

Mirco-Optics Summit 2024

Enhancing Photonic Devices with Precision Nano Imprint Lithography

Thomas Achleitner | Business Development

The banner features a blue background with glowing, translucent spheres. An orange and brown abstract shape on the right contains the text 'Bringing together the full value chain for micro-optics'. The bottom of the banner has an orange bar with the event details.

Micro-optics
SUMMIT & EXPO

Bringing together
the full value chain
for micro-optics

2-3 December 2024 in Amsterdam (NL)
Micro-Optics Summit & Expo

Leading supplier of wafer processing equipment for the nanotechnology, MEMS and semiconductor markets

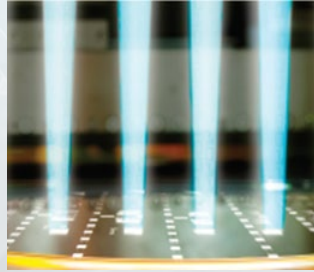
Founded in 1980 by DI Erich and Aya Maria Thalner. More than 1400 employees worldwide

Headquarters in Austria, with fully owned subsidiaries in the USA, Japan, South Korea, China and Taiwan

Recent Developments



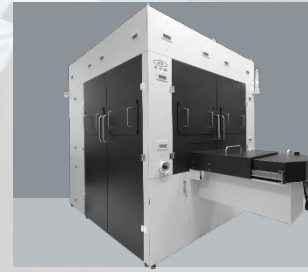
GEMINI® FB
Hybrid Bonding



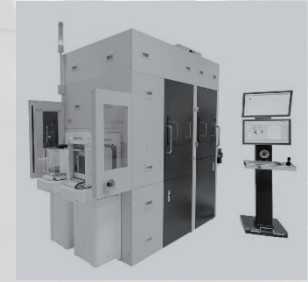
EVG® MLE™
Maskless Exposure
Technology



EVG® HERCULES® NIL
SmartNIL® HVM
Up to 300 mm



EVG® 770 NT
S&R NIL System

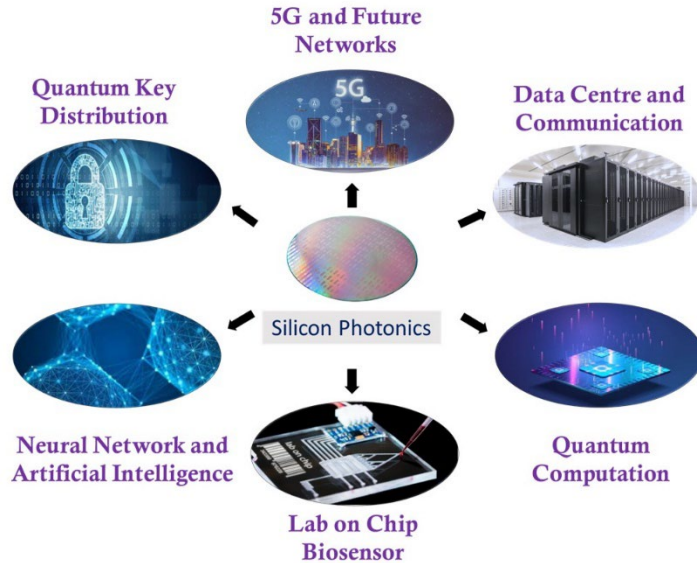


EVG® 7300
SmartNIL® and WLO
Up to 300 mm

Nanoimprint Lithography (NIL) Developments

Si Photonics | Introduction and Applications

- Photonics = science of generating, manipulating and detecting light ... crucial in optical communications
- Si Photonics is a material platform from which photonic integrated circuits (PICs) can be made
- SOI wafers are typically used, most of standard CMOS foundry manufacturing processes can be applied → Cost effective mass production of SiPh devices



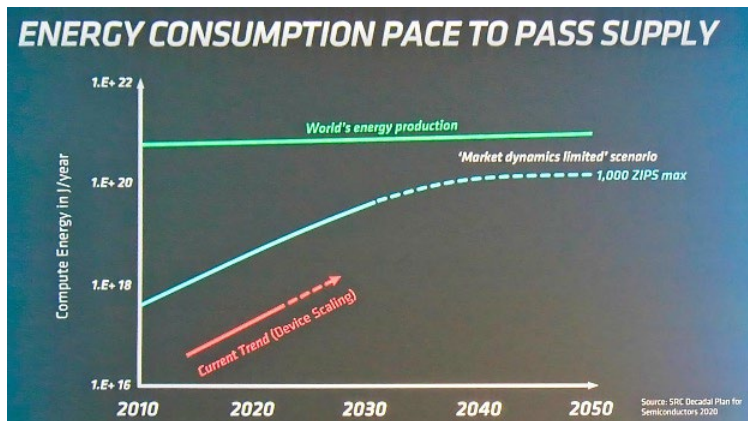
Source: Centre for Programmable Photonic Integrated Circuits and Systems

→ Rapid growth of SiPh is expected over the next years

→ All applications are in need of advanced / new manufacturing technologies for light management as a supplement to the existing and known advanced capabilities of semiconductor technology

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Datacenter interconnect applications: growing demand for high bandwidth while maintaining low power consumption & package footprint

Key Components

Light source → laser

- Optical source on Si remains challenge → hybrid co-integration with III-V materials

