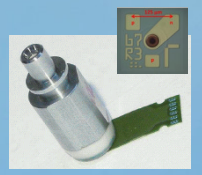
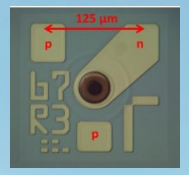
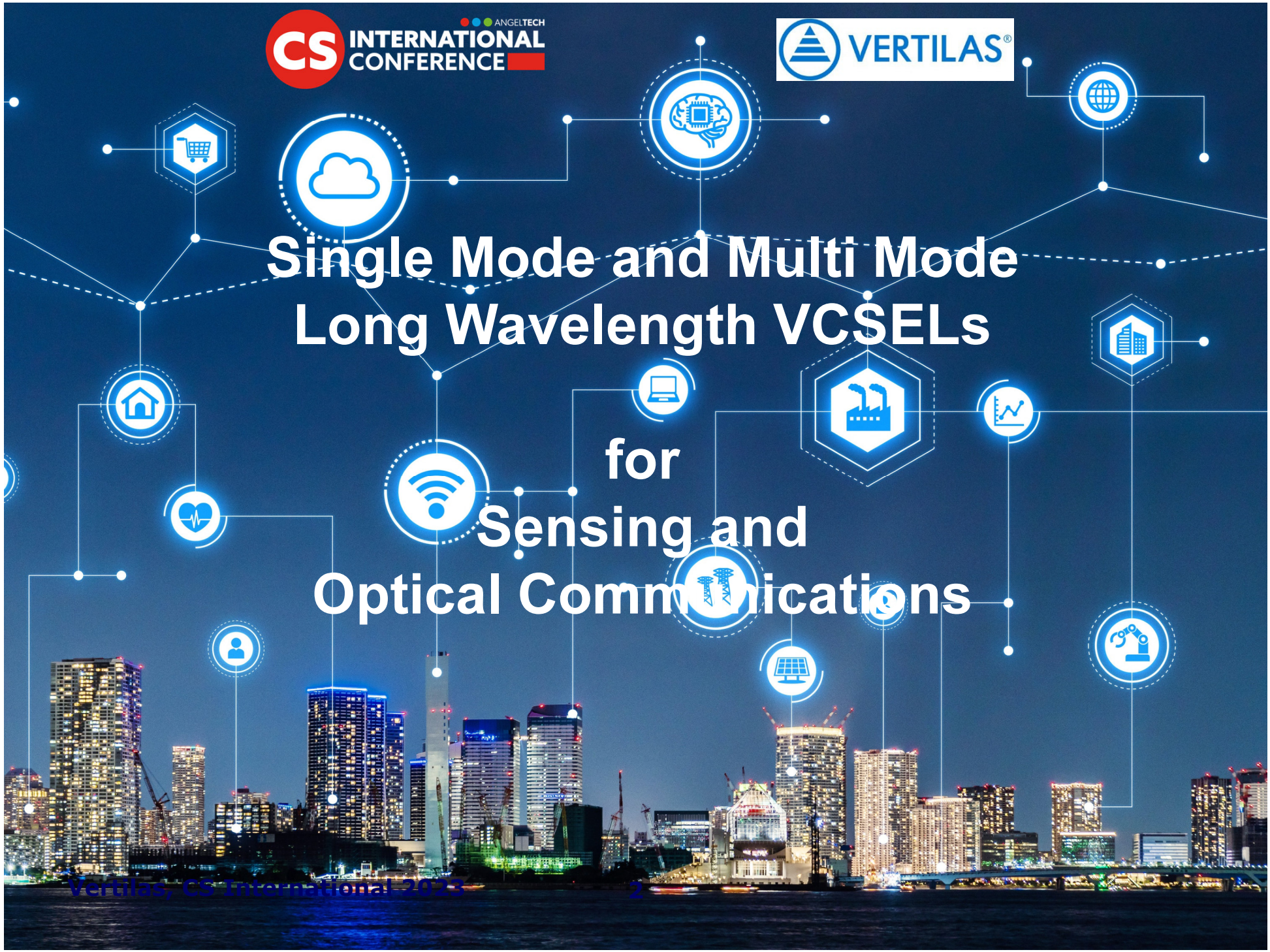
InP Long Wavelength VCSELs

Vertilas GmbH, Christian Neumeyr

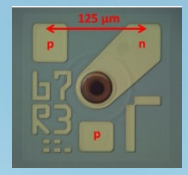





CS INTERNATIONAL CONFERENCE
ANGELTECH
VERTILAS®
Single Mode and Multi Mode
Long Wavelength VCSELs
for
Sensing and
Optical Communications

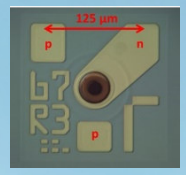
Agenda

- Vertical Cavity Surface Emitting Lasers - VCSELs as light sources for sensing and optical communications
- InP BTJ VCSEL structure and performance parameters
- High data rate VCSELs for optical communications and photonic integration with SiPh
- InP VCSELs for gas sensing (Tunable Diode Laser Spectroscopy)
- 2D VCSEL arrays for 3D sensing
  - From few mWs to 10s and 100s Watts optical power
- Outlook



Short and Long Wavelength VCSELs

- VCSEL products enable high performance, cost competitive and energy efficient solutions (proven by short wavelength VCSELs)
- Interest and demand for VCSELs with wavelengths for 1.3 µm, 1.5 µm and beyond is growing
- Higher wavelength VCSELs can improve eye safety and reduce impact of sunlight radiation for 3D sensing applications
- Long wavelength VCSELs enable the transition of VCSEL benefits to applications from 1 µm to 2 µm



VERTILAS – 20 Years of InP VCSEL Innovation

Leading supplier of lw VCSELs
(**V**ertical **C**avity **S**urface **E**mitting **L**asers)

