MATERIALS THAT MATTER

High Power VCSELs for 3D cameras

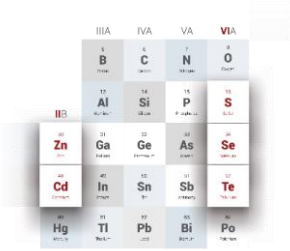
2019-10-17, EPIC meeting (Stuttgart)

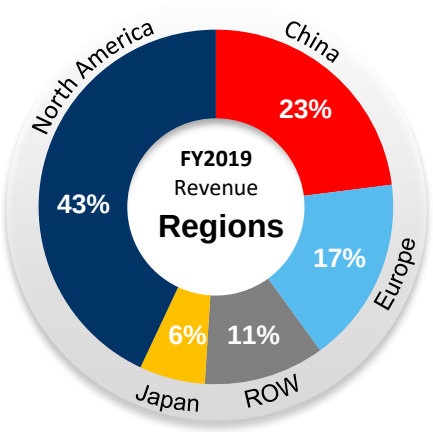
Dr Julien Boucart, Senior Product Manager

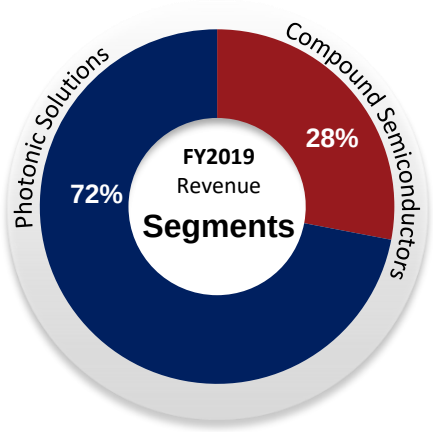
II-VI Overview

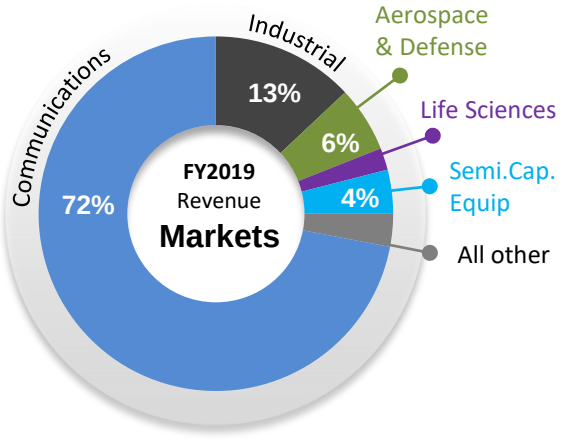
"TWO SIX"

