

EPIC Technology Meeting on Photonic Integration and Packaging

Advances in PIC Manufacturing for Sensing and Datacom Applications – All thanks to Nano Imprinting Lithography

Thomas Achleitner | Business Development



4-5 June 2024. Berlin, Germany

EPIC Technology Meeting on
Photonic Integration and Packaging at Fraunhofer IZM



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

Founded in 1980 by DI Erich and Aya Maria Thallner. More than 1300 employees worldwide

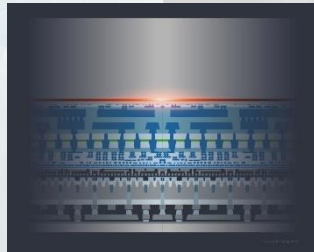
Headquarters in Austria, with fully owned subsidiaries in the USA, Japan, South Korea, China and Taiwan

Recent Developments



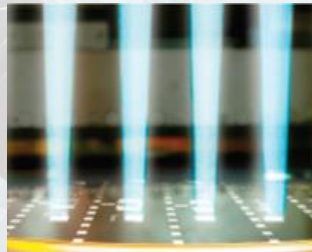
EVG® GEMINI® FB
SmartView® NT3

Hybrid Bonding



EVG® 880 DB

LayerRelease™



EVG® Lithoscale
Maskless Exposure Technology

Back-end Lithography



EVG® HERCULES® NIL
SmartNIL® HVM

Nanoimprint Lithography



EVG® 7300
SmartNIL® and WLO

Nanoimprint Lithography

Key Components

Light source → laser

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

Guide

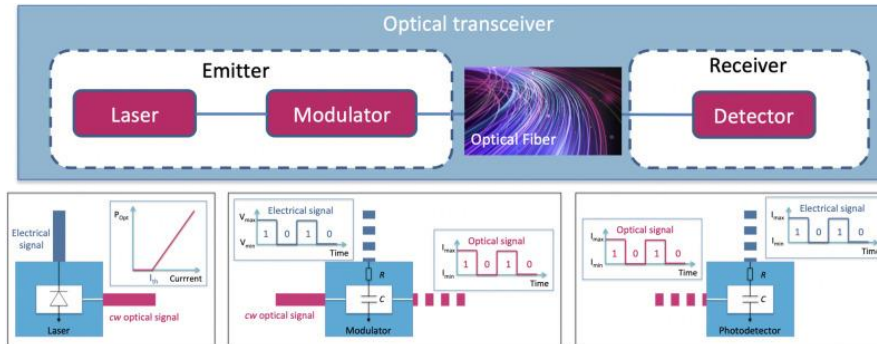
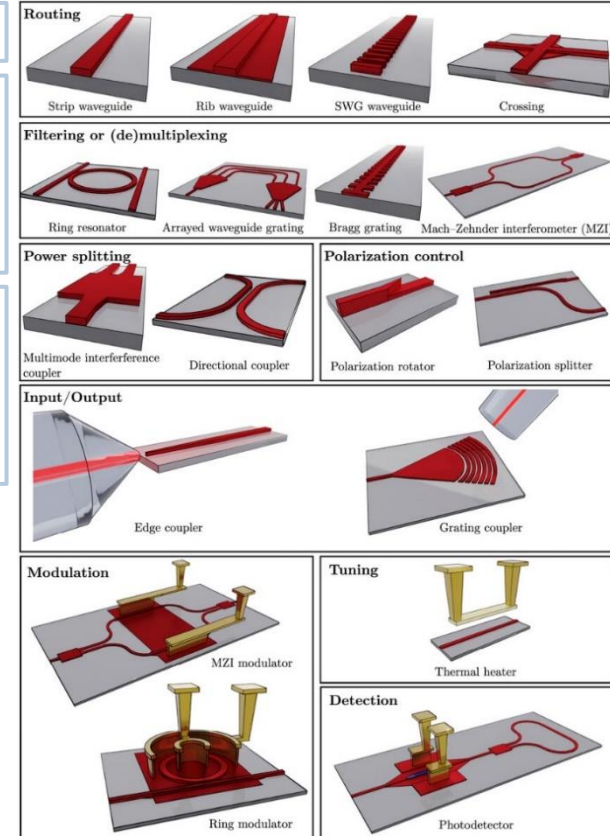
- Interconnects between photonic devices in the circuit → waveguides
- Device to device connection
- External connection

