Ruggedized Packaging of High-Power Quantum Cascade Lasers

Arunkrishnan Radhakrishnan, PhD
Laser Scientist, Alpes Lasers

Pioneering photonics for a brighter future

Outline

1. Company Outline
2. Applications (High power QCLs)
3. Ruggedized Packaging
4. Hermetic Sealing
5. Qualification Tests
6. Conclusion

Alpes Lasers

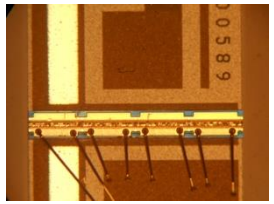
Products

Laser Modules

Laser Package

TO-3

Laser Driver



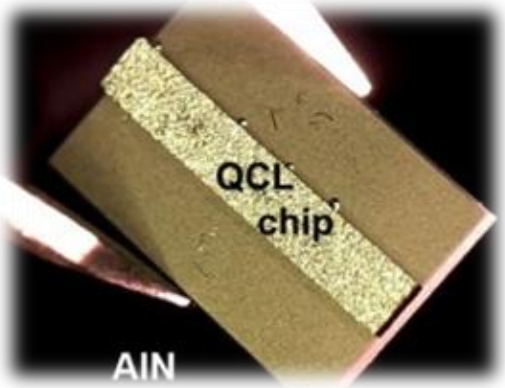
Chip on submount

Laser Systems

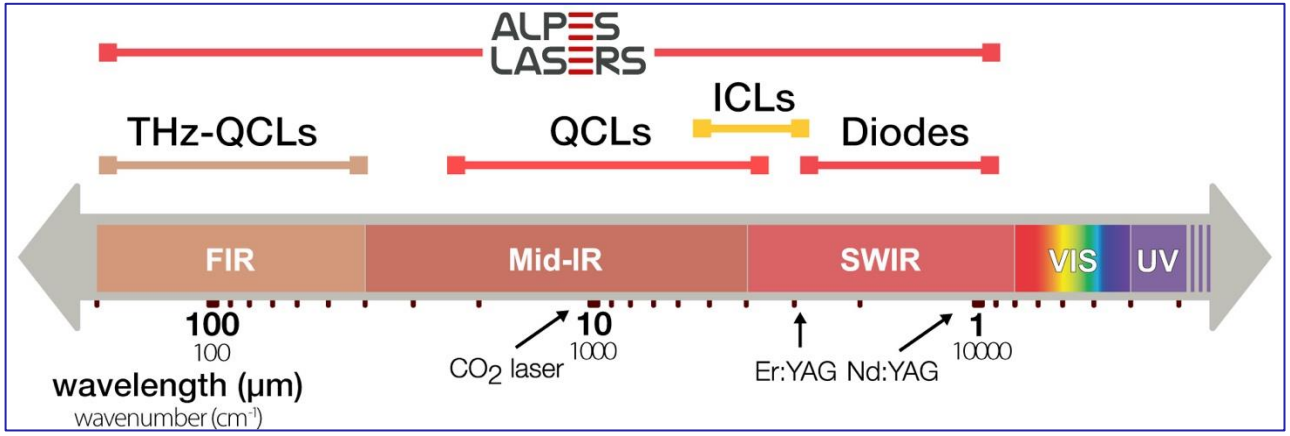
Glider

Pointer

- Headquarter in St. Blaise, Switzerland
- Work force : 40 people
- Worldwide operation
- Founded by Prof. Jerome Faist and Dr. Antoine Muller.