Refers to groups **II** and **VI** of the Periodic Table of Elements









Core Competency
ENGINEERED MATERIALS

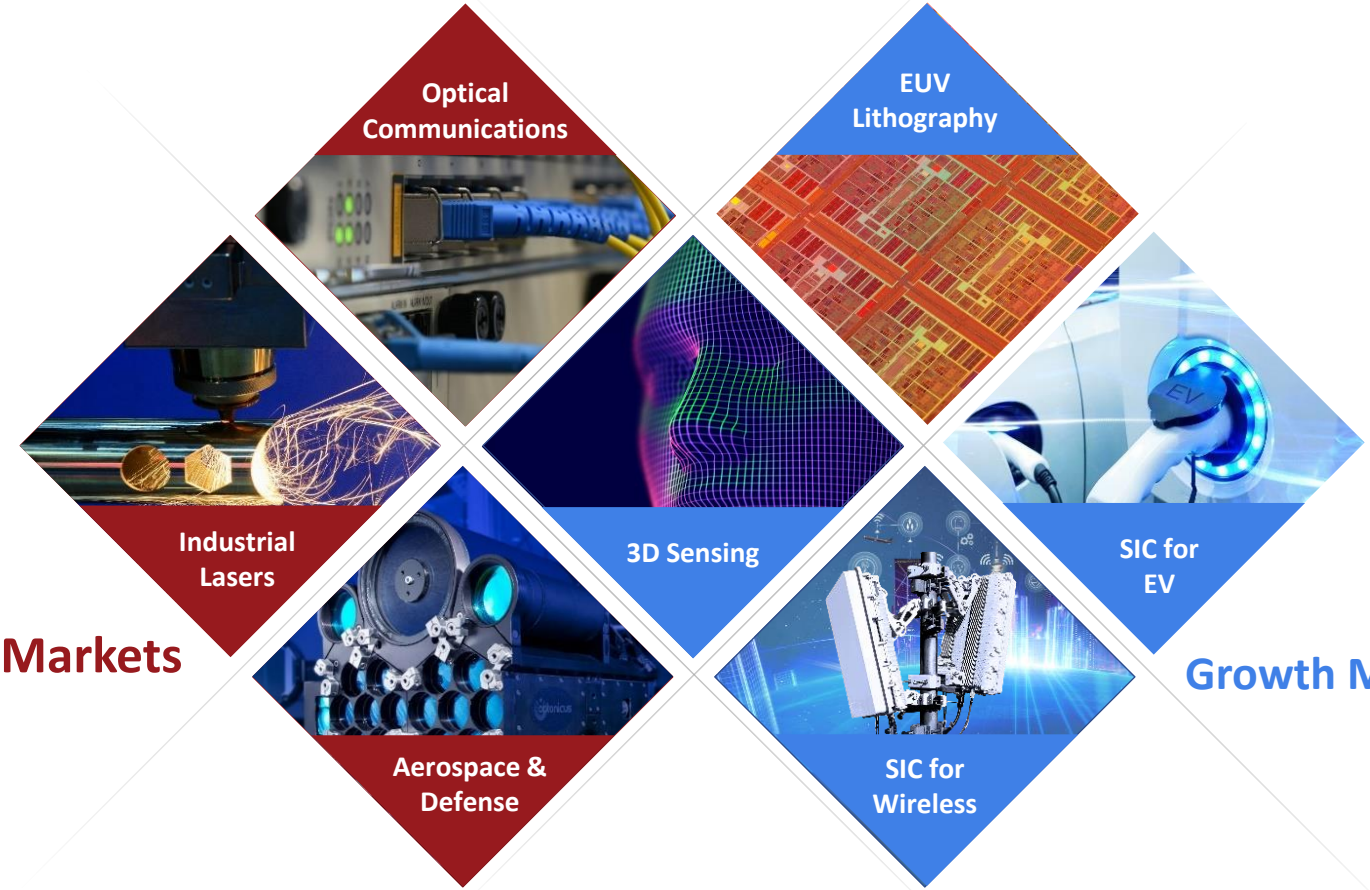
26,000
Worldwide Employees

70
Worldwide Locations

21
Countries

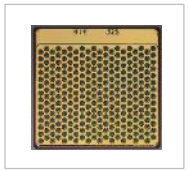
$2.6B
FY2019 Revenue (II-VI + Finisar)

Our Core & Growth Markets

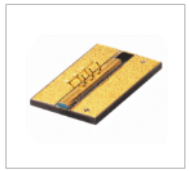


Growth Application: 3D Sensing & LiDAR

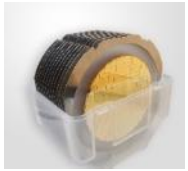
- **Components for 3D Sensing & LiDAR**
  - Semiconductor Lasers: VCSELs & edge emitting lasers
  - Optics: Dual pass band filters, wide incidence angle mirrors
- **Current market drivers: Face Biometrics**
  - II-VI's vertically integrated 150 mm GaAs compound semiconductor platform is one of the largest in the world
- **Emerging applications: Augmented Reality, Automotive LiDAR**