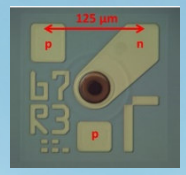
World Wide
Customer Base

Garching
(near Munich),
Germany

Founded in 2001

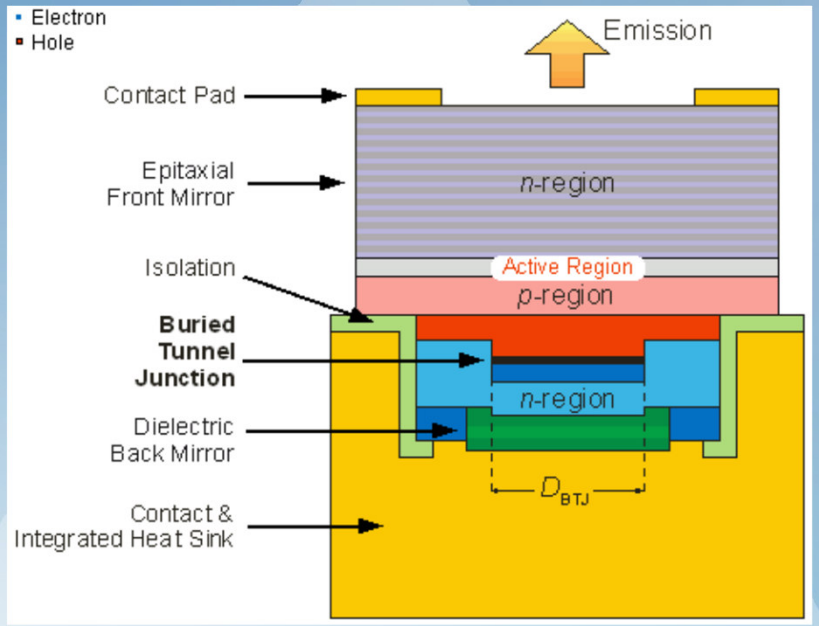
QMS ISO9001

Spin-Out from
TUM/WSI



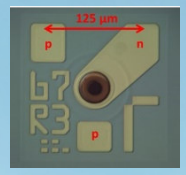
Vertilas InP BTJ VCSEL

VCSEL Structure

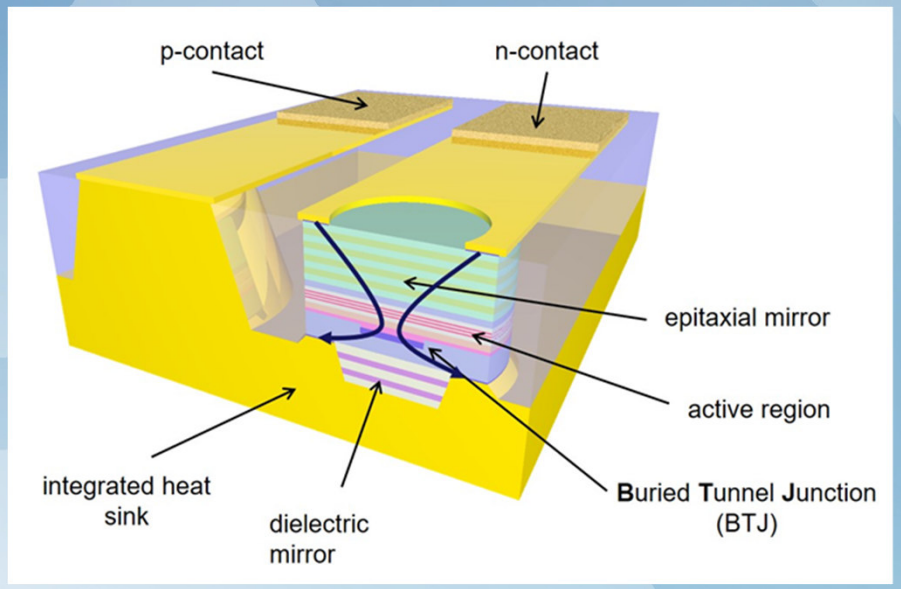


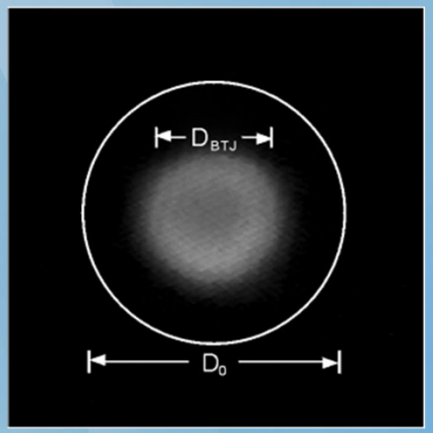
InP BTJ Technology

- Optimized thermal design
- Current confinement by BTJ (not oxide)
- Polarisation stabilized
- Passed 30k hrs accelerated aging
- Telcordia compliant qualification
- Singlets, 1D and 2D arrays
- Addressing applications from 1.3 µm to 2.3 µm
- Single mode and and multi mode

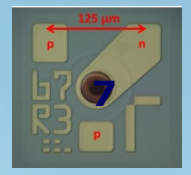


Active Area Defined by Buried Tunnel Junction



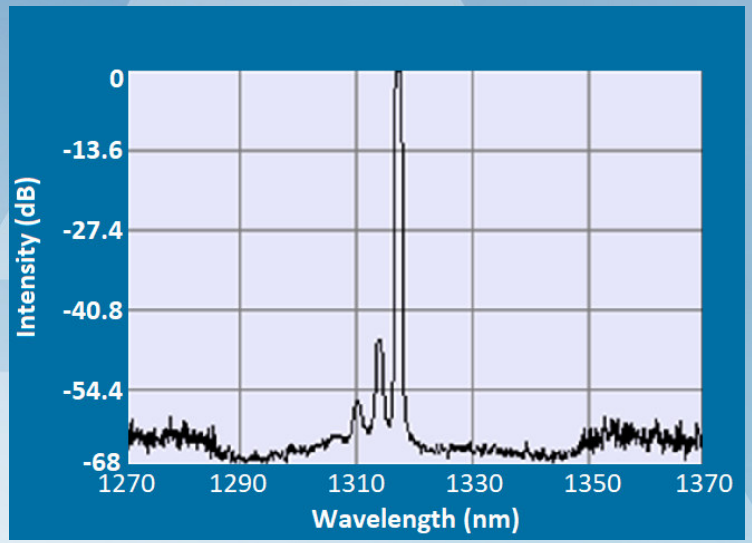


Active area, SMSR and optical power defined by diameter of buried tunnel junction

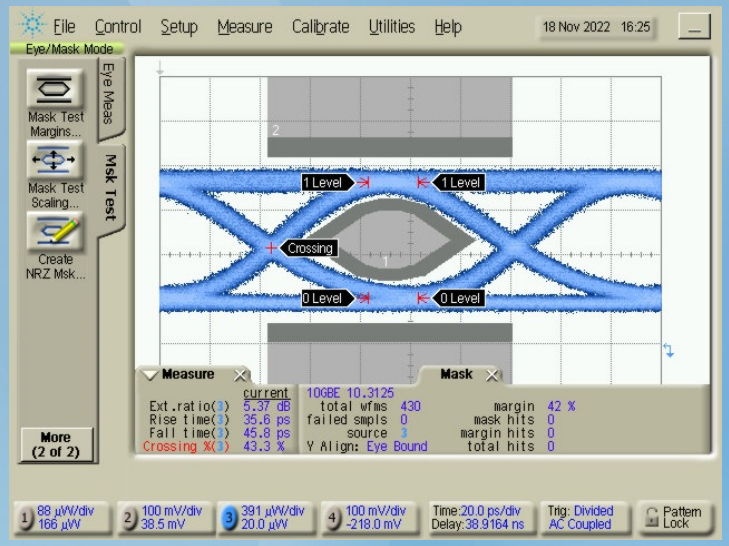


Single Mode VCSEL 1.3 µm for Optical Communications

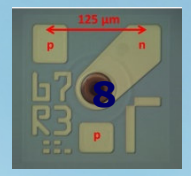
Side Mode Suppression Ratio
SMSR > 40 dB



