MATERIALS THAT MATTER

Laser Diode Assembly - from Single Emitter VCSEL to High Power Laser Bars

Stefan Weiss, Manager Chip Assembly and Testing

24.02.2022

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Outline

1. Who is II-VI Laser Enterprise?
   a. II-VI company overview
   b. History of Laser Enterprise
   c. Overview of products
2. Single Emitter VCSEL for Data Center
3. Multi Emitter VCSEL for 3D-Sensing
4. Single Edge Emitter for Pump Lasers for Amplifier in Telco
5. Single Edge Emitter as Pump Lasers for Fiber Laser in Industry
6. Multi Edge Emitter for Welding in Industry, High Power Laser Bars
7. Testing and BI of components
8. Reliability of Telco Pump Lasers

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Global Footprint II-VI

Dayton, OH
Romeo, MI
Champaign, IL (2)
Warrendale, PA
Saxonburg, PA
Horseheads, NY
Pine Brook, NJ
Wilmington, MA
Woburn, MA
Newtown, CT
Monroe, CT
Warren, NJ
Hillsborough,NJ
Horsham, PA
Philadelphia, PA
Newark, DE
Alpharetta, GA
New Port Richey, FL
Port Richey, FL
Fremont, CA (3)
Eugene, OR
Santa Rosa, CA
Sunnyvale, CA
Longmont, CO
San Jose, CA (2)
Easton, PA
Colorado Springs, CO
Tustin, CA
Murrieta, CA
San Diego, CA
Sherman, TX
Dallas, TX
Huntsville, AL
Starkville, MS

Braunschweig, Germany
Kista, Sweden
Jarfalla, Sweden
Newton Aycliffe, UK
Oakham, UK
Berlin, Germany
Zele, Belgium
Paignton, UK
Kleinmachnow, Germany
Weiterstadt, Germany
Milano, Italy
Zurich, Switzerland

Seongnam, South Korea
Daejeon, South Korea
Chiba-Shi, Japan
Suzhou, China (4)
Wuxi, China
Shanghai, China
Fuzhou, China
Guangzhou, China
Shenzhen, China (2)
Taipei, ROC
Hsinchu City, ROC
Hyderabad, India
Cavite, Philippines
Calamba, Philippines
Bangkok, Thailand
Ho Chi Minh City, Vietnam
Ipoh, Malaysia
Singapore
Sydney, Australia

22,000+

Employees

73

Locations

18

Countries

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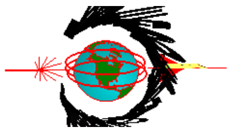
IBM



Start R&D AlGaAs laser

Ship first 980 nm pump

MCI link (Chicago-Sacramento)

Move to Binz

Volume ramp

HPL portfolio

mW to kW 780 – 1500 nm

Build GaAs R&D

Start VCSEL R&D

Ship first 760 nm VCSEL

Ship first 850 nm VCSEL

Shipment of 4M VCSEL

Shipment of 100M

1985 — 1990 — 1995 — 2000 — 2005 — 2010 — 2015

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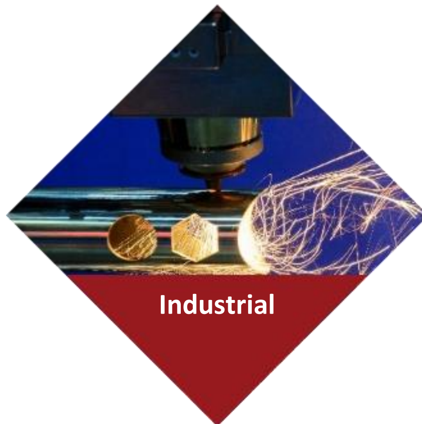
Addressing Multiple Strong and Growing Markets

3D Sensing & LiDAR

GaAs

Optical Communications

GaAs



For terrestrial, submarine & wireless optical infrastructure and datacenters

Marea Transatlantic Subsea Cable (2017)

- Microsoft, Facebook, Telxius
- Running from Virginia in USA to Bilbao in Spain
- 6600 km long
- 4.650.000 kg
- 160 TB/s, streaming of **71 Million HD videos**

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II-VI Laser Enterprise

Zürich:

- 11’000 m^2
- 350 employees
- Epitaxy: MBE, MOVPE
- Waferfab
- Bar/Chip-Line
- Assembly and Test
- R&D

Philippines:

- 1’300 m2
- 80 employees
- Assembly and Test

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Assembly Lines in Zurich and Calamba

Die Bonder:
10 x Micron 2 (ESEC) for p-up
1 x FC 250 (SET) for p-up and p-down
1 x Palomar 3800 for p-down
1 x Palomar 6500 for p-down
2 x Infotech IP-600 for p-up and p-down
1 x Datacon 2200 evo for PnP and p-up
2 x ATV SRO ovens for manual assemblies

