

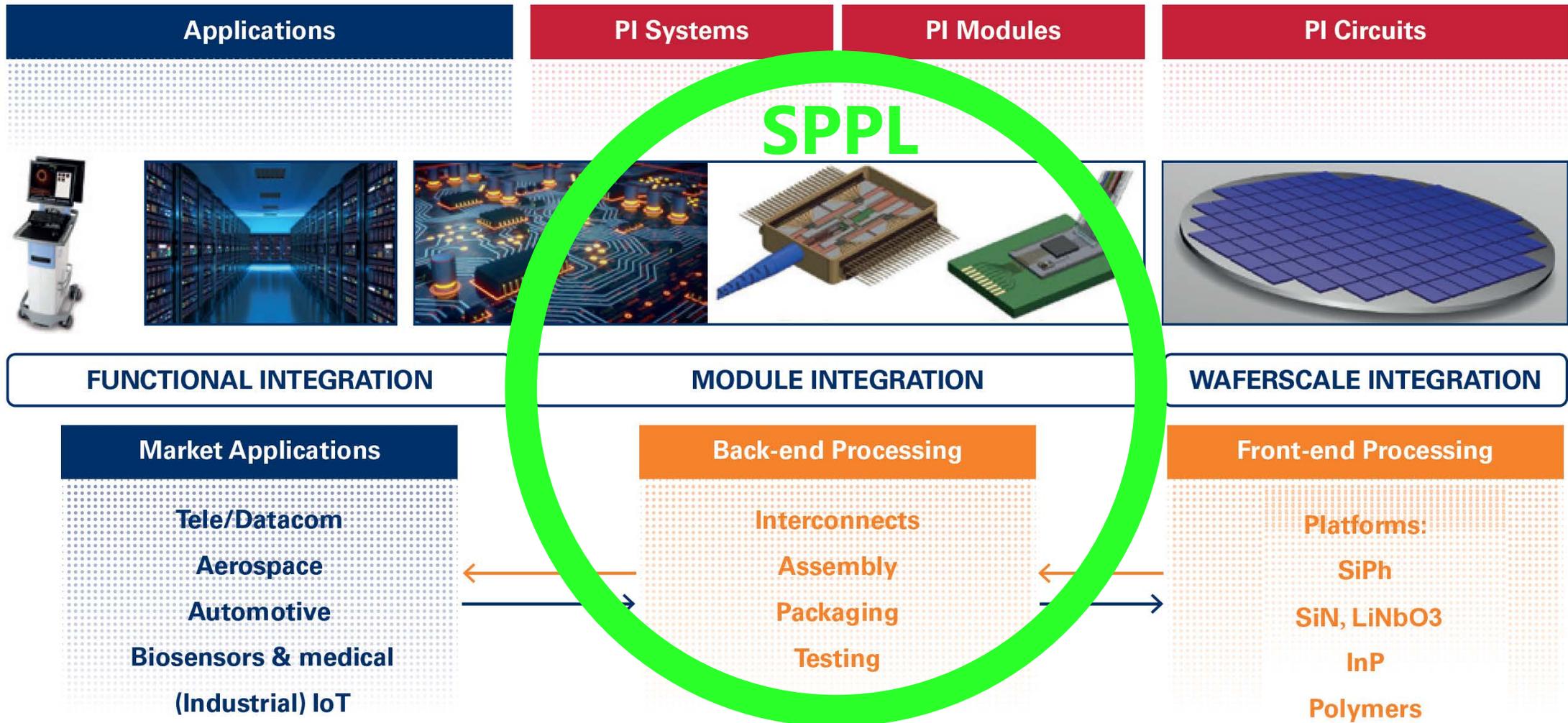
SPPL - **S**wiss **P**hotonics **P**ackaging **L**ab

Stefan Mohrdiek

Swissphotonics Lunch Chat Presentation

23. November 2021

SPPL vs. Basic Building Blocks in Photonic Integration



SPPL Mission & Main Services

**One-stop shop contact to serve and support the Swiss industry, especially SMEs,
in the field of photonics packaging and related joining technologies**

Services

- Development and integration of micro-optical, micro-mechanical and electronic systems into self-contained **packages**
- **Interfacing** with external electronics, optical fibers and waveguides
- **Assembly** process developments on micrometer scale
- **Custom-designed solutions** in general, and in particular the field of **joining**

Who are we ?