10 Gbps Eye Diagram
EMM = 42%

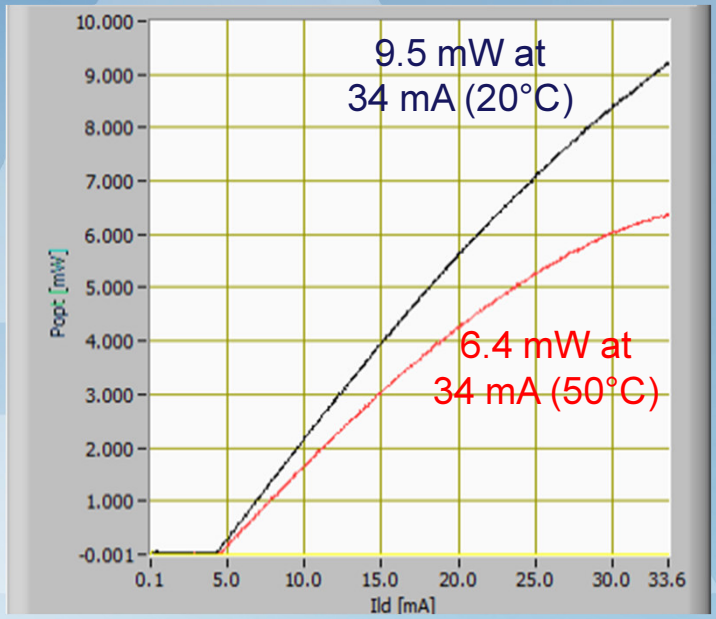


Excellent single mode performance
Low threshold current and low power dissipation

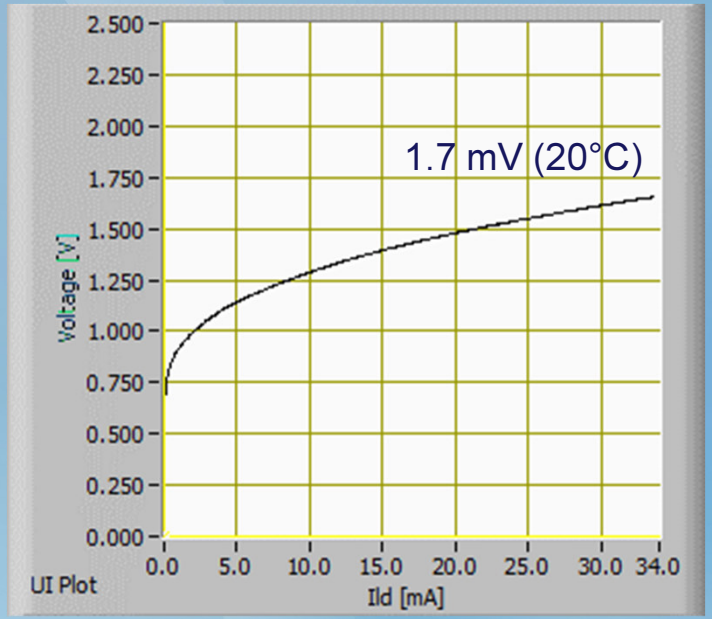


Multi Mode VCSEL 1.3 µm Emitter (12 µm BTJ)

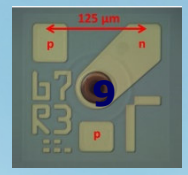
Light-Intensity-Curve
(20°C black, 50°C red)



Voltage – Current-Curve



ca. 10 mW max. Po per emitter
Low Ith and low V



Markets for Single Mode Long Wavelength VCSELs

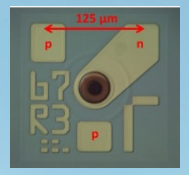
Optical Communications

NIR VCSEL

NIR Sensing TDLS

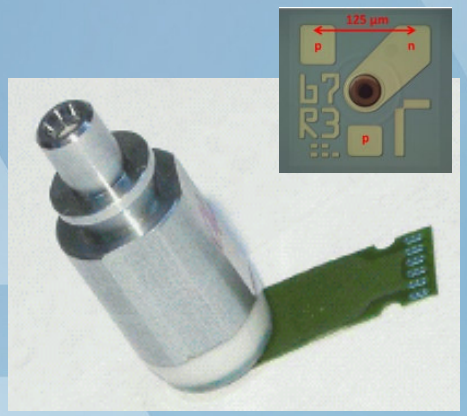
(Tunable Diode Laser Spectroscopy)

New: 1.3 µm to 2 µm 2D VCSEL arrays for 3D sensing



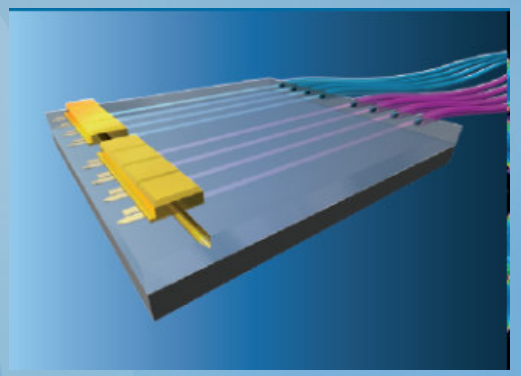
High Speed InP VCSELs for Communications

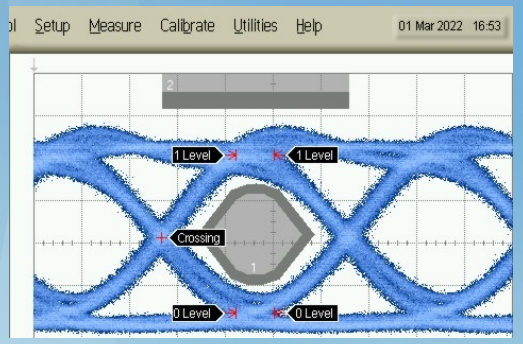
Data Center



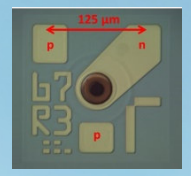
1.3 µm to 1.6 µm
O-, C-, L-Band

Integration with Silicon Photonics

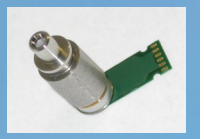


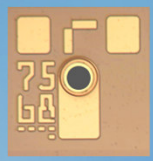


25G to 40G



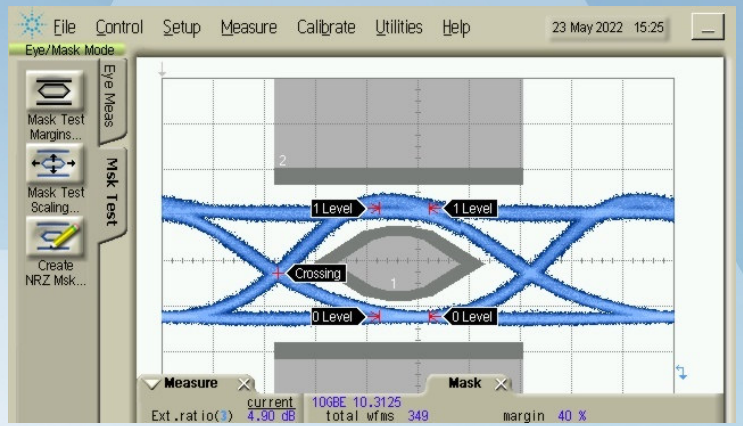
Single Mode LW VCSEL Record Performance for Single Mode Data Communications (NRZ)