Wire Bonder:
2 x G4 Delvotec
3 x G5 Delvotec
1 x Palomar 8000

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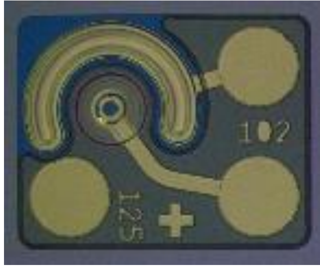
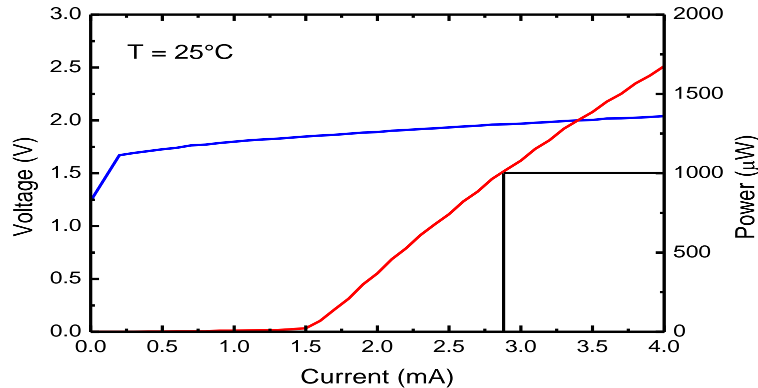
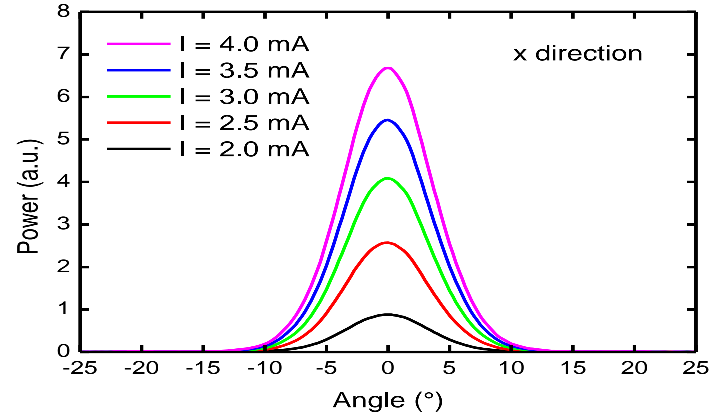
VCSEL for Computer Mouse and Data Center



- Vertical Surface Emitting Laser
- Size: 150 micron x 100 micron
- Power: > 1 mW, Single Gaussian mode emission for computer mouse
- Shipment to customers as KGD typically on frame
- Assembly only for lot validation, wafer release and reliability tests on test boards
- Die Bonding using Ag-Epoxy





