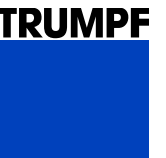




Company Introduction

TRUMPF Photonic Components



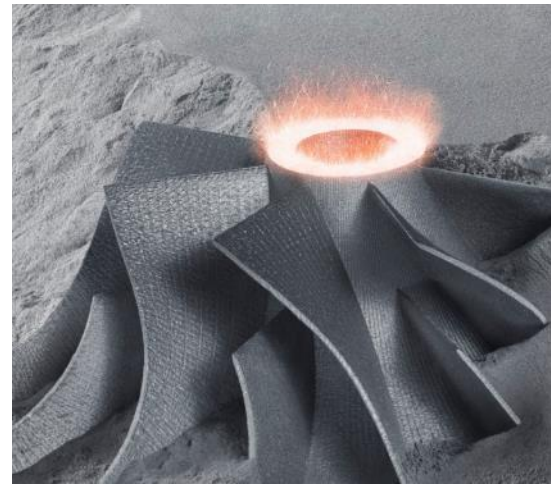
TRUMPF is...



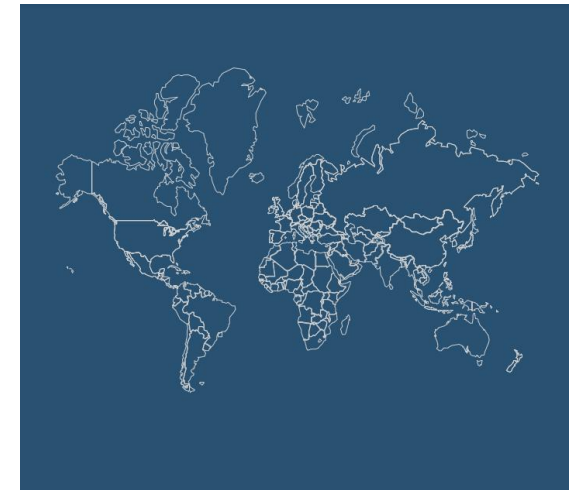
**Family business
since 1923**



**Technology leader in
two business divisions**

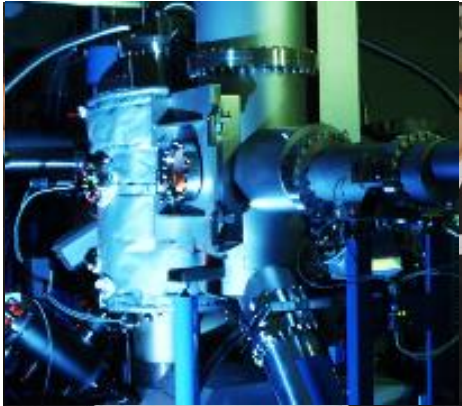


**Innovation promise –
holistically and constantly**

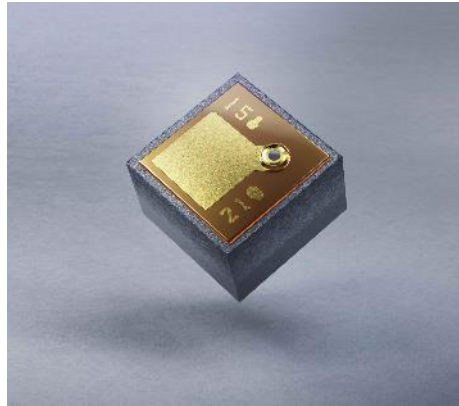


**Close to its customers
with over 70 subsidiaries**

About TRUMPF Photonic Components



**Spin-off from
University Ulm (HQ)**



**For 20 years:
Top Player in VCSEL
industry mainly
addressing Datacom,
Consumer Electronics
and Industrial
markets**



**Since 2019: Photonic
Components (PC)
business field of
TRUMPF**



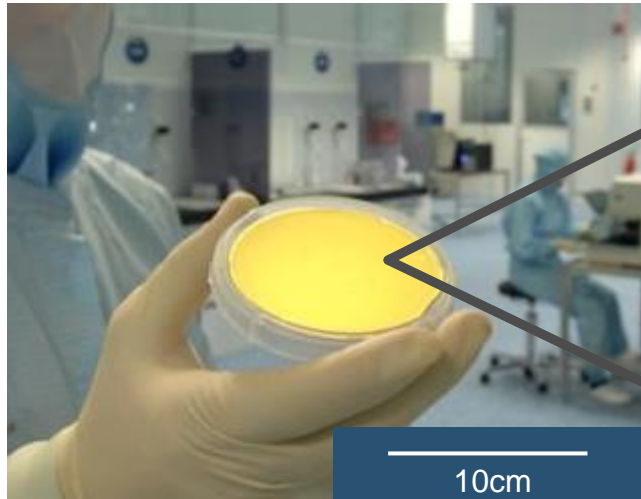
**~300 Employees at
5 sites worldwide**



**~ 2 billion VCSELs &
Photodiodes shipped**

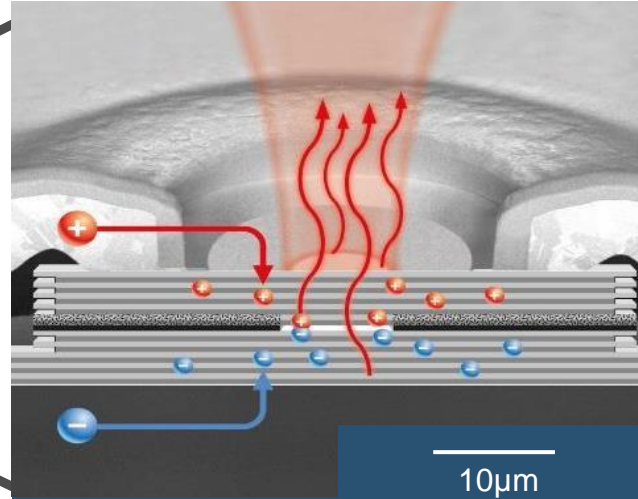
