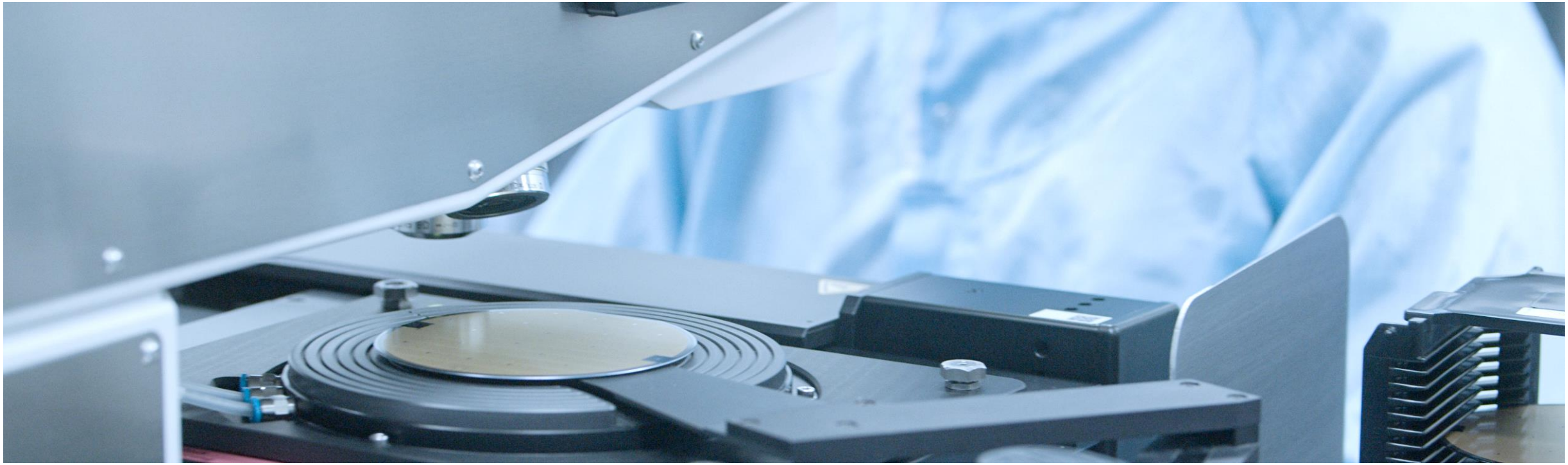


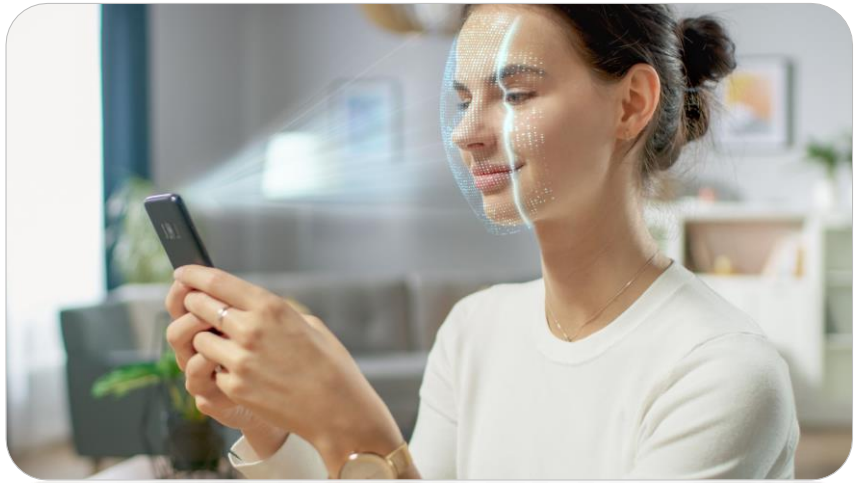
EPIC Technology Meeting on Electronics and Photonics - November, 14th 2022