VCSEL ARRAYS



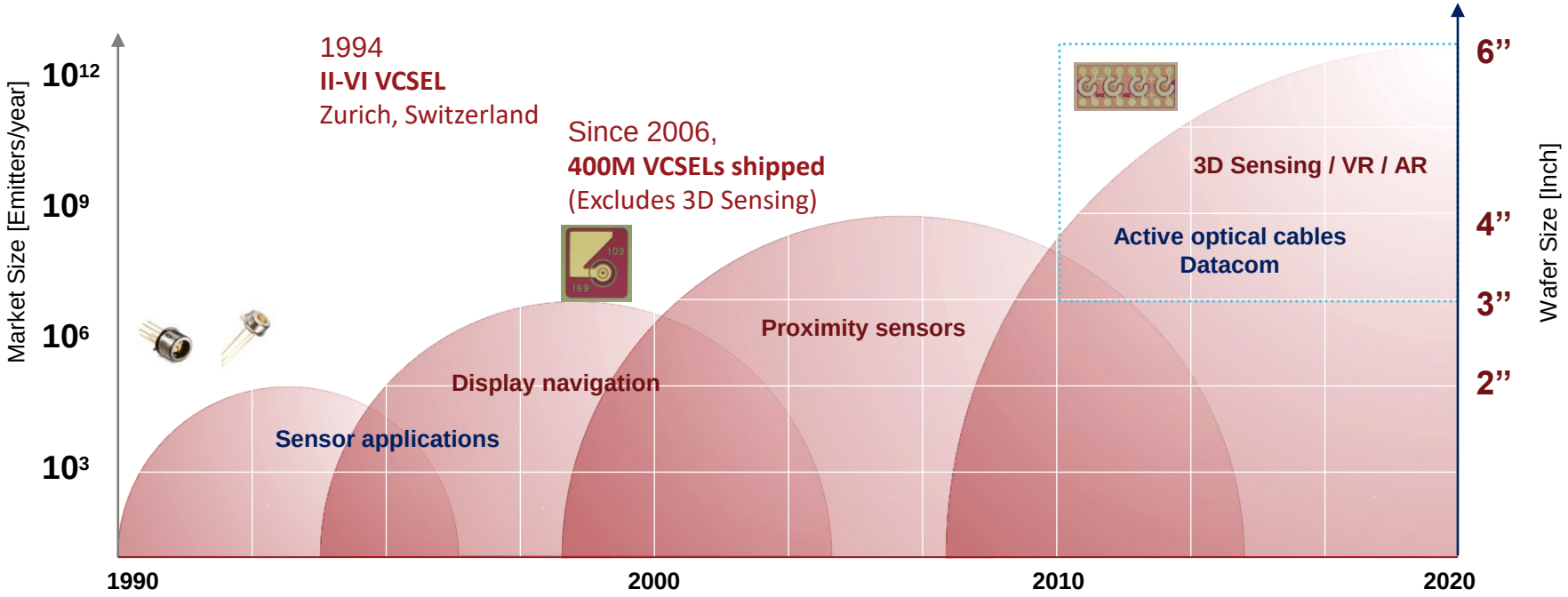
EDGE EMITTERS

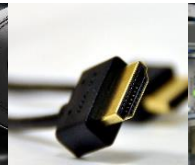


DUAL PASS BAND FILTERS

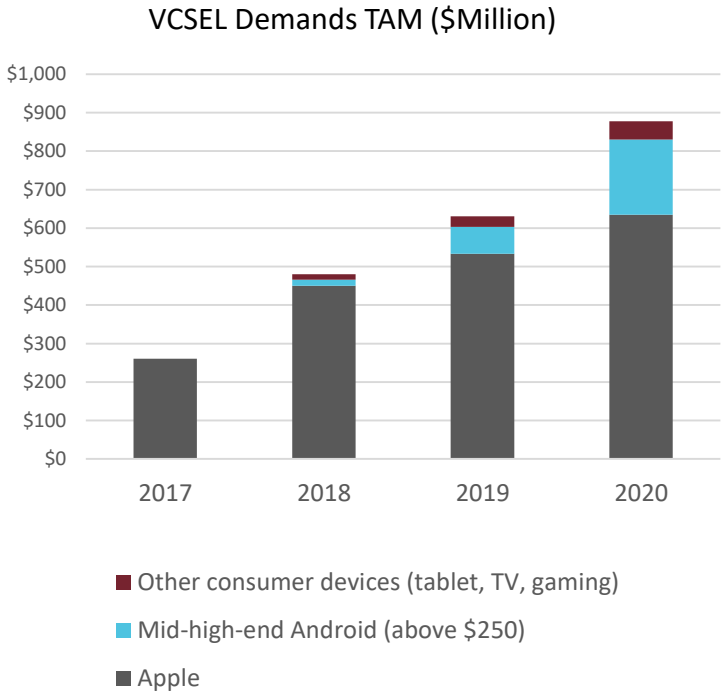
WIDE INCIDENCE ANGLE MIRROR

Increasing Wafer Diameter Enables Market Growth





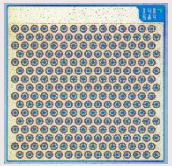
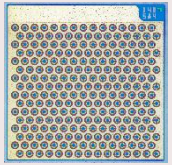
Smartphones with 3D Sensing



