

Integrating CAE Tools: a *Package Deal*

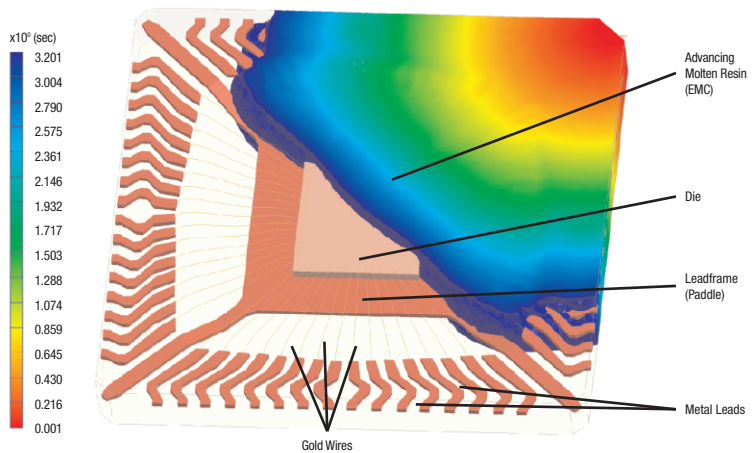
Moldex3D and ANSYS Mechanical team up to simulate microchip encapsulation.

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Integrated circuits (ICs), also called microchips, are at the core of the modern electronic device. Packaging — the final stage of IC fabrication — is the essential technology that distributes electrical signals from a silicon chip onto the printed circuit board and provides protection against environmental stresses. Customer demand for highly sophisticated and ever-smaller electronic products has made IC packaging a challenging procedure and, thus, critical to system performance. Moreover, this trend is driving the technology toward higher packaging densities with thinner and smaller profiles, which makes the encapsulation process much more complicated and unpredictable.

Despite recent trends in copper internal heat spreaders, a significant fraction of ICs are encapsulated by plastic, a process that is usually accomplished by transfer molding. A typical transfer molding begins with loading a leadframe into the mold, placing and preheating the preforms, and then closing the mold. The molten epoxy molding compound (EMC) is then forced into the mold system by the transfer ram. The packages are ejected once the packing and curing processes have been completed. Common defects in the transfer molding process arise from the improper selection of processing conditions, molding material, leadframe layout or mold design. These defects include short shot, air trap, wire sweep and paddle shift.