EMPA: Laboratory Joining Technologies and Corrosion in Dübendorf

Lars P. H. Jeurgens, Jolanta Janczak-Rusch



OST-IMP: University of applied sciences OST with the institute for microtechnology and photonics in Buchs

Dietmar Bertsch, Tobias Lamprecht



CSEM: Functional Packaging @ Center Alpnach & beyond

Stefan Mohrdiek



Swissphotonics: Networking platform

Christoph Harder, Christian Bosshard



Each individual partner offers unique technologies beyond the scope of SPPL

SPPL is open to additional partners

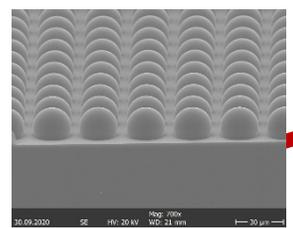


Compact System

Value chain in photonic integration

Value chain ↑

Single Component



PIC

Monolithic Integration

Tuneable InP multisection Laser
Reference: Bookham

Heterogeneous Integration

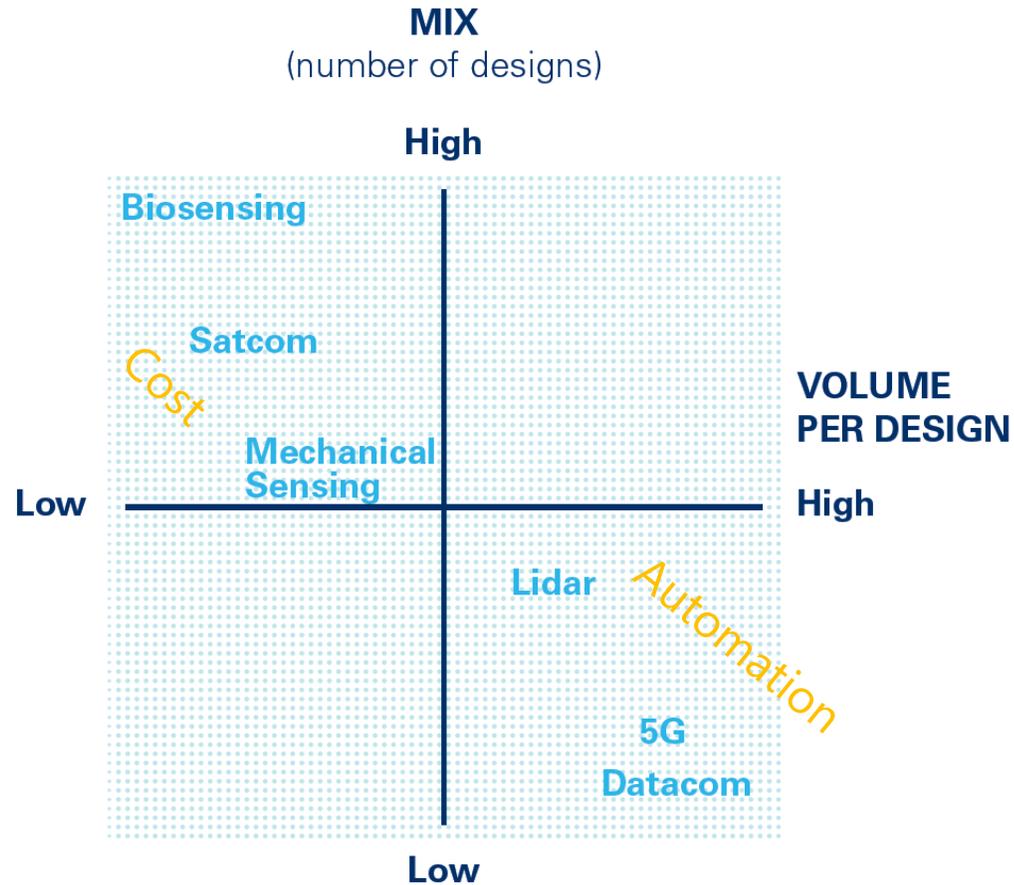
DFB laser on Si substrate with waveguide
Reference : UGent