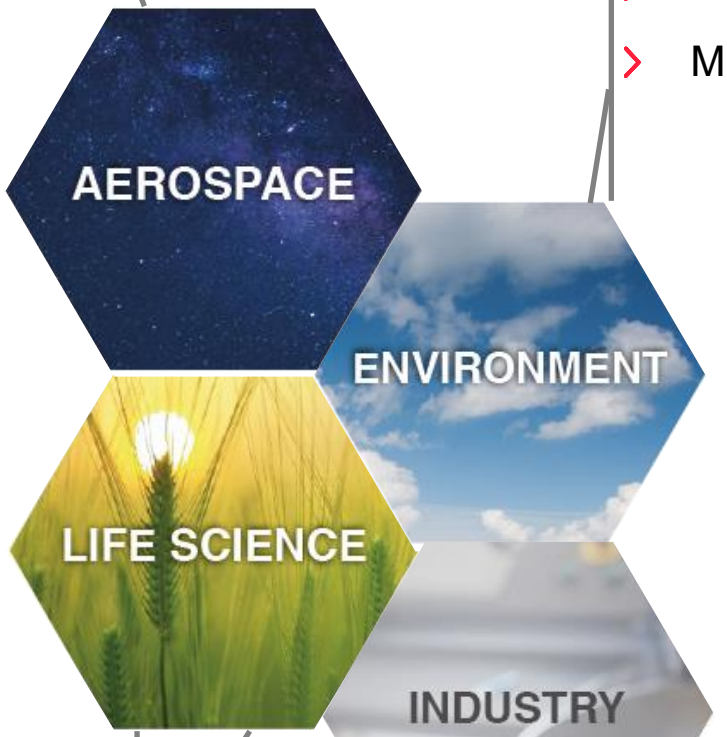


Quantum Cascade Laser



Applications

- Instruments calibration
- Defense and security
- Laser-based communication
- Spectroscopic instrumentation



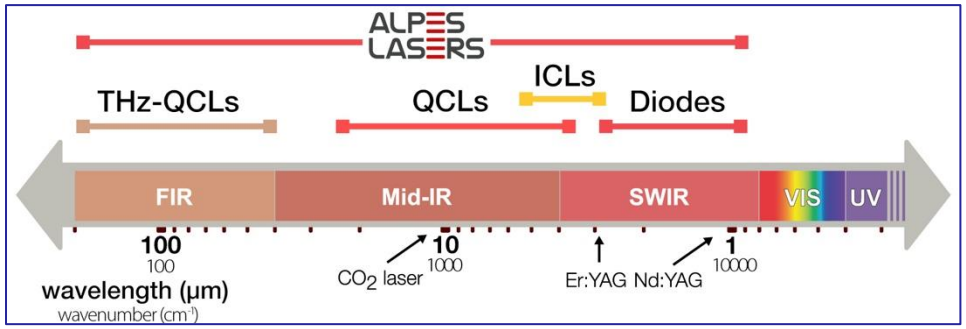
- Greenhouse gases measurement
- Water and ground pollution monitoring
- Air quality monitoring
- Micro plastic monitoring

- Health: Blood and liquids analysis
- Medical: VOC analysis in breath
- Medical hyperspectral imaging
- Biology: Biomarkers monitoring

- Oil & gas leak detection
- Process monitoring
- Hazardous substances detection
- Food safety

Applications

- Instruments calibration
- **Defense and security**
- Laser-based communication
- Spectroscopic instrumentation



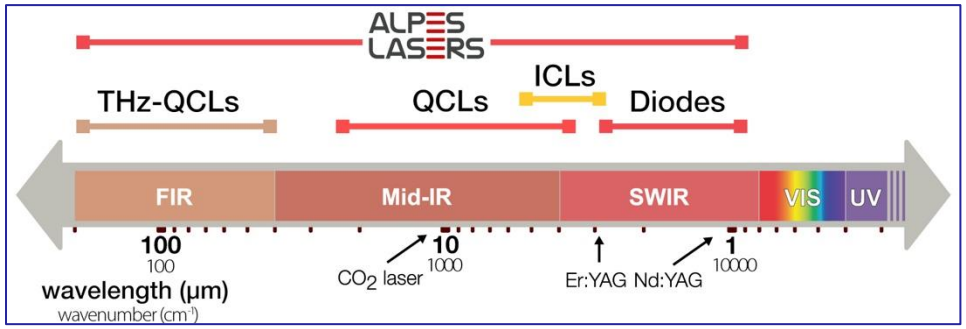
Mid wave IR (3-5 microns)