Guide

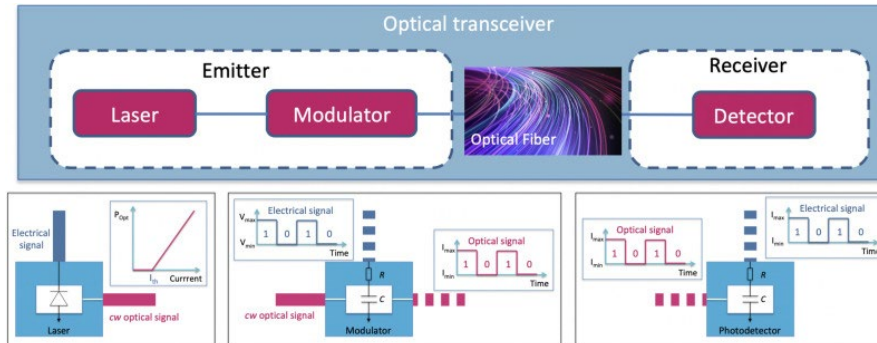
- Interconnects between photonic devices in the circuit → waveguides
- Device to device connection
- External connection

Modulate / Manipulate

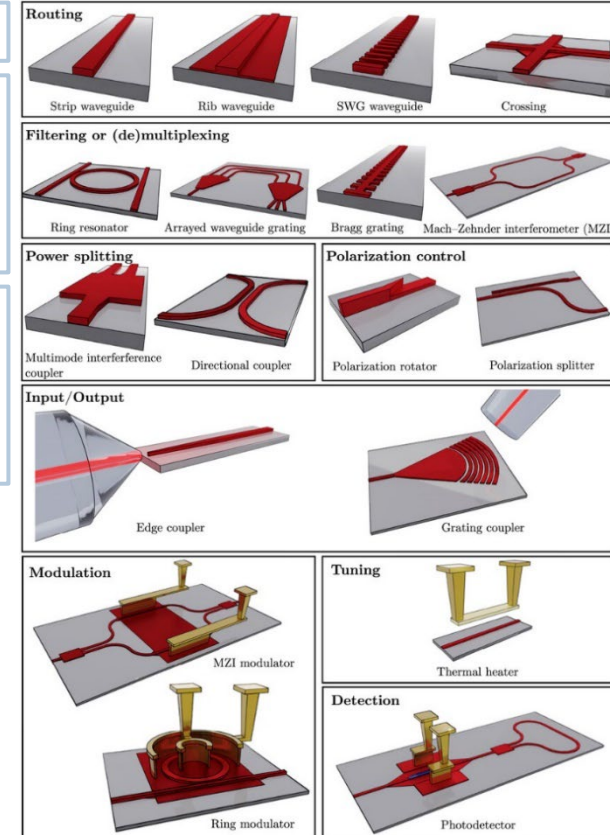
- Laser light is modulated by a high-speed electrical signal
- Altering characteristics of a light wave in response to external signal
- Filtering / splitting of signals / polarisation

Detect

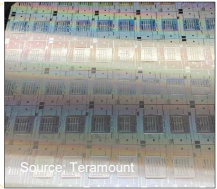
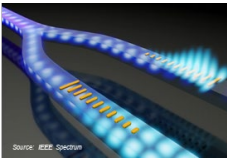
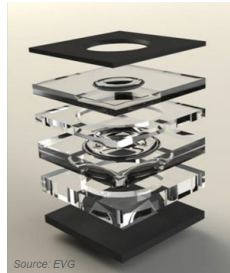
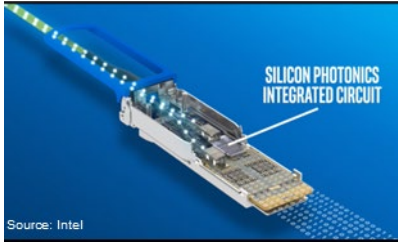
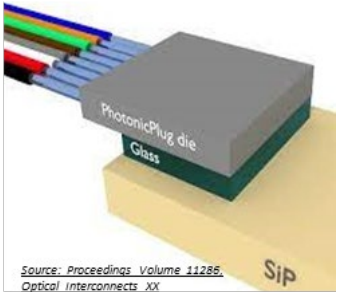
- Photodetectors convert incoming light into electrical signals



Source: Building blocks of silicon photonics, DOI:10.1016/BS.SEMSEM.2019.07.006

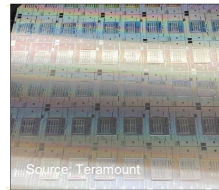
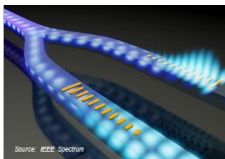
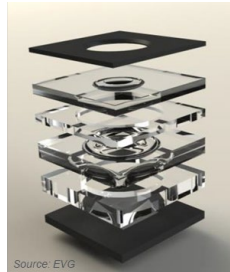
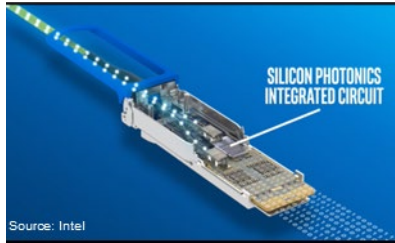
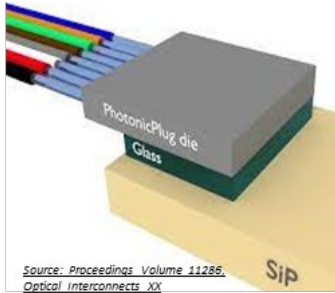


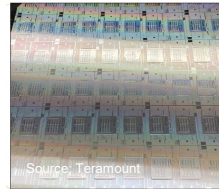
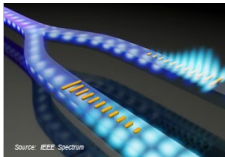
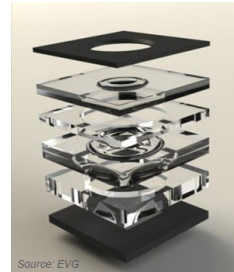
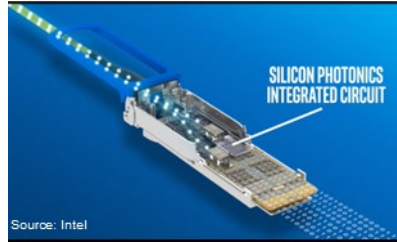
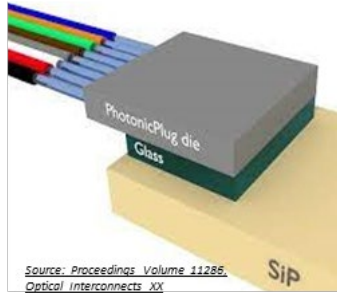
Source: Scaling capacity of fiber-optic transmission systems via silicon photonics, DOI:10.1515/nanoph-2020-0309