SPPL Hybrid Integration

PIC on microbench in package with optical fiber and peltier cooler

Functionality →

General considerations of different markets



- Low(er) volumes
 - Small batches with high design mix
 - Typically, higher added value
 - The cost for development and prototyping becomes critical
- High volume (big data market)
 - Fueled by social media companies such as Google, Facebook, Microsoft, Amazon etc.
 - Mainly challenged to get production cost down
 - Cost reduction: Large volumes allow for fully automated processes & hence best economy

Trends – Common challenges in photonic integration

Heterogeneous/Hybrid integration is key element to drive new technologies and scientific advances for the next decade

- ❖ Large diversity of material platforms
Si, SiN, InP, GaAs, polymers
- ❖ Wavelengths ranging from UV to the far IR
- ❖ Multiple functionality: optical, electrical, fluidic, biological, thermal and mechanical aspects

A standardized technology requires substantial production volume for reaching a maturity and a strong market volume to become profitable

- Affordable, compact and hybrid packaging
- Assembly on micrometer scale
- Thermal management concepts
- Long term hermeticity
- Small footprint packages
- Packaging solutions for an increasing exposure of devices to an environment of higher temperature and humidity
- Towards wafer level packaging

Sources

Photonics21 Multiannual Strategic Roadmap 2021–2027, www.photonics21.org

Integrated Photonics Systems Roadmap (IPSR-I) 2020, www.photonicsmanufacturing.org

IEEE Electronics Packaging Society 2020, <https://eps.ieee.org/technology/heterogeneous-integration-roadmap>

Addressing the Photonic Ecosystem in Switzerland

- ❑ Switzerland is a leader in the development of novel photonic devices
- ❑ Such photonic devices need dedicated packaging, including mounting and advanced joining solutions for mechanical, electrical as well as optical interfaces.
- ❑ This is in most cases expensive and requires special skills, as there are currently hardly any standards in photonics packaging

- ❑ Difficult for SMEs to keep up with the rapidly developing opto-electronic and opto-mechanical miniaturization and integration
 - ❑ Usually due a lack of funding
 - ❑ Unawareness of recent progress of technology
 - ❑ Missing specialized know how

- ❑ SPPL helps closing this gap in order to increase international competitiveness of Swiss companies
- ❑ New products can be conceived by applying the sophisticated expertise of the packaging team partners

Partner Presentation EMPA

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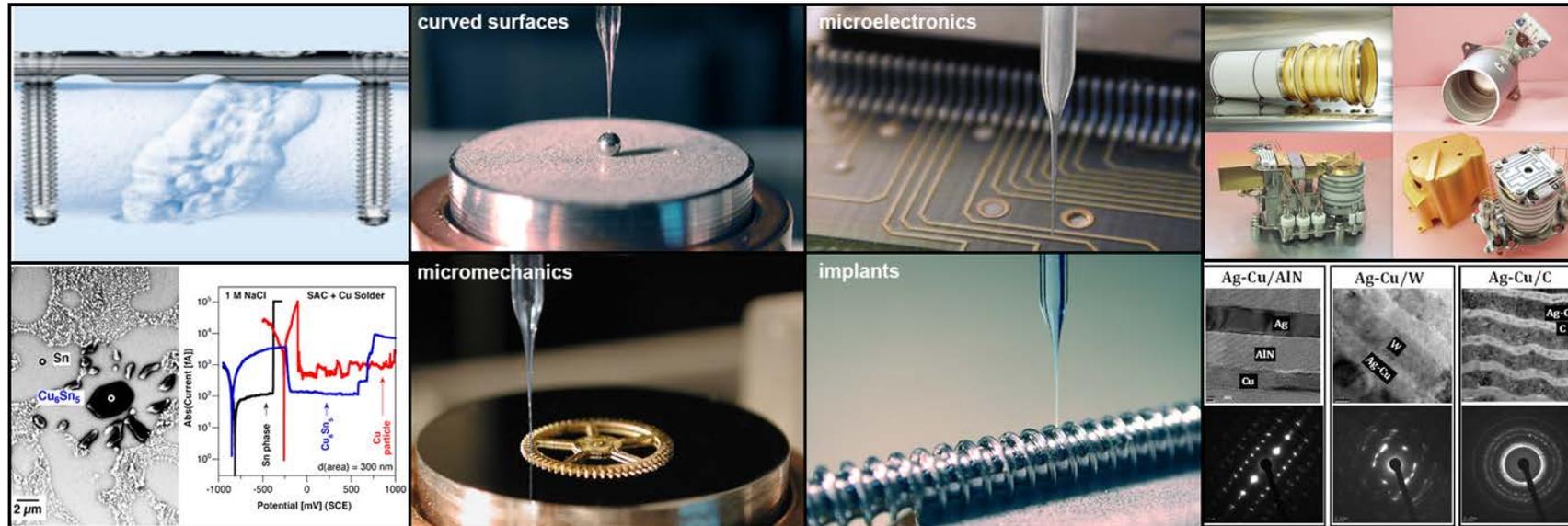