Small VCSEL but Big Range of Applications

TRUMPF Photonic Components – Dr.-Ing. Roman Koerner

TRUMPF

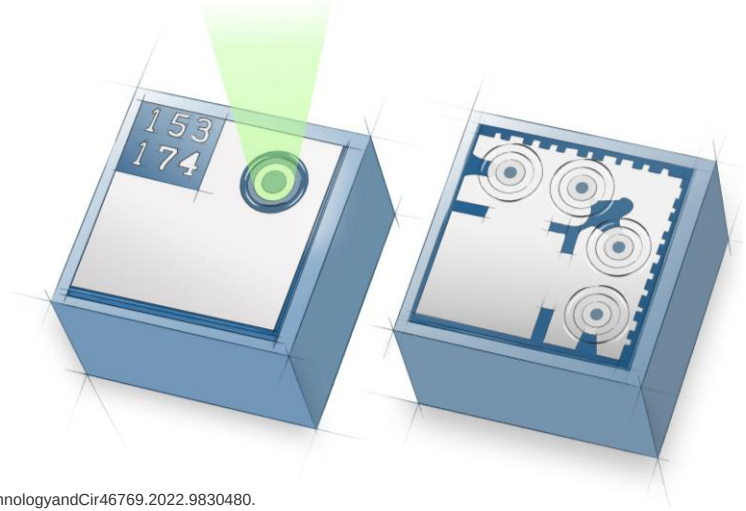
VCSELs are everywhere …



> 1 200 000 000 VCSEL chips shipped worldwide in 2020 (1)

VCSEL of today:

- Energy efficient and scalable device
- Low cost by fast yield improvement (2)



VCSEL of tomorrow:

- Enhanced functionality per chip area
- Naturally eye safe (3)
- Directly integrated with Silicon (4)

(1) J. Tatum et al. (2021). *Commercialization of VCSELs*., 10.23919/MOC52031.2021.9598106.
(2) T. Baehr-Jones et al. (2012), *Myths and rumours of silicon photonics,* 10.1038/nphoton.2012.66
(3) S. Gronenborn et al. (2022), *ViBO-VCSEL with integrated backside optics,* 10.1117/12.2607355
(4) M. Peeters et al. (2022), *(Why do we need) Wireless Heterogeneous Integration (anyway),* 10.1109/VLSITechnologyandCir46769.2022.9830480.

3D Integration - Is the VCSEL industry ready to follow ?