Front facing | World facing | Front & World facing

Source: Morgan Stanley Research Estimates

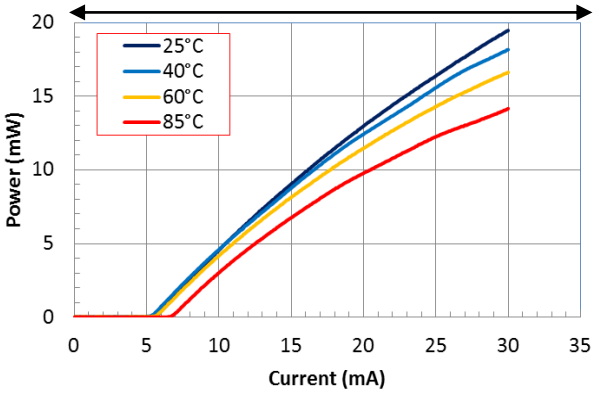
VCSELs for consumer

Application	Power levels	Wavelength	Other Characteristics	Pictures
Display Navigation	<1mW	850nm	Single mode, polarization locked	
3D Sensing, indoor (IoT)	0.2-4W	850nm	Multimode array for ToF	
Proximity sensor, mobile	5-20mW	940nm	Single Mode or multimode	
3D camera, mobile	0.2-4W	940nm	Multimode array	

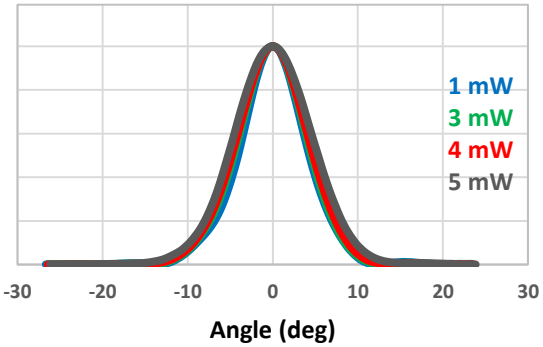
Next Generation High Power Single Mode VCSELs

- **Applications**
  - Proximity sensors
  - Other 3D sensing illumination
- **Low beam divergence**
  - Simpler optics
  - Reduced jitter
- **Simple power scaling by number of emitters**
  - 3mW of single mode power per emitter
- **Small chip size (150x150x150µm3)**
  - Compact cost effective illumination
- **940nm emission wavelength**
  - Outdoor operation

LI characteristic for 5 Emitters

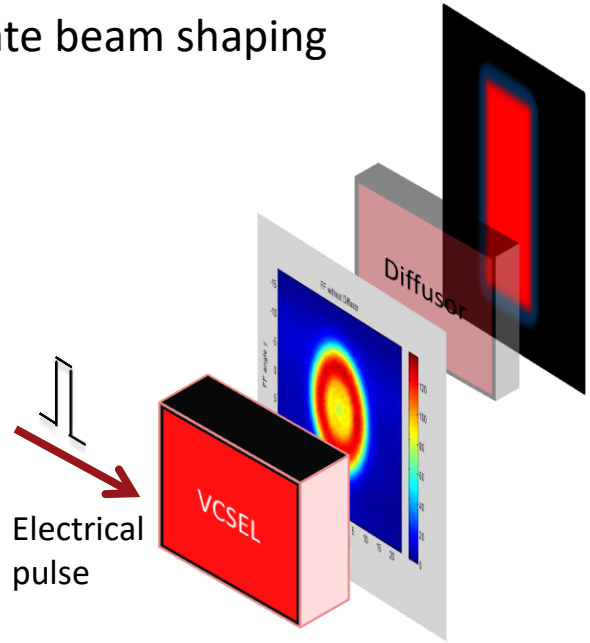


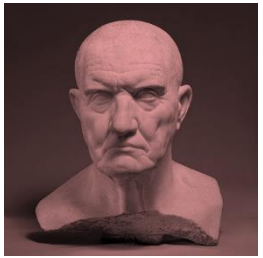
Farfield intensity for 1 Emitter



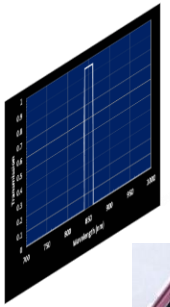
3D Cameras Time Of Flight requirements on the illumination

1. High modulation speed
2. High power conversion efficiency
3. Narrow wavelength spread
4. Reliable laser sources
5. Accurate beam shaping





