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MARKET DATA

24 January 2022

San Francisco, USA

EPIC World Photonics Technology Summit

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European Photonics Industry Consortium

EPIC World Photonics Technology Summit

AGENDA

SESSION 1: The Photonics Revolution in Semiconductor Photonics

intel · NeoPhotonics · hp · JABIL OPTICS

SESSION 2: Upcoming Technological Challenges in Optics

SUSS MicroOptics · LEADOPTIK · iBeam Materials · AGM · cadence

SESSION 3: The Photonics Revolution in Life Science

KINETIC RIVER · modulight · PACBIO · PICARRO · AERIS TECHNOLOGIES

SESSION 4: The Role of Photonics in the Future World

Meta · Leia Inc. · PsiQuantum · AegiQ · oyla

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Flow Cytometry
KINETIC RIVER

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Miniaturized/Autonomous Sensors
Miniaturized Spectrometers
SENORICS
OMNITRON SENSORS
Gas Analysis
AERIS TECHNOLOGIES

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Laser Diodes
modulight
Menhir Photonics
Ultrafast Lasers
FEMTUM
LIGHT CONVERSION
EKSPLA
Swept VCSELs
OCTLIGHT
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Quantum Computing
PsiQuantum
Quantum Key Distribution
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oplatek inspired by optics
Metal Optics
SON
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AG Microsystems, Inc. Excellence in Optical MEMS
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PowerPhotonic
SUSS MicroOptics
LEADOPTIK
CDA We inspire and manufacture value

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Xenics Infrared Solutions
MidIR Detectors
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AN INCREASING NUMBER OF PRODUCTS ARE REACHING THE MARKET*

Non exhaustive list of products


NYSE OPENING BELL®
AUGUST 12, 2021
RKLY
LISTED
NYSE
Rockley®
RKLY
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NEW YORK STOCK EXCHANGE

