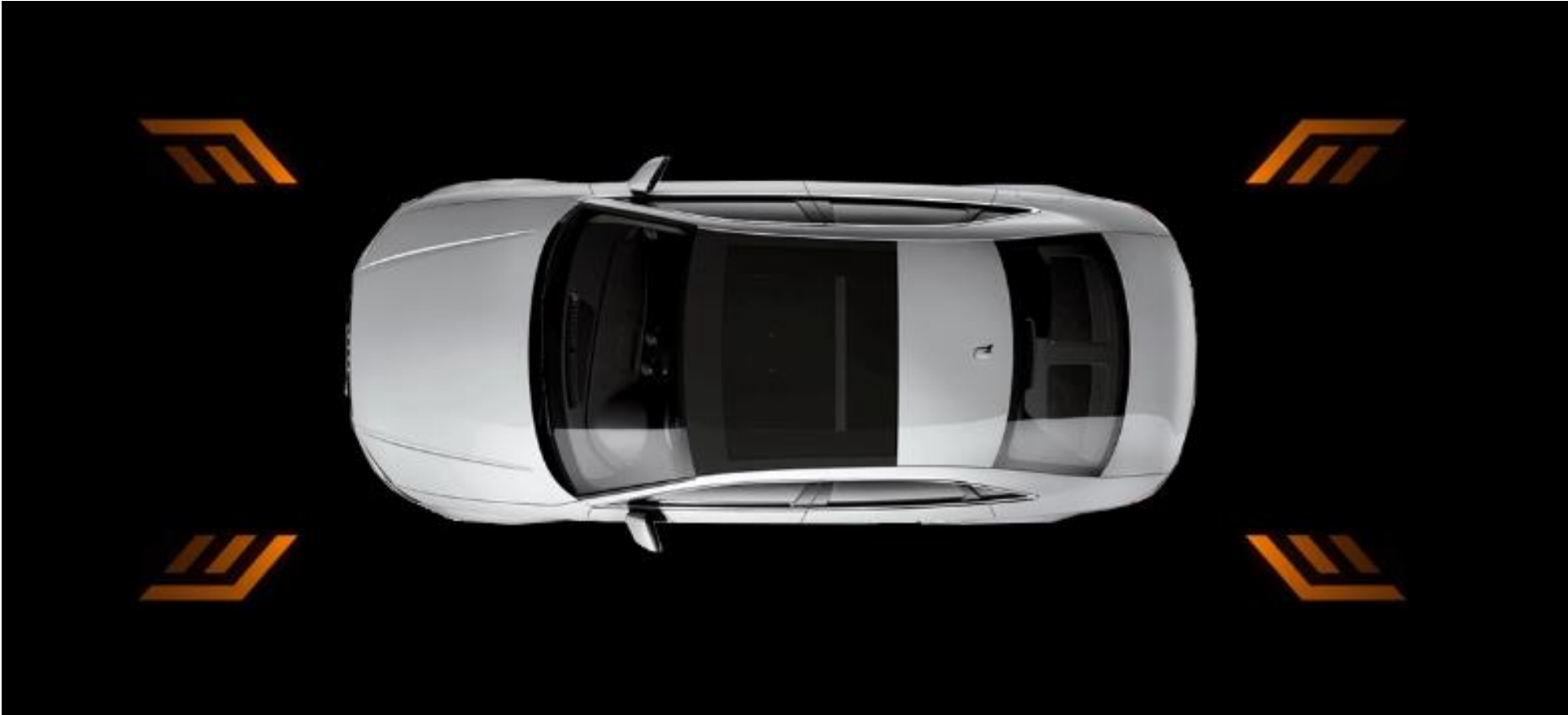
Free form high-speed dicing



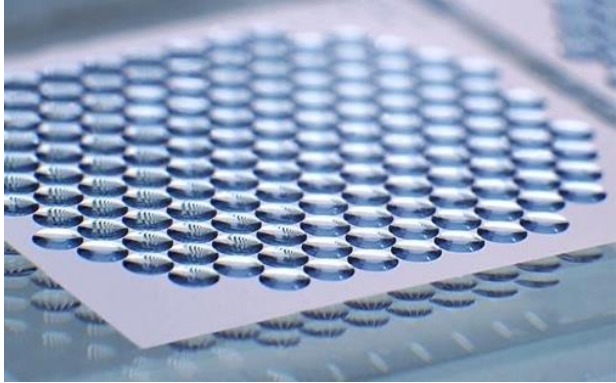
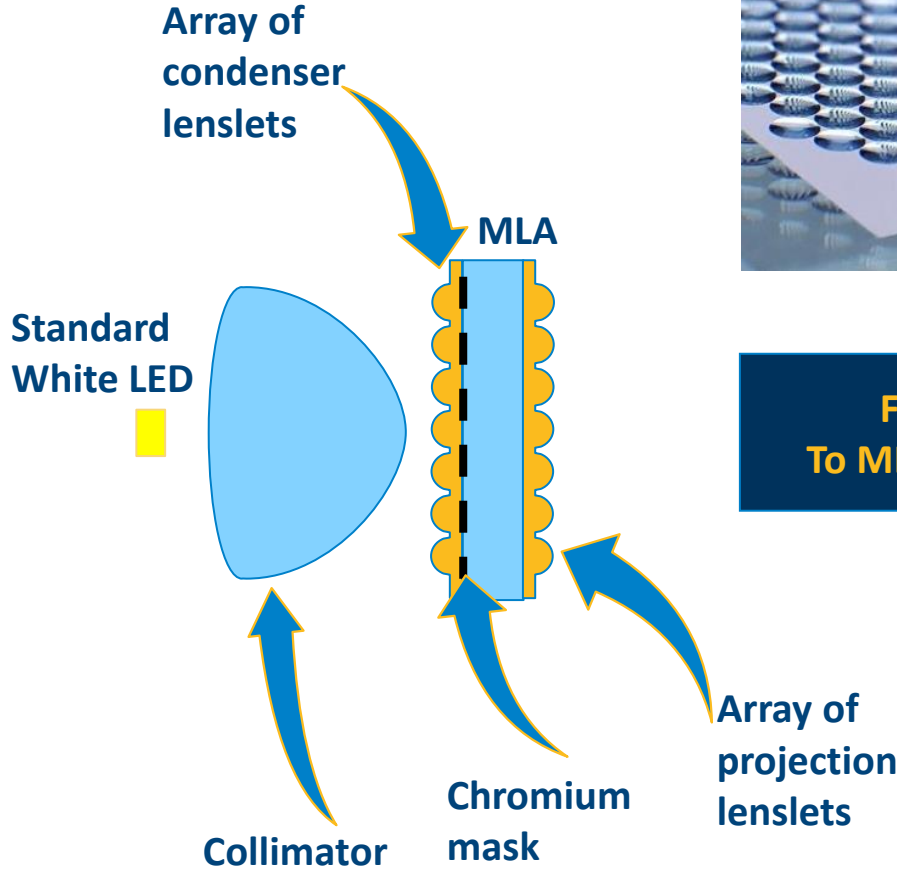
Larger square wafers



THE NEXT BIG THING: SAFETY WITH LIGHT