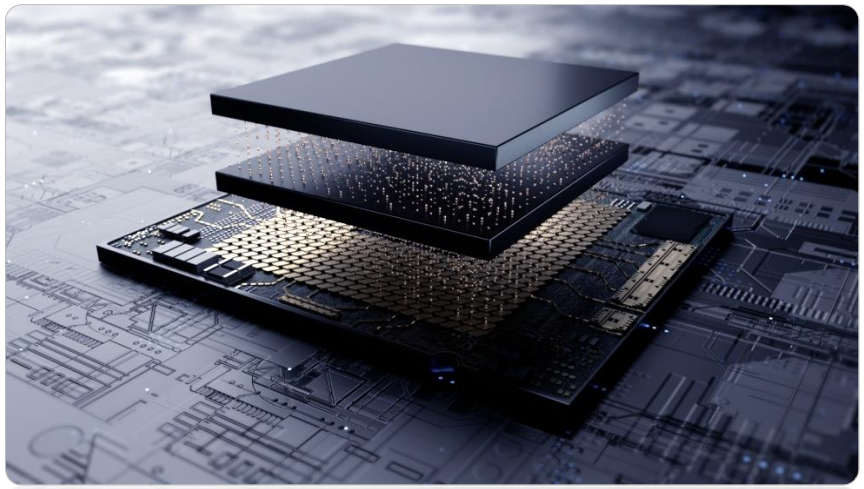


Image credit: SAMSUNG

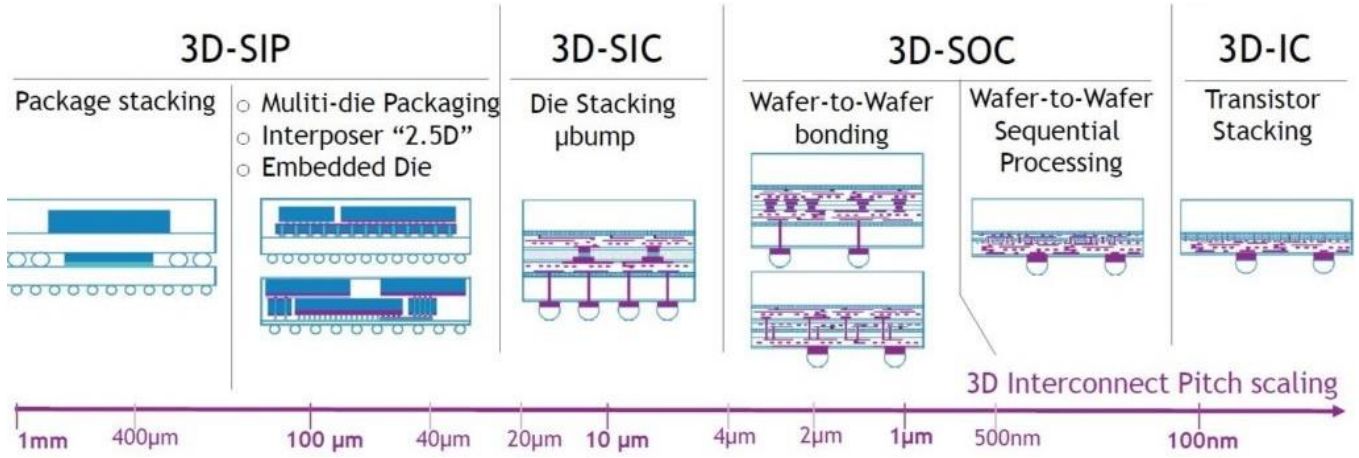


Image credit: IMEC, IEDM plenary, Dez. 2020

Energy saving, higher packaging density and performance enhancements are strong economic driving factors.

→ Consumer sensing industry is adapting the newest silicon to their releases (as M2 from Apple)