➤ Technology

- Structuring and patterning of arbitrary geometrical shapes
- High resolution from easy to complex shapes (e.g. lenses, gratings, slopes, slants, various orientations, ...)
- Repeatable fidelity all over the required area
- Scalable from small area to larger area and from low volume to large volume
- Dedicated material properties



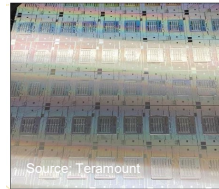
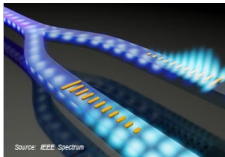
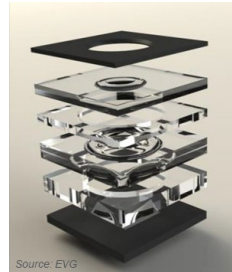
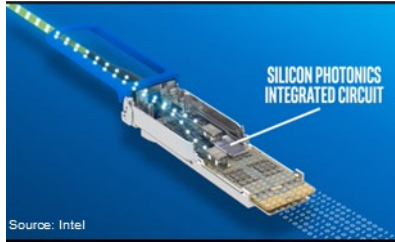
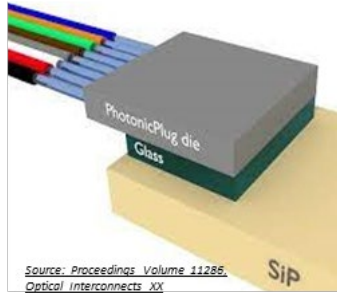


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- Std. semiconductor chain compliant
- Structuring of functional wafers / full area & selective area
- Precise alignment accuracy
- Residual layer control



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Required Know-how

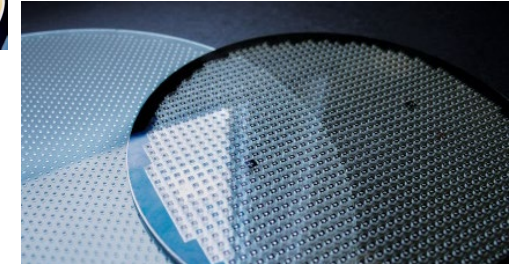
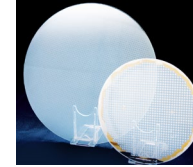
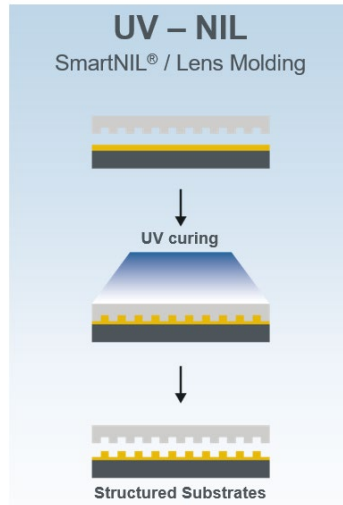
**Material
Equipment
Process**

Nano Imprint Lithography (NIL) | Focus Topic



NIL is a cost-effective and flexible technology to enable nanostructured surfaces as well microstructures on wafer-level

- Volume-proven replication technology (= imprinting)
- Parallel processing of hundreds or thousands of micro- and nanostructures
- High degree of flexibility on replicable structures on substrates

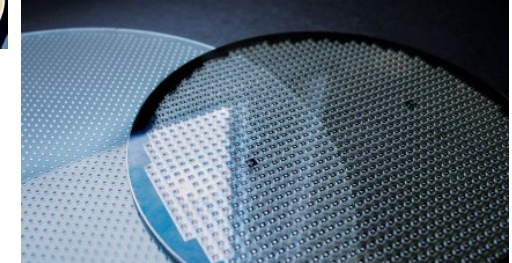
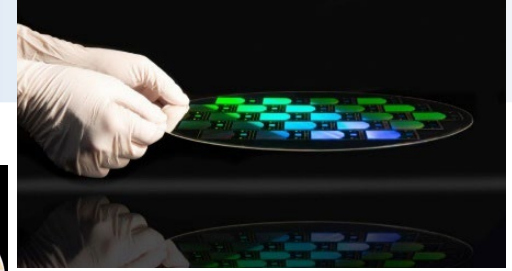
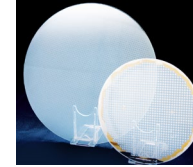


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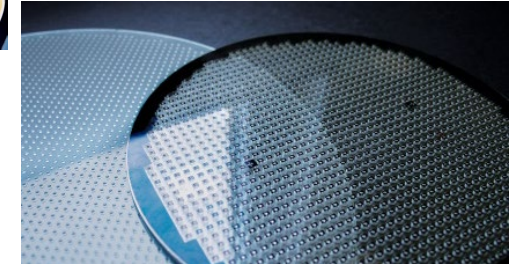
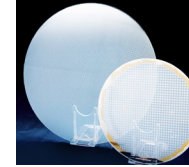