What is so special about a VCSEL?

vertical-cavity surface-emitting laser



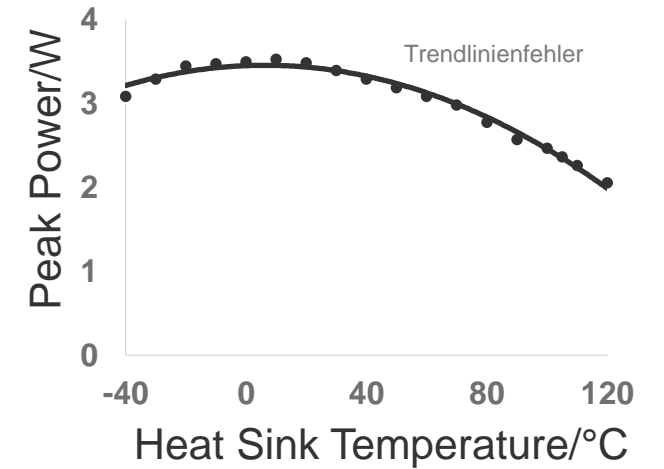
Many

>200,000 VCSEL chips on 4" wafer



Small

All functions integrated within 10µm

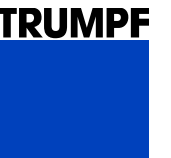


Robust

Works at all temperatures
-40 to 120°C

Markets which we operate in

Marketing & Sales | TPC



Digital megatrends drive VCSEL demand



Big Data

Optical interconnects in

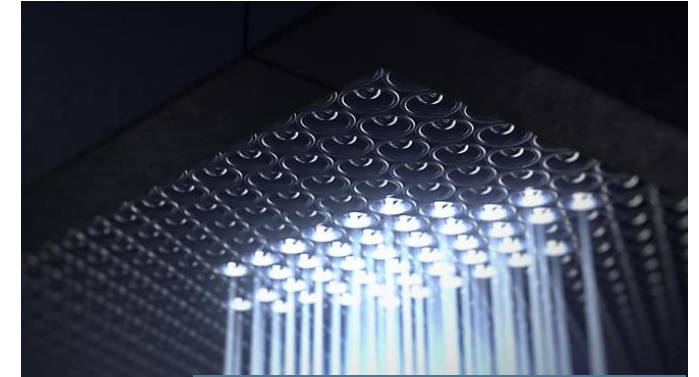
- HPC, data centers
- Networks
- Consumer



Sensors

Scanning distance, speed, 3D contours, identification

- Smartphones, IoT, etc.
- Autonomous driving
- Industrial Sensing



Digital Manufacturing

Digital manufacturing flows

- Additive manufacturing
- Battery production
- Tailored Industrial Heating

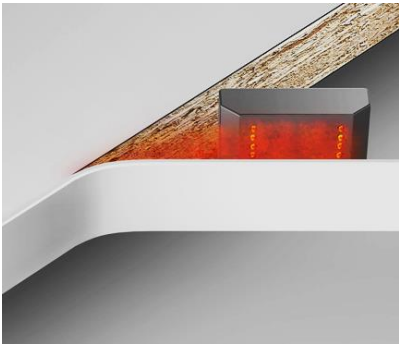
Application: VCSELs in smartphones (Sensing, Connecting)