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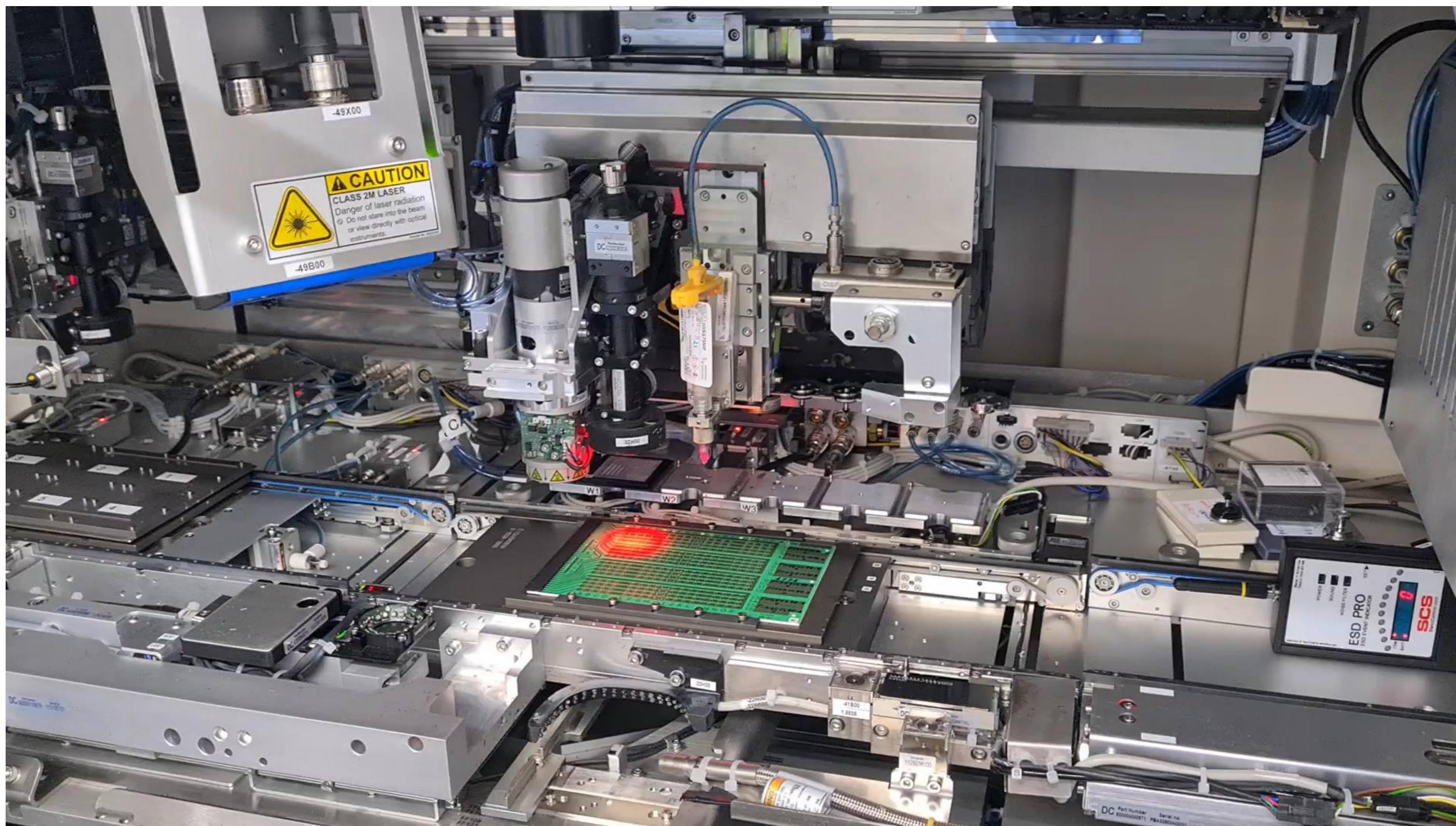
Die Bonding of Single Emitter VCSEL using Datacon



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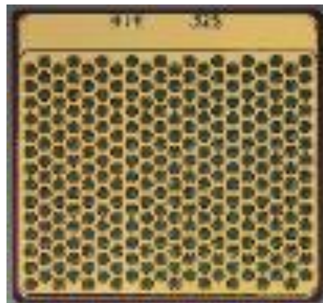
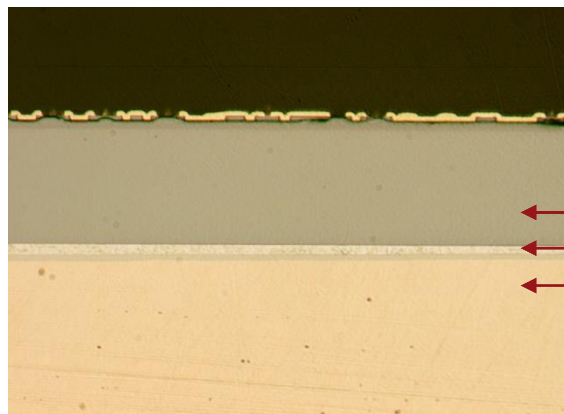
Multi Emitter VCSEL for 3D Sensing



- Size: 1 mm x 1 mm
- Power: > 2 W
- Shipment to customers as KGD typically on frame
- Assembly only for lot validation, wafer release and reliability tests on test substrate
- Die Bonding using AuSn Soldering or pressure less Ag-Sintering