Directional counter-measure applications

- High-Power laser >1W at MWIR regime
- Ruggedized packaging design
- Wavelength specific

Applications

- Instruments calibration
- **Defense and security**
- Laser-based communication
- Spectroscopic instrumentation



Mid wave IR (3-5 microns)

Directional counter-measure applications

- High-Power laser >1W at MWIR regime
- Ruggedized packaging design
- Wavelength specific

Ruggedized Packaging

Specifications

Beam pointing tolerance:

Horizontal/Vertical: ±3 mRad

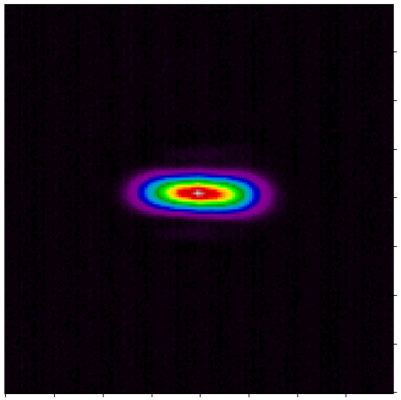
Beam pointing retention:

Horizontal: ±0.7 mRad, Vertical: ±0.4 mRad

Beam divergence tolerance:

Horizontal: ±1.0 mRad, Vertical: ±0.5 mRad

Beam divergence retention: ±10% of divergence



Beam profile

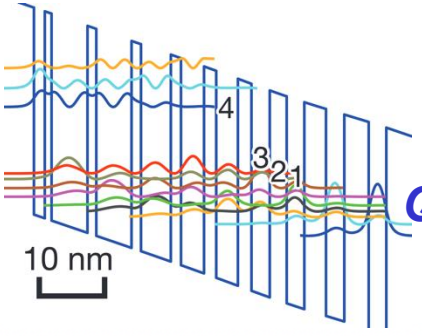
During and after any combination of the following environmental conditions:

1. **Ambient temperature* (operating):** -54ºC to +71ºC
2. Storage temperature (non-operating): -54ºC to +71ºC
3. **Thermal shock:** +55ºC to 0ºC, rate = 11ºC
4. Vibrations: 0.04 g^2/Hz, from 20 Hz to 2 kHz, 1 hour per axis
5. **Mechanical shocks:** 85 g, 5 ms, half-sine profile, 6 shocks per axis