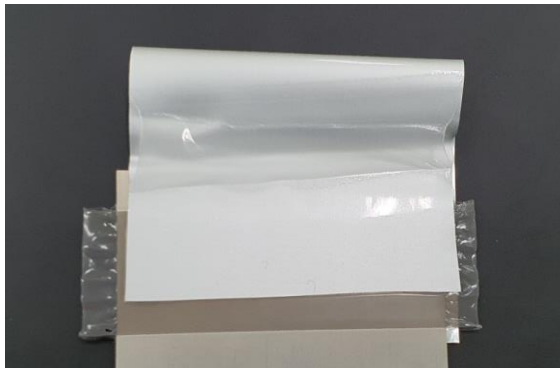
Industrial Applications

Plastic / Carbon Heating

- ➔ Edge banding of furniture panels

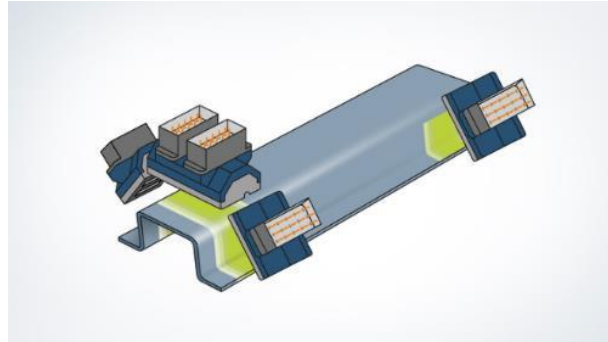


- ➔ Battery pouch sealing



Metal Heating

- ➔ Local weakening of high-strength steel



- ➔ Pre-heat 3D metal printing

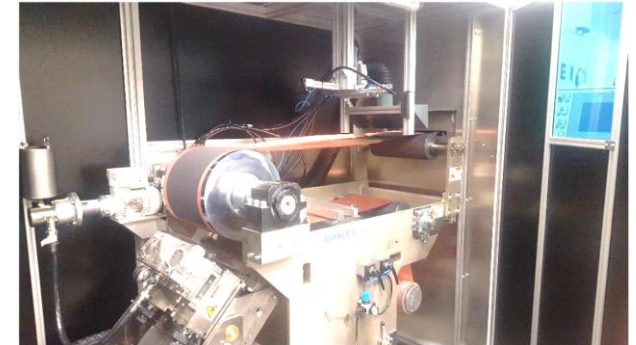


- ➔ Thermal stressing jet-engine blades

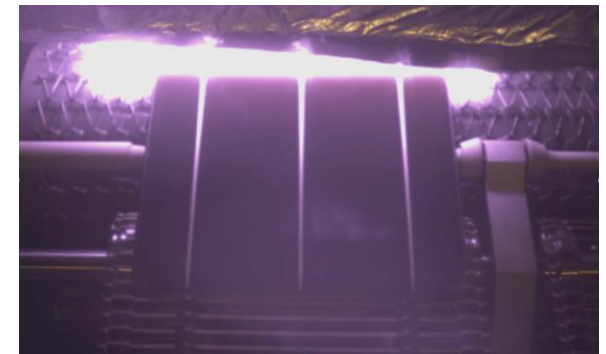


Surface Treatment / Modification

- ➔ Drying of battery electrodes for e-mobility

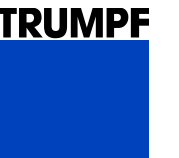


- ➔ Solar cell ultra-fast regeneration and Semiconductor packaging



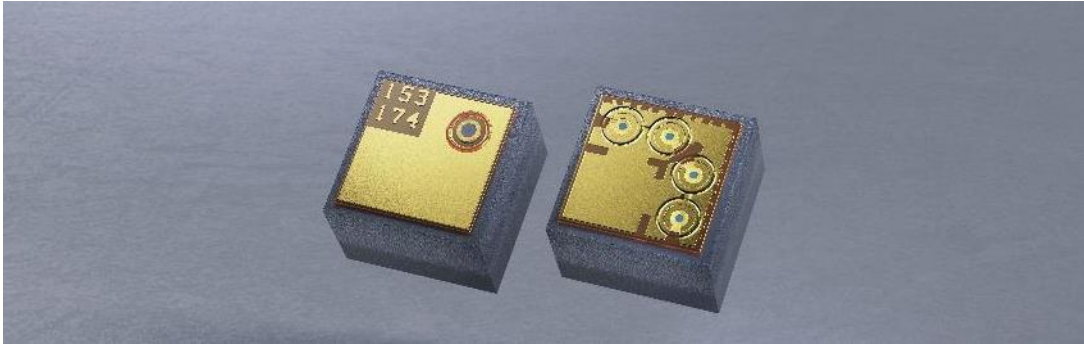
Products

Marketing & Sales | TPC



Our product categories

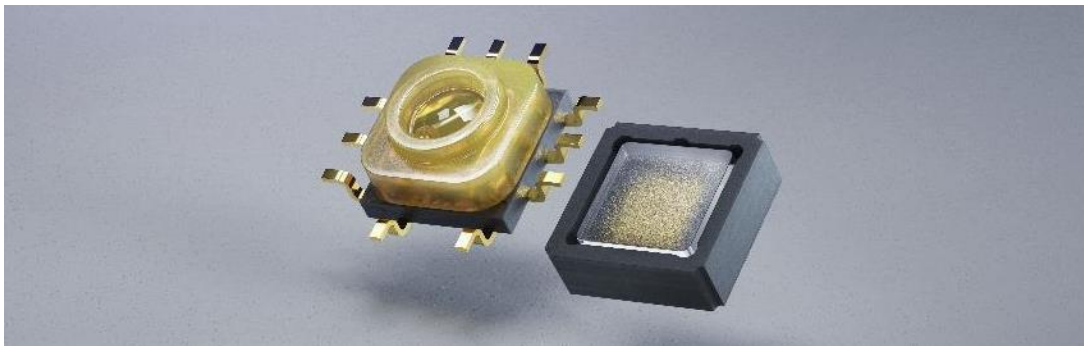
Single- and multi-mode VCSELs



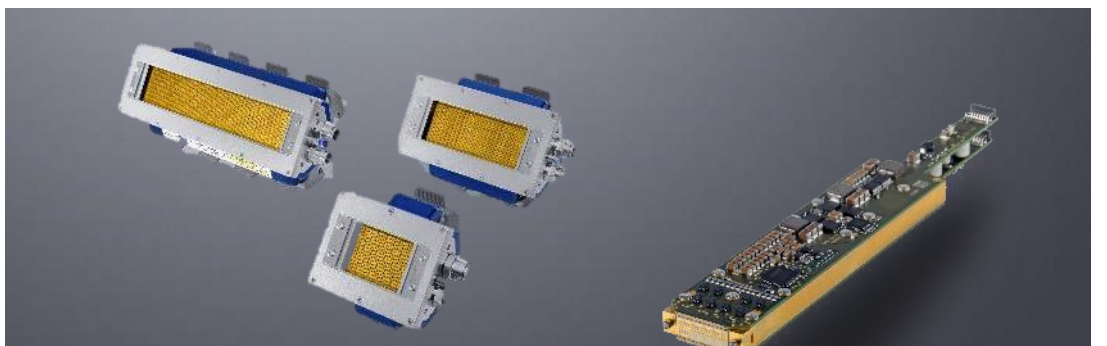
Datacom VCSELs & photodiodes



VCSEL modules & sensors



VCSEL heating systems / pixelated heating



VCSELs designed to the application

VCSELs come in many forms: we have them all



Consumer Sensing

Smallest Chips

- 150µm chip size
- 2-20 mW optical power
- 850 & 940 nm emission wavelength

VCSEL arrays

- 0.5-4W (cw)
- High pulse power 10x cw
- 850 & 940 nm emission wavelength
- Short pulses down to 1ns

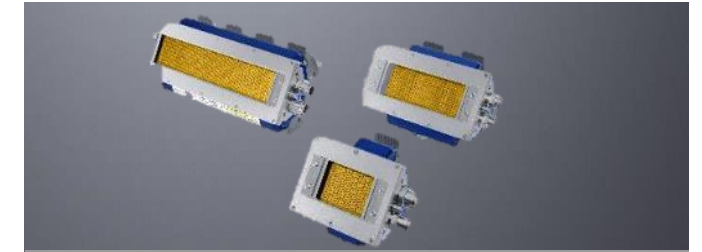


SMD packages including
integrated optics available



Datacom










- VCSELs and PDs at 850 nm
- up to 56 Gb/s bandwidth
- various array configurations (1x4, 1x12, ...)
- Large 2D arrays with addressable zones possible



Power Systems

- Many chips to scale the power to multi kW
- Addressable zones
- slope efficiency > 1 W/A