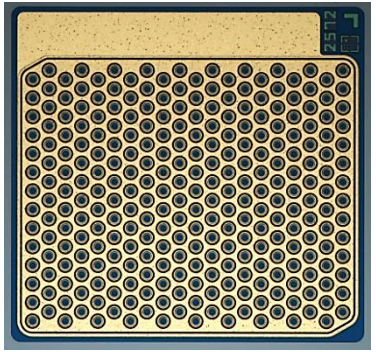
Ambient
parasitic light

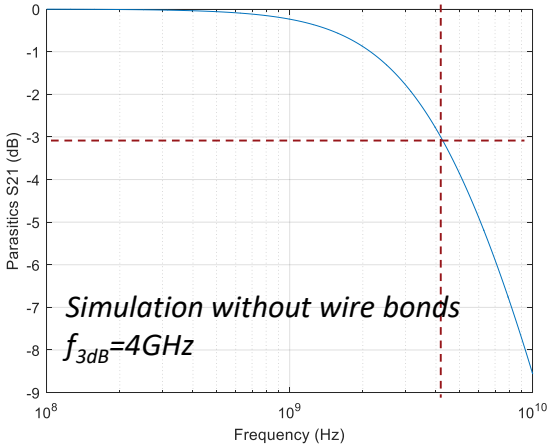


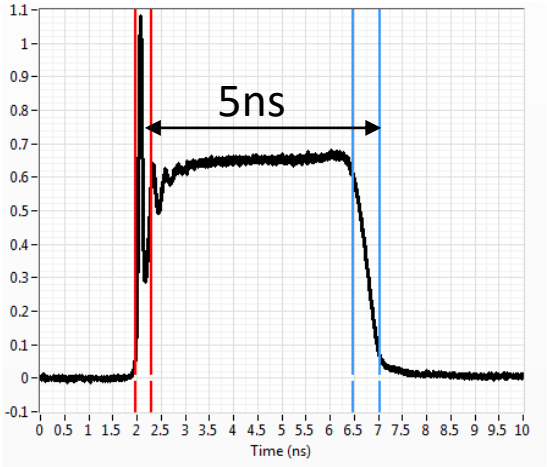
CMOS
TOF
Sensor

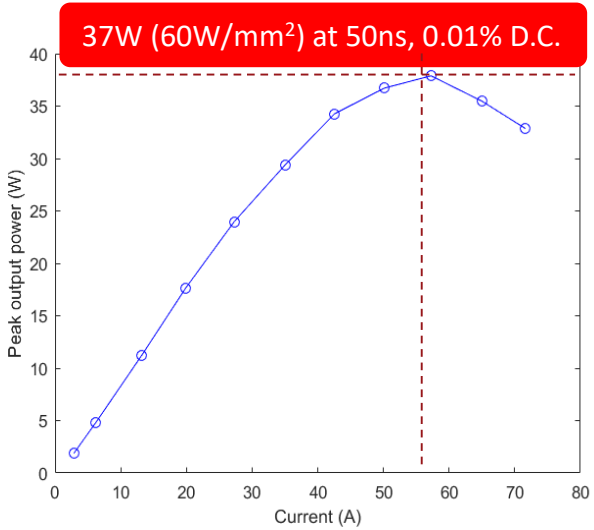
Fast speed modulation

- Modulation speed allows greater depth resolution
- VCSEL chip is intrinsically fast
- Limitations will come from assembly / driver setup
- Low duty cycle allows for high peak power



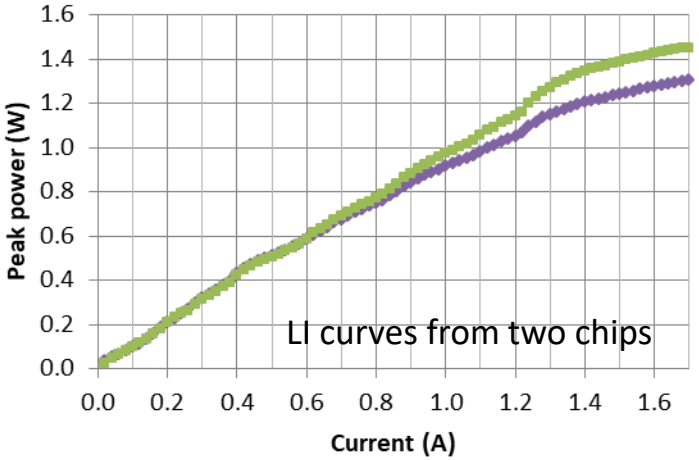




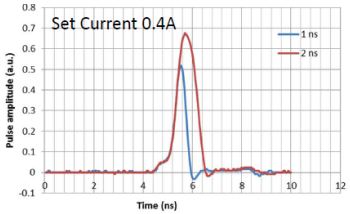


Single Emitter Short Pulse Operation

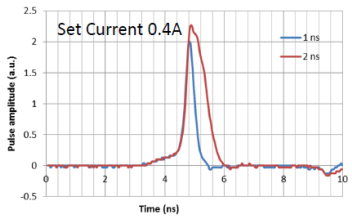
Single Emitter: Pulsed (1ns / 100kHz)