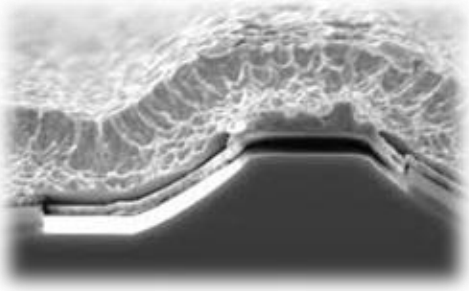
Steps in Packaging

Design and Simulation

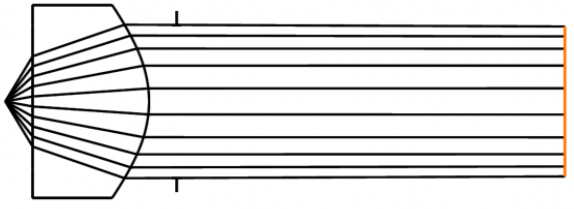
1. Chip design



QCL Band structure



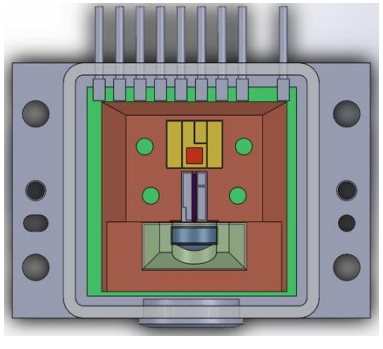
2. Optical design



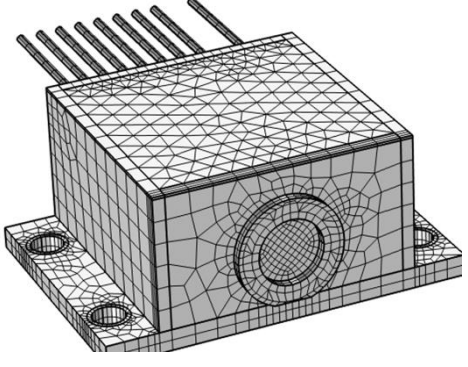
Collimator (Ray tracing)

3. **Mechanical design and simulation**

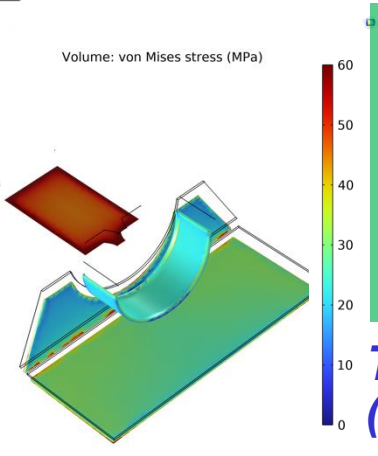
   (CAD and FEA)



CAD Design

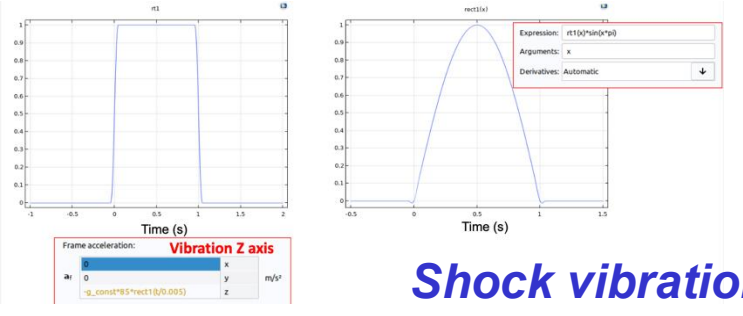


Simulation Model



- Linear Elastic laws
- Viscoplastic law
- Viscoelastic law
- Creep and fatigue analysis
- Modal, harmonic and dynamic analysis

Thermal stress analysis (-40°C, Operational state)