- 850, 940 & 980 nm emission wavelength

Application: data communication

	VCSEL chip format	Wave-length	Status		Receiver PIN-Diode (Production)	
5 Gbps	1x1	850 nm	Production		-	
10 Gbps	1x1	850 nm	Production		1x1, 1x4, 1x12	
14 Gbps	1x1, 1x4, 1x12	850 nm	Production		1x1, 1x4, 1x12	
25 Gbps	1x1, 1x4, 1x12	850 nm	New generation release Q2 2021		1x1, 1x4, 1x12	
56 Gbps PAM4	1x1, 1x4	850 nm	New generation release Q4 2021		New generation release Q3 2021	
112 Gbps PAM4	1x1, 1x4	850 nm	In development, release 2022		In development, release 2022	

VCSEL solutions for consumer and automotive in-cabin sensing








Target applications:

- Consumer (smartphone): facial recognition, 3D sensor, AR/VR
- Automotive in-cabin sensing: driver monitoring, facial recognition, gesture control



Proposition:

- High power 850nm and 940nm VCSEL arrays
- Hybrid package or bare die
- Self Mixing Interference (SMI) know how and system designs
- Integrated optical designs
- Integrated driver designs
- Continuous wave and short pulse (ToF) designs
- Supports SMI, Structured Light, and (spot) ToF technologies
- Automotive qualified products (AEC-Q102)

Products*		Dimensions (LxWxH)	CW optical output power	Emission wavelength	Field of view**
PLA5506-940		3.2 x 1.95 x 1.15mm ³	600mW	940nm	65° x 85°
PLA5220-940		3.7 x 3.6 x 1.25mm ³	2W	940nm	110° x 85°
PLA5320-940		3.7 x 3.6 x 1.25mm ³	2W	940nm	70° x 60°
PLA5420-940		3.7 x 3.6 x 1.25mm ³	2W	940nm	40° x 30°
PLA5220-850		3.7 x 3.6 x 1.25mm ³	2W	850nm	110° x 85°
PLA5320-850		3.7 x 3.6 x 1.25mm ³	2W	850nm	70° x 60°
PLA5420-850		3.7 x 3.6 x 1.25mm ³	2W	850nm	40° x 30°