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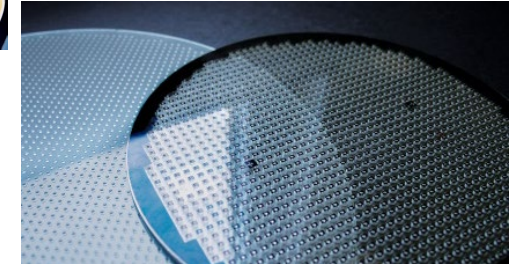
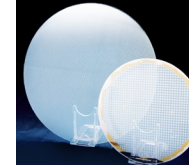
- **Design** → Close collaboration with master suppliers

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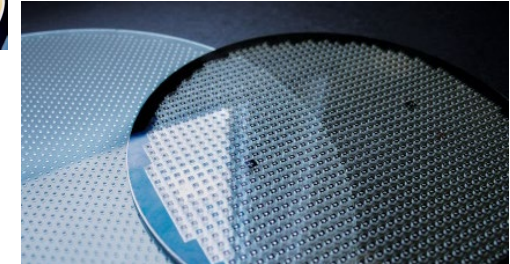
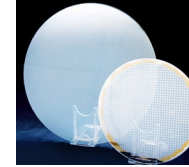
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• **Process**

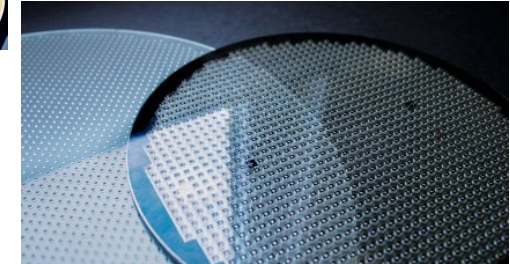
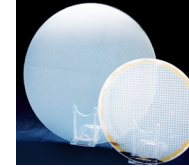


- Step-and-Repeat Mastering
- SmartNIL®
- Lens Molding / Wafer Level Optics
- Lens Stacking



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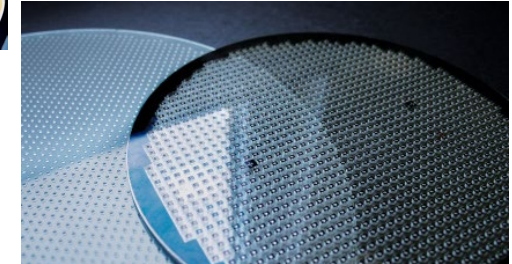
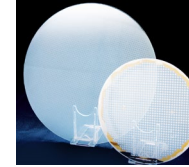
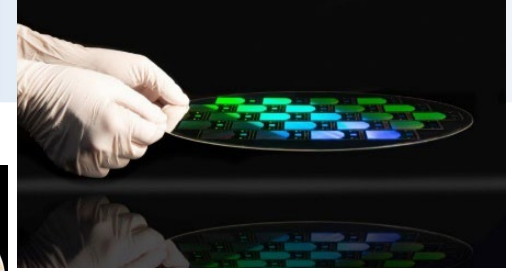
• **Equipment**

- Tools from R&D to fully automated HVM



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• **Equipment**

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NIL Photonics Competence Center → Innovation Incubator

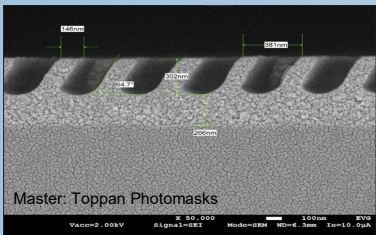
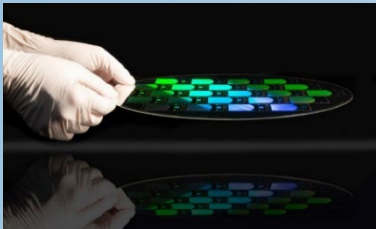
- Helping to ramp up
- Access to available network and ecosystem

Application

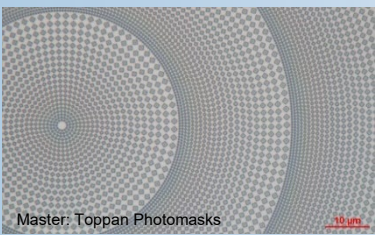
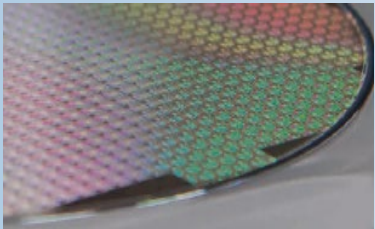
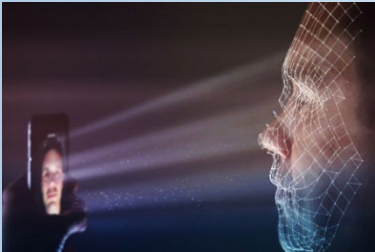
Wafer

Structures

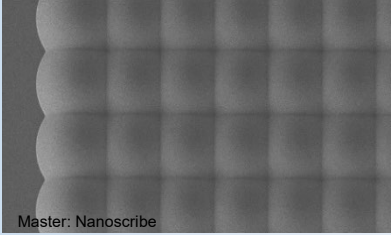
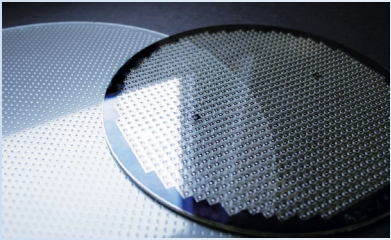
Displays & Augmented Reality



