BE CAE, ITALY

THERMAL CHARACTERIZATION OF AN ELECTRONIC DEVICE WITH A CUSTOM APP

By distributing high-fidelity multiphysics models as custom simulation apps, engineers at BE CAE & Test leverage their expertise and streamline the consulting process.

by GIUSEPPE PETRONE

Simulation consultants are using custom applications as an effective way to communicate their work to clients. Instead of delivering a static report, they can now deploy a product that contains the intricacy of an unabridged mathematical model, with the clarity and usability of an app. This lets clients run their simulations independently. At BE CAE & Test, we have created such an app to simulate a surface-mount device (SMD).

⇨ SIMULATION APPLICATIONS FOR ENHANCED ENGINEERING COMMUNICATION

In simulation consulting, apps are the next step in engineering communication: They're a streamlined way to communicate and work with clients. With a custom application, a client can access a complete simulation through a user-friendly interface. Using an app is advantageous for both the simulation specialist and the client, as the client receives an easy-to-use tool with which they can independently investigate their system, and the numerical expert is able to dedicate more time to the detail of the simulation rather than running computations for the client.

In this example, which describes the characterization of an SMD, the client has access to the numerical model through the app and can modify a few parameters and material choices.

⇨ THERMAL CHARACTERIZATION OF A SURFACE-MOUNT DEVICE

Whether devices use or convert energy, they must properly manage heat so that they continue to operate in a designated temperature range. An SMD is an example of one electronic system that clients ask us to model. We make use of COMSOL Multiphysics® software to investigate these systems due to the wide range of physics that can be taken into account and the ease with which one can couple them.

In our SMD model, the parts we're mainly interested in are the copper frame, lead-free solder layer, and the silicon die (see Figure 1).

The material of the solder layer and silicon die, the thickness of the solder layer, and the dissipated thermal power each have the potential to impact the maximum junction temperatures and junction-to-case thermal resistance. In our model, we investigate the effect of varying these parameters on heat distribution, as it ultimately affects the

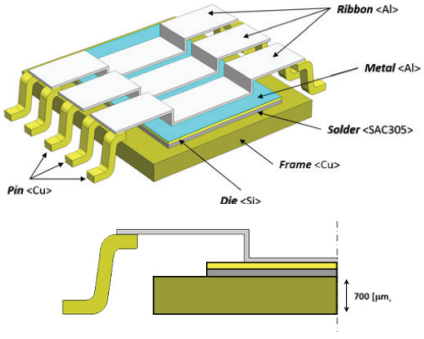

FIGURE 1. Top: Geometric details and materials used in the SMD. Bottom: Side view of the frame, die, solder, pin, and ribbon.

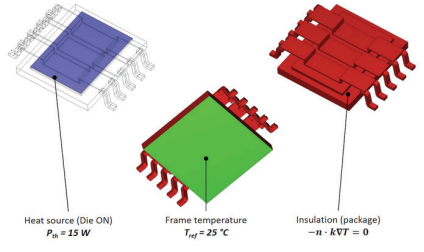

FIGURE 2. Highlighted regions of the SMD depicting the boundary conditions used in the multiphysics model.

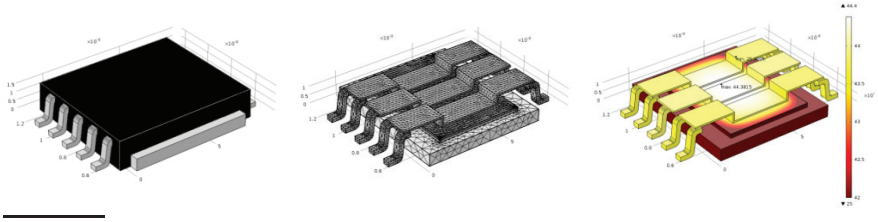

FIGURE 3. From left to right: 3D geometry, mesh, and simulation results from COMSOL Multiphysics® software.

