Contextualisation

Quantum Cascade Laser (QCL) are mid to far infrared laser exhibiting a very good efficiency due to emission of several photons with a single electron. Used in many different field such as aircraft protection against missiles, optical communication in space, night vision infrared illuminators or chemical sensing. QCL chips are encapsulated in high heat load (HHL) packages with thermoelectric coolers and collimation optics and powered by a PCB called S-2. The environmental reliability of packaged QCLs is strongly dependent on the mechanical properties of the package assembly.

HHL : Ameliorations

CuW Heat sink instead of Cu less expansion
Cu ductile structure below Heat sink release stress + strain
Mechanical guide only on one side solders stress concentration
Silica glass, transparent for UV cured possible less expansion
Lens not constrained less stress

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Values to sustain</th>
<th>Geometry 1</th>
<th>Geometry 2</th>
<th>New subcontractor design</th>
<th>Final improved design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural frequencies</td>
<td>&gt; 2 kHz</td>
<td></td>
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<tr>
<td>Vibrations</td>
<td>0.08 g/turn for 20 Hz to 2 kHz, 5 µm per side</td>
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<tr>
<td>Shocks</td>
<td>1.25 g, 3.5 ms constant profile, 4 shocks per axis</td>
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<tr>
<td>Storage temperature</td>
<td>-55°C to +85°C</td>
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<tr>
<td>Thermal shocks</td>
<td>From -55°C to -20°C at 15 °C chips</td>
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<tr>
<td>12 operation thermal conditions</td>
<td>Room 7°C to 40°C</td>
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</table>

Simulations assumptions

S-2:
Structural analysis :
- Modal
- Harmonic structural analysis
- Dynamic structural analysis
- Static structural analysis
Thermal stress analysis :
- Quasi Static thermomechanical analysis
Solders :
Viscoplastic behavior
Anand model

HHL :
Structural analysis :
- Modal
- Harmonic structural analysis
- Dynamic structural analysis
Thermal stress analysis :
- Static thermomechanical analysis
- Static thermomechanical analysis
Adhesive :
Viscoelastic behavior
Generalized Maxwell model
Prony serie

Model verifications

Weigh correlation < 1%
Simplifications verification : < 5%
Natural frequencies correlation < 10%
Damping determination

Strain correlation
6% relative error

Conclusion

- Model and simulations developed and verified available also for other devices ➔ Confidence on the results
- Understanding of the problems
- Ruggedized S-2 and HHL devices
- Beginning of the in house development of the package