Cross section of Multi Emitter VCSEL using Ag Sintering

Laser Die

Silver Sintered Interface

Test Substrate

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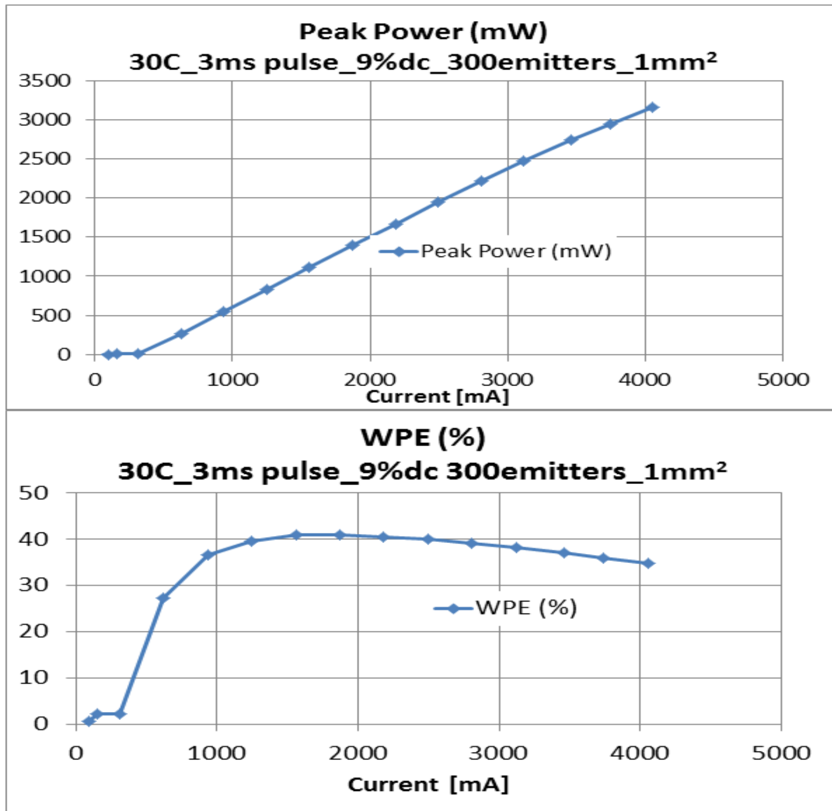
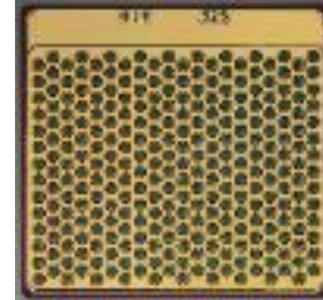
Multi Emitter VCSEL arrays





- Arrays scalable
- > 2W output power pulsed
- High efficiency (up to 40%)

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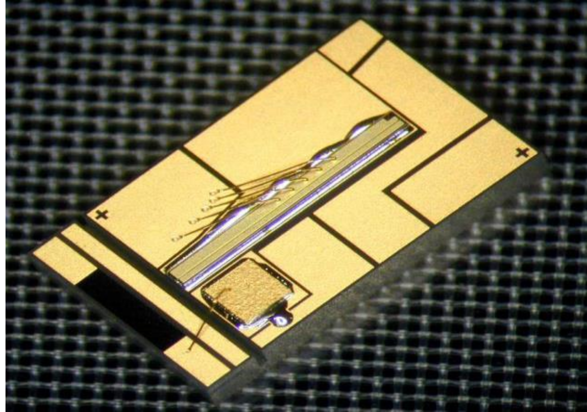
Single Edge Emitter for Telco Pump Applications



- Single Edge Emitter
- Size: 400 micron x 3600/4800 micron
- Power: 200 - 600 mW as Single Chip Package
- Power: 400 – 1000 mW as Dual Chip Package
- Shipment to internal customers on substrate (Chip on Carrier) incl. thermistor and optional photo diode for fiber coupling and module building (1 000 000 per year)
- Die Bonding using AuSn solder preforms

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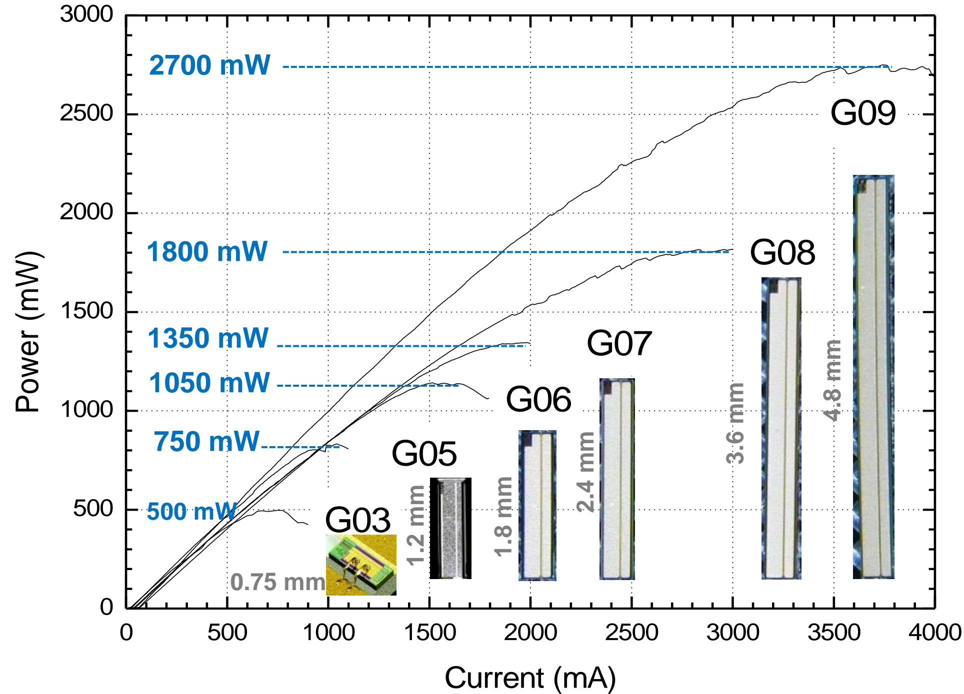
980-nm Pump Laser Generations G0x (1998 - 2021)



