Multi-physics Model for Thermal Management of Packaged Mid-IR Laser

Guido Spinola Durante[1]

[1]CSEM SA, Switzerland

Abstract

Applications of mid-infrared photonic technologies are fueled by innovative advances in quantum cascade lasers, and other key optical components like MEMS gratings and fiber-optics. The integration of devices into optoelectronic packages for stable operation at high powers poses also challenges in terms of thermal management.

We present here a thermal model of a packaged mid-infrared laser with embedded thermoelectric cooler and sealed in air. The advantage of using COMSOL Multiphysics® is clearly identified by the availability of the multi-physics coupling scheme for solving simultaneously thermal, electric and fluidic models in both stationary and time-transient fashion.

The following steps were followed to set up the model: at first a readily available 'thermoelectric cooler' (TEC) model was selected from the COMSOL Application Library and extended to enable a better mesh control, with a moderately high number of Peltier elements (12x24). The Peltier model was then calibrated with measured material properties (Seebeck coefficients) provided by the TEC supplier. In a third phase the model was validated against a design software to extrapolate TEC (lumped model) performances, also provided by the TEC supplier. Once the model was validated a parametric analysis was set-up to support the package thermal design phase, by checking model temperature field across variations of relevant parameters.

Goal of the simulations was to optimize for lowest peak laser operating temperature and therefore to ensure its longest reliability and system lifetime. The simulations results ensured the correct choice of heat spreader material, heat spreader thickness and laser mounting position, before the actual prototype was being built. A parametric analysis was also done depending on a range of different ambient temperatures, to ensure an acceptable operating temperature range of the laser itself.

These simulations are in general beneficial to significantly decrease the development time and costs involved in the packaging design, assembly and testing steps. The alternative practical approach would have required a trial-and-error approach and to purchase expensive materials with long delivery times. It would also require much assembly and characterization effort, in order to find out the most viable packaging design solution.

Figures used in the abstract

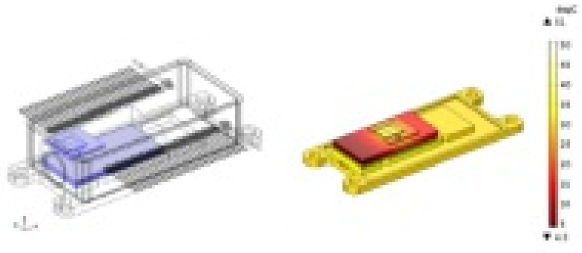

Figure 1: Sealed package with mid-infrared laser mounted on a heat spreader and cooled by a thermoelectric cooler element.