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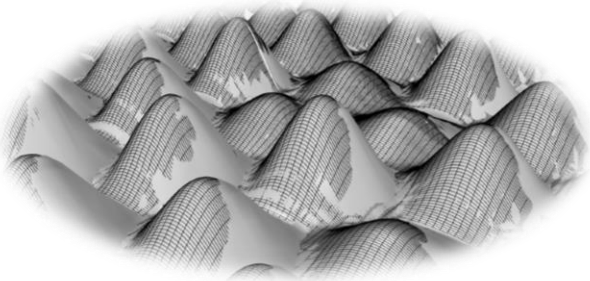
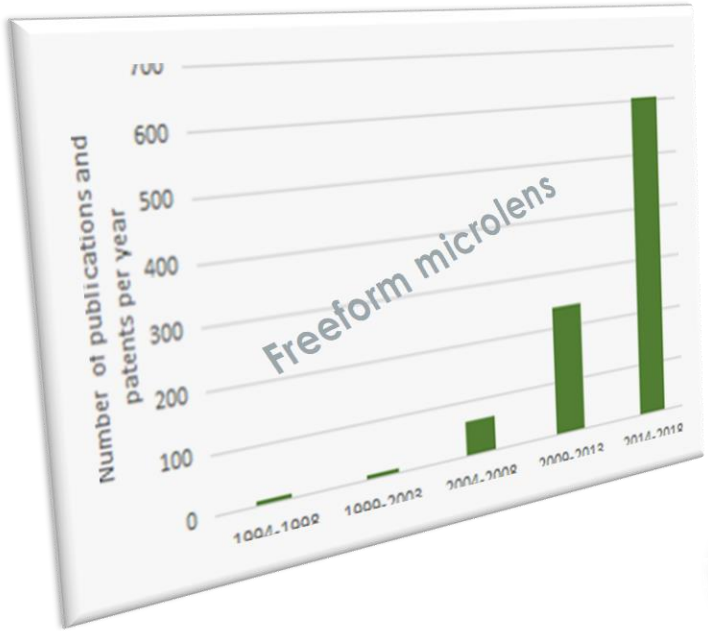
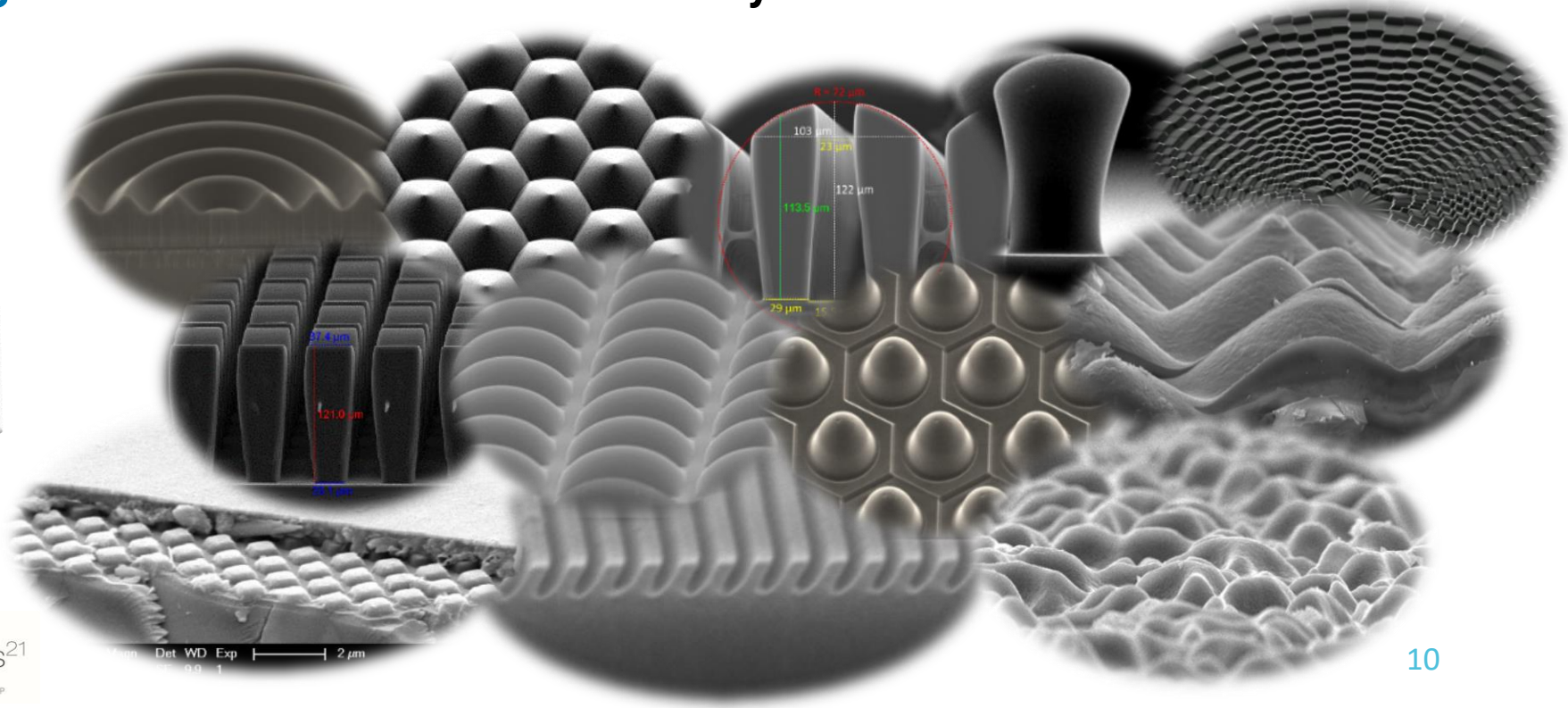
The European Micro-Optics Revolution!



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

- ❑ with no symmetry restrictions
- ❑ gaining an increasing industrial interests in the last few years





2023 Genesis G90 – Source: *www.Motortrend.com*

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OPTICAL TRANSCEIVER – **TECHNOLOGY TRENDS**

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

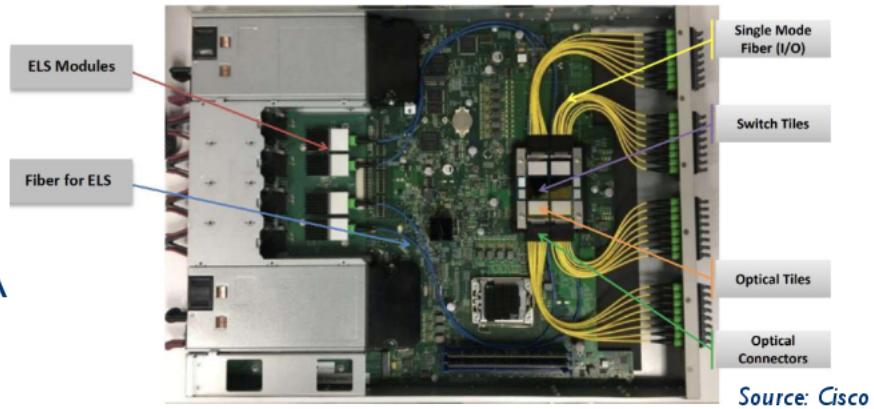
2019 → **2023/2024**

12.8 Tbps

32x 400G QSFP-DD or OSFP

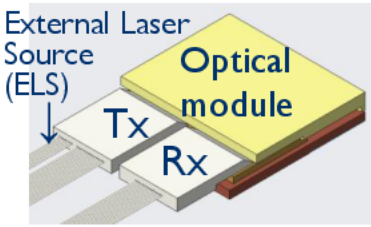
Evolution toward CPO assembly with pluggable ELS modules on the switch PCBA