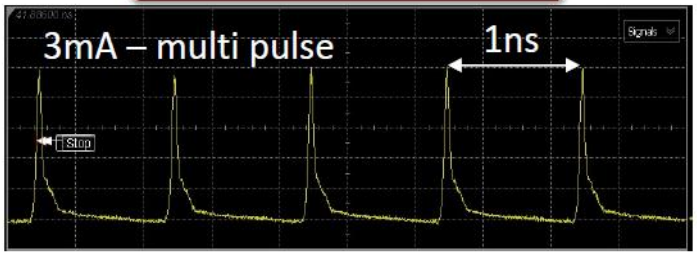
Optical Pulse

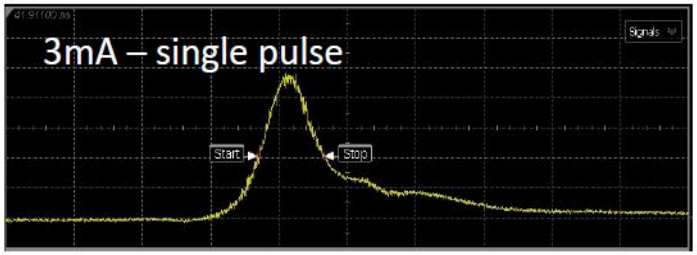


Electrical Pulse



100ps pulse / 1ns period

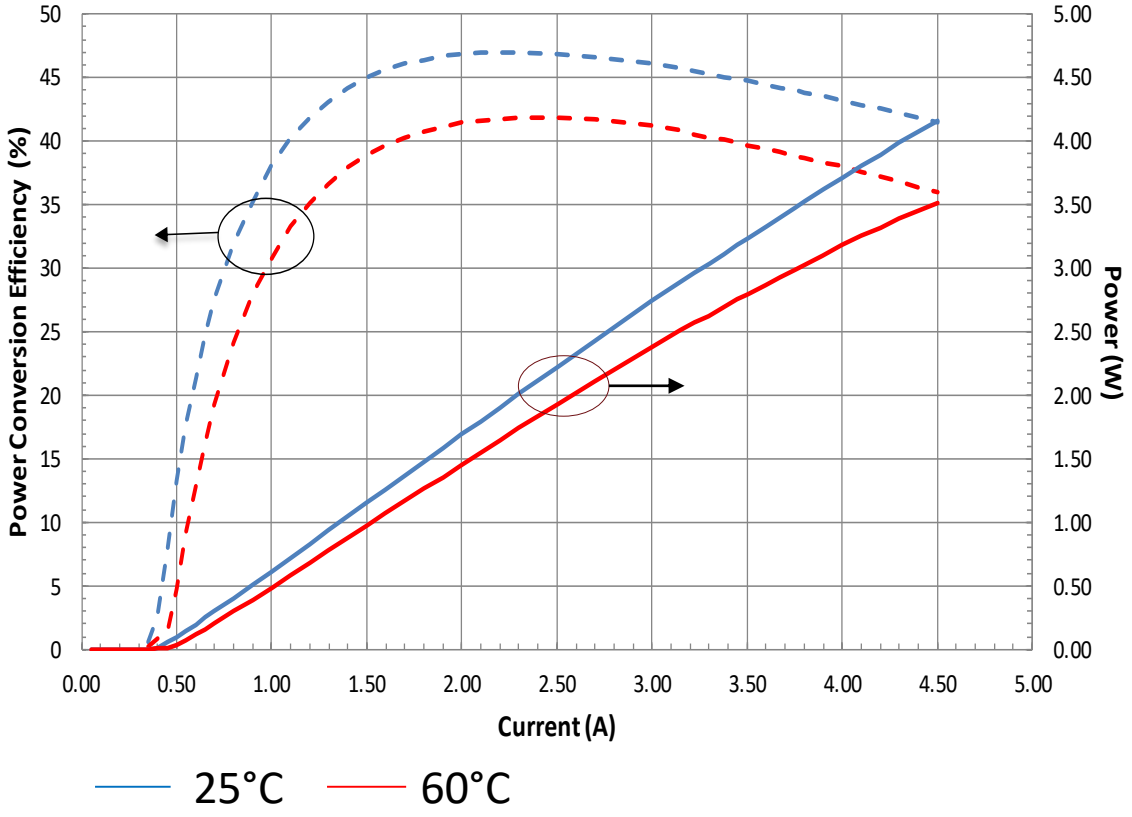




Current (mA)	Vpp (V)	Rise time (ps)	Fall time (ps)
3	2	18.1	57.6

High Power Conversion Efficiency

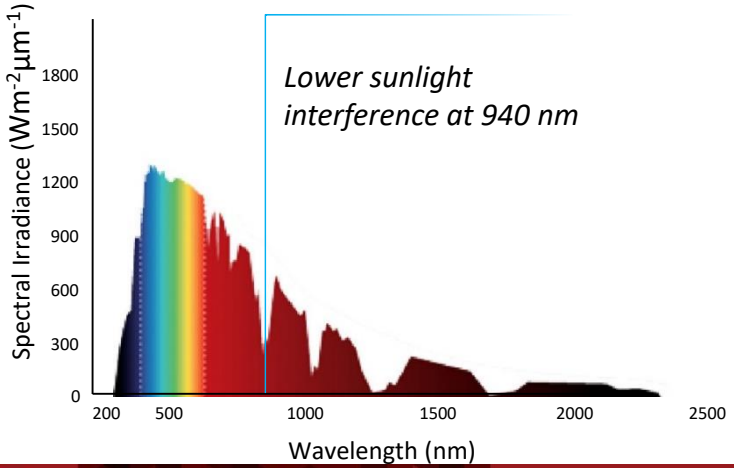
- Higher PCE allows longer battery life in mobile phones
- Chip delivers up to 47% PCE at 25°C and 42% at 60°C

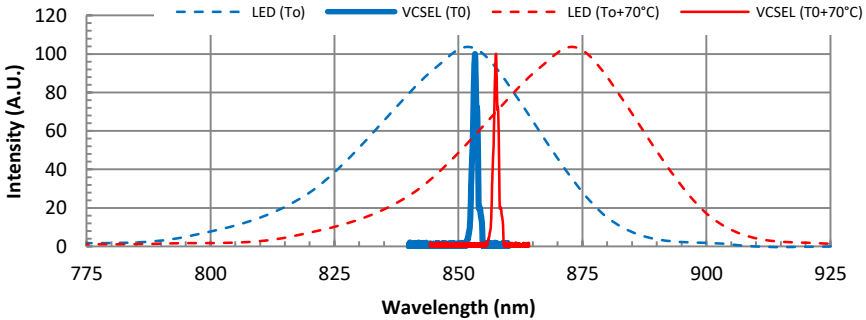


Wavelength Consideration