Our USP: VCSEL with intelligent properties

TRUMPF

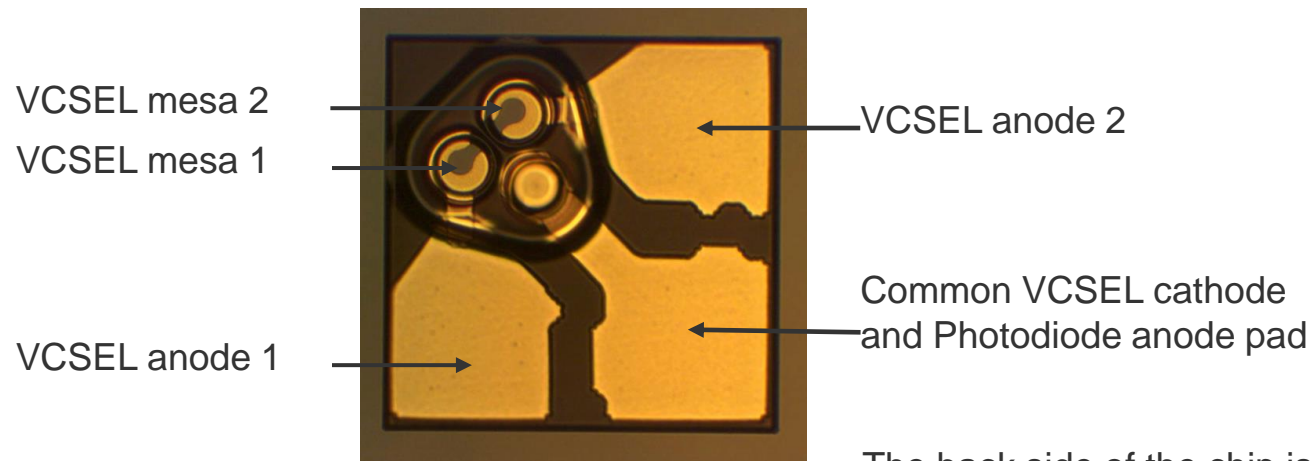


Our latest development: VIP* - VCSEL with Intelligent Properties

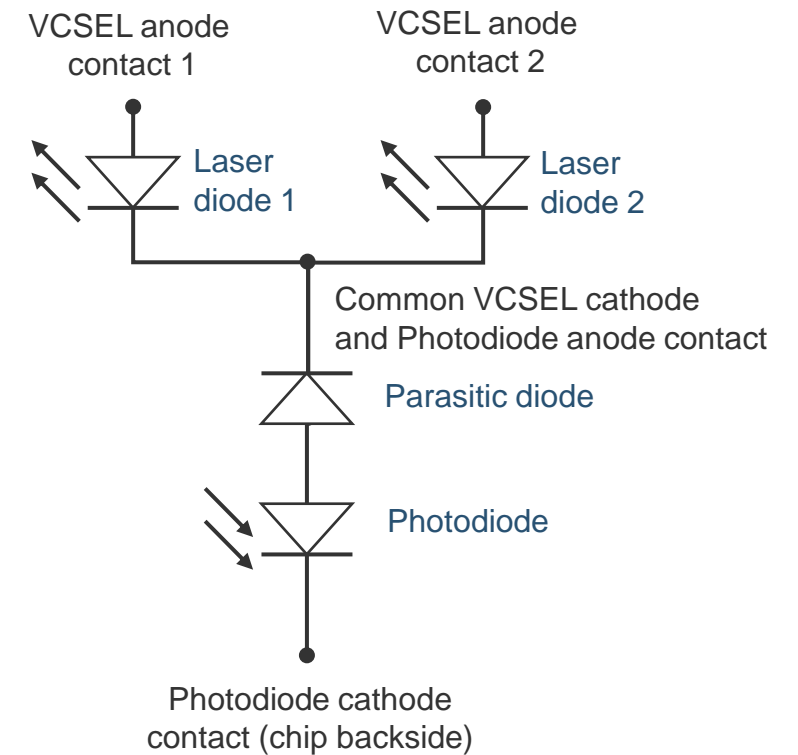
* better known as VCSEL with Integrated Photodiode

Characteristics latest generation VIP:

- 2 VCSELs: individually addressable
- 3 front side contacts, 1 back side contact
- Chip size: 165x165 μm
- Chip thickness: 130 μm