51.2 Tbps

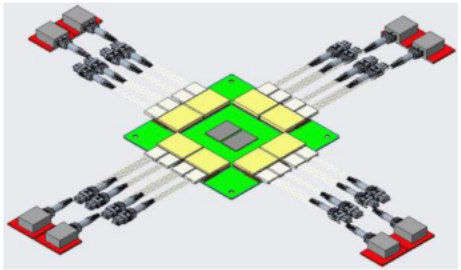


Source: Cisco

Evolution toward CPO optical modules



8x optical modules for CPO

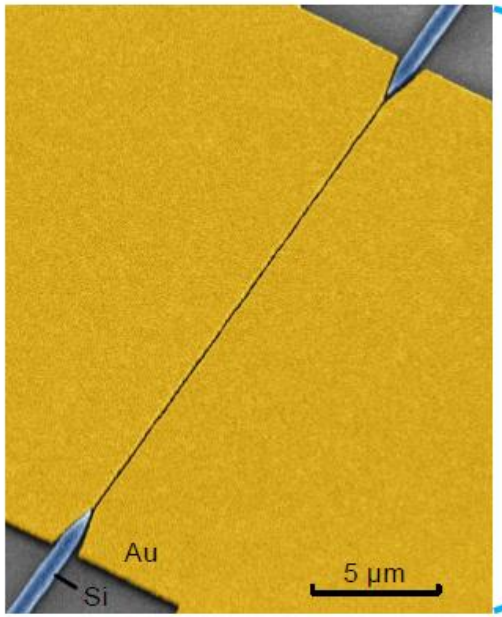


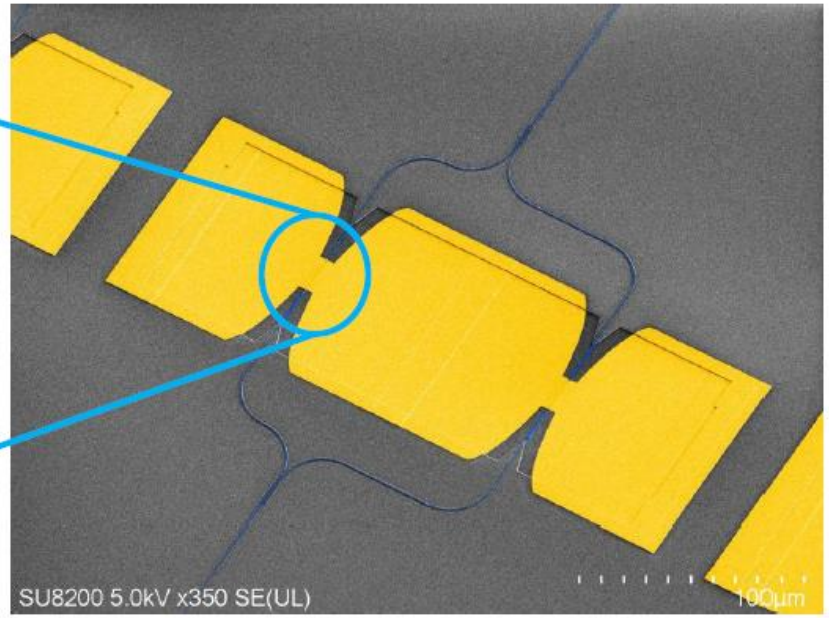
QSFP-DD W: 18.35 mm, L: 89.4 mm and T: 8.5 mm
OSFP W: 22.58 mm, L: 107.8 mm and T: 13.0 mm