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

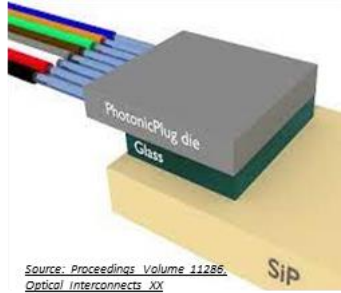
- Photodetectors convert incoming light into electrical signals



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

PIC Manufacturing and Packaging | Requirements



Source: Proceedings Volume 11285, Optical Interconnects XX



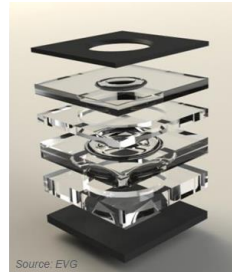
Source: Intel

➤ Technology

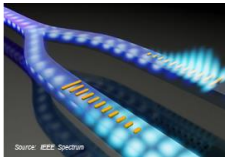
- Structuring and patterning of arbitrary geometrical shapes
- High resolution from easy to complex shapes (e.g. lenses, gratings, slopes, slants, various orientations, ...)
- Repeatable fidelity all over the required area
- Scalable from small area to larger area and from low volume to large volume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

➤ Integration

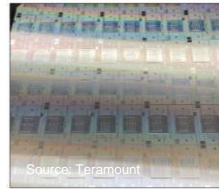
- Std. semiconductor chain compliant
- Structuring of functional wafers / full area & selective area
- Precise alignment accuracy
- Residual layer control



Source: EVG



Source: IEEE Spectrum



Source: Teramont

Required Know-how

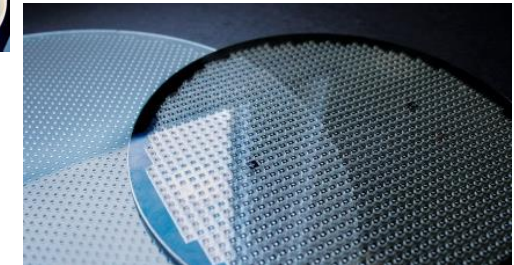
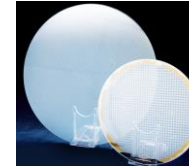
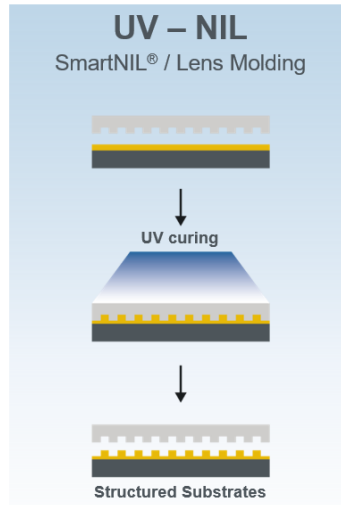
**Material
Equipment
Process**

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 an substrates

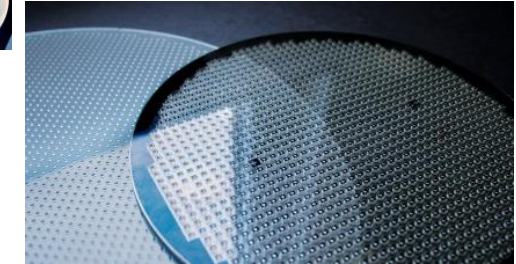
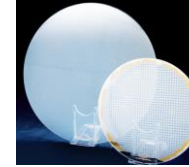


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NIL Infrastructure / Ecosystem