VCSEL - Small semiconductor device but bulky package

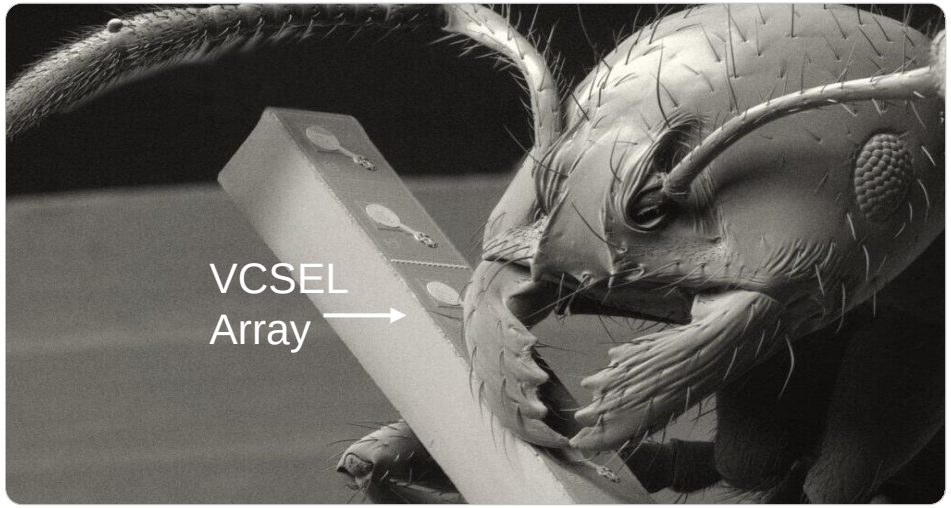
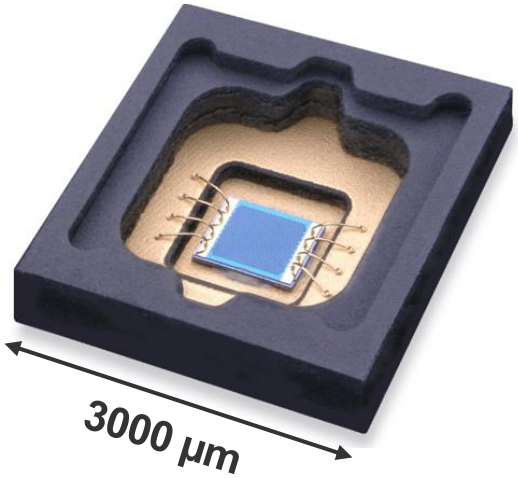
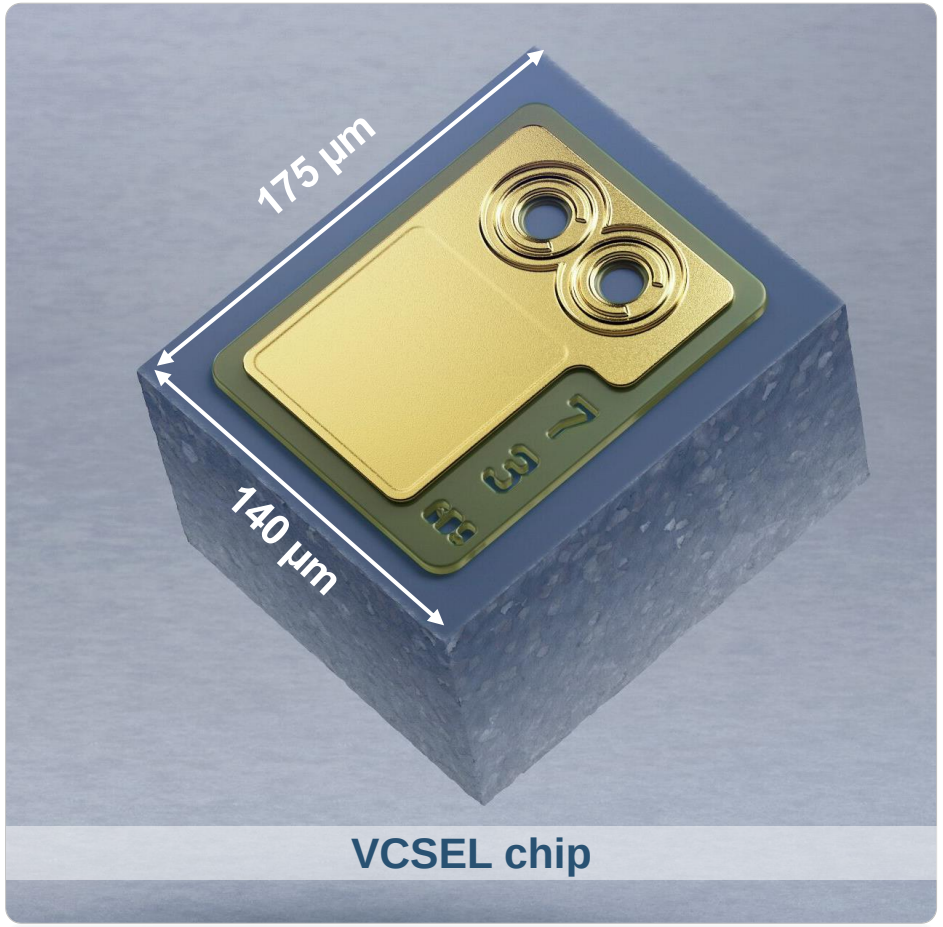


Image credit: Coherent

✓ VCSEL device already scaled to a suitable footprint…

✗ But close silicon integration is not reached



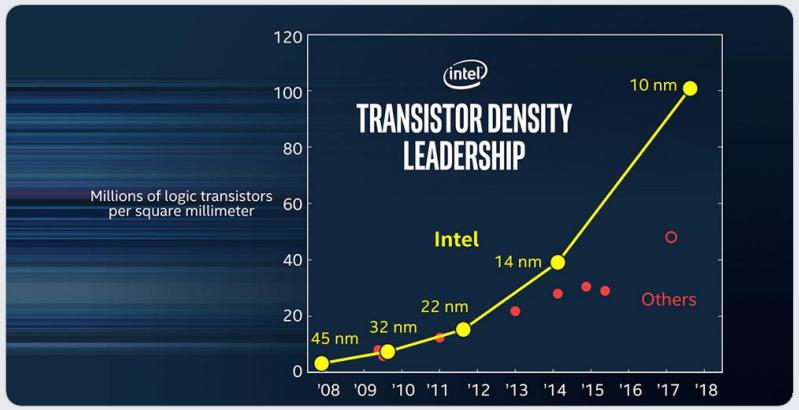


> 300 000 VCSEL chips per 6 inch wafer…

Functional elements for close integration

Silicon Industry:

„Moores-Law“ drives the silicon industry to shrink the transistor size more and more …



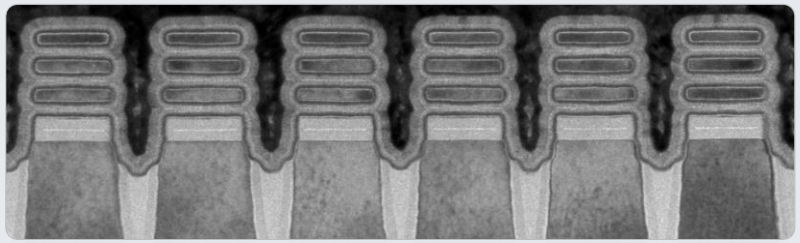
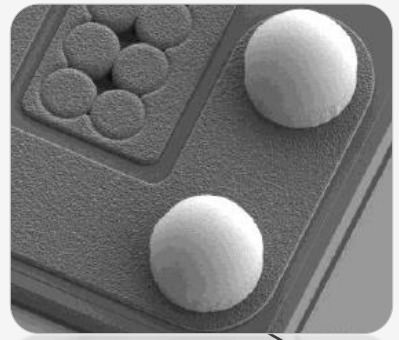
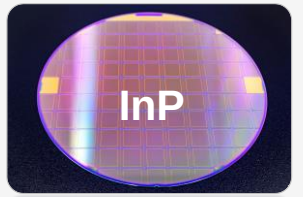
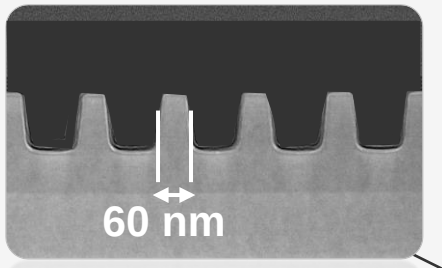


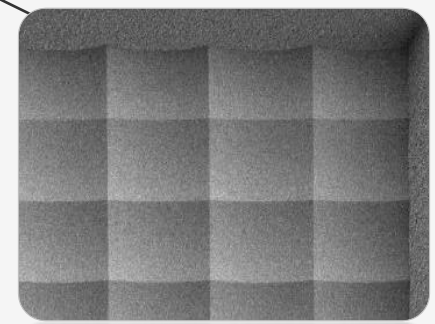
Image credit Intel and IBM

VCSEL Industry:



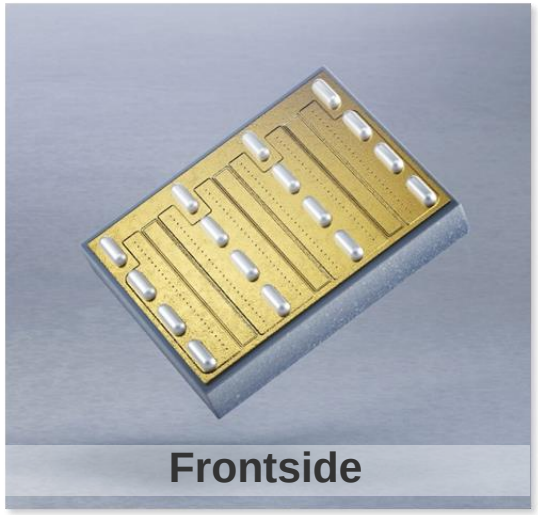


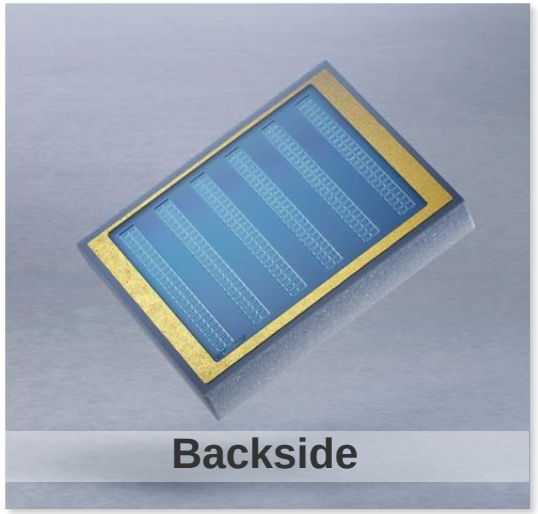


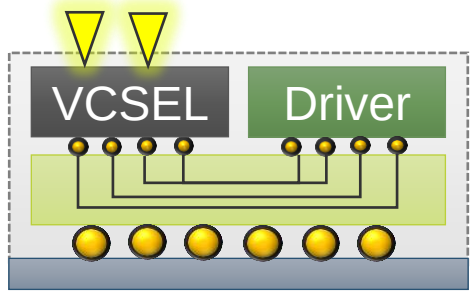


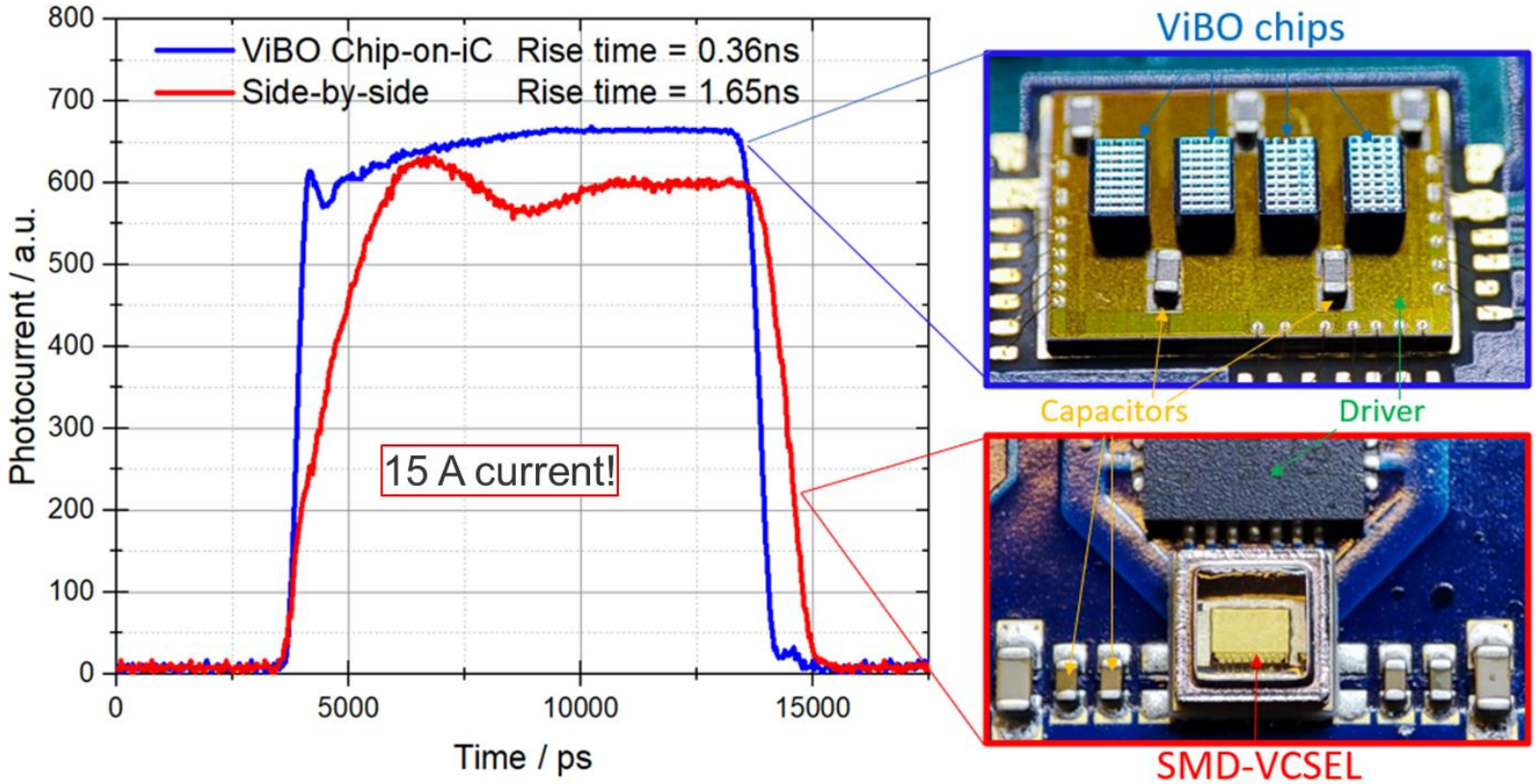
More functionality per chip area is the “Technology-Motor” of the VCSEL industry

