Packaging Design and Simulation for Space Applications

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In the framework of an ESA funded project (Hopwell) aiming at developing miniature hermetic optoelectronic packages, CSEM has devised an integrated methodology to design packages for functionality. The methodology consists at first in defining a parametric (Solidworks) CAD model for the packages. Optical simulations are then performed on a simplified model and the optical simulation results, including tolerancing, are taken into account into the parametric CAD model. It is then directly imported into a FEM simulation tool (COMSOL) and solved to validate the coupled thermo-mechanical performances and ensure long-term functionality of the design by minimizing mechanical stress, while operating in the environment.

Four different miniaturized optoelectronic package designs were developed within an ESA funded project. In Figure 1 is represented schematically the integrated design flow approach.

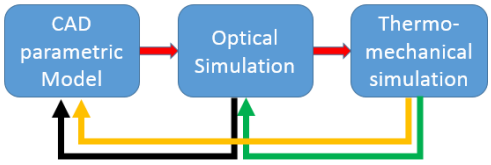

Figure 1: Optical micro-packages design flow.

The design concepts have been discussed and agreed with ESA, according to CSEM previous experience in the field of laser-based hermetic sealing of transparent substrate [1,2,3]. A first design includes the VCSEL type laser array without any collimating lens. The second design includes the VCSEL array with a collimating multi-lens array. In two more designs a focusing multi-lens array is included (see Figure 2).

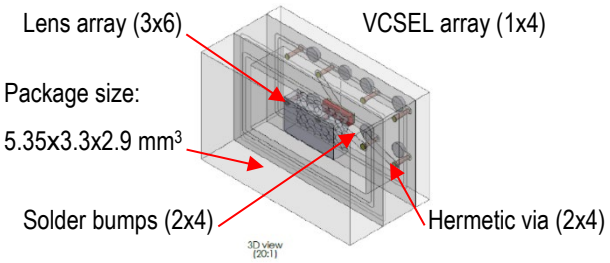

Figure 2: Parametric CAD Model including focusing lens (Solidworks).

All of the designs require to be analyzed at first with a ray-tracing software to assess if the performance is within the limits of the optical requirements. A simplified model is set up and solved with the optical design software tool ZEMAX. The designs include the mechanical dimensioning and tolerancing of all components and subcomponents. In particular, the effect of geometrical tolerances on the optical performance is considered in Figure 3.

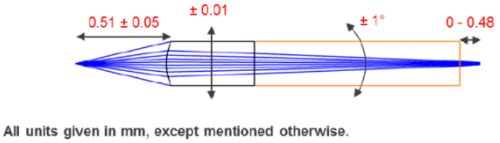

Figure 3: Optical tolerance simulation results (ZEMAX).

All of the designs have to be optimized during optical simulation by means of a goal function. Then the CAD models are consistently updated and imported into the COMSOL program for simulation of thermo-mechanical stress (Figure 4).

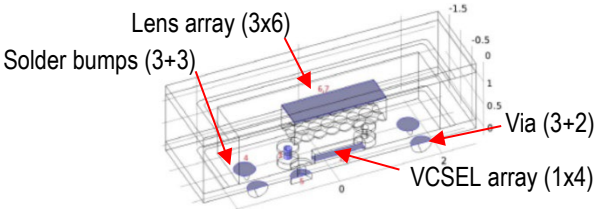

Figure 4: FEM model imported and cut to half-symmetric (COMSOL).

Figure 4 shows highlighted in blue the areas where stress is averaged out for easier comparison. The purpose is to ensure low levels of stress during laser die-attach and/or adhesive bonding of the VCSEL, and adhesive via-filling. Thermo-mechanical stress analysis can also be used to check stress levels assuming different materials and ambient temperature, according to the extremes defined in the thermo-cycling requirements (Figure 5).

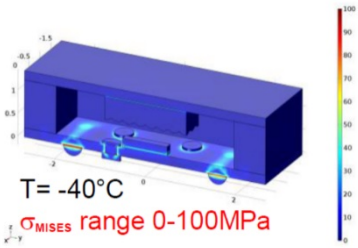

Figure 5: Example of Von Mises stress-plot for comparative analysis of adhesive choices at -40°C during thermo-cycling test.

The last step of the package design requires careful choice of metallization and its layout design. The packaging design phase is usually concluded with the description of the assembly process flow.

In conclusion the comparison of different design approaches is therefore much simplified and supported by an integrated design flow, to find the most promising package designs in accordance with stringent reliability requirements as present in a space environment. This research activity has received funding from the European Space Agency.

[1] R. Jose James, *et al*., "Low Temperature Hermetic Sealing of Sapphire Substrates", CSEM Scientific and Technical Report (2014) 41.

[2] S. Berchtold, *et al*., "Low-temperature Laser-assisted Sealing of Glass Lid on Silicon", CSEM Scientific and Technical Report (2016) 31.

[3] M. Fretz, *et al*., "ACTION − Hermetic Packages and Flexible Substrates for Implants", CSEM Scientific and Technical Report (2016) 33.