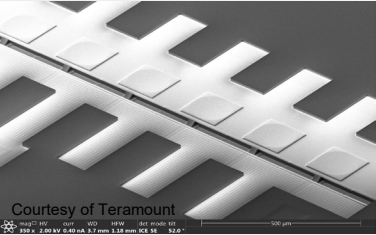
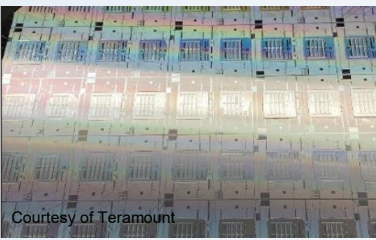
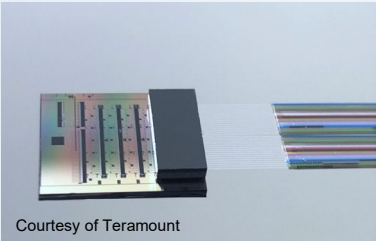
Sensors & Wafer Level Optics



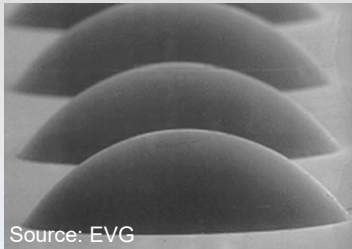
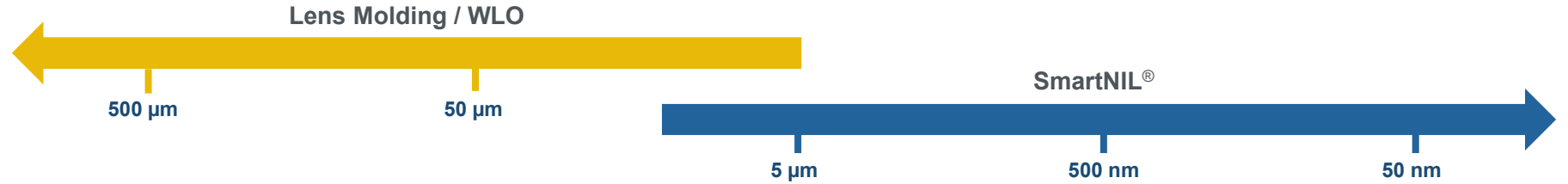
Automotive & LiDAR



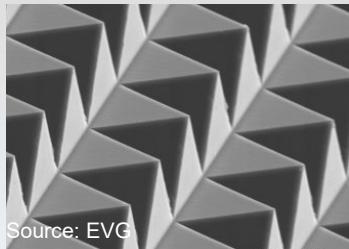
Silicon Photonics / PIC



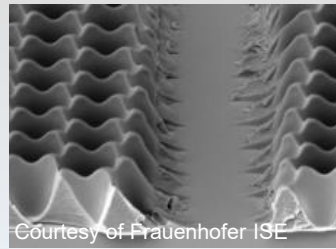
Nano Imprint Lithography | Resolution



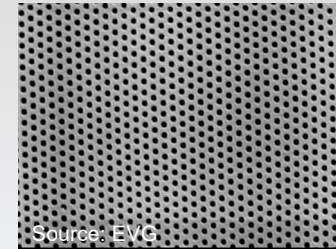
Lenses
[300 μm]



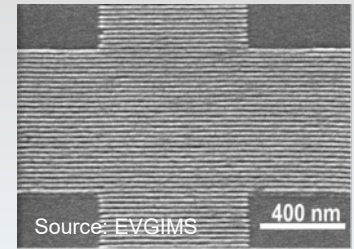
Pyramidal Structures
[50 μm]



3D Anti reflective Structures [7 μm]



Photonic Crystal
[350 nm]



High Resolution Imprinting
[12.5 nm]

Nano Imprint Lithography | Process Flow Example

Working stamp
fabrication

Master Wafer



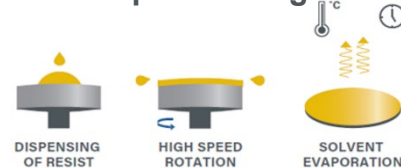
Working stamp fabrication



Re-usable
Working Stamp



Spin Coating



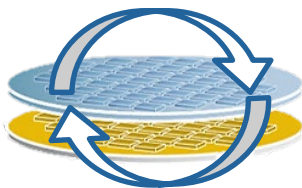
Imprinting
Process

HERCULES® NIL
EVG® 7xxx

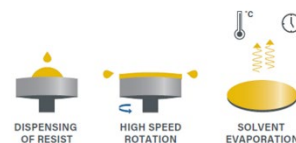


Multiple Imprints

Imprinting Process

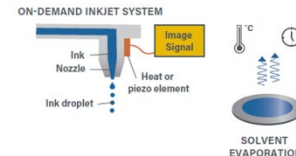


Spin Coating



1a) Spin coating

Ink Jet Coating

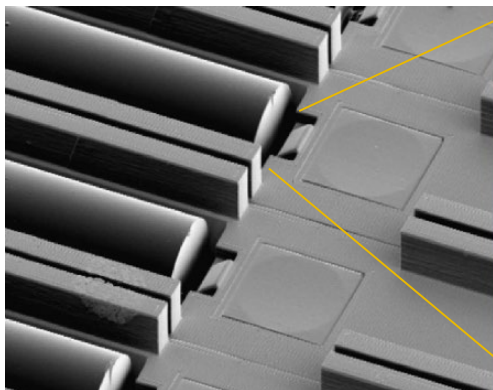
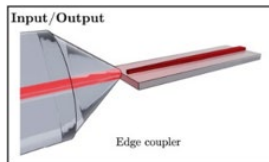


1b) Ink jet coating

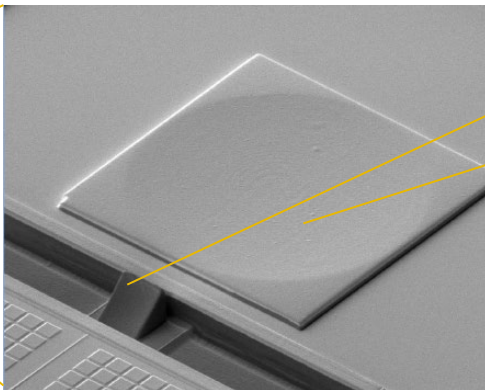
Bridging the gap in SiPh packaging towards wafer level HVM