Laboratory Joining Technologies and Corrosion

Laboratory Head: Dr. Lars P. H. Jeurgens

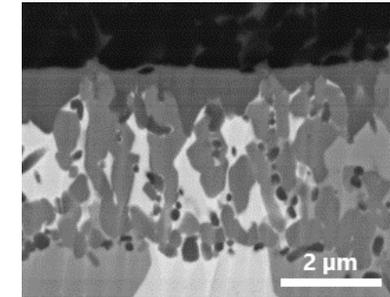
Our Portfolio:

- Advanced Joining Technologies
(soldering, brazing, TLP, diffusion bonding, micro- & nano-joining)
- Corrosion Management
(investigations of corrosion failures, mechanisms and prevention strategies)
- Surface & Interface Engineering
(of metals, alloys, oxide films and their coating systems)

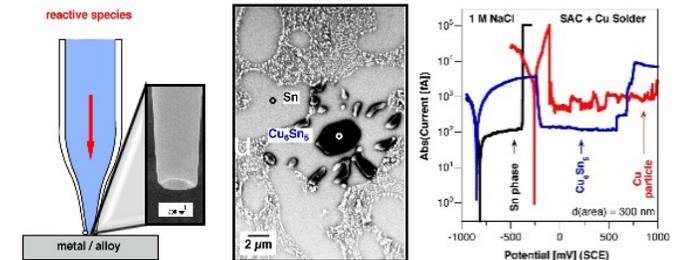


Advanced Joining Technologies – Our Research Topics

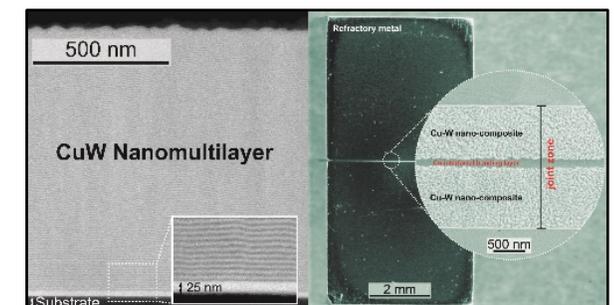
- Wetting, diffusion, and phase formation phenomena at materials interfaces
- Joining of dissimilar materials (e.g. metal-ceramic, metal-glass, metal-composite joints), and of sensitive materials and devices
- Thermal, chemical, and mechanical integrity of joined assemblies under harsh operating conditions
- Investigation and utilisation of nanoscale effects for joining (Nano- & Micro-Joining)



Reaction zone between brazing filler and ceramic



Local electrochemical investigation of solders



Cu/W NML joint between two refractory metals

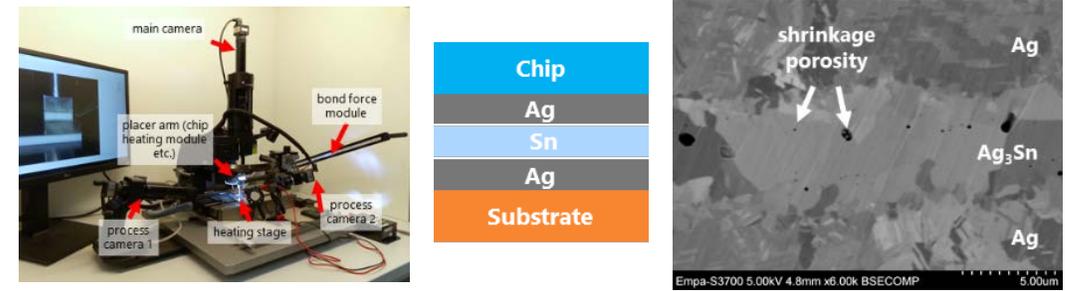
Advanced Joining Technologies – Examples