CPO optical module W: ~20 mm, L: ~60 mm

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

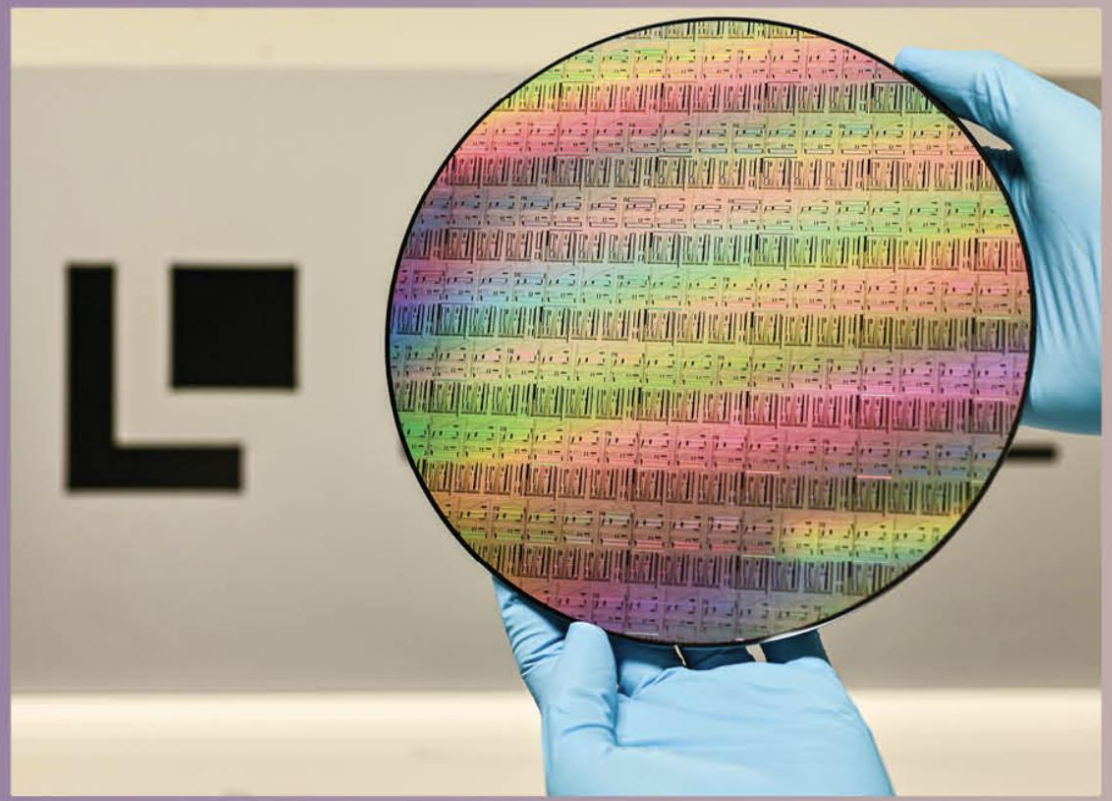
→ Efficient amplitude mod.

→ >500 GHz EO bandwidth


TheraBreath
NASDAQ WELCOMES
LIGHTWAVE LOGIC, INC.
SEPTEMBER 10, 2021
LWLG NasdaqListed
LIGHTWAVELOGIC™
Nasdaq

LIGENTEC

xfab



New PIC Partnership!

"LIGENTEC and X-FAB collaboration creates Europe's largest capacity foundry service for integrated photonic circuits"