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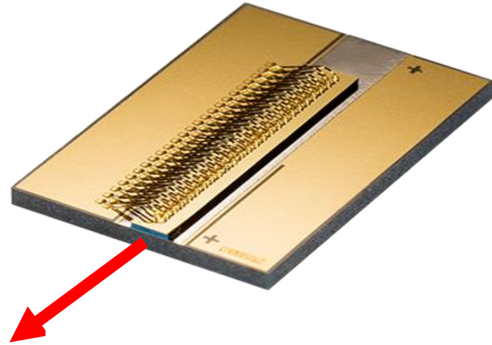
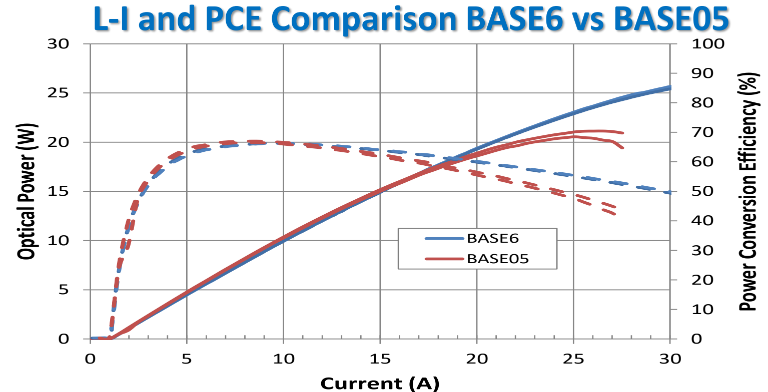
Single Edge Emitter as Pump Lasers for Fiber Lasers



- High Power Single Emitter
- Size: 0.4 mm x 3.6 mm
- Power: > 20 W
- Shipment to customers as KGD typically on frame or as Chip on Submount (CoS) and on C-Mount
- P-Down Die Bonding using AuSn solder



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Flip Chip Bonding of CoS

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Multi Edge Emitter for Welding

- High Power Laser Bar
- Size: 10 mm x 3.6 mm, approx. 20 Emitter
- Power: 80 – 250 W per bar
- Shipment to internal and external customers on passive or active Cu Cooler (25 000 per year)
- Die Bonding using Soldering (AuSn, SnAgCu, SnInAg)

- Customers doing integration of stacking, optics, fiber coupling etc..

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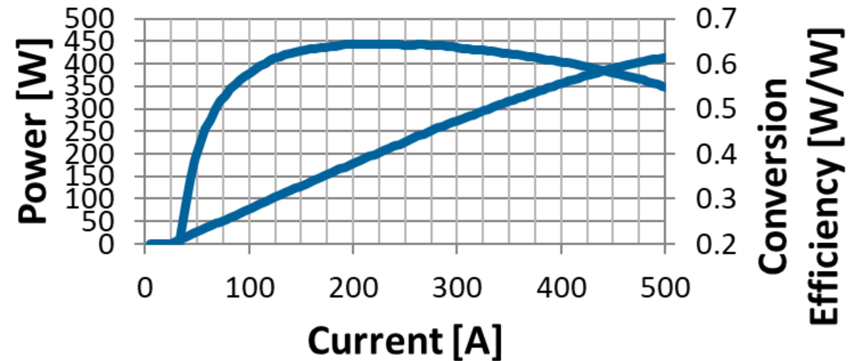
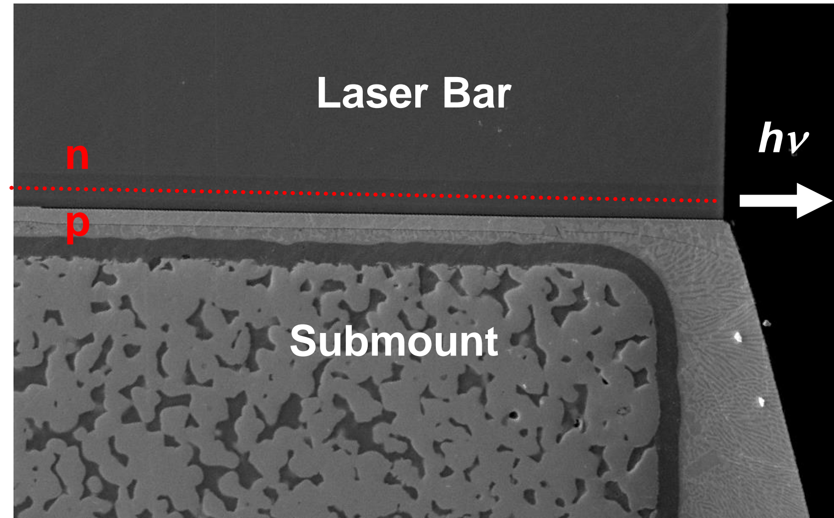
Multi Edge Emitter for Welding