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



• **Material** → Strong partnership with material vendors



• **Process**

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



• **Equipment**

- Tools from R&D to fully automated HVM



NIL Photonics Competence Center → Innovation Incubator

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

Nano Imprint Lithography | Structure Examples

Diffractive Optical Elements

Holographic Optical Elements

Waveguides

Light Coupling / Optical Gratings

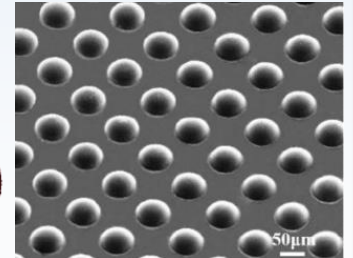
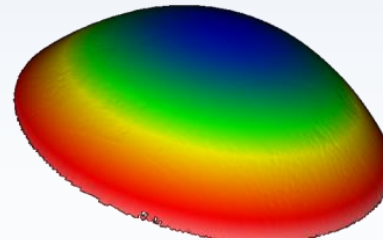
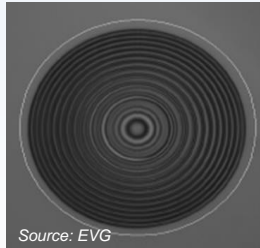
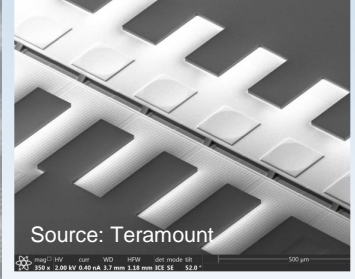
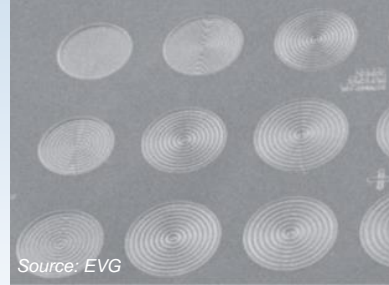
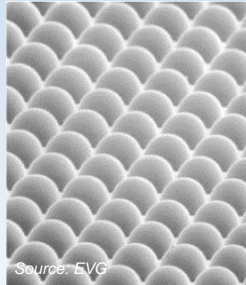
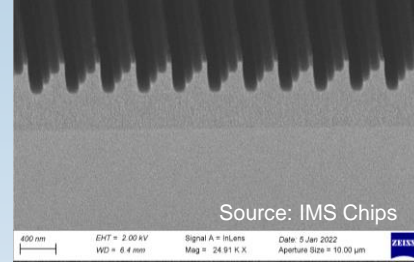
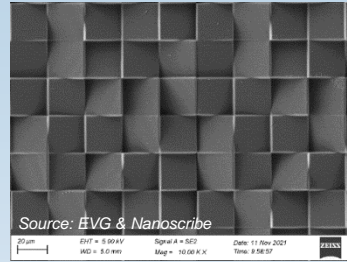
Diffusor Optics

Lenses & Micro Lens Arrays

Mirror & Deflectors

Anti Reflective Structures

Plasmonic & Photonic Structures



Arbitrary Structures

Nano Imprint Lithography | Resolution



Lens Molding / WLO



500 μm

50 μm

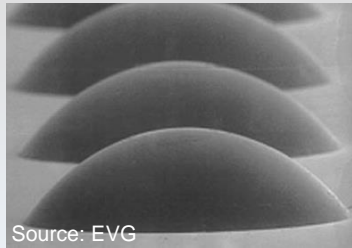
SmartNIL[®]



5 μm

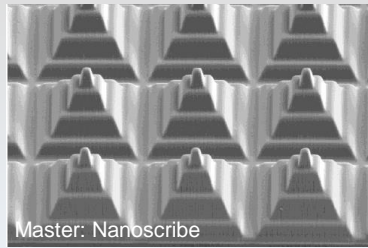
500 nm

50 nm



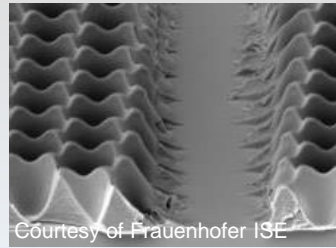
Source: EVG

Lenses
[300 μm]



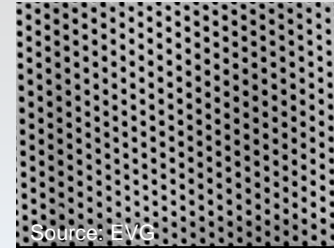
Master: Nanoscribe

Pyramidal Structures
[50 μm]