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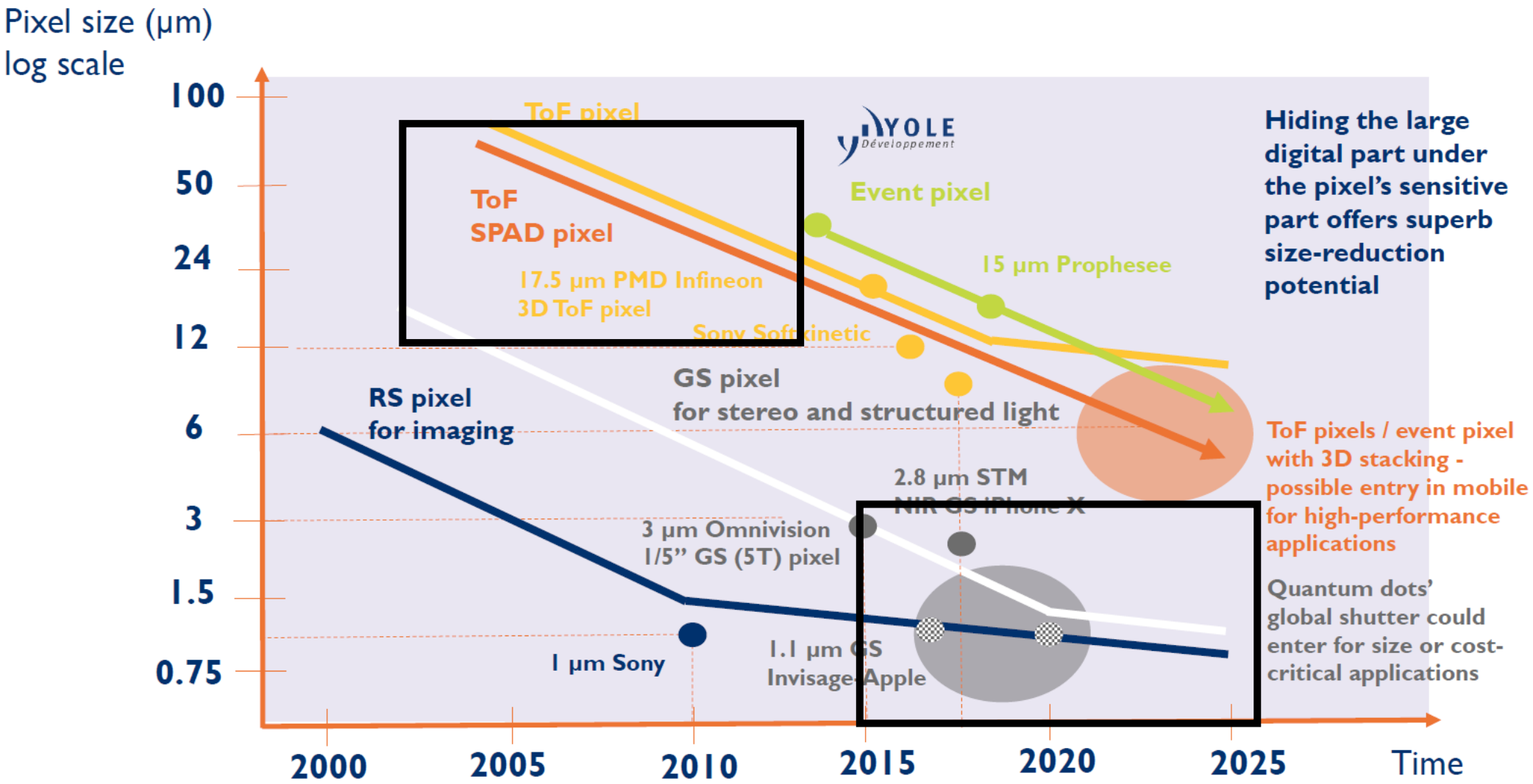
IMAGING AND SENSING TECHNOLOGY

Pixel size roadmap - shrinking with time

Pixel-shrink potential varies depending on the technology




Monday, 27 September 2021, 15:00 CEST
EPIC Online Technology Meeting on Head-Up Displays: from 2D to AR
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organisations working in the field of photonics
We foster a vibrant photonics ecosystem
by maintaining a strong network and acting
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MOE 1M | 1M for NIR/SWIR camera