Assembly Specification:
- P-down Bonding
- Alignment to Cooler Edge depending on Edge Quality (Direct Bonding or using Submount)
- Assembly Height limited to optimized Pitch for Stacking => Brightness





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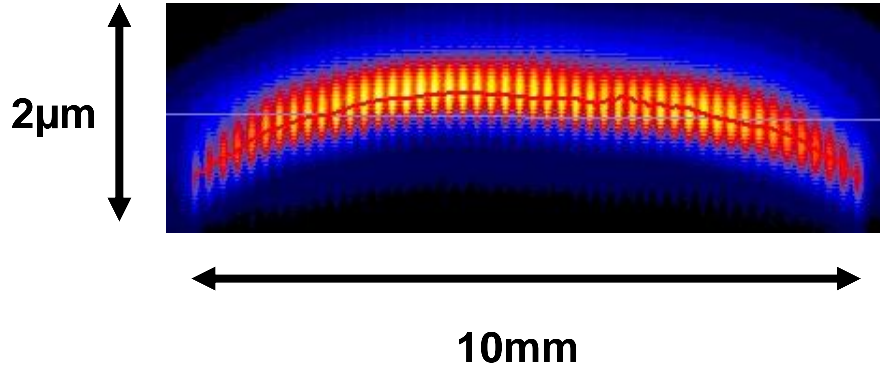
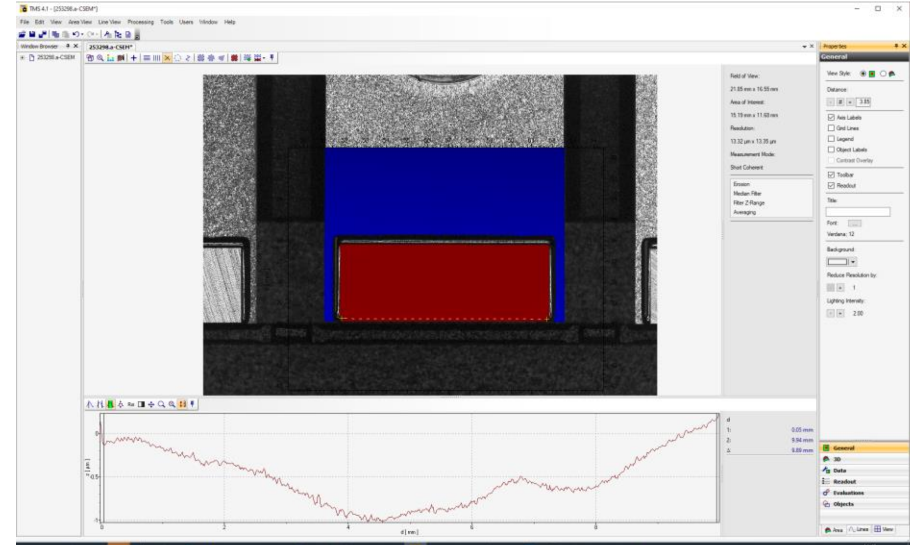
Multi Edge Emitter for Welding