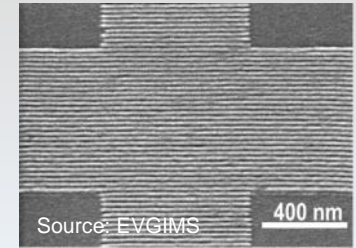
Courtesy of Fraunhofer ISE

3D Anti reflective Structures [7 μm]



Source: EVG

Photonic Crystal
[350 nm]



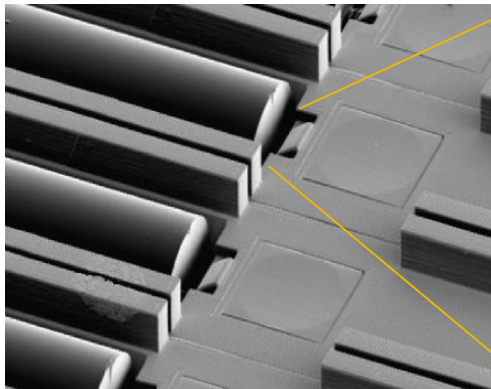
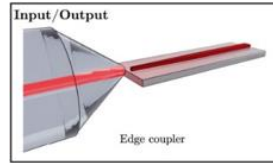
Source: EVGIMS

High Resolution Imprinting
[12.5 nm]

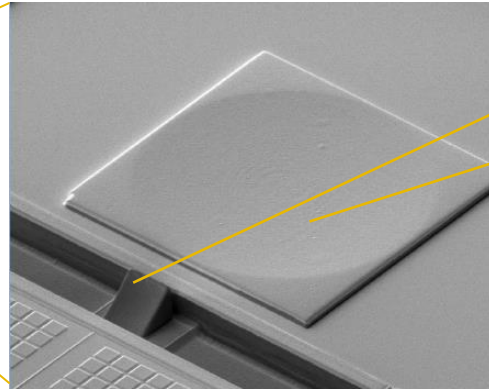
Bridging the gap in SiPh packaging towards wafer level HVM

Teramonts PhotonicPlug und PhotonicBump: Done by NIL

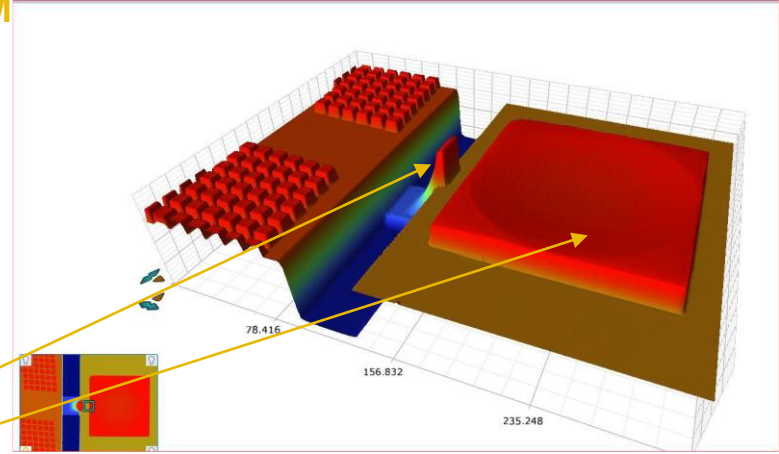
- Imprint inside a 20µm trench (imprint in deep cavities)
- In combination with v-grooves fiber assembly
- Fiber trenches perfectly aligned to the mirrors



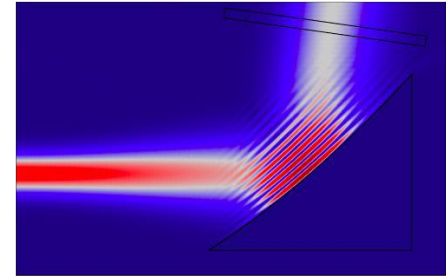
PhotonicPlug fiber connector



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

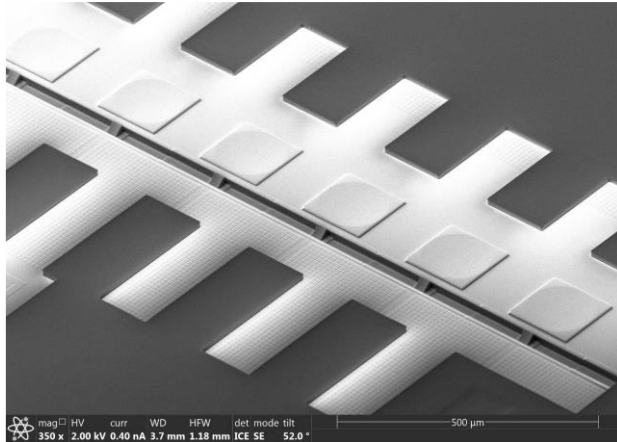
Bridging the gap in SiPh packaging towards wafer level HVM

