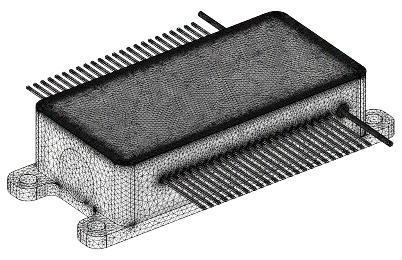
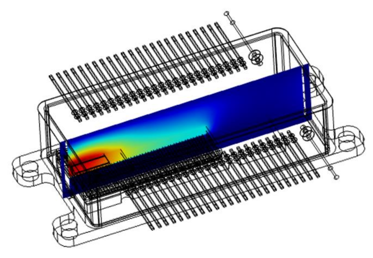
Multiphysics Model for Thermal Management of Packaged Mid-IR Laser





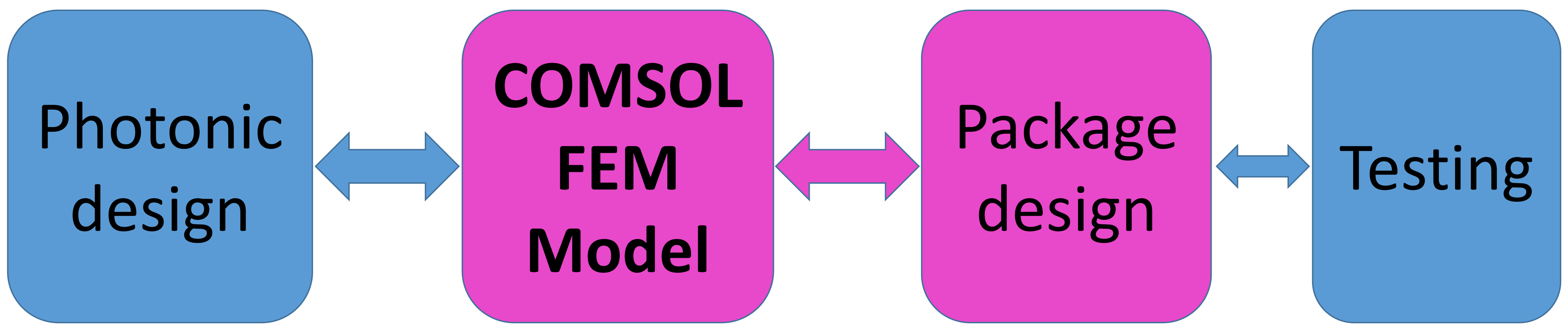
G. Spinola Durante[1], J. Kaufmann[1], K. Krasnapolski[1], M. Lützelschwab[1], J. Pierer[1]

1. CSEM SA, Alpnach Dorf (OW), Switzerland

Corresponding author: gsd@csem.ch – CSEM Website: www.csem.ch

INTRODUCTION:

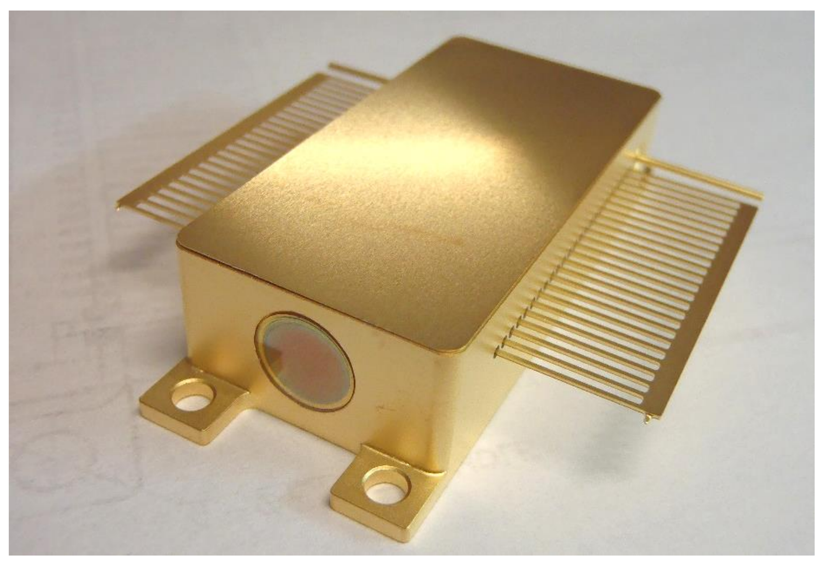
- Mid-IR photonics is growing thanks to advances in Lasers, QC-Lasers, MEMS gratings and fiber optics [1]
- Temperature is the key to stable and reliable operation of photonics systems [2]
- Thermal management and package design can be handled with multi-physics FEM models



