SESSION 1: The Photonics Revolution in Semiconductor Photonics

SESSION 2: Upcoming Technological Challenges in Optics

SESSION 3: The Photonics Revolution in Life Science

SESSION 4: The Role of Photonics in the Future World
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<th>Verticaly Integrated Solution Provider</th>
<th>Facebook</th>
<th>HP</th>
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<td>System Integrator</td>
<td>Leia Inc.</td>
<td>Kinetic River</td>
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<td>Consumer Products</td>
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<td>Flow Cytometry</td>
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<td>Gas Analysis</td>
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<td>SENORICS</td>
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<td>Miniaturized Spectrometers</td>
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<td>Lasers</td>
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<td>modulight</td>
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<td>Swept VCSELs</td>
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<td>Quantum Computing</td>
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<th>Coatings/Thin Film</th>
<th>Vortex</th>
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<td>Metal Optics</td>
<td>skon</td>
<td>Opletek</td>
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<td>Optical MEMS</td>
<td>AG Microsystems Inc.</td>
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<td>PowerPhotonic</td>
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<td>Laser System Components</td>
<td>SWIR InGaAs Imagers</td>
<td>Laser Beam Shaping / MPLC</td>
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<td>MidIR Detectors</td>
<td>Xenics</td>
<td>cristal Laser</td>
</tr>
<tr>
<td>Lasers</td>
<td>cailabs</td>
<td>Imagine Optic</td>
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</tbody>
</table>

| Design Software                      | cadence            | Photon Design |
| Semiconductor Manufacturer           | Cadence            | MolecuLight |
| Specialty Optical Fiber              | intel              | artphotons |
| Market Intelligence/Consultancy      | AUCCEPT            | bmbg consult Tarkas |

| Association                           | EPIC Swiss Photonics | EPIC |
| Integrated Modules                    | Flash LIDAR         | fastree 3D |
| Metrology                             | Spectrum Scan LIDAR | BARAJA |
| Precision/Automation Equipment/Tools  | LIDAR - LIDAR + Video Fusion | ficonTEC |
| Illumination / Display                | LEDS on Metal       | iBeam |
| R&D                                   | Fraunhofer HHI     | Medical Technologies |
| OSATs/Contract Manufacturing          | Photonics          | Photonics.com |
| Biotech/DNA Sequencing                | Optical MEMS       | MicroOptics |
| Gas Analysis                          | InGaAs Imagers     | Xenics Infrared Solutions |
| Spectra-Physics                       | MidIR Detectors     | cristal Laser |
| Non-linear Crystals                   | Laser Beam Shaping / MPLC | Laser Beam Shaping / MPLC |
| Laser System Components               | SWIR InGaAs Imagers | Laser Beam Shaping / MPLC |
| Design Software                       | cailabs            | imagine Optic |
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**EPIC World Photonics Technology Summit 2022. 24 January 08:30 PST**
AN INCREASING NUMBER OF PRODUCTS ARE REACHING THE MARKET*

*Non-exhaustive list of products
The European Micro-Optics Revolution!

Free-form micro-optics consists of micro-optical components

- with no symmetry restrictions
- gaining an increasing industrial interests in the last few years
OPTICAL TRANSCEIVER – TECHNOLOGY TRENDS

On-Board Optics (OBO) / Co-packaged Optics (CPO)

**2019**

- 12.8 Tbps
- 32x 400G QSFP-DD or OSFP
- **QSFP-DD** W: 18.35 mm, L: 89.4 mm and T: 8.5 mm
- **OSFP** W: 22.58 mm, L: 107.8 mm and T: 13.0 mm

**2023/2024**

- 51.2 Tbps
- 8x optical modules for CPO
- **CPO optical module** W: ~20 mm, L: ~60 mm

Evolution toward CPO assembly with pluggable ELS modules on the switch PCBA

Evolution toward CPO optical modules

*The Consortium for On-Board Optics does not intend to define a fixed form factor for the ELS module.*
Technology – Plasmonic Modulators

Plasmonic Phase Modulator
- Efficient phase mod.
- High-speed
- Compact footprint

Integrated in Mach-Zehnder
→ Efficient amplitude mod.
→ >500 GHz EO bandwidth
NASDAQ WELCOMES
LIGHTWAVE LOGIC, INC.
SEPTEMBER 10, 2021
LWLG NasdaqListed
New PIC Partnership!

“LIGENTEC and X-FAB collaboration creates Europe’s largest capacity foundry service for integrated photonic circuits”

CLICK TO READ THE PRESS RELEASE
IMAGING AND SENSING TECHNOLOGY

Pixel size roadmap - shrinking with time

Pixel size (µm) log scale

- ToF pixel
- SPAD pixel
- Event pixel
- GS pixel for stereo and structured light
- RS pixel for imaging
- 3 µm Omnivision 1/5" GS (ST) pixel
- 1.1 µm GS Invisage Apple
- 1 µm Sony
- 2.8 µm STM NIR GS iPhone X
- 17.5 µm PMD Infineon 3D ToF pixel
- 15 µm Prophesee

Hiding the large digital part under the pixel's sensitive part offers superb size-reduction potential

ToF pixels / event pixel with 3D stacking - possible entry in mobile for high-performance applications

Quantum dots' global shutter could enter for size or cost-critical applications

Pixel-shrink potential varies depending on the technology

Time

Monday, 27 September 2021, 15:00 CEST
EPIC Online Technology Meeting on Head-Up Displays: from 2D to AR

SUSTAINABLE GROWTH FOR INDUSTRY
www.epic-assoc.com
MOE 1M | 1M for NIR/SWIR camera