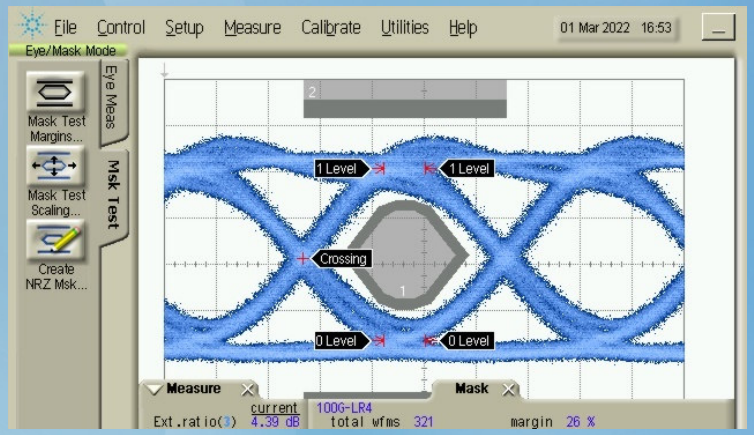


NRZ Modulation - Eye Diagram 10G and 25G VCSEL

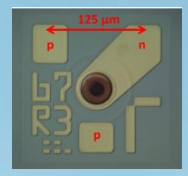
10 Gbps – 1310nm, 75°C
EMM 40%



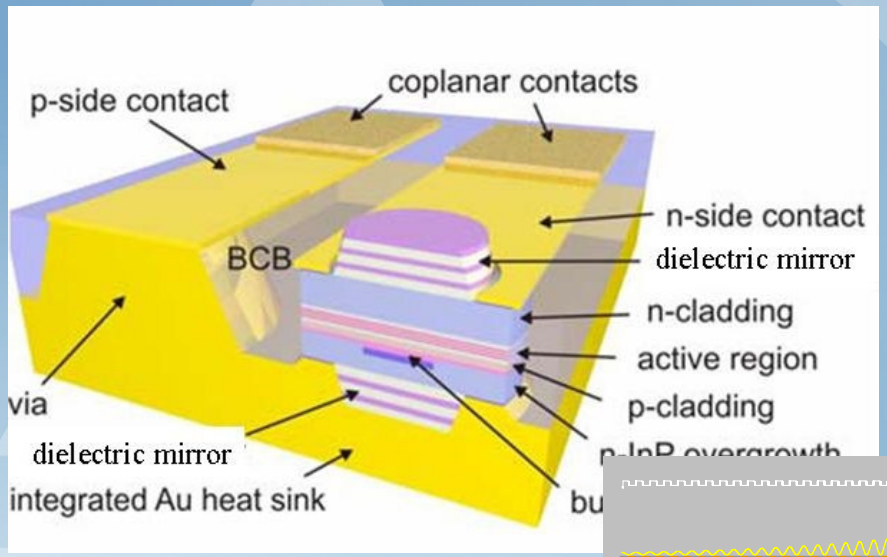
25 Gbps - 1550 nm, RT
EMM 26%

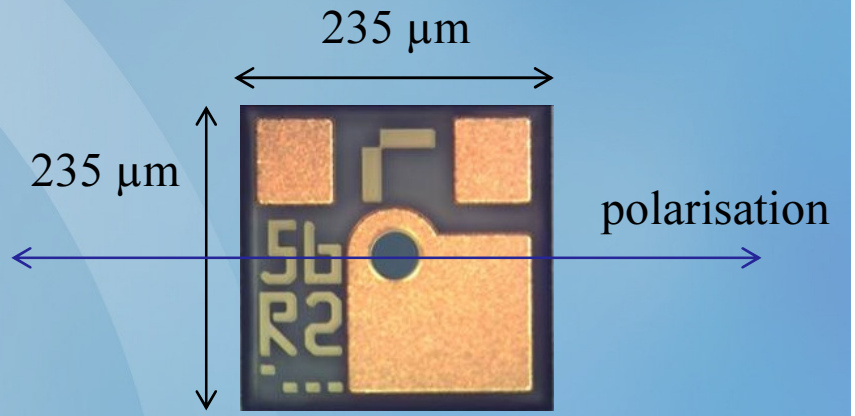


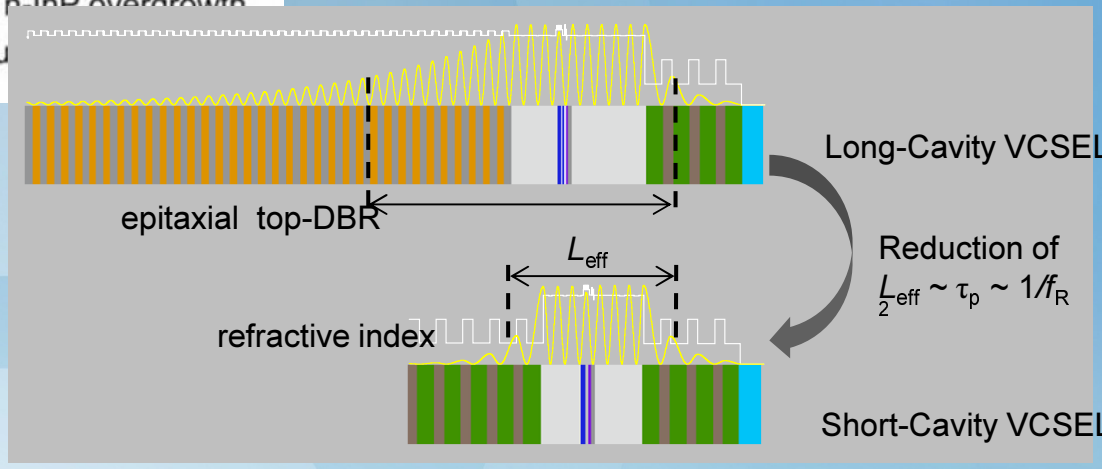
With equalizer 50 Gbps demonstrated

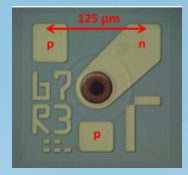


Short Cavity Ultra High Speed InP BTJ VCSEL
1.3 µm SM VCSEL - 25 Gbps Performance