Bow of bar: < +-2 micron
over bar length of 10 mm





White Light Interferometer for Bow Measurement

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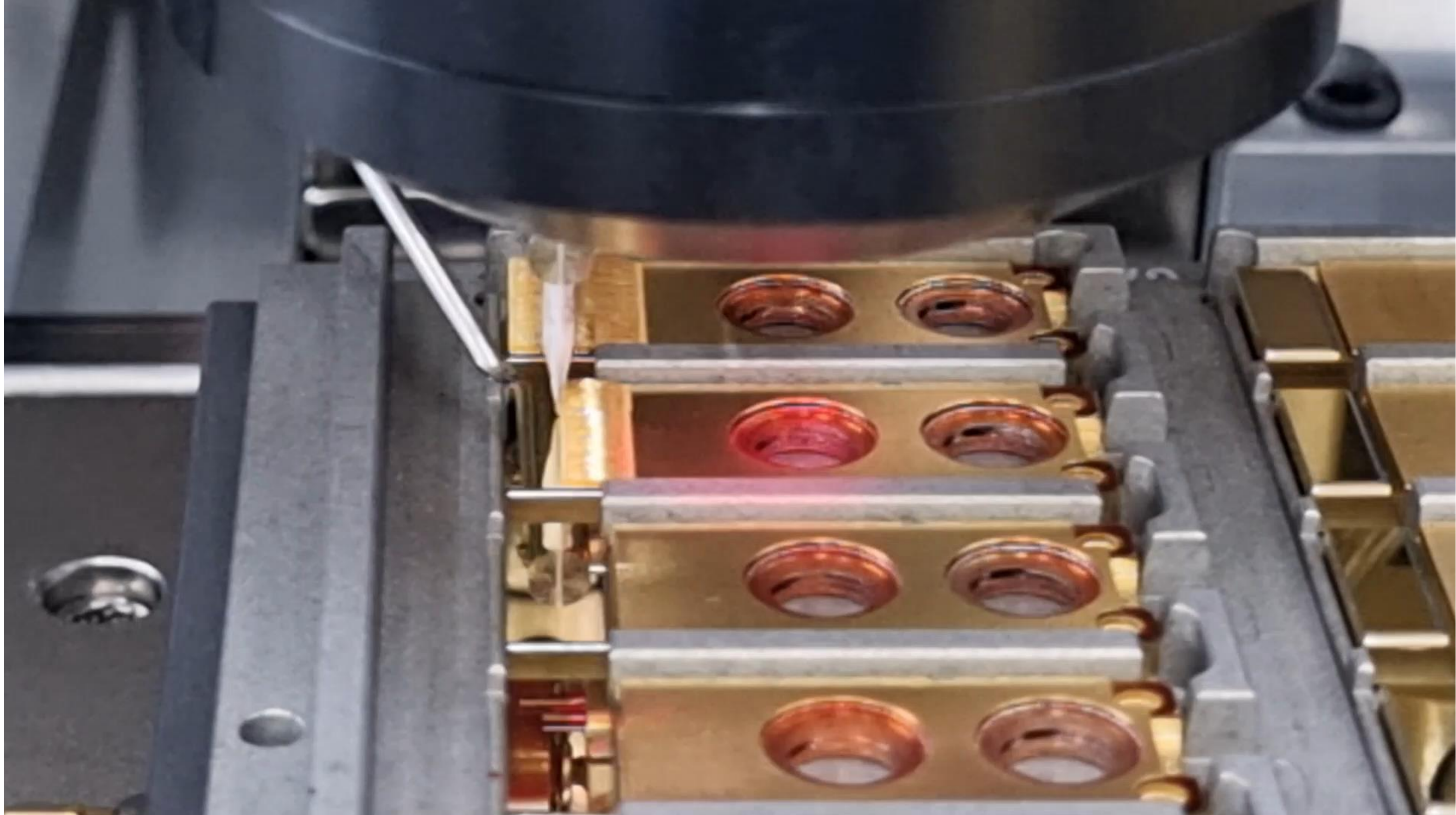
Wire Bonding of Laser Bar



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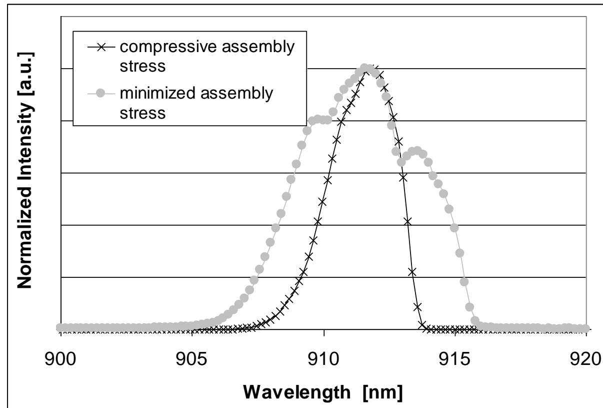
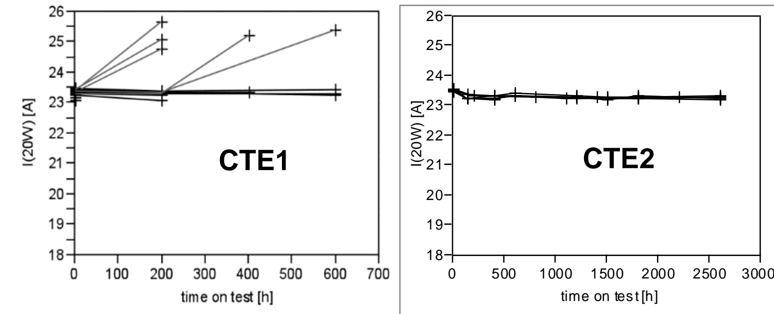
Influence of Assembly Stress