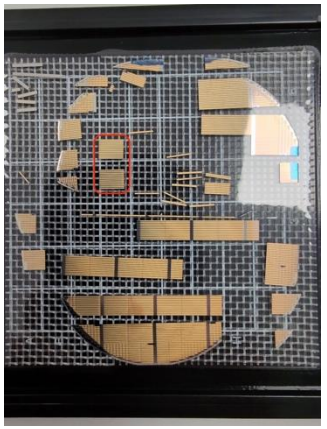


Shock vibration analysis

Fabrication of laser module

1. Cleaving

- *Automated scribe and break*

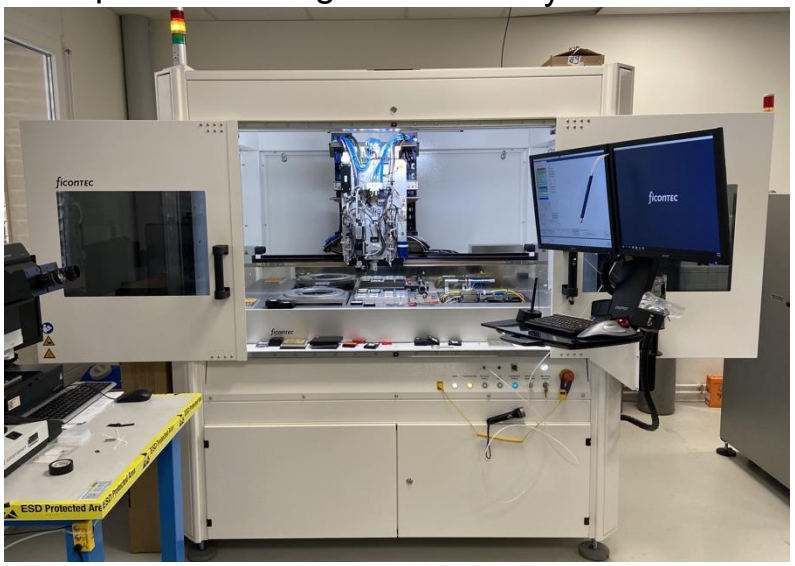


Chips for cleaving

Dynatex cleaver

2. Automated Die Bonder

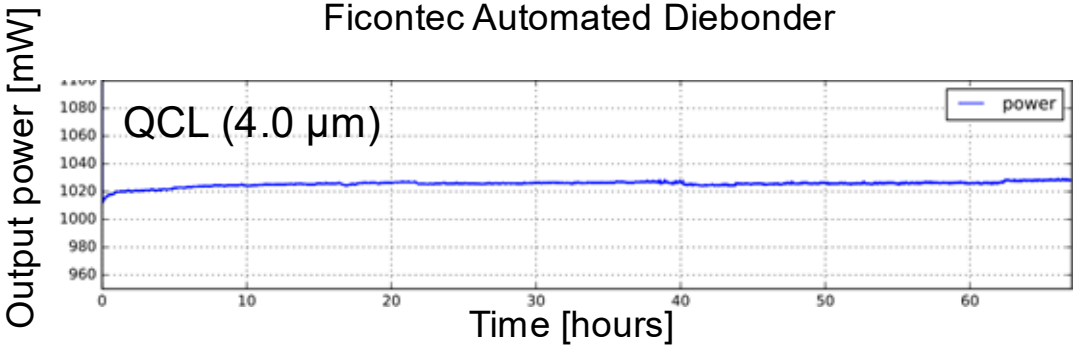
- *Soldering chip on submount (Epi up and Epi down)*
- *Soldering sub-mount to insert*
- *Improved precision* (+/- 2 microns) *and high throughput.*



Ficontec Automated Diebonder

3. Burn-in

- *Burned in for at-least 200 hours.*
- *Life time estimate using ALT.*



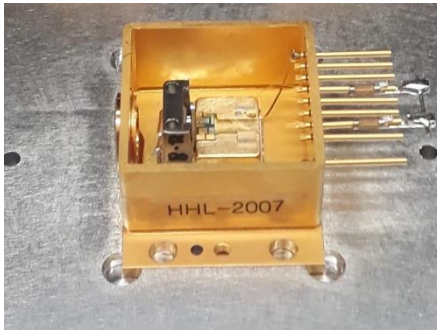
Steps in Packaging

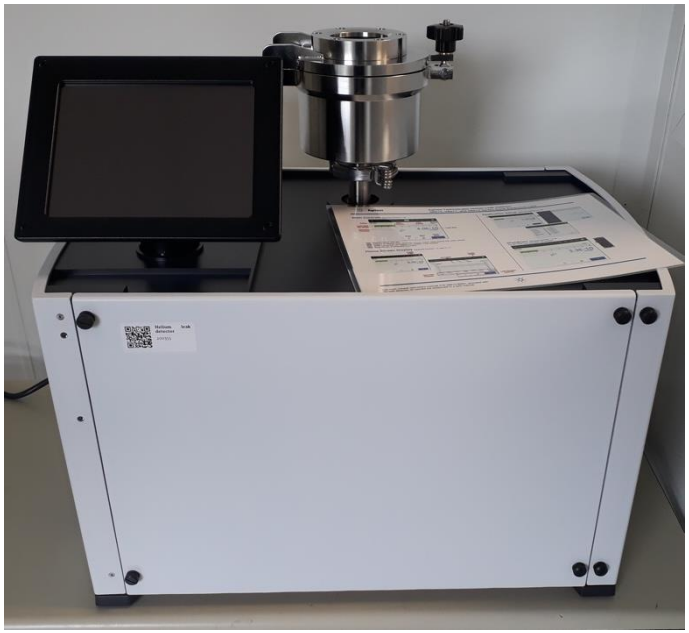
4. Optical assembly (hot alignment)

- In-house Optical assembly with pyro electric camera.
- Automated optical assembly in future.