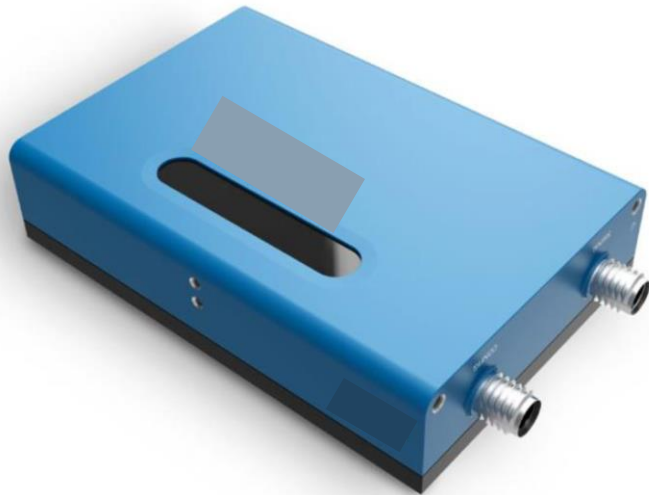
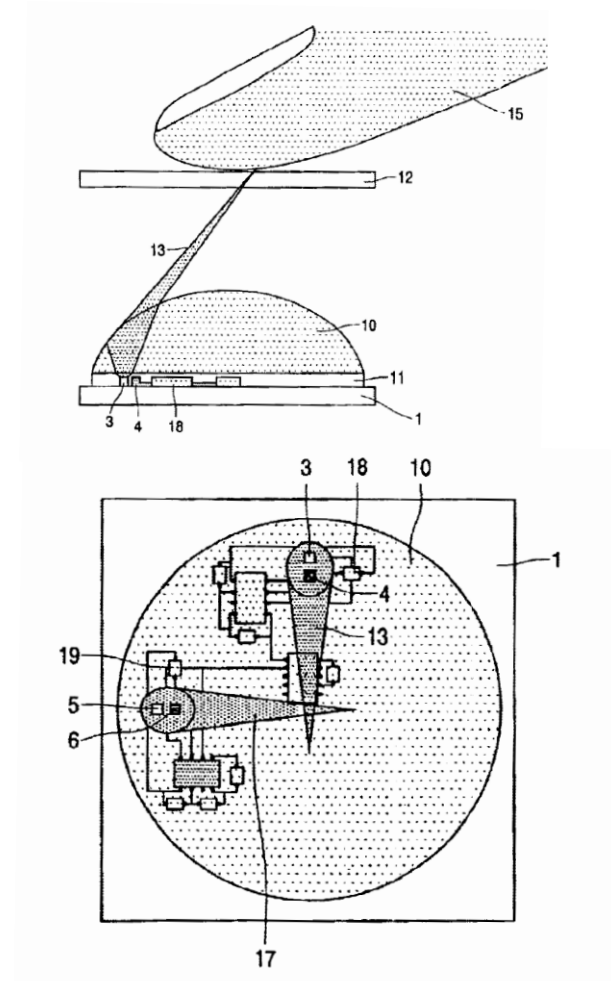
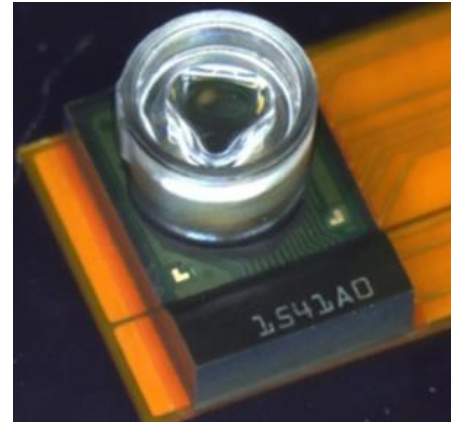
The back side of the chip is the contact of the photodiode cathode.



VIP: the engine for laser Self-Mixing Interference technology

VIP enabled SMI applications allows compact detection of:

- Navigation movement (optical mouse)
- Small particles passing by (dust sensor)
- Observation of a membrane (optical microphone)
- Finger movement
- Industrial movement



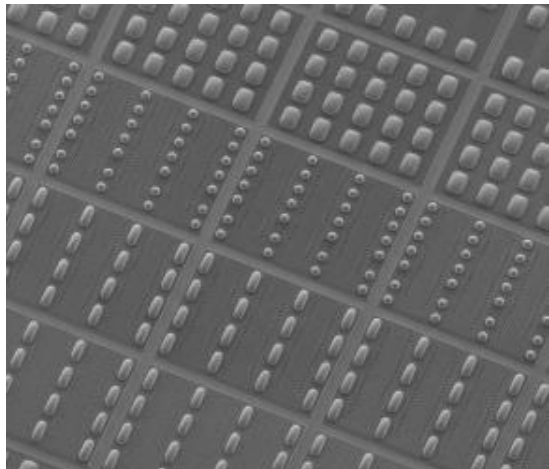
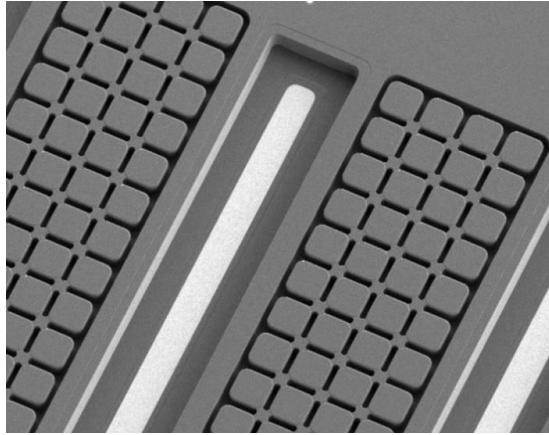
ViBO - VCSEL with integrated backside optics

TRUMPF



ViBO: monolithically integrated optics

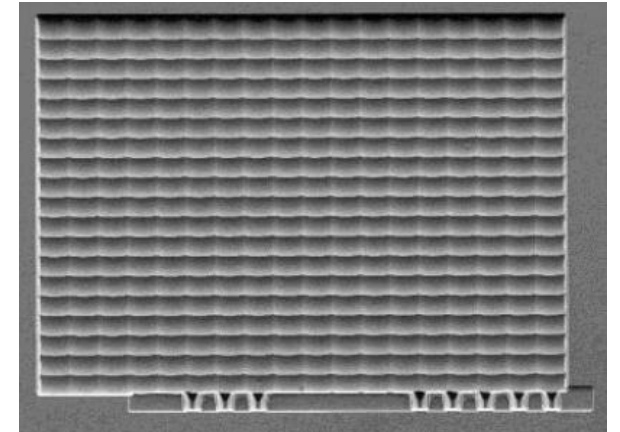
Integrated optics reduce system size and complexity