PACKAGING STRATEGY of Mid-IR laser:

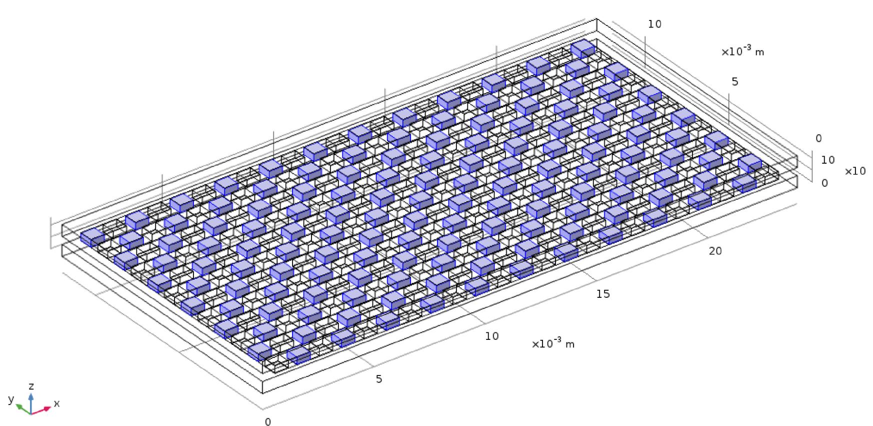
- Heat-spreading submount to efficiently remove heat
- Thermo-electric cooler (TEC) below heat spreader
- Kovar package to reduce thermo-mechanical stress and enable hermetic sealing

Mid-IR Laser with Joule heating loss of P_{th} ~40(W)

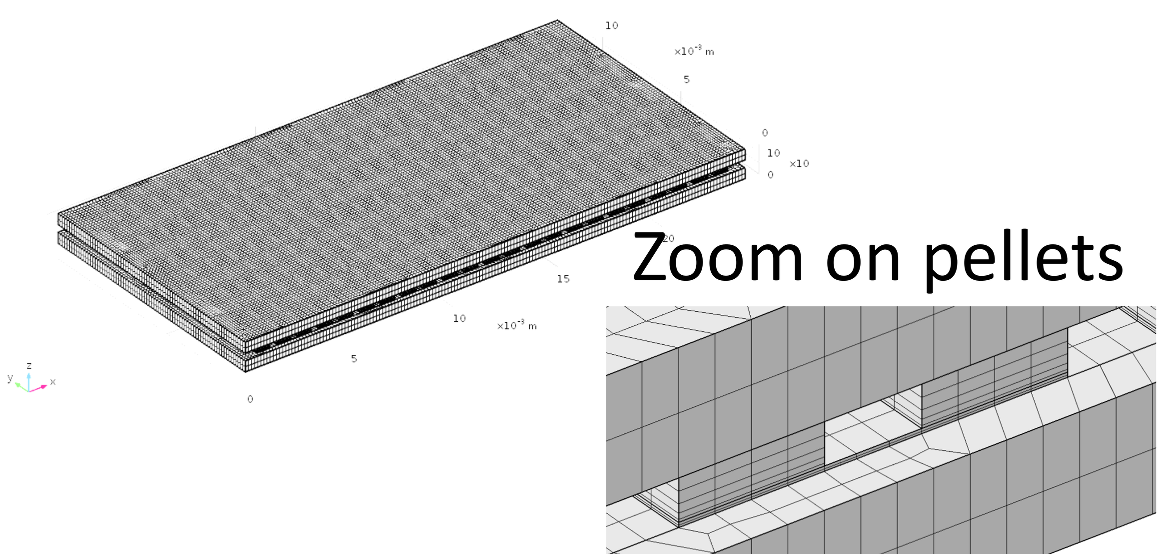


Thermo-electric Cooler (TEC) model:

- Use of COMSOL® Application
- Improved Mesh approach to cope for large model with 12x24 pellets
- TEC model calibrated with supplier material data (Seeback, k, other…)
- Calibrated TEC model comparison with lumped-model simulator. Heat flux accurate to >99%



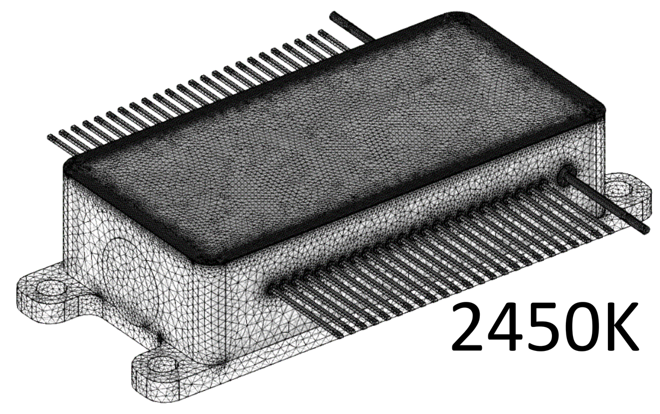
TEC: Δtmax ~71(K), Qmax ~ 56(W)



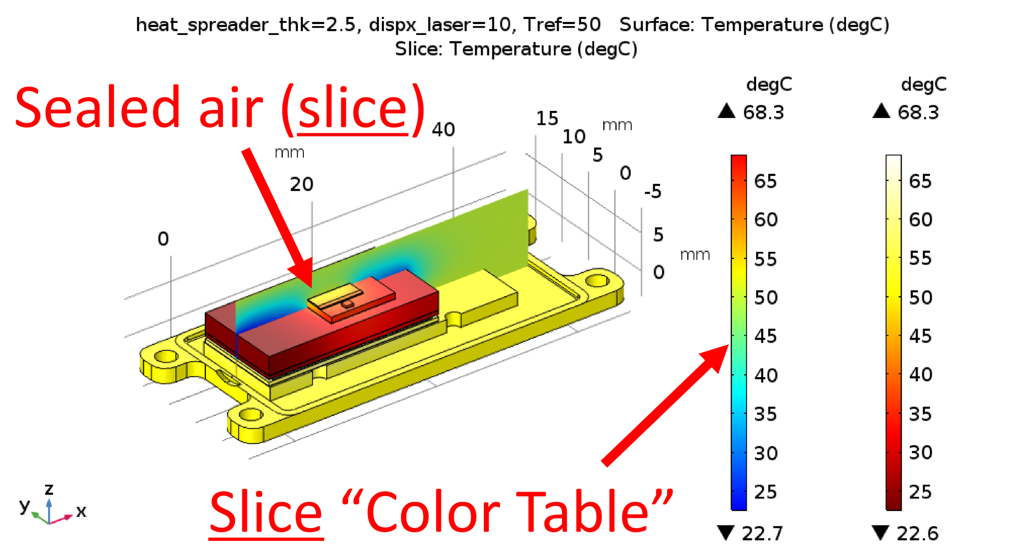
- 120K Elements
- Avg. Element Quality is 0.99 (Skew.)

Kovar package COMSOL model:

- Conjugated heat transfer (air sealed in Kovar package)
- Convective and Radiative effects from external package
- Multi-physics coupling also to Thermo-electric cooler (TEC)
- Parametric analysis to find optimum laser peak temp.
- Iterative solver found optimal (segregated approach)