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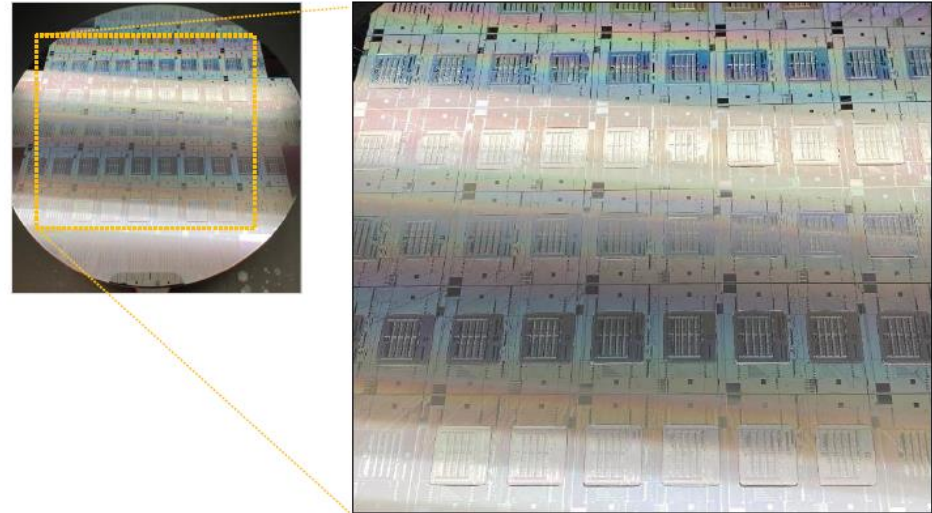
→ Imprinted complex optical microstructures (e.g. lenses or mirrors) on SiPh wafers

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



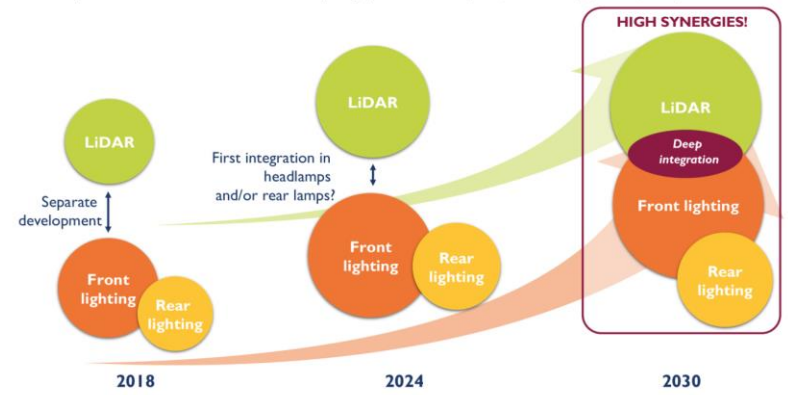
Source: <https://www.carscoops.com/>

EVG NIL
Tools, Process
Development, Support, ..

<u>Automotive</u>		<u>Semiconductor</u>
Seeking for new manufacturing possibilities, enhanced functionalities, ..		Wafer level based, miniaturizing, cost-effectiveness

Possible synergies between LiDAR and lighting for ADAS* vehicles

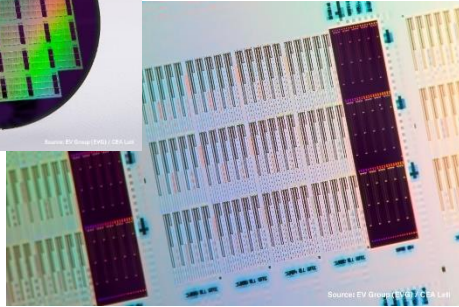
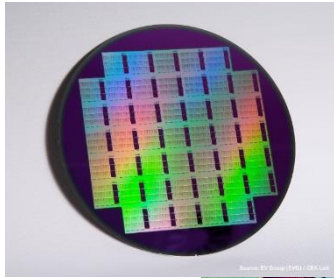
(Source: Automotive Advanced Front-Lighting Systems 2019 report, Yole Développement, 2019)