Joining with reactive nanomultilayers (Nanofoils)



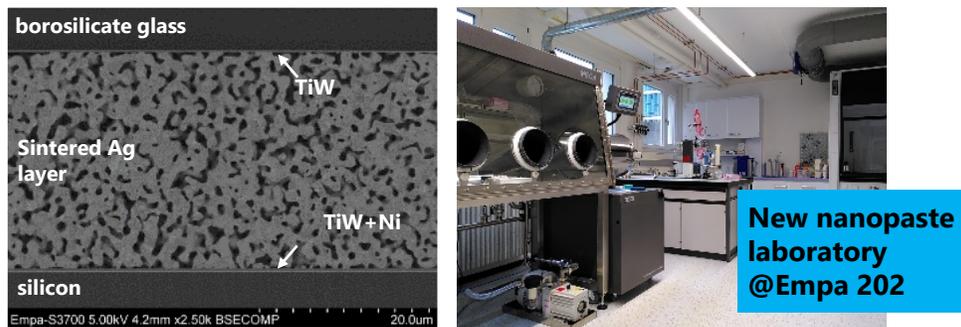
Joining at room temperature

Transient liquid phase bonding



High strength, high operation temperatures

Sinter-bonding with nanoparticle pastes



High thermal & electrical conductivity, high reliability

Vacuum brazing & hybrid joining processes



Components for space applications, processes for high-performance tools, bearings & coatings

Advanced Joining Technologies – Our Service Portfolio

- Consulting, failure analysis, feasibility studies, prototype development, research and development projects with industrial partners (e.g. Innosuisse), brazing and soldering of small product series, ...
- Vacuum brazing, gas-shielded brazing and soldering, transient liquid phase bonding, sintering with nano-pastes, reactive joining, hybrid joining processes (coating and brazing), micro- and nanojoining
- Joint design, residual stress control, surface engineering and interface optimization
- Mechanical, thermal and chemical integrity (corrosion) of joints

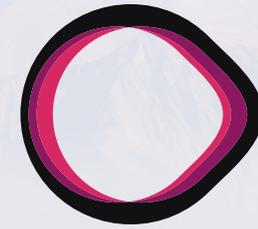
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Partner Presentation OST-IMP

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OST

Ostschweizer
Fachhochschule

Photonic Packaging

IMP Institute for Mikrotechnology and Photonics

Services at IMP

Prof. Tobias Lamprecht

Cleanroom with competence areas

- The constant demand to miniaturize components and systems requires new manufacturing processes and specialized analytical methods.
- At OST there are over 600m² of state-of-the-art cleanroom facilities (ISO 5-7)
- The various technologies are operated by a team of highly qualified specialists and are used for applied research and development topics



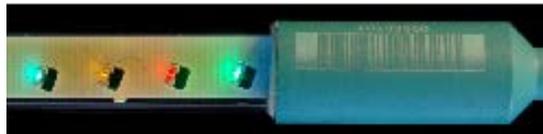
Competence areas

- Coating
- Structuring
- Packaging
- Printing
- Analytics

Packaging of Photonic Systems at IMP / OST

Photonic component assembly

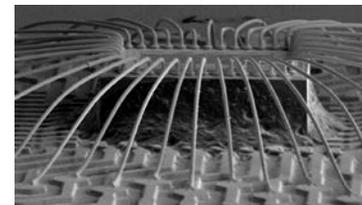
- Alignment: active / vision-based / passive
- Componentes: chips, optics, fibers



Electronic component assembly

- Flip-chip Bonding: soldering, adhesives
- Wire-bonding
- Cleaning and housing

wire bond



flip chip



Packaging of Photonic Systems at IMP / OST

Analytics & optical characterization

- Reliability, failure analysis, ..
- SEM (Scanning electron microscopy)
- Insertion loss measurement