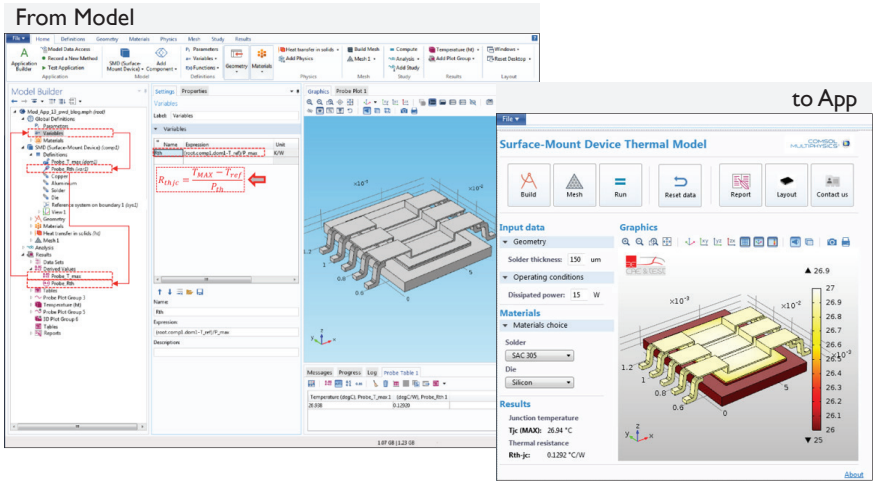

FIGURE 4. The Surface-Mount Device Thermal Model app, created with the Application Builder available in COMSOL Multiphysics® software. The user can change factors such as the solder thickness, operating conditions, and materials in order to analyze the thermal behavior of different SMD designs.

proper functioning of the SMD. In our test simulation run, the heat source is 15 W, the initial frame temperature is set to 25°C, and the remaining parts are thermally insulated.

With COMSOL Multiphysics, it is straightforward to model heat transfer through the device, as all modeling steps are carried out in the same environment. We were able to quickly build the geometry; add materials; use the Heat Transfer in Solids physics interface to set up boundary conditions; mesh; solve; and postprocess the results with the expressions we defined, such as the junction-to-case thermal resistance.

⇨ BUILDING A CUSTOM SIMULATION APP FROM A NUMERICAL MODEL

Once the COMSOL Multiphysics model is complete (see Figures 2 and 3), it can be wrapped in a user-friendly interface with the Application Builder tool. As the experts in the physics at hand, we consider both our mathematical model and our client's specifications in order to choose the parameters that the app user can access and modify within an acceptable range (see Figure 4).

The app user can see the geometry of the SMD, adjust the solder thickness, generate a mesh, launch the simulation, return to default settings, and generate a report. These features are easily created with the functionality available in the COMSOL Application Builder.

As the application user progresses through the steps of the simulation, graphical output is displayed: first the geometry of the SMD, then its mesh, and finally the computed temperature distribution. Thus, the interactive, dynamic nature of the model is preserved in the app. When the app user modifies a parameter, all visualizations are easily regenerated.

The final result is a clear and easy-to-use application that relies on the accuracy and predictive power of the mathematical model defined by simulation specialists, but does not overwhelm the user. The app described here allows the user to examine maximum junction temperature and junction-to-case thermal resistance as a function of the materials of the components, thickness of the solder layer, and dissipated thermal power. The app user can modify parameters and view the output quickly, confirming or contradicting predictions to make informed design decisions.

⇨ IMPROVING ENGINEERING COMMUNICATION

In our experience of creating simulation apps, clients have been pleased to be provided with an interactive tool with which they can investigate their system.

Previously, after providing clients with the outputs of simulations, there would be requests for further computational modeling with different parameters. Now, it is possible for the simulation expert to deploy a custom application with which the client can investigate all of their remaining uncertainties. This is optimal for the simulation expert as well as clients — the time spent on repeating simulations with different parameters is better spent adding complexity to the simulation and app.

Now, with simulation apps, upon receiving a request for parametric simulations, we can say, "Let us provide you with a COMSOL custom application, and you will be able to inspect your product yourself." ❖

> "In simulation consulting, apps are the next step in engineering communication: They're a streamlined way to communicate and work with clients."

ABOUT THE GUEST AUTHOR

Giuseppe Petrone is a cofounder and the sole administrator of BE CAE & Test, a COMSOL Certified Consultant. He received his master's degree in mechanical engineering from the University of Catania in Italy and later earned his PhD in energetic and process engineering from the Université Paris-Est in France. Before starting BE CAE & Test, Petrone devoted his time to academic research ventures, which included exploiting numerical methods in fluid dynamics and thermal analyses. He has been a user of the COMSOL Multiphysics® software since 2005.