Teramonts PhotonicPlug und PhotonicBump: Done by NIL

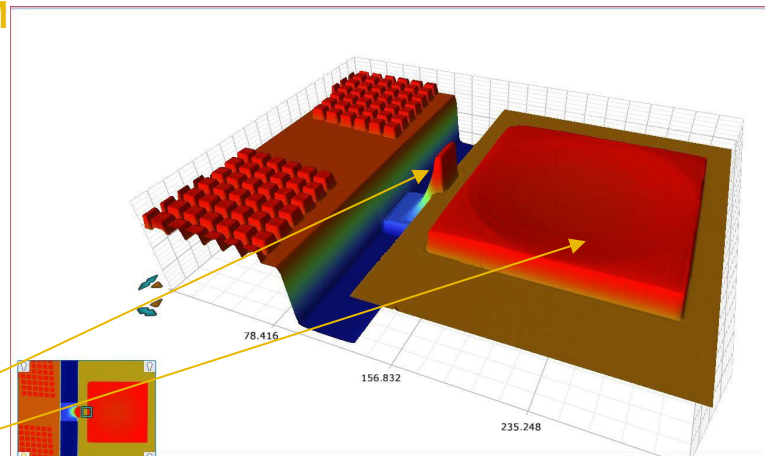
- Imprint inside a 20 μ m trench (imprint in deep cavities)
- In combination with v-grooves fiber assembly
- Fiber trenches perfectly aligned to the mirrors



PhotonicPlug fiber connector

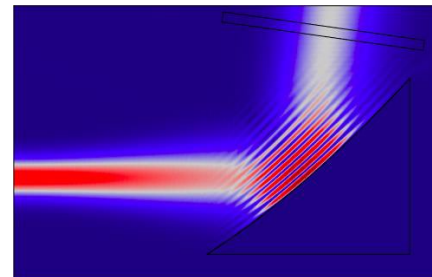


PhotonicBump: Beam expansion mirror and deflector/mode-match mirror



PhotonicBump imprint on a SiPh wafer at accurate placement relative to waveguide channel

Mode conversion deflector



Ideally suited for photonics industry, where light-matter interaction relies largely on shape and geometry

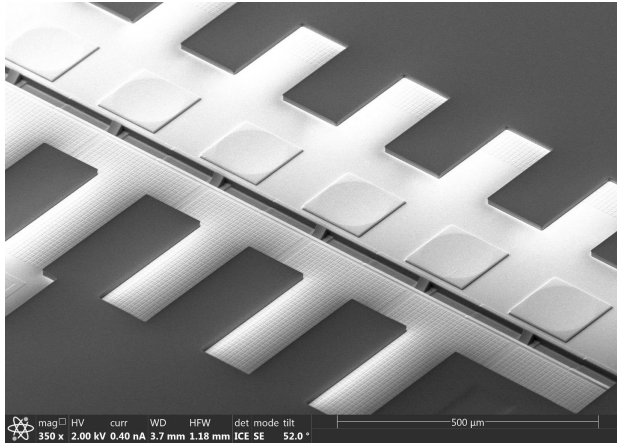
Bridging the gap in SiPh packaging towards wafer level HVM

Teramounts PhotonicPlug und PhotonicBump: Done by NIL

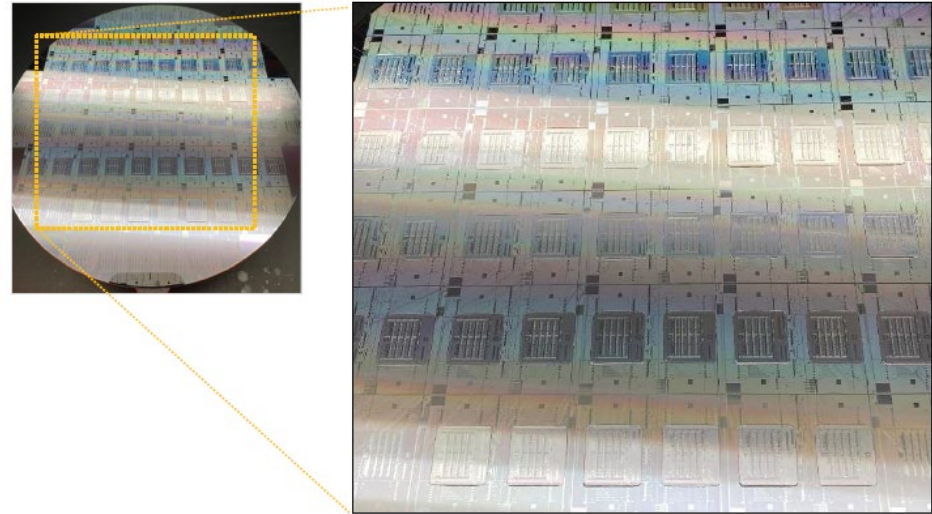
→ Imprinted complex optical microstructures (e.g. lenses or mirrors) on SiPh wafers

Important

- Pattern fidelity and repeatable → optical functionality of shape
- Highest alignment accuracy → matching to device wafer
- Residual layer control → thin and uniform
- Material → specific optical properties



WLO for wide-band surface coupling, mode conversion and wafer level inspection.