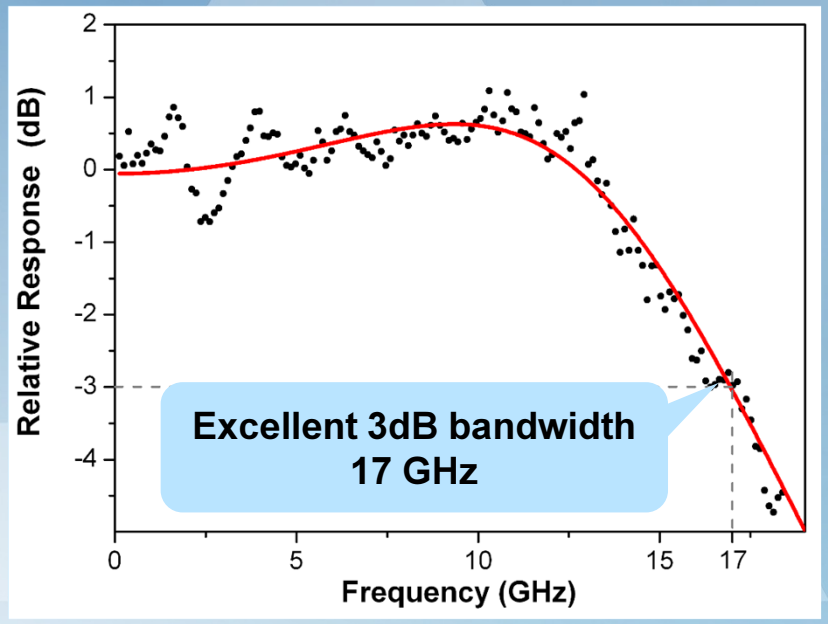


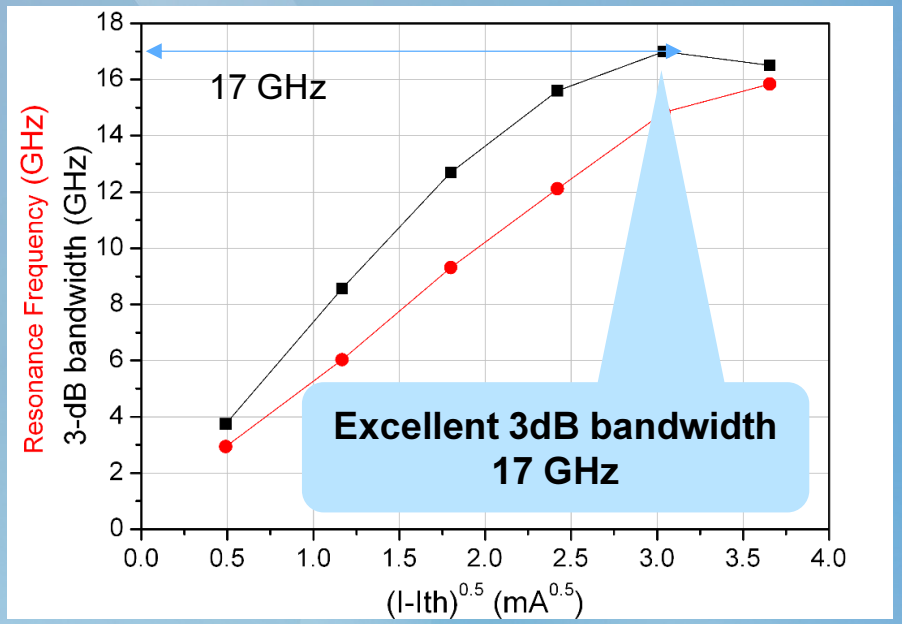




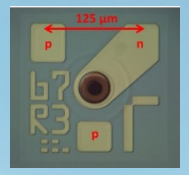


1310 nm High Speed VCSELs
Excellent World Record Bandwidth of 1.3 µm InP VCSEL



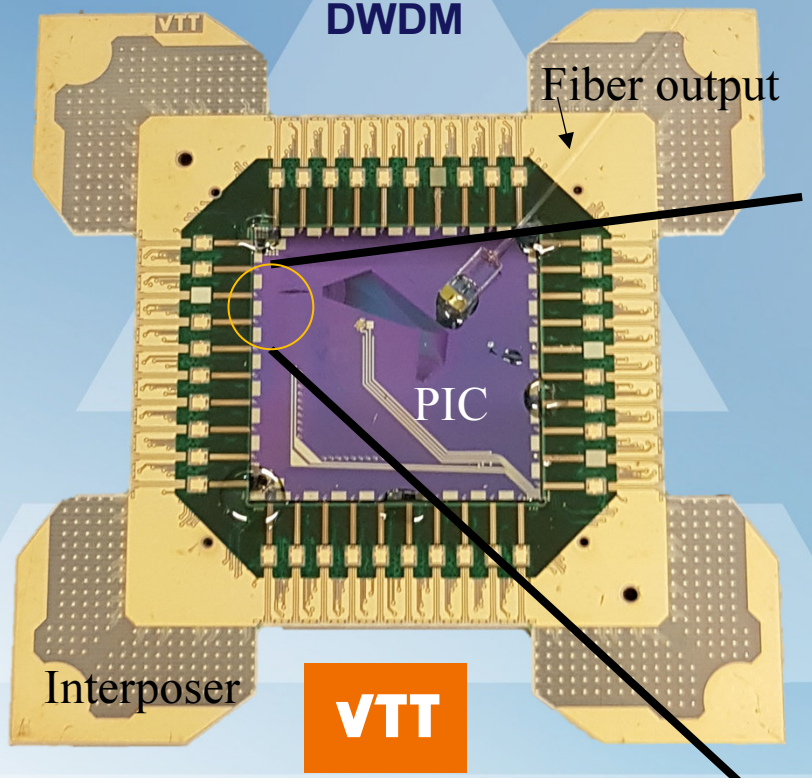


1310 nm VCSEL small signal response
S21 3dB bandwidth at 20°C

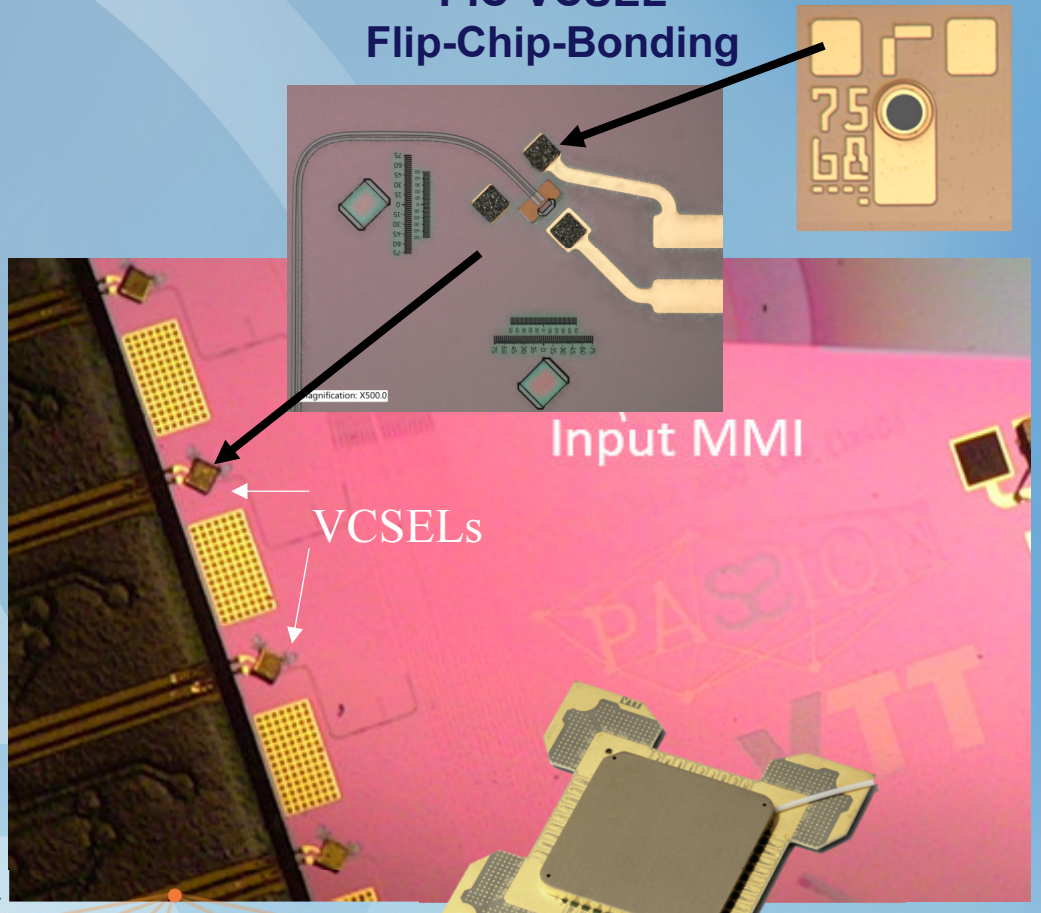


SiP VCSEL integration – 2 Tbps Transmitter

40 VCSELs @ 50 Gbps
DWDM



PIC-VCSEL
Flip-Chip-Bonding

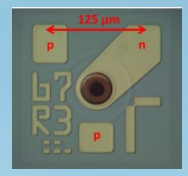


Applications for NIR Gas Sensing TDLS

Industry and Safety

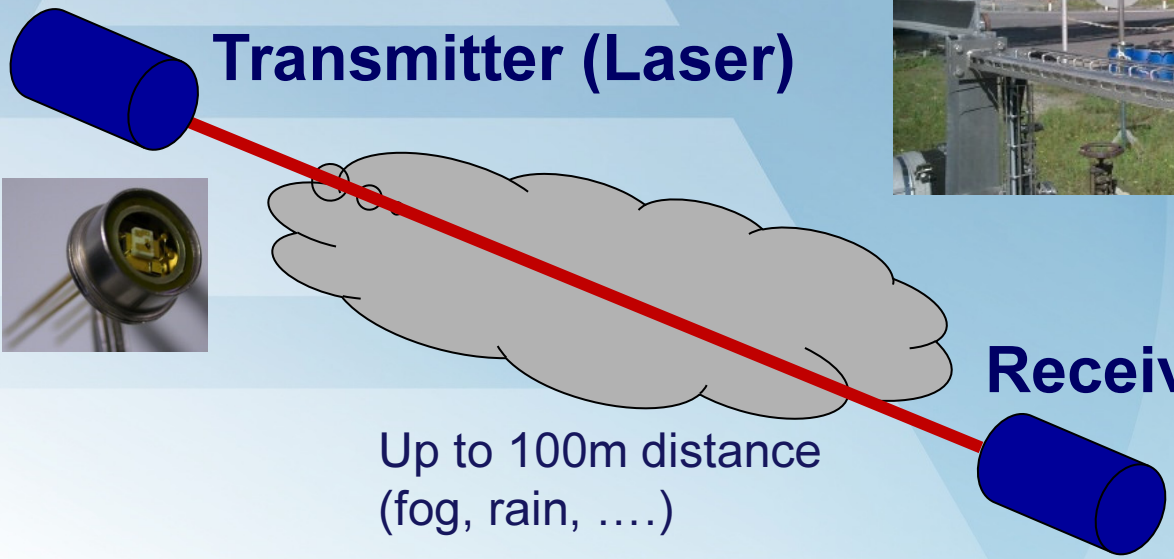
Environmental Monitoring

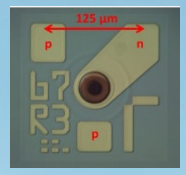
Medical and Analysis



NIR Gas Sensing- TDLS Open Path Detector in Petrochemical Plants

Measurement of
H2S, CH4:
1580 nm, 1654 nm