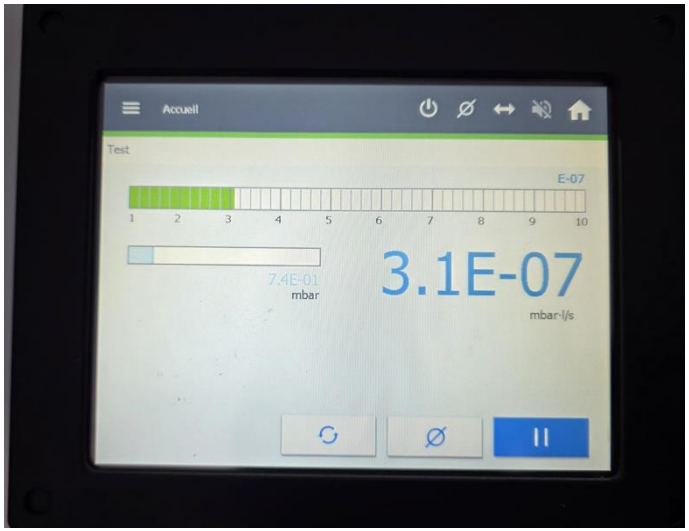
5. Hermetic sealing and leak detection

Labstar Eco seam sealer





Leak detector



We have the capability to have produce hermatic sealing with leak rate < 1x10 $^{-6}$ mbar l/s (MIL-STD-883H) with He.

Qualification tests

Thermal tests

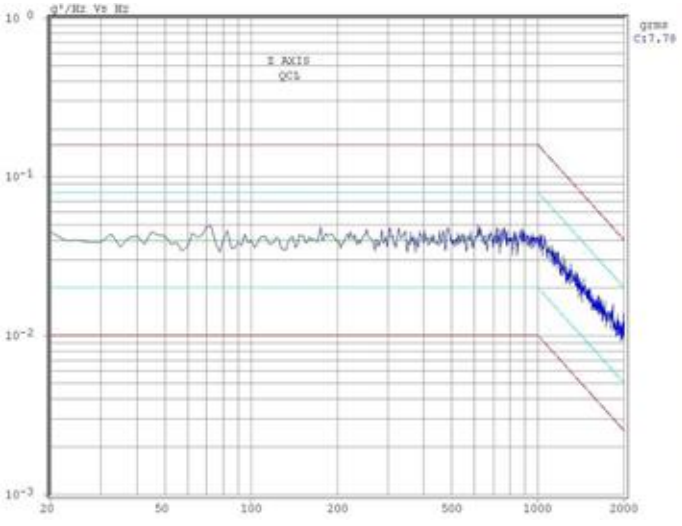
- Both operational and storage temperature tests.
- Temperature range: -80 to 120°C.
- Low and high temperature cycles (MIL-STD 810F)

Shock/Vibration tests

- Shock: 85g for 5 ms
- Can recreate various vibration profiles (flights, helicopters etc)