- Impact of assembly stress on performance and reliability depends on chip design
- Assembly stress minimization not always preferred solution
- Design rules established based on:
  - Laser and assembly (FEM simulations)
  - Experiments
- Impact of Assembly stress on smile (curvature of emission line) => Can be partly compensated by assembly process



Spectrum of devices with same chip design, but different assembly stress



Split lot life tests of devices assembled on same type of Cu cooler using submounts with different CTEs

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Testing and Burn In Systems

- Equipment Engineering for Tester and BI-systems inhouse, building all testers by ourself
- 15 000 Burn In Slots for Telco Pump Lasers in Zurich

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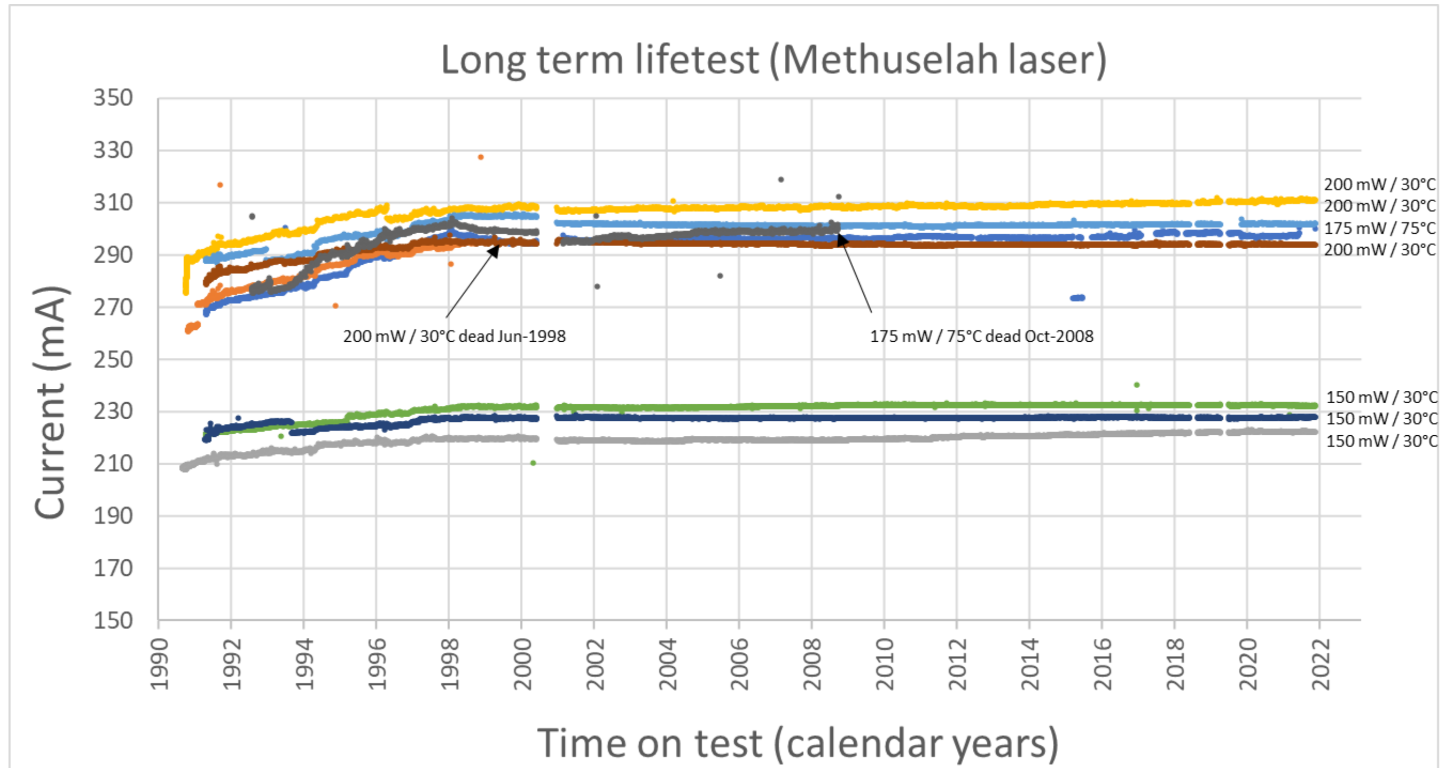
Reliability of Telco Pump Lasers



Depending on Conditions accelerated lifetime 91 – 2580 years

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Thank You!

- Dr. Michael Moser
- Dr. Tomas Pliska
- Dr. Sebastian Arlt
- Goran Eskic
- Dominik Hälg
- Dr. Brigitte Ketterer
- Franco Marandino
- Javier Moizello
- Dr. Rokhaya Müller
- Daniel Sticherling

We are hiring !

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