VIBO – VCSEL with Integrated Backside Optics





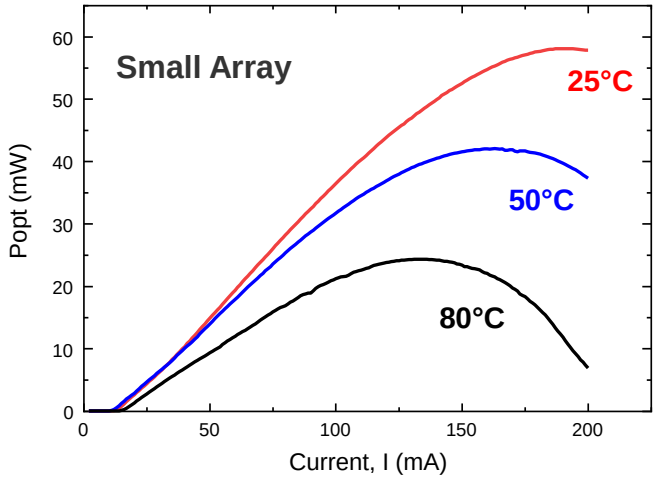




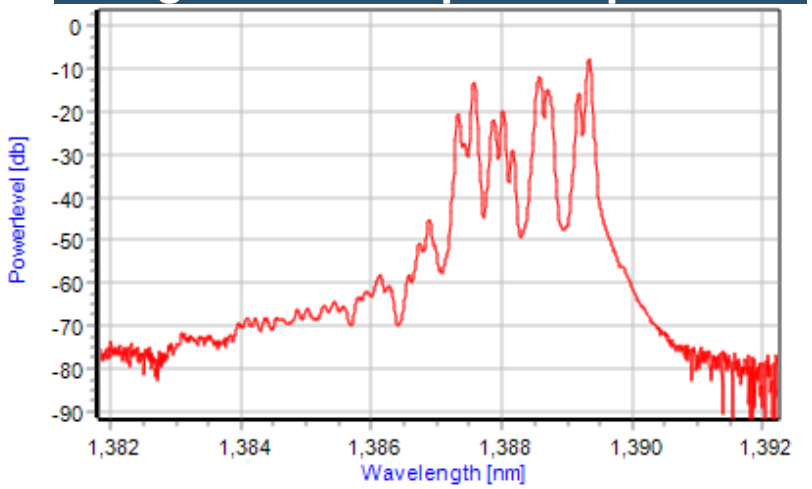
Superior pulse performance by direct integration with Silicon