Operational thermal tests

Vibration shaker machine

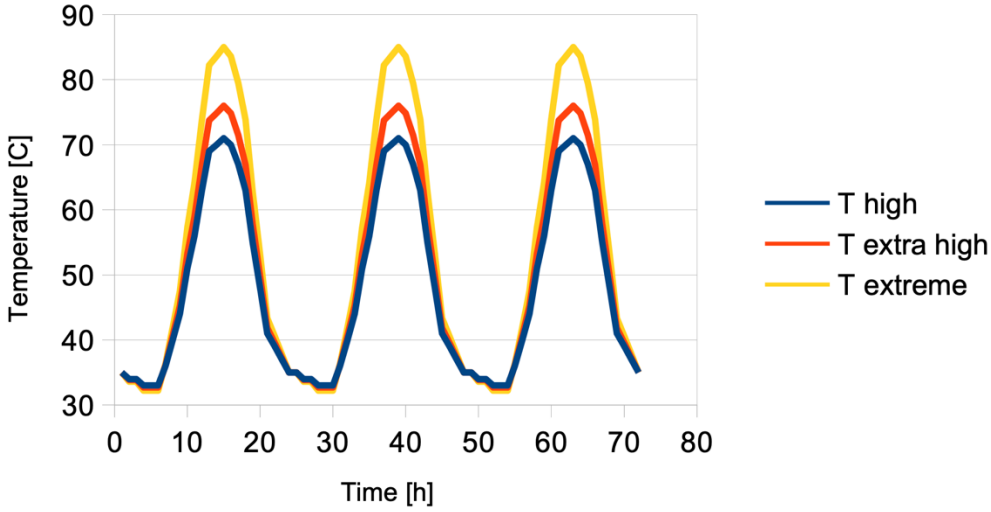


Vibration profile 0.04g²/Hz (MIL-STD 810F)

Qualification tests

Thermal tests

- Both operational and storage temperature tests.
- Temperature range: -80 to 120°C.
- Low and high temperature cycles (MIL-STD 810F)

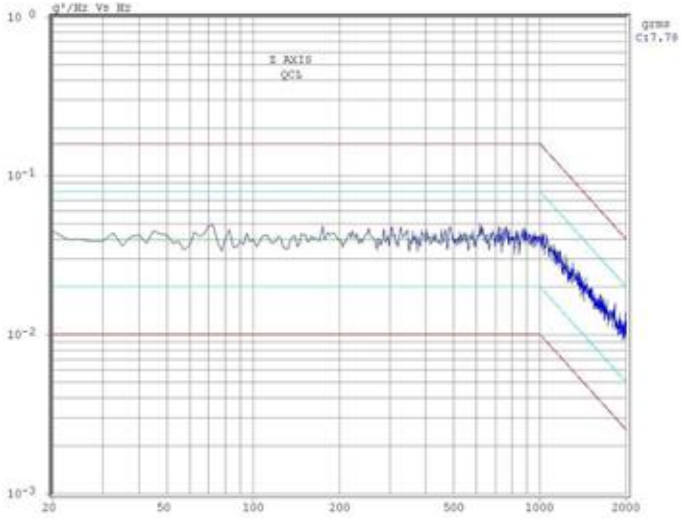


Operational thermal cycles

Shock/Vibration tests

- Shock: 85g for 5 ms
- Can recreate various vibration profiles (flights, helicopters etc)