NIL TECHNOLOGY

- 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

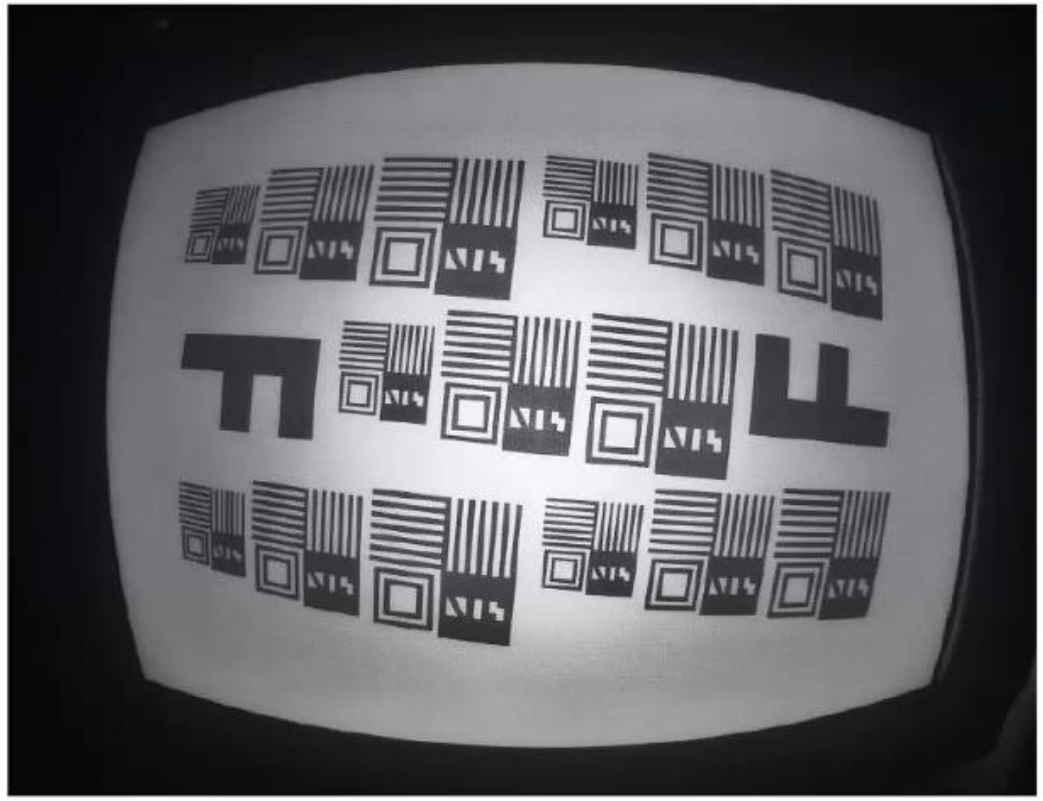

Image from a near Infrared imaging system using a single meta optical element surface (1M MOE) designed for 940 nm wavelength. The demonstrated NILT image has excellent resolution for NIR imaging, all the way to the edge, and is comparable to images captured with a multi-element refractive lens.

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QUBIT OR NOT QUBIT? WHAT DOES «QUANTUM» MEAN? EXAMPLES OF PLAYERS

Quantum Technology

Qubit-based
(using superposition of measurable values)

Computing

Google, intel, IBM, Atos, PsiQ, Microsoft, 阿里云, D-Wave The Quantum Computing Company, HUAWEI, rigetti, IONQ

Entanglement

Telecommunication/QKD

IDQ, 国盾量子 QuantumCTek, 问天量子, QUANTUMXCHANGE

Not qubit-based but uses at least one of the following quantum effects:

- Quantized energy levels*
- Quantum coherence**
- Entanglement***

According to Degen et al. ****, 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.

Gravimeters

μQUANS

Atomic clocks

μQUANS, AtomSensors, M SQUARED

Others (SQUIDs, magnetometers, imagers ..)

supracon SQUID AND MICROFABRICATION TECHNOLOGIES, PTB, Twinleaf, QUSPIN AN ATOMIC DEVICES COMPANY, SEE DEVICE, nami

*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.

**** Degen, C. L.; Reinhard, F.; Cappellaro, P. (2017). "Quantum sensing". Reviews of Modern Physics. 89 (3): 035002. arXiv:1611.02427. Bibcode:2017RvMP...89c5002D. doi:10.1103/RevModPhys.89.035002.

QUANTUM OPPORTUNITY

CATAPULT
Compound Semiconductor Applications

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

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VIGO SYSTEM

Laser System Components
Beam Shaping / MPLC
cailabs SHAPING THE LIGHT
Non-linear Crystals
Cristal Laser

Design Software
cadence
Photon Design

Semiconductor Manufacturer
intel

Specialty Optical Fiber
art photonics

Market Intelligence/Consultancy
AUCCEPT
bmbg consult
TARKAS

Association
EPIC
SWISS PHOTONICS

Journalist
PHOTONICS MEDIA photonics.com

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EPIC

Integrated Modules
Flash LIDAR
fastree 3D
LIDAR - LIDAR + Video Fusion
oyla
Optical Transceivers
NeoPhotonics
Spectrum Scan LIDAR
BARAJA

Metrology
Wafefront Sensing
imagine optic
3D surface Metrology
SENSOFAR

Precision/Automation Equipment/Tools
ficontec photonics assembly & testing
mps MICROSYSTEMS

Illumination / Display
Microscopy Illumination
CoolLED Simply Better Control
LEDs on Metal
iBeam Materials

R&D
leti ceatech
Fraunhofer HHI
A? Aalto University
Medical Technologies
SCIENCES TECHNOLOGY RESEARCH AND DEVELOPMENT