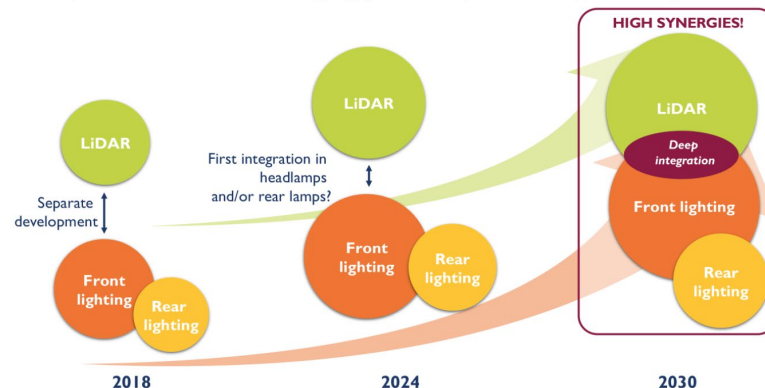
PhotonicBump – Imprint inside 20μm on 8" SiPh wafer

➔ Miniaturization needed to meet integration requirements from roadmap



Possible synergies between LiDAR and lighting for ADAS* vehicles

(Source: Automotive Advanced Front-Lighting Systems 2019 report, Yole Développement, 2019)



*Advanced Driver-assistance Systems

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Développement

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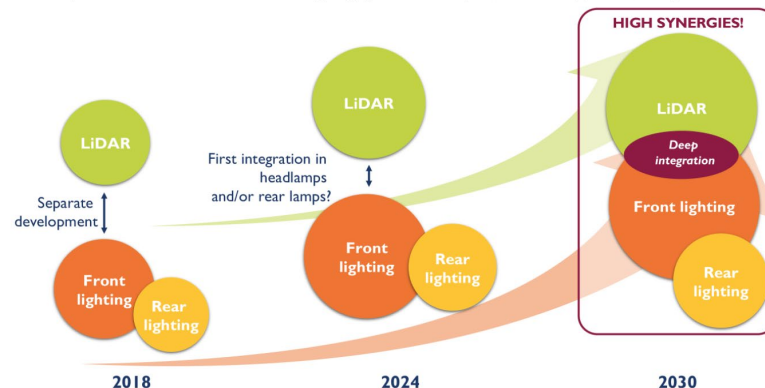
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Automotive
Seeking for new manufacturing possibilities, enhanced functionalities, ..

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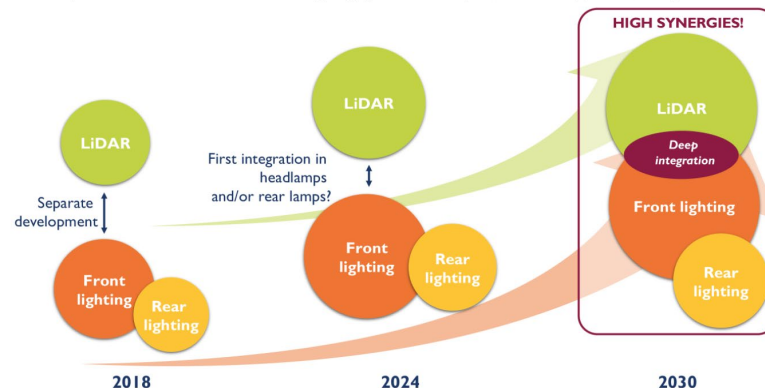


Automotive
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Semiconductor
Wafer level based, miniaturizing, cost-effectiveness

Possible synergies between LiDAR and lighting for ADAS* vehicles

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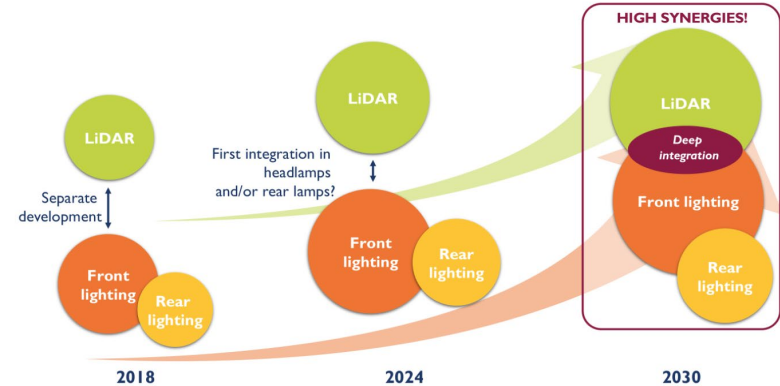
Source: <https://www.carscoops.com/>

EVG NIL
Tools, Process
Development, Support, ..

Automotive  **Semiconductor**
Seeking for new manufacturing possibilities, enhanced functionalities, ..
Wafer level based, miniaturizing, cost-effectiveness

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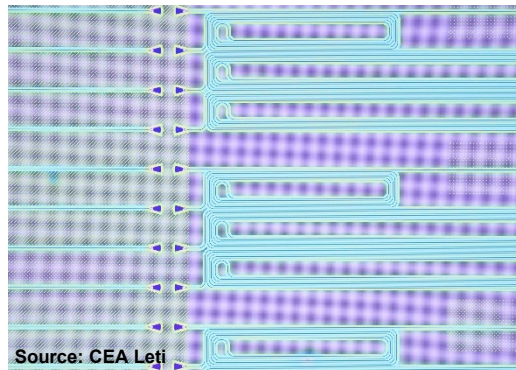
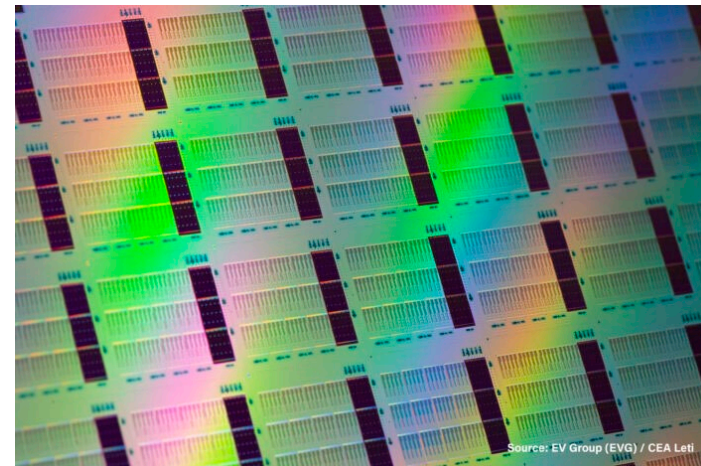
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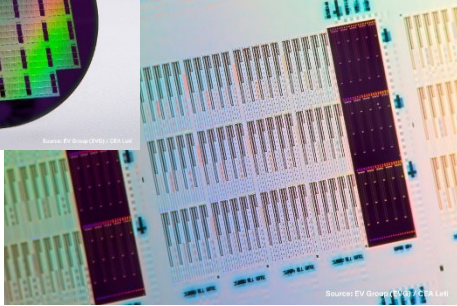
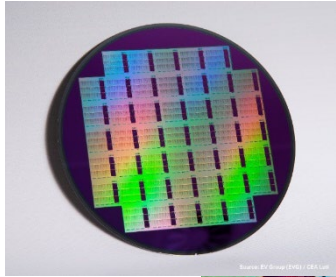