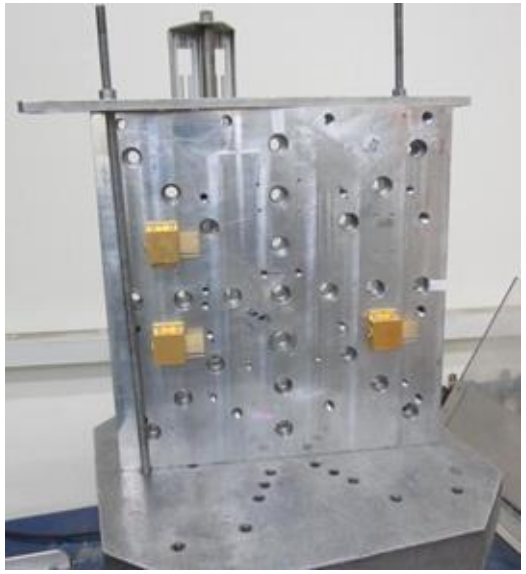
Vibration shaker machine

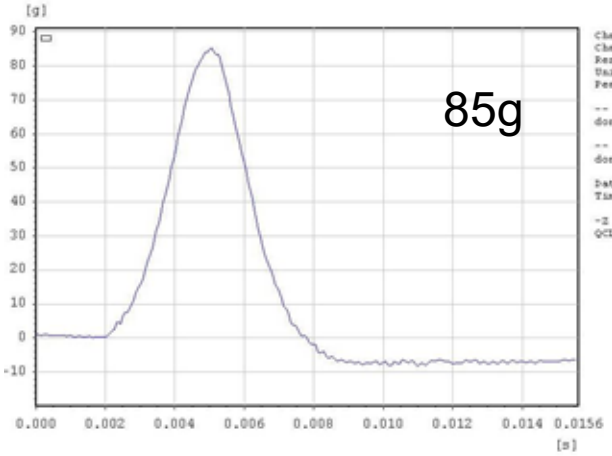


Vibration profile 0.04g²/Hz (MIL-STD 810F)

Qualification tests

Mechanical Shock Tests





10-15g

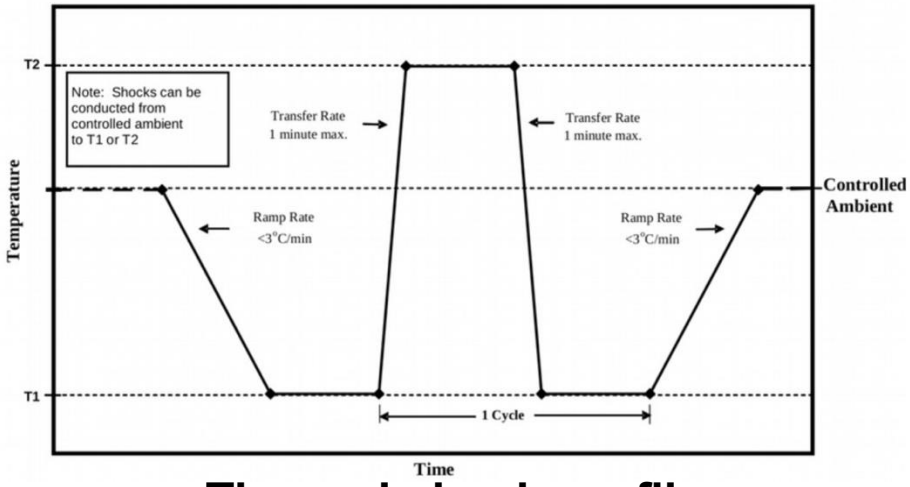
60-80g

- As per MIL-STD 810F, Method 516.5, procedure I
- Half sine, 85 g, 5 ms
- 3 axes, 6 shocks per axis

Thermal Shock Tests

- Profile based on MIL-STD 810G

We perform rigourous line of sight (LOS) and beam divergence measurements after each qualification tests.



Thermal shock profile

What we offer

- Customised chip design (QCLs, ICLs etc).
- Ruggedized packaging solutions.
- **Hermetic sealing and leak detection** of laser modules.
- Cryogenic and cyclic thermal tests.
- Vibration and shock measurements.
- Laser characterization.
- Customised laser systems based on customer requirements.
- Collaborative R&D projects (10+ ongoing).

Funded by the European Union

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

EPFL ETH zürich csem Empa Materials Science and Technology FEMTOPRINT 3D PRINTING FOR GLASS MICRODEVICES

NETHELIX FORESIGHT

GASPOF MultiLab

MIR MENiR Integrated, Modular, Multisensing Mid-IR and Near-IR sensing platform

MedPhab Photonic Medical Devices

TUMOR LN-oC vocorder Revolutionizing Healthcare Through Breath Analysis

enviromed Aims to better understand the lifecycle of pharmaceutical products to reduce their environmental footprint

dairy 4.0 Advanced, trustworthy AI and data solutions for individualised automated milking & feeding of dairy cows

Bio.3DGREEN

ALPES LASERS

Thank you for your attention

www.alpeslasers.ch