Bottom emitter VCSEL

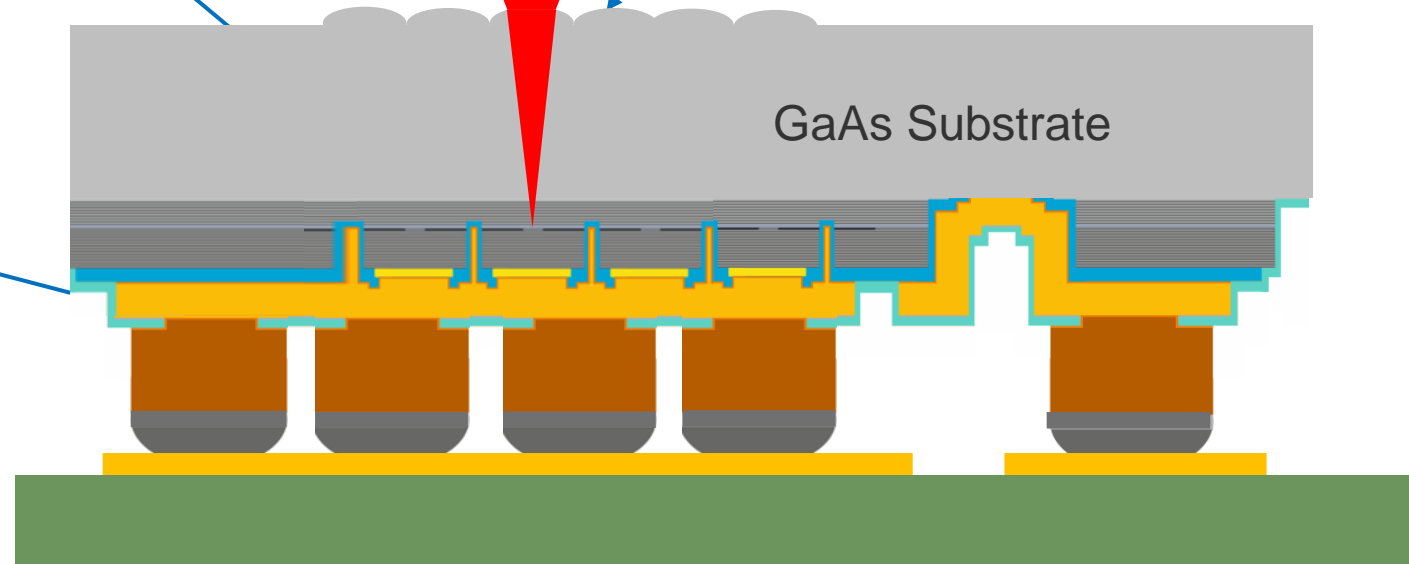
Light emission

Integrated micro lenses



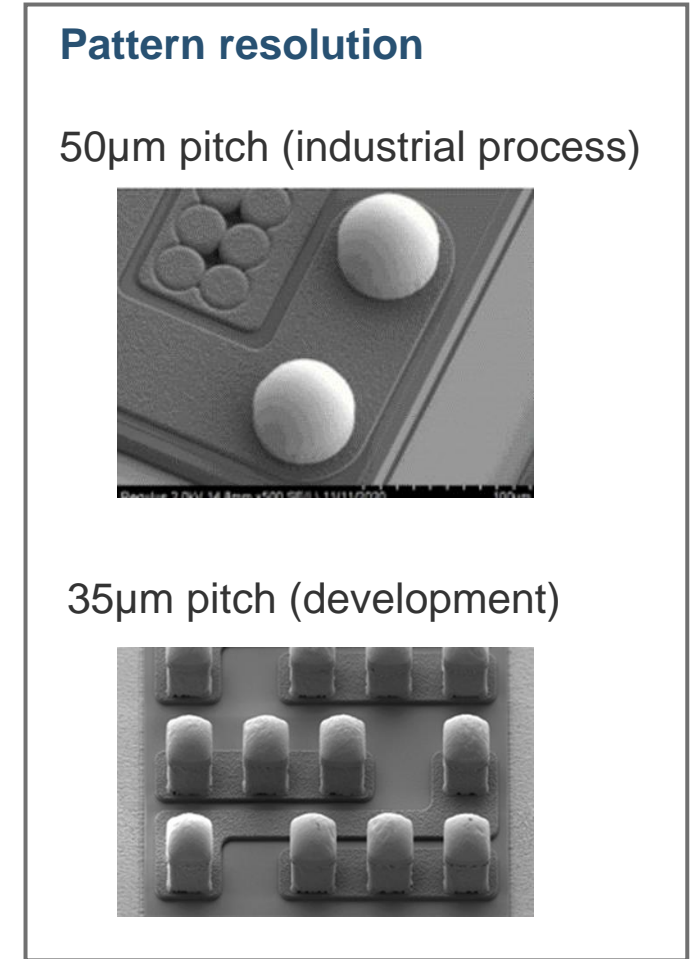
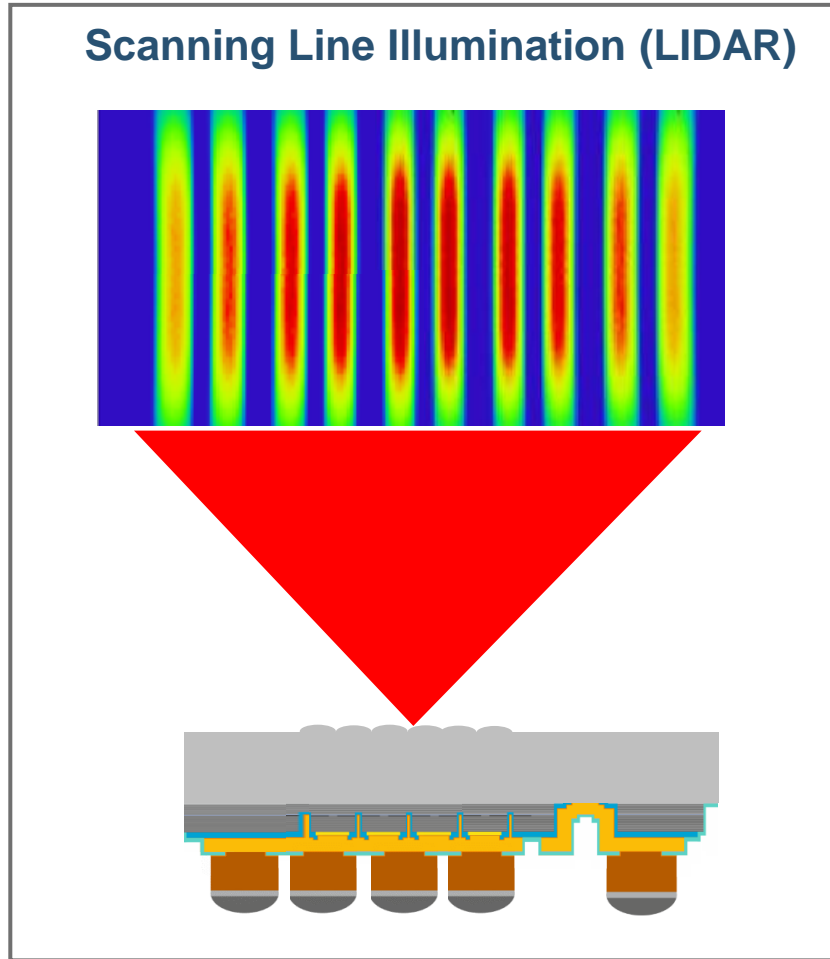
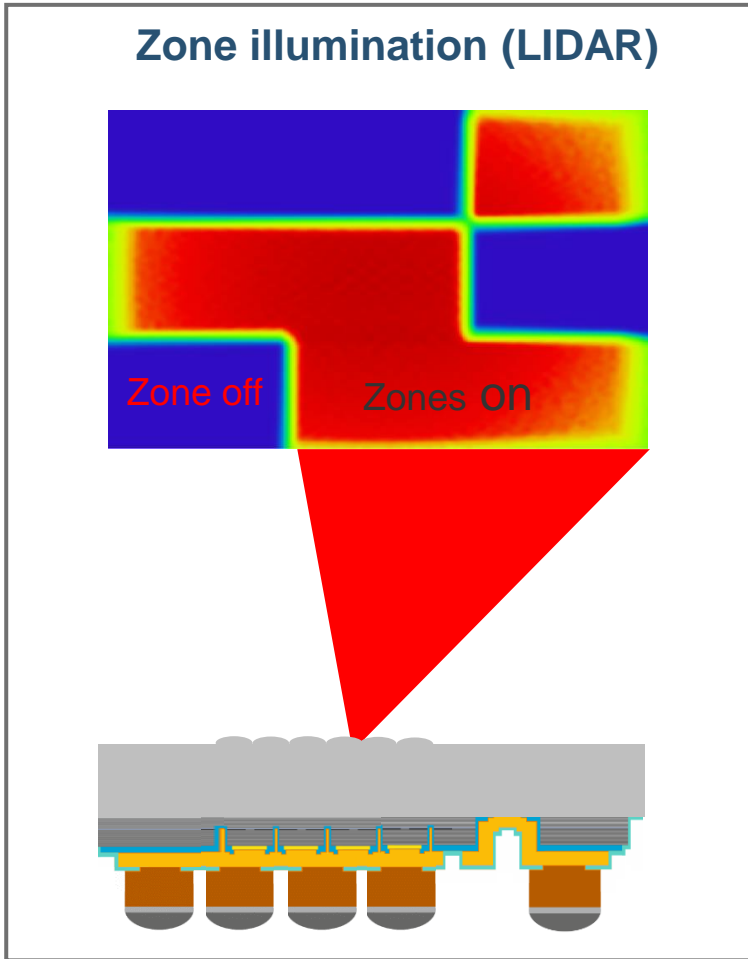
Copper pillars (Copper + SnAg)

GaAs Substrate



Next generation products with structured electrode geometry

Bottom emitters allow straightforward 2d electrode patterns



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