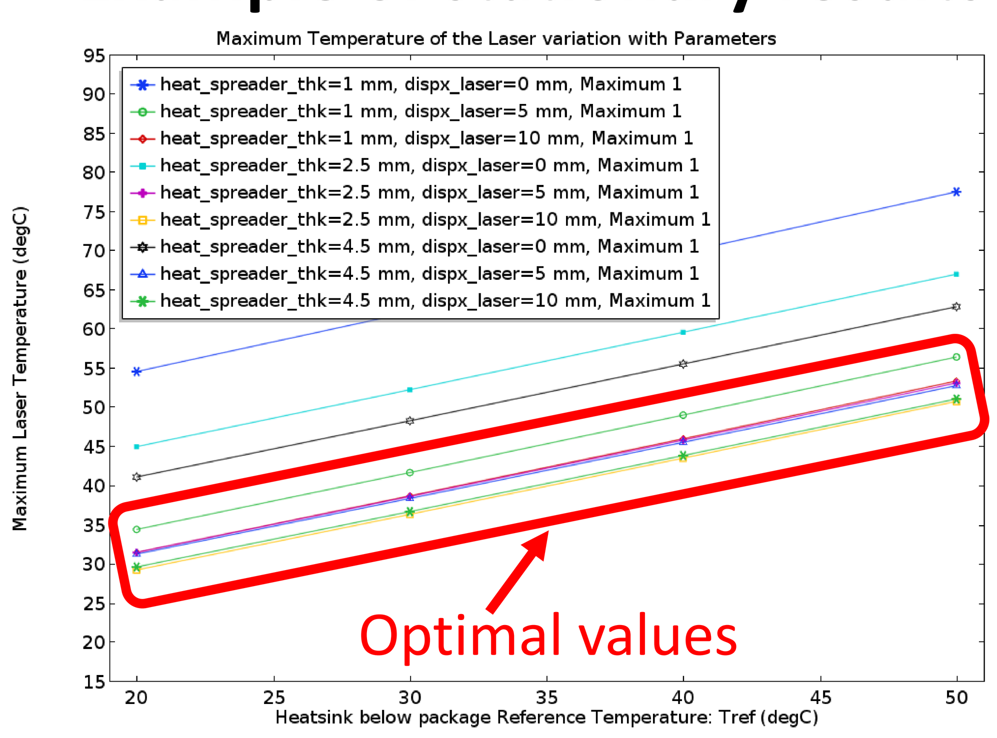
2450K Elements



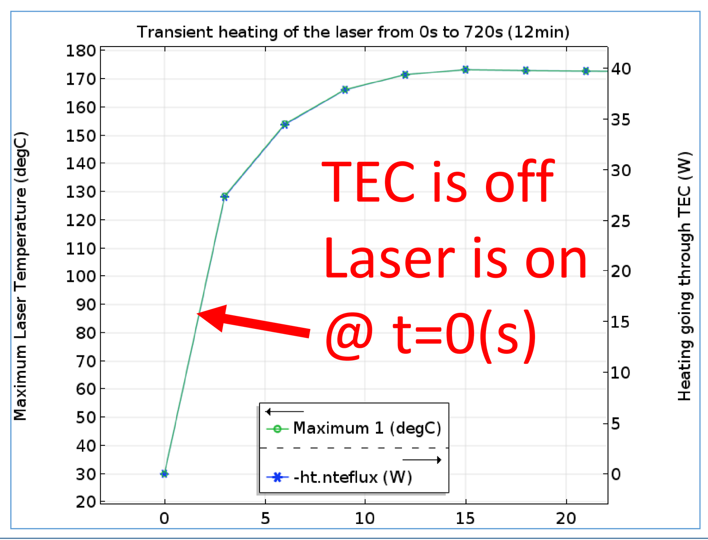
- 9 independent parameter sets
- 112h solution time (high res.)

Comsol simulation results:

- Optimal set of submount parameter minimize laser temp.
- Optimal laser mount position
- Impact of reference heatsink and ambient temperature
- Transient simulation to check thermal time-constants
  - **Example of stationary results**



- **Example of transient results**



CONCLUSIONS:

- Laser mounting position on submount is critical to achieve minimum laser peak temp.
- Heat spreader thickness plays an important role. Thickness of 2.5-4.5(mm) is optimal
- TEC must be on if laser is active (risk of damage)

REFERENCES:

1. MIRPHAB is an all-services integrated Pilot Line for the development of MID-IR photonics sensors in Europe. http://www.mirphab.eu/
2. G. Spinola Durante et al., Thermal Management Solutions for mid-IR Optoelectronics Packages, CSEM Scientific and Technical Report 2017, pag. 36 (2017)

BENEFITS OF SIMULATIONS:

- Parametric analysis for optimal package components design choice, by skipping trial-and-error effort and costs (purchase, assembly and testing)
- Full-model provides insight in ambient & heatsink temperatures impact on the laser max. operating temp.
- Insight on TEC model choice and its behavior
- Transient simulation provides insight on pulsed (LF) & short-time operation mode

Excerpt from the Proceedings of the 2018 COMSOL Conference in Lausanne