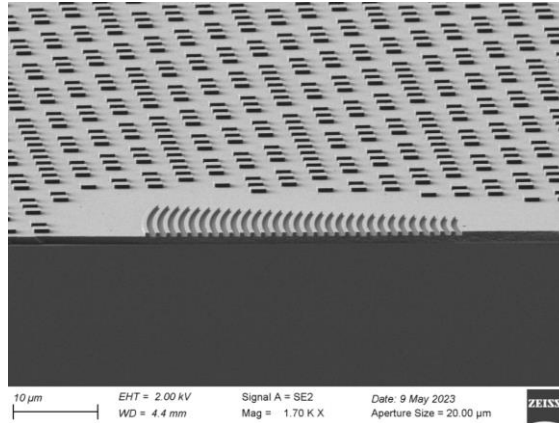
*Advanced Driver-assistance Systems



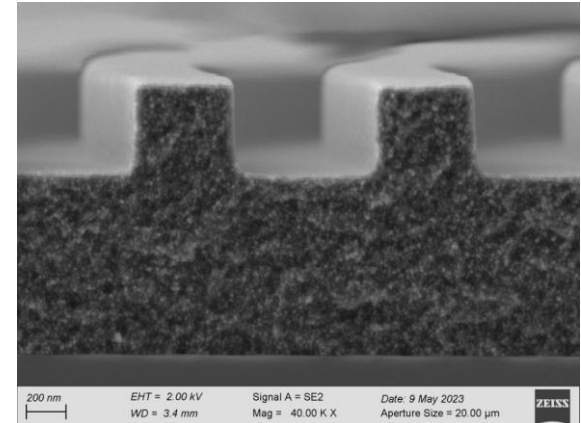
© 2020 | www.yole.fr - www.i-micronews.com



Waveguides on wafer



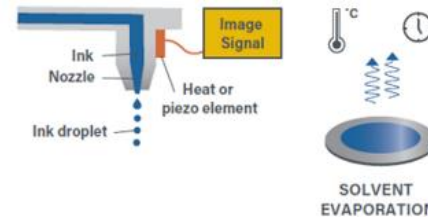
Waveguide gratings



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

**“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

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



Cleanroom space for
rent → quick
turnarounds



High quality
standards, ISO
certified, full
documentary and
reporting



Helping customers to ramp up their ideas!

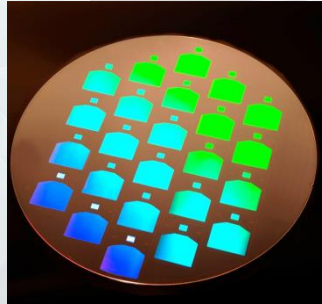
NILPhotonics® Competence Center – A smart way to collaborate for success

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

Bridging the gap between photonics R&D and volume manufacturing



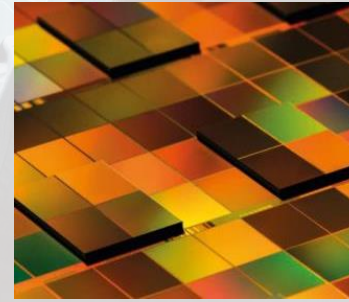
Wafer Level Optics & Photonics Packaging



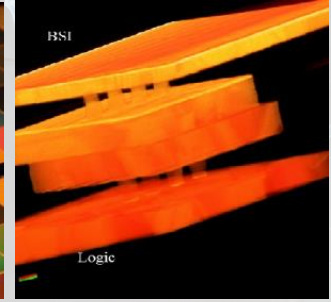
Nanoimprint & S&R Mastering



Advanced Resist Processing



Heterogeneous Integration



3D Integration & Hybrid Bonding

Thank you

Thomas Achleitner
Business Development

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