- NIR camera module using a 940 nm single MOE and a NIR sensor.
- Both demonstrator and customer-specific 1Ms are currently being prototyped, shipped, and made ready for mass production.
- Simplest possible camera consisting of only one lens element including the aperture stop and a sensor
- The performance would be impossible to achieve with a single refractive lens
- High efficiency optics for 3D sensing (ToF/SL/LIDAR) by MOE and DOE are being shipped to customers

Image from a near infrared imaging system using a single meta optical element surface (1M MOE) designed for 940 nm wavelength. The demonstrated NILT image has excellent resolution for NIR imaging, all the way to the edge, and is comparable to images captured with a multi-element refractive lens.
**Quantum Technology**

<table>
<thead>
<tr>
<th>Quantum Technology</th>
<th>Computing</th>
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<tr>
<td>Qubit-based (using superposition of measurable values)</td>
<td>Google, Intel, IBM, Atos, PsiQ, Microsoft, D-Wave, Rigetti, IONQ</td>
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<tr>
<td>Entanglement</td>
<td></td>
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<tr>
<td>Telecommunication/QKD</td>
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<table>
<thead>
<tr>
<th>Not qubit-based but uses at least one of the following quantum effects:</th>
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<tbody>
<tr>
<td>- Quantized energy levels*</td>
</tr>
<tr>
<td>- Quantum coherence**</td>
</tr>
<tr>
<td>- Entanglement***</td>
</tr>
</tbody>
</table>

According to Degen et al. (2017), there are 4 criteria for quantum sensors:

- The system has to have discrete, resolvable energy levels.
- You can initialize the sensor and you can perform readout (turn on and get answer).
- You can coherently manipulate the sensor.
- The sensor interacts with a physical quantity and has some response to that quantity.

<table>
<thead>
<tr>
<th>Gravimeters</th>
<th>Atomic clocks</th>
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Others (SQUIDs, magnetometers, imagers ..)

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*Only certain photon energies are allowed when electrons jump down from higher levels to lower levels.

**Two separate states are superposed (e.g. interference)

***Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated, interact, or share spatial proximity in ways such that the quantum state of each particle cannot be described independently of the state of the others, even when the particles are separated by a large distance.

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<tr>
<th>Market</th>
<th>Defence</th>
<th>Transport</th>
<th>Digital Economy</th>
<th>Health</th>
<th>Space</th>
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<tr>
<td>Application Trends</td>
<td>GPS-Deprived Precision and Robust timing</td>
<td>Infrastructure Monitoring (Gravity Sensing)</td>
<td>Beyond HAMR – all optical data storage</td>
<td>Low Light Imaging</td>
<td>Secure Space comms (Cubesat to GEO sat)</td>
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<td></td>
<td>Long Range LiDAR – Through adverse weather conditions</td>
<td>LiDAR – Quantum Enhanced</td>
<td>Quantum Computing</td>
<td>Time-gated spectroscopy</td>
<td>Precision Timing Gravimetry</td>
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<td></td>
<td>Secure Comms</td>
<td></td>
<td>Long Range LiDAR</td>
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<tr>
<td>Enabling Technology</td>
<td>Lasers at specific frequencies</td>
<td>Gravimetry requires atomic clocks</td>
<td>Manipulation of single atoms/photons</td>
<td>Single Photon Detectors</td>
<td>Manipulation of single atoms/photons</td>
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<tr>
<td>Next Steps</td>
<td>Industrialisation and Miniaturisation of lasers and MOT</td>
<td>Gravimetry – see Quantum Timing</td>
<td>Co-packing of Si and CS</td>
<td>Detector Supply Chain Development</td>
<td>Co-packaging of Si and CS</td>
</tr>
<tr>
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<td>Detector Supply Chain Development</td>
<td>LiDAR – cost-down from Defence solution</td>
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EXPLORING MARKETS  
EXPANDING APPLICATIONS  
CONNECTING PEOPLE

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Good Bye, EPIC
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Extra slides
MICROLENSES – FEATURE OPTIONS

Protruding lenses

Recessed microlens

Microlenses with “adhesive management”
Bacterial adhesion
Bacterial adhesion

**Figure 4:** Scanning electron microscopy image of *Staphylococcus aureus* CIP 4.83 adhesion on 316L stainless steel. Stainless steel surface before (a) and after (b) the bacterial adhesion. Bacteria attach to the crevices and align often along longitudinal scratches. The scale bars in the images are 25 μm (a) and 5 μm (b).

Source: Khelissa et al
Photonics at Marel

Applied or ‘near-to-apply’

- X-Ray
- VIS-NIR

3D

R&D potential

- Laser welding
- Coherence Tomography
- Hyperspectral Imaging
- Multispectral technologies
- Laser based technologies
- TerraHz imaging

Future landscape

- SD-OCT
- Biofilm detection
- Defect detection
- Contaminant detection
- Quality grading
- Beam shaping
- Beam splitting
- Beam interference
- Wave length
- Energy profiles
- Lifecycle analysis
- Ceramic layers

Application related

- Contaminant detection
- Weighing
- Fat analysis
- Volumetric Weight estimation
- Defect detection
- Quality grading
- Additive Manufacturing
- Laser Texturing
- Laser-shock Forming
- Diode Laser based Annealing & Hardening

Manufacturing related

- Laser welding
- Shelf life
- Product Quality
- Wettability / Cleanability
- Adhesion / retention
- Biofouling
- Recognition / selection
- Biofilm forming
- Tribology