EXPLORING MARKETS
EXPANDING APPLICATIONS
CONNECTING PEOPLE

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EPIC

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Outgoing CTO – EPIC

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EPIC

European Photonics Industry Consortium

EPIC World Photonics Technology Summit

AGENDA

SESSION 1: The Photonics Revolution in Semiconductor Photonics

intel · NeoPhotonics · hp · JABIL OPTICS

SESSION 2: Upcoming Technological Challenges in Optics

SUSS MicroOptics · LEADOPTIK · iBeam Materials · AGM · cadence

SESSION 3: The Photonics Revolution in Life Science

KINETIC RIVER · modulight · PACBIO · PICARRO · AERIS TECHNOLOGIES

SESSION 4: The Role of Photonics in the Future World

Meta · Leia Inc. · PsiQuantum · AegiQ · oyla

Extra slides

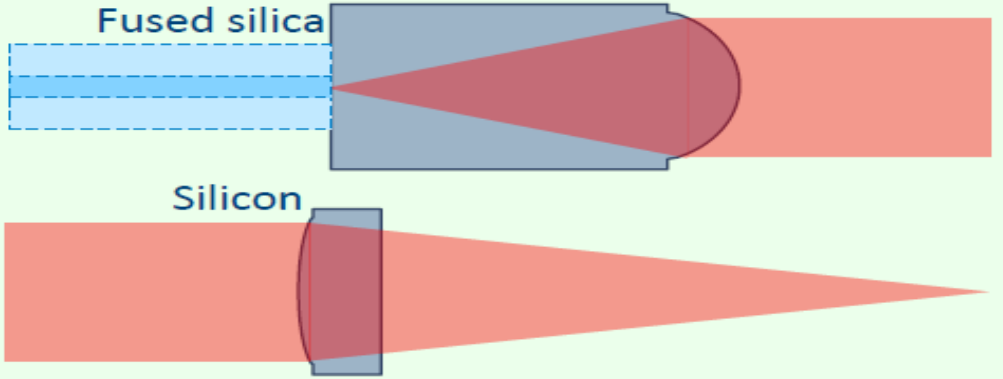