Photonic system

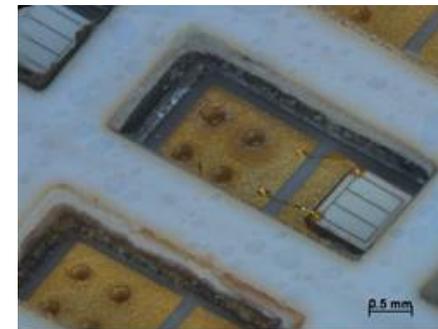
- System design
- Process design
- Material evaluation
- Transfer to production

Kontaktinformationen

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LED package



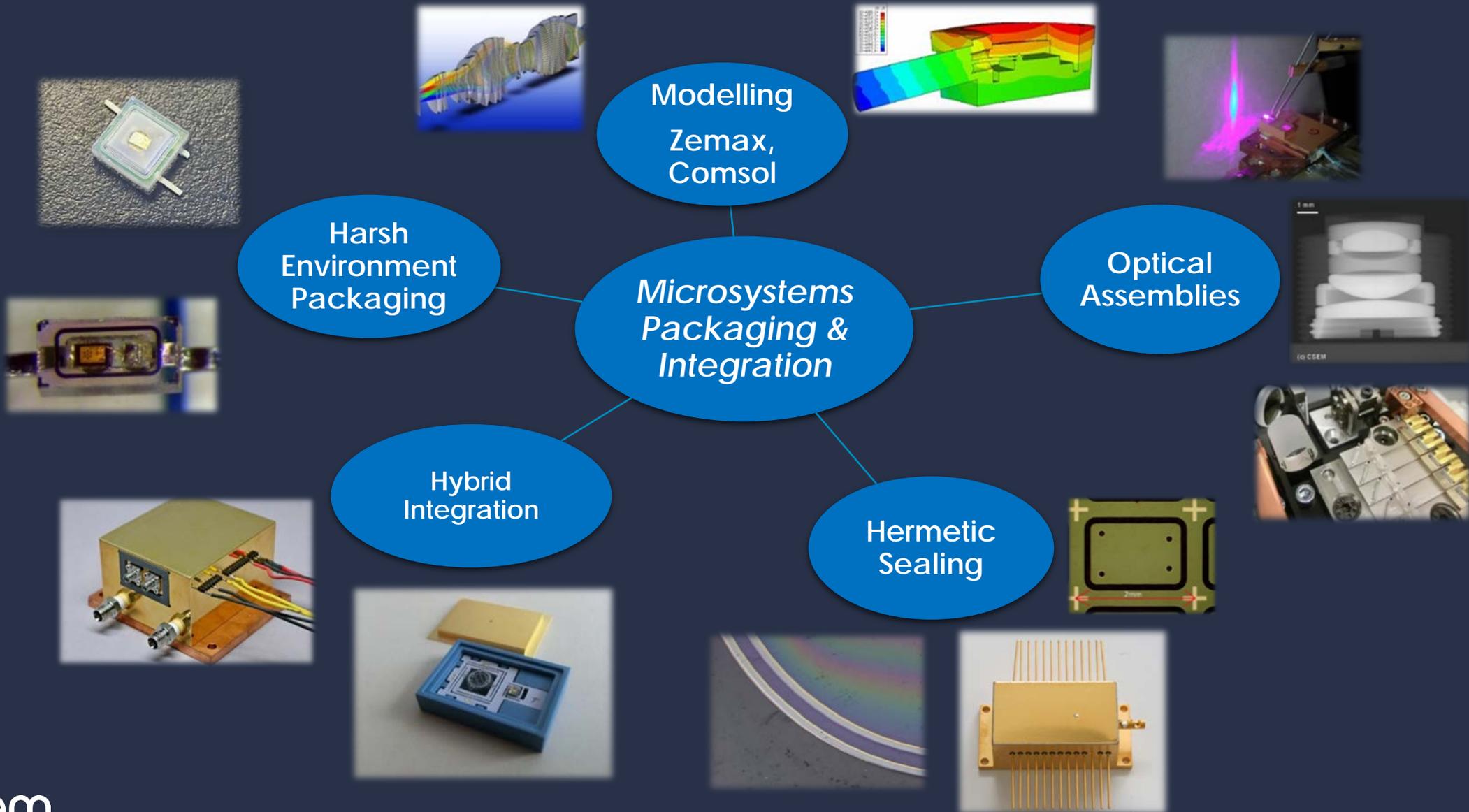
hermetic, autoclavable

Partner Presentation CSEM

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Portfolio of offerings to response to industry needs