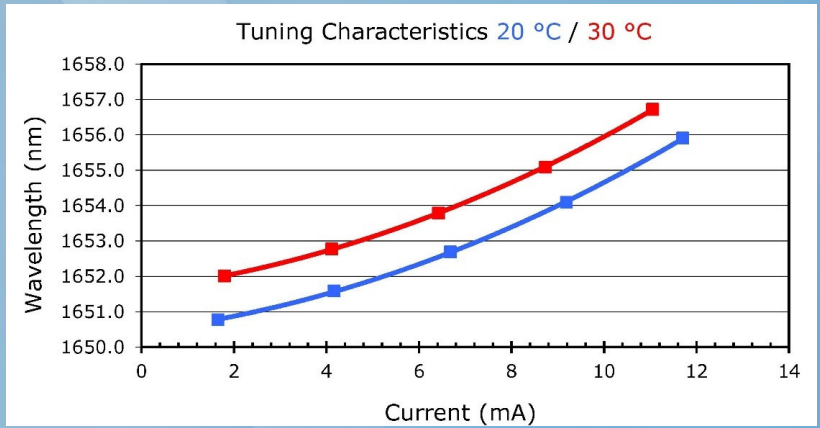
Tunable VCSELs for Gas Sensing TDLS

Wavelengths Range

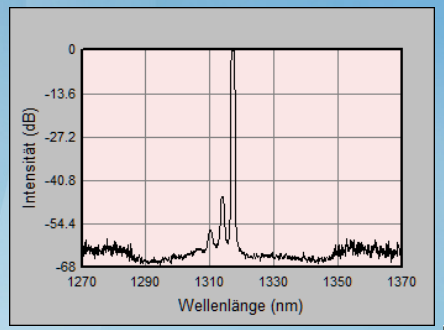
Wavelength in nm	Gas
1278	HF
1392	H2O
1512	NH3
1564	CO
1651, 1654, 1680	CH4
1742	HCl
1854, 1877	H2O
2004, 2008	CO2

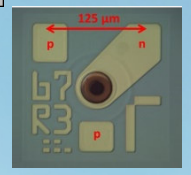
Any wavelength from 1.3 µm to 2.3 µm can be manufactured on demand

Wavelength Tuning

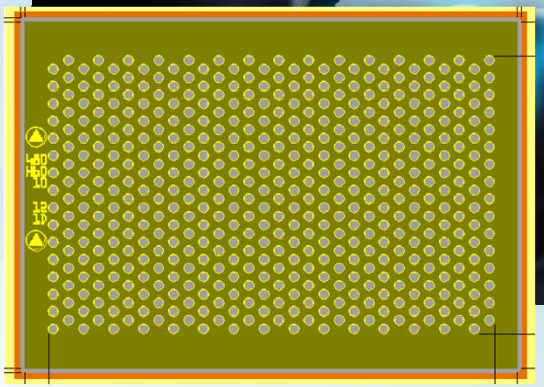


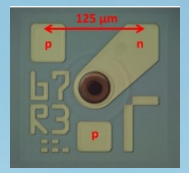
Single Mode SMSR





LW InP 2D VCSEL Arrays for 3D Sensing: 1.27 µm to 2 µm

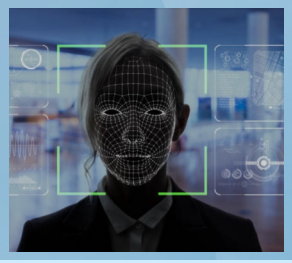




3D Sensing and LW VCSEL Arrays

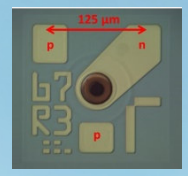
- **Target applications**
  - Illumination
  - ToF
  - Automotive
    - In-cabin monitoring, LiDAR
  - Health care
  - Robotics, autonomous vehicles
  - AR/VR
  - Consumer electronics






Optical power requirements from few mWs to 100s Watts and more

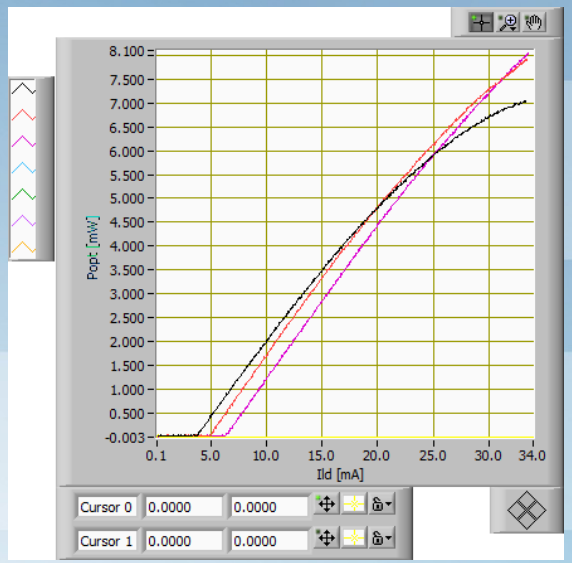
- **Application Scenarios / Requirement for LW VCSEL Arrays**
  - Eye safety
  - Reduced sunlight interference
  - Special applications / markets requiring wavelengths > 1 µm

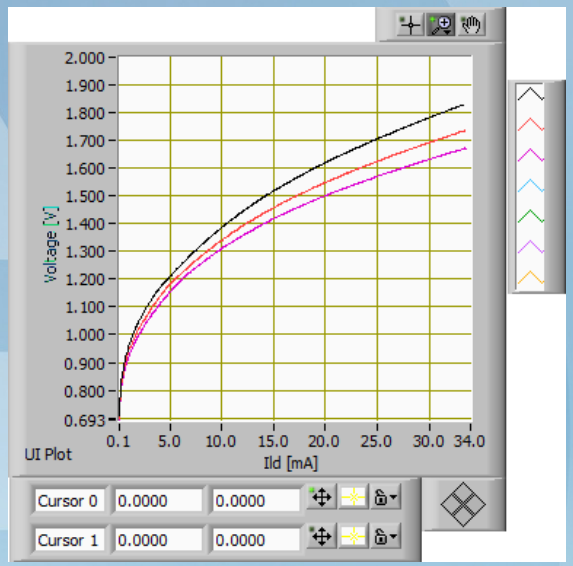


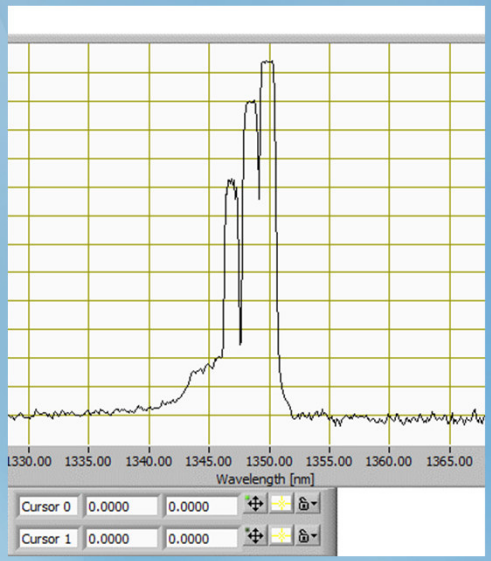
Optical Power: From few mWs to 10s and 100s of Watts

Single VCSEL Multi Mode Emitter 1.3µm

20°C EZ 3-4 BTJ 8µ (black) 10µ(red) 12µ (purple)



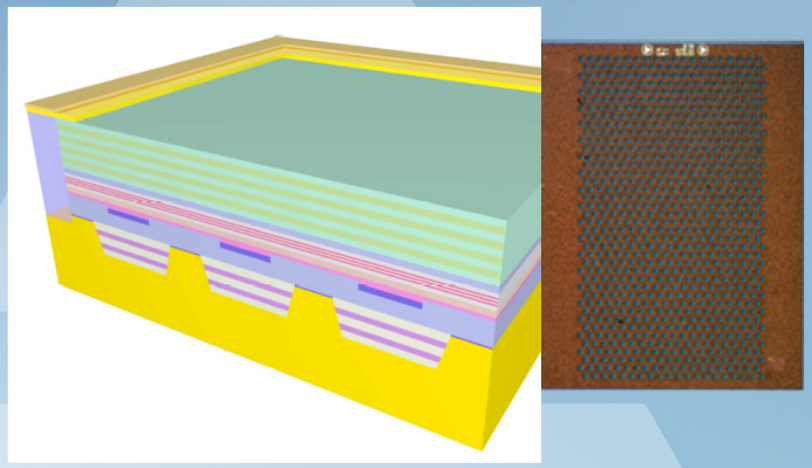


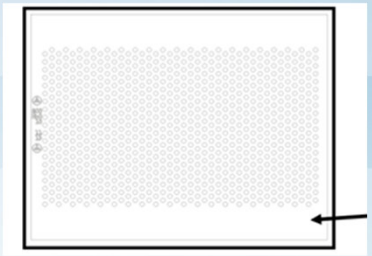


ca. 10 mW max. Po per emitter; Low Ith and low V

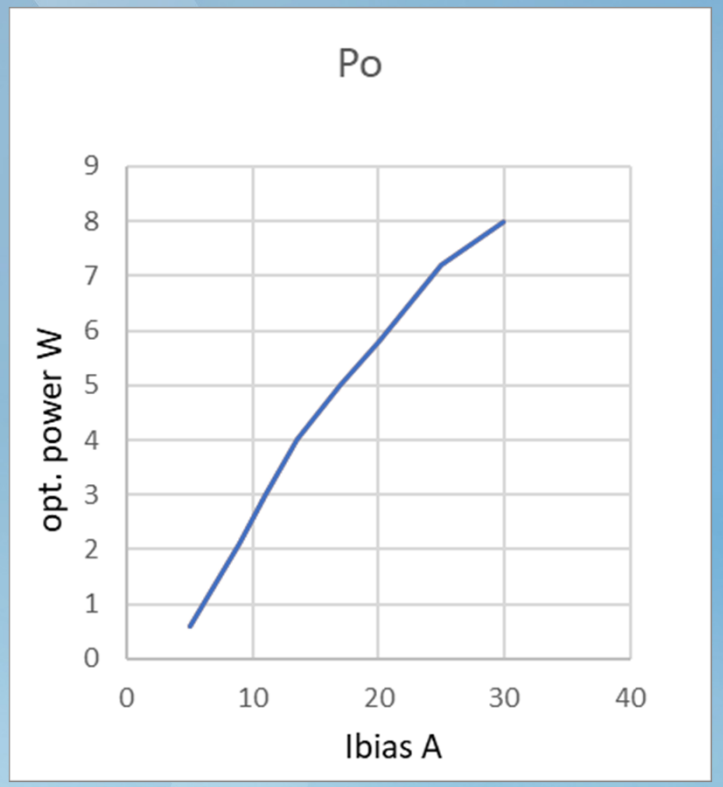
800 Emitter 1.3 µm 2D VCSEL Array

2D VCSEL Array Cross Section

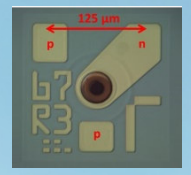




> 8 W optical power (qcw)