MICROLENSES – FEATURE OPTIONS

SÜSS MicroOptics

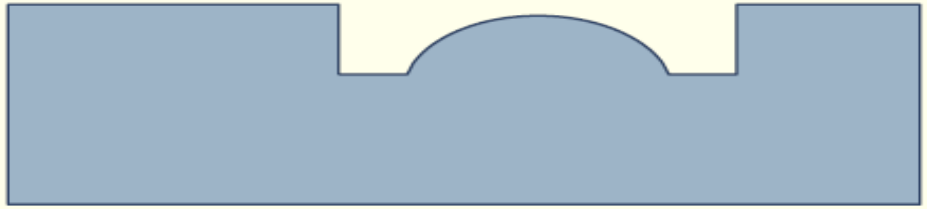
Packaging easier

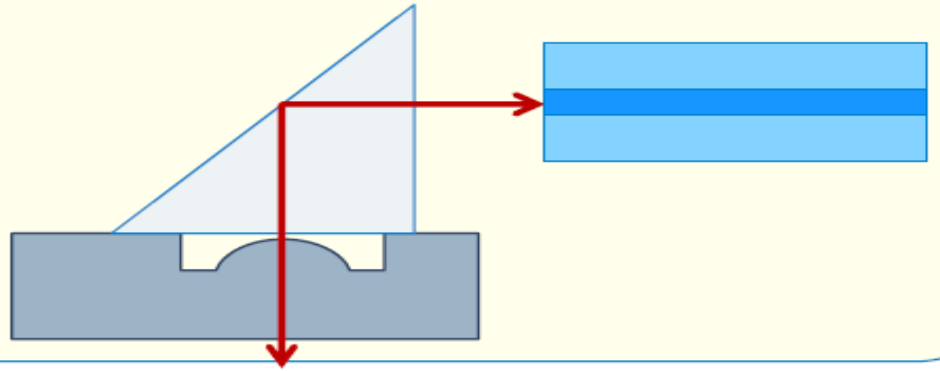
Microoptics costs lower

Protruding lenses

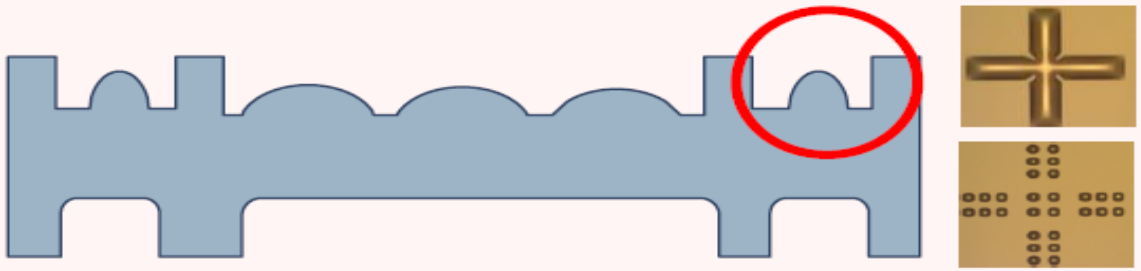


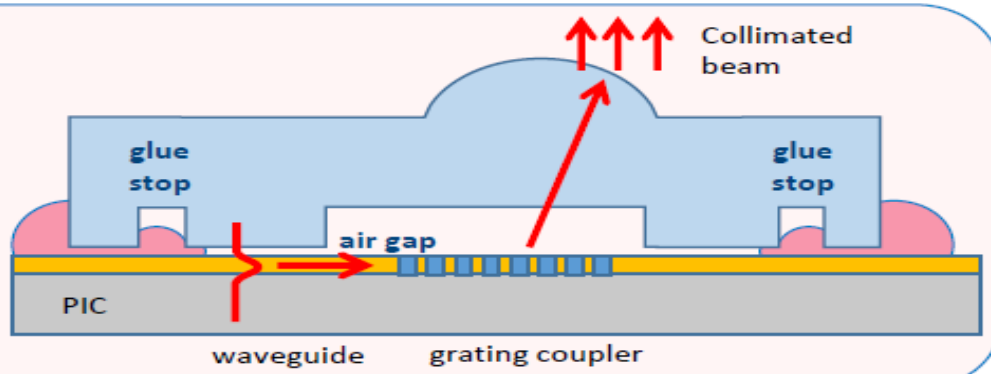
Recessed microlens





Microlenses with “adhesive management”





Bacterial adhesion

SensorX Magna

Bacterial adhesion

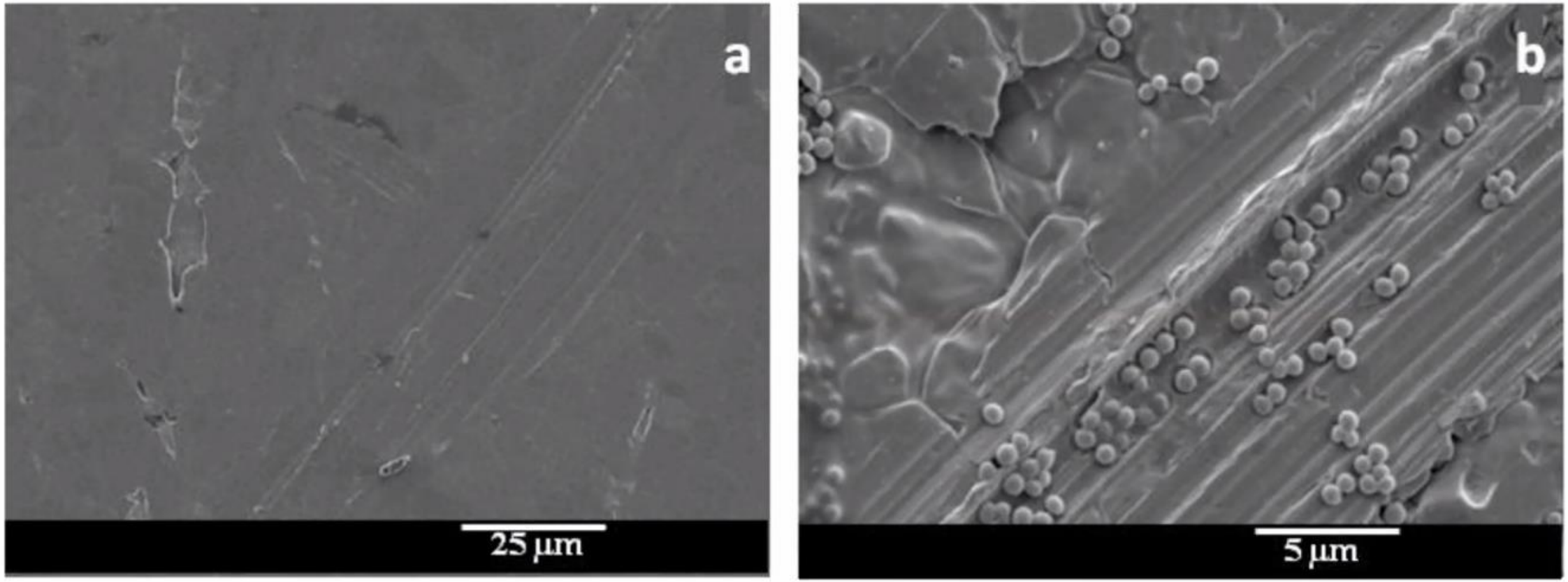


Figure 4: Scanning electron microscopy image of *Staphylococcus aureus* CIP 4.83 adhesion on 316L stainless steel. Stainless steel surface before (a) and after (b) the bacterial adhesion. Bacteria attach to the crevices and align often along longitudinal scratches. The scale bars in the images are 25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

Source: Khelissa *et al*

Photonics at Marel