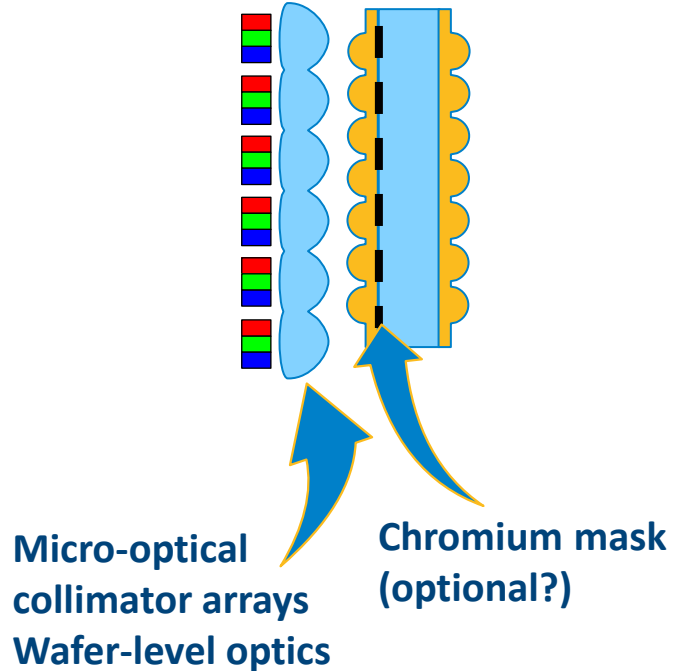


HOW MICRO-OPTICS CAN HELP MICROLEDS



From "classical" MLA
To MLA-enhanced MicroLEDs

MicroLED Array with integrated microoptics



Thank you!



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