EU Project: TINKER

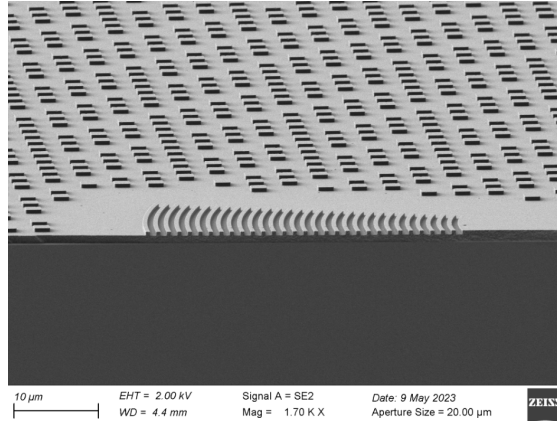
- Development received funding from the European Union's Horizon 2020 program

Light Guide structures developed by **CEA Leti**
Part of the sensors to be integrated into **Marelli's** smart headlight lamp

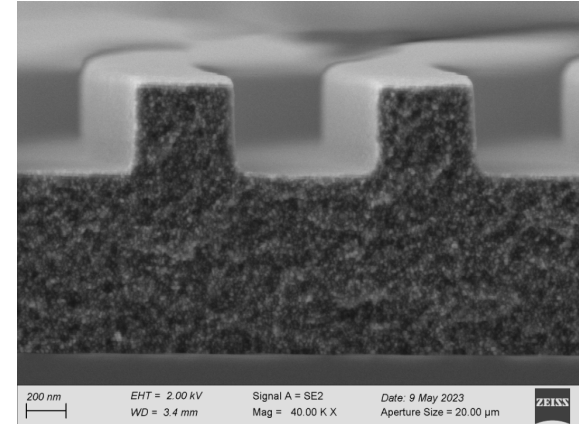




Waveguides on wafer



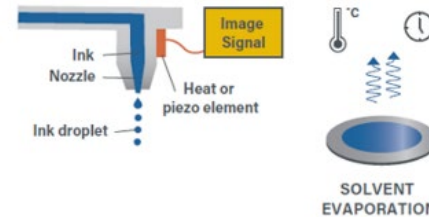
Waveguide gratings



Waveguide structures

- Direct imprinting into high refractive index material
- Complex in- and outcouple gratings possible

Inkjet coating → structuring only dedicated areas on the wafer



Waveguides manufactured by SmartNIL[®] and inkjet coated high refractive index material

A large, light gray outline of a house with a chimney on the right side of the roof. The text and list are contained within the house's footprint.

**“All in one cleanroom”
Competence Center at EVG HQ**

- R&D and HVM NIL Tools
- S&R Mastering Service
- R&D and Process Development
- Customer Sampling and Demo
- Pilot Line Production
- Supplier Guidance (e.g. Materials, Masters, Substrates)
- Metrology Infrastructure

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Over 1.300 m²
cleanroom area (class
10 – 100) and
application labs



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Cleanroom space for
rent → quick
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High quality
standards, ISO
certified, full
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Helping customers to ramp up their ideas!

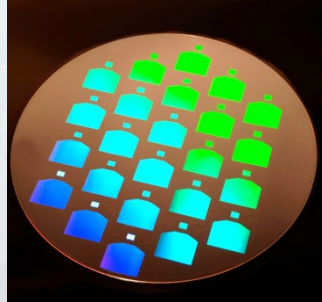
NILPhotonics® Competence Center – A smart way to collaborate for success

Establish decisive manufacturing steps in close collaboration with process and equipment experts

Bridging the gap between photonics R&D and volume manufacturing



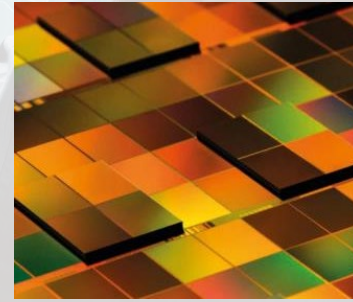
Wafer Level Optics & Photonics Packaging



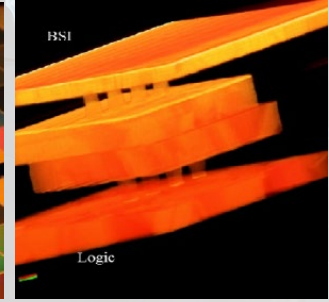
Nanoimprint & S&R Mastering



Advanced Resist Processing



Heterogeneous Integration



3D Integration & Hybrid Bonding

Thank you!

Thomas Achleitner, Business Development Manager



May 2022

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