- **850nm versus 940nm:**
  - 850nm: high efficiency from sensors, generates red glow
  - 940nm: no red glow, less interference from sunlight, but detectors suffer from lower QE
  - 1550nm is an “eye safe” wavelength, sources and sensors are high costs.
- **VCSEL light sources allow narrower band pass filters to better system performance**

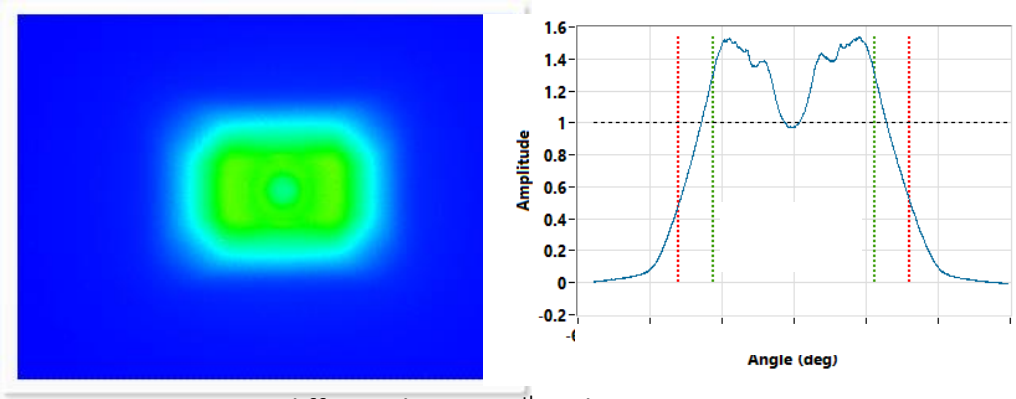
Wavelength	Non visible	Laser Efficiency	Sensor efficiency	Eye Safety	VCSEL Availability
850nm	⊖	⊕	⊕⊕	⊖	⊕
940nm	⊕	⊕⊕	⊖	⊖	⊕⊕
1550nm	⊕⊕	⊖	⊖⊖	⊕⊕	⊖⊖