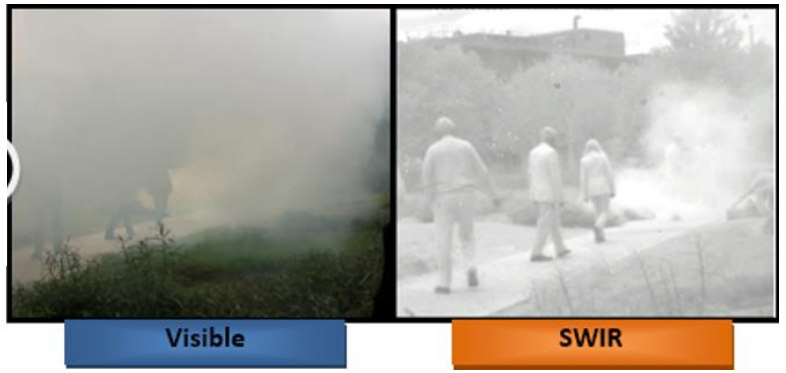
Integration of different semiconductor materials

Optical power up to high T



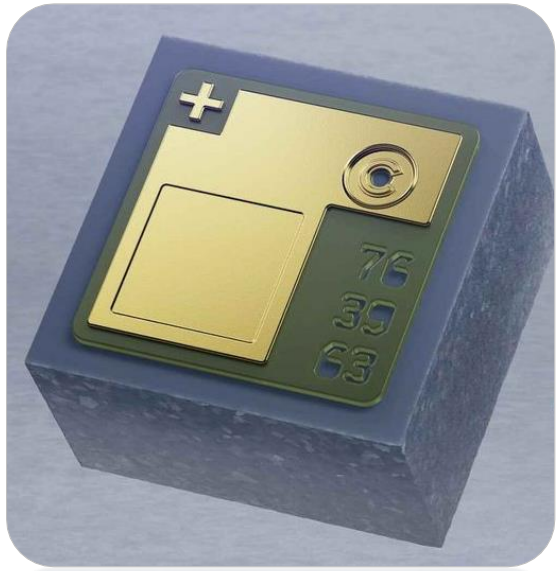
Single emitter optical spectrum





Up to 50 mW output power, while drastically increasing the eye-safety margin at 1380 nm wavelength.

And many more …



Oxygen Sensing

- Strict wavelength stability
- Polarization stabilization by integrated grating
- Long used conditions with strict reliability restrictions

Particle Detection

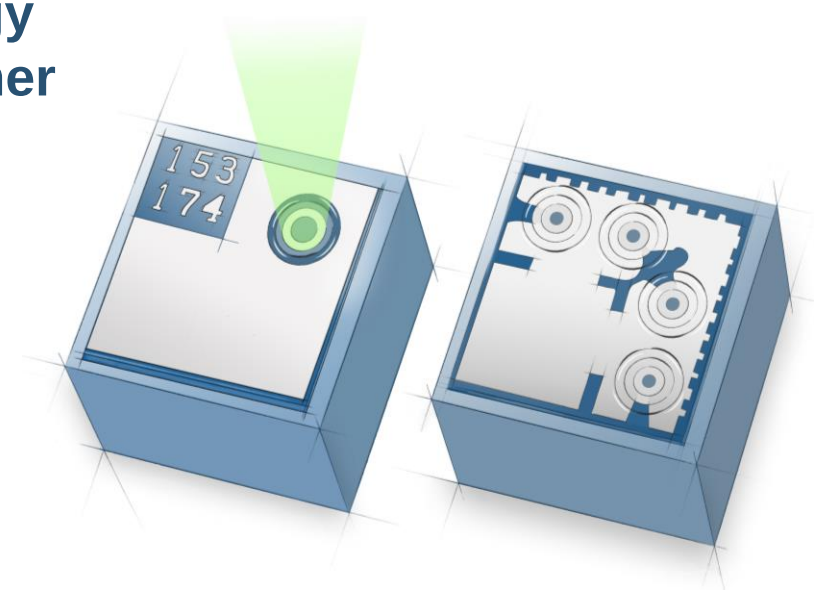
- VCSEL with integrated Photodiode for self mixing interference
- Polarization stabilization by integrated grating

Heating

- Homogenous irradiation with high WPE > 60%
- Flexible scaling
- Wavelength 980 nm

Summary

- **VCSELs still have the same basic concept as 20 years ago**
- **The level of functionality per chip area has increased tremendously and will continue to do so**
- **Integration of Indium Phosphide to the VCSEL technology setting enables cheap and safe long wavelength consumer light sources**



Speaker

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