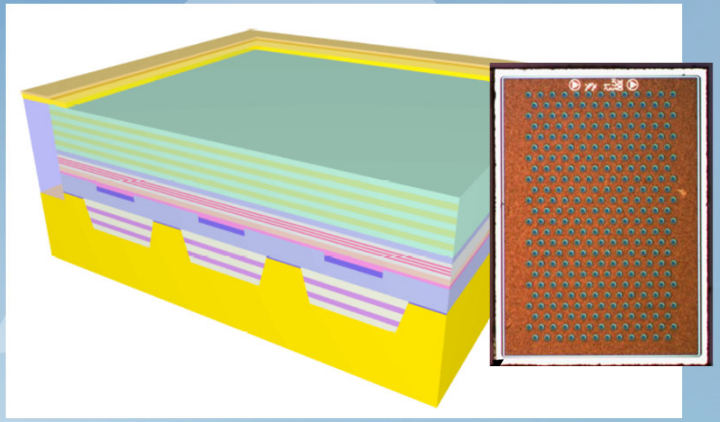


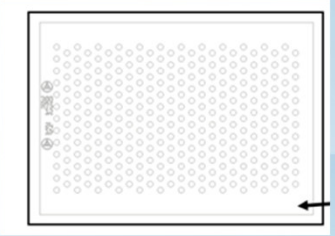
300 µs pulse



300 Emitter 1.3 µm 2D VCSEL Array

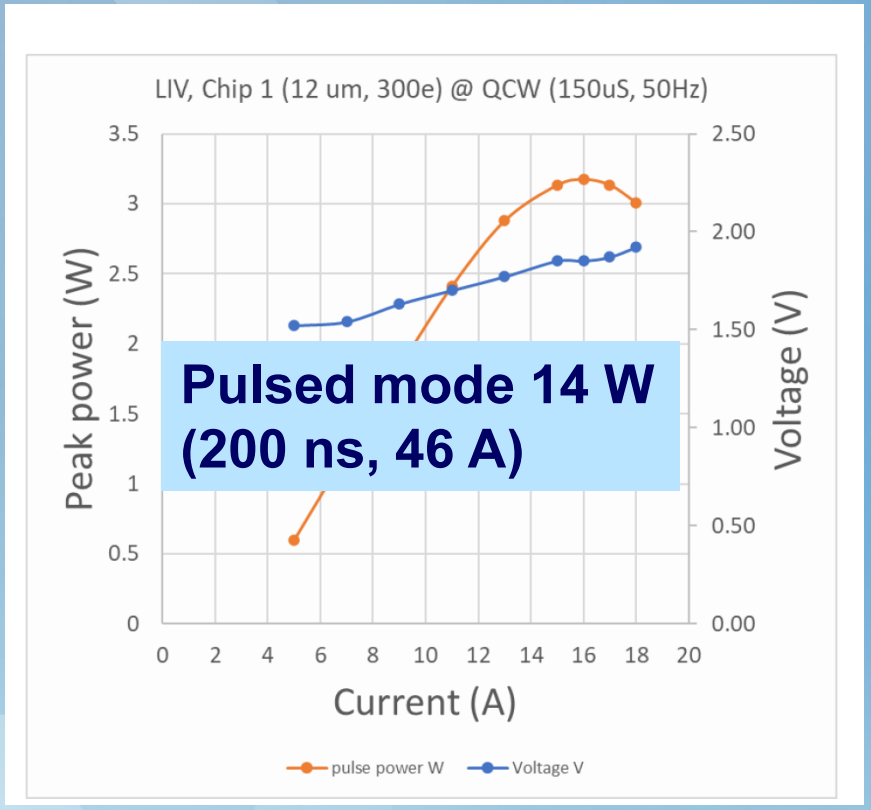
2D VCSEL Array Cross Section

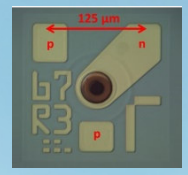




300 emitters

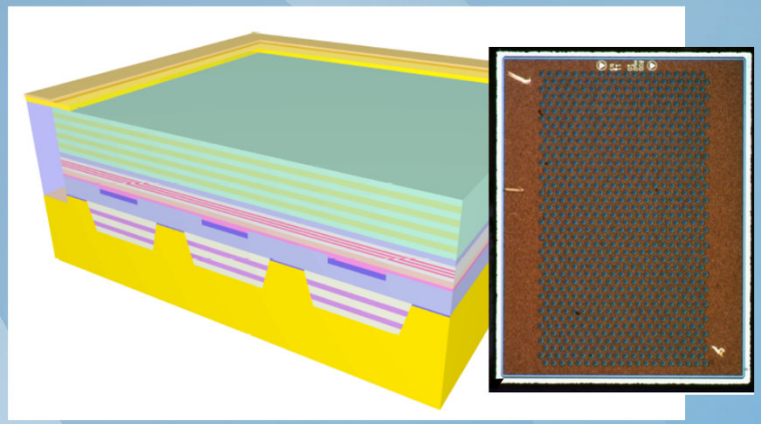
3.2W optical power (qcw)

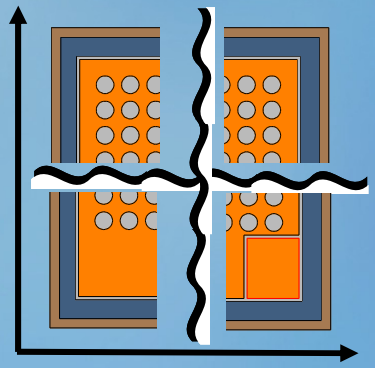




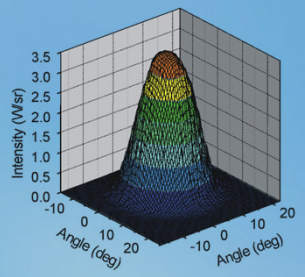
2D Array Examples 1.3 µm

# of emitters	Po (qcw)
12	0.125 W
24	0.25 W
48	0.5 W
160	1.5 W
300	3 W
480	5 W
800	8 W

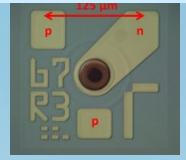




- From single emitter to > 1000 emitters
- From few mWs to 10s and 100s of Watts (pulsed mode)
- Single mode and multi mode versions
- Configurations can be designed per demand



Several VCSEL chips can be combined and integrated into one package to multiply optical power



LW InP VCSEL Outlook and Roadmap

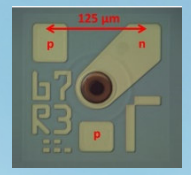
High Power
2D VCSEL Arrays for
3D Sensing

Wide tunable
VCSEL
(upto 100 nm)

Integration with
Silicon Photonics

Wavelengths
> 2.3 µm (GaSb)

10G – 100G
Optical Communications



Thank you

CS INTERNATIONAL CONFERENCE ANGELTECH

InP VCSEL products enable Smart City Systems and Green Photonics