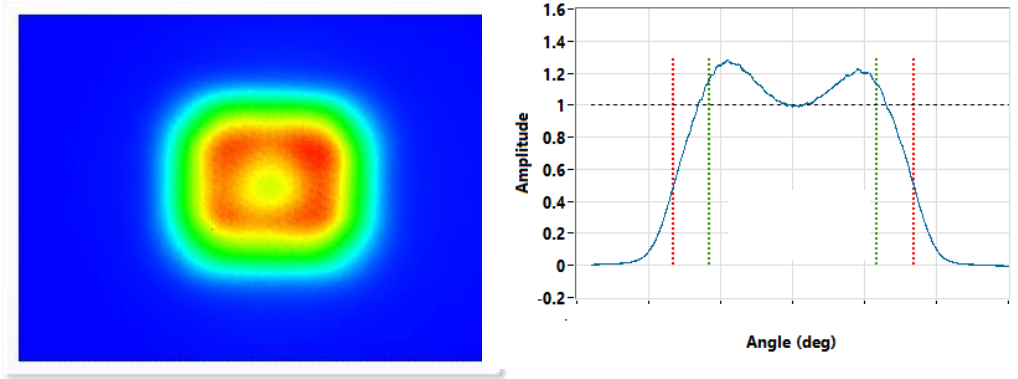


Beam Shaping

- **Optical elements need to provide uniform illumination for the application**
  - Low high frequency noise
  - Steep FOI to match FOV
    - Requires low divergence VCSELs
  - Angle emphasis to match illumination
  - Good 0th order suppression
    - Could favor MLA vs DOE
  - Low cost
  - Robust performance: environment and mechanical
    - Issues for polymer based vs glass based



DOE type diffusor showing 0th order transmission



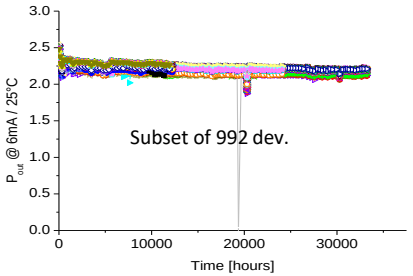
MLA type diffusor showing no 0th order transmission

High Reliability Lasers

DATACOM

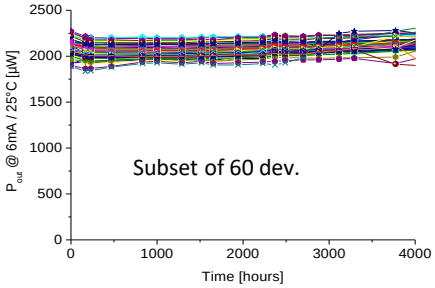
FIT Rate

- 33,000 hours at 90 C, 6 mA
- > 200M true cum. dev hours
- < 10 FIT at stress from 2 fails



Environment

- 4000 h 85C/85%
- Zero Failures



Wear-out

- 28G Multi-cell layout: Ea=1.2, n=2.7
- 70°C/7mA operation: TT1%Fail: 151years

3D SENSING

Wafer Release

- Hundreds of thousands of devices from a production subset
- Device failure rate: 0 DPPM
- Emitter failure rate: < 40 FIT

Environment (selection)

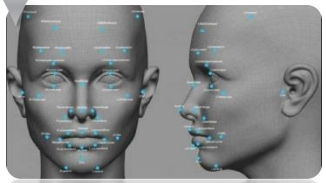
Humidity	Pass
Op / Non-op Heat soak	Pass
Temperature cycling	Pass
High temperature storage	Pass
ESD	Pass

Outlook

Applications

Wearables

Face Recognition



Face Tracking

Emotion Tracking

Indoor Mapping

Health Monitoring

…towards a complete and seamless VR and AR experience

Flickr: BrotherUK, Creative Commons

II-VI

MATERIALS THAT MATTER

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