Functional packaging services

Packaging . . . the ultimate interface, the connecting force

between photonic and electronic components and finished product

CSEM's cleanroom packaging technologies include:

- :: Design and simulation (optical, thermal, thermomechanical, RF) of components and systems
- :: Prototyping and semi-automatic assembly of optical modules like lasers and optical detectors
- :: Flip-chip and die bonding (soldering, thermocompression, adhesion) of sensitive components
- :: High-precision positioning and adhesive fixing of components with tolerance less than 1 μm
- :: Hermetical sealing of packages (vacuum and gas sealing)
- :: Wire bonding



Packaging Infrastructure



Pick & Place Machine

Cleanroom
class 10'000
Humidity &
Temperature
controlled



Reflow Oven



Laser soldering & welding station

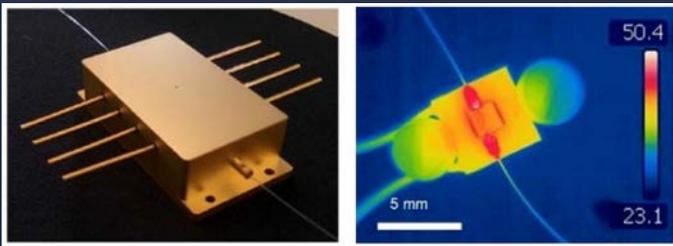


Wire Bonder

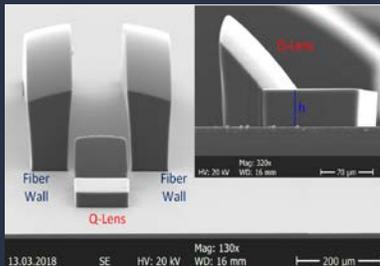
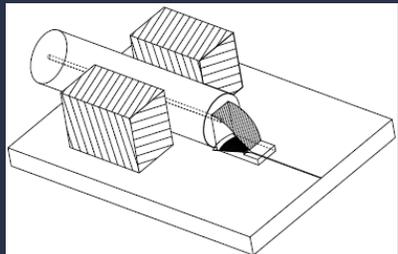
Precision μm assembly for optical and electrical components

- From design to prototyping in cleanroom environment
- Hybrid integration of multiple functionalities (high frequency, fluidics, etc.)

Thermal management and hermetic solutions



UV-replicated waferscale fiber optic connector for waveguide grating couplers



Aixemtec Machine Installation

- Flexible 6 DOF assembly
 - Fibers (PM, arrays)
 - Waveguides
 - Lasers
 - Lenses

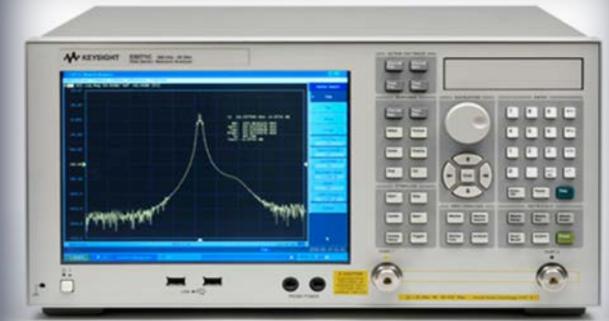
Collaboration with Aixemtec

- Process development & tooling
- Production transfer

RF design and characterization capabilities

RF simulation and measurement

- ADS RF simulation software
- COMSOL RF Module
- Keysight VNA E5071C
 - 300 kHz to 20 GHz with bias tees, 2-port test set
 - Enhanced time domain analysis (TDR)



On-wafer RF Probe Station

- MPI TS150
- 150 mm Manual Probe System, RF wafer chuck, platen for 4 RF and 10 DC micro-positioners,
- RF probes (DC to 26 GHz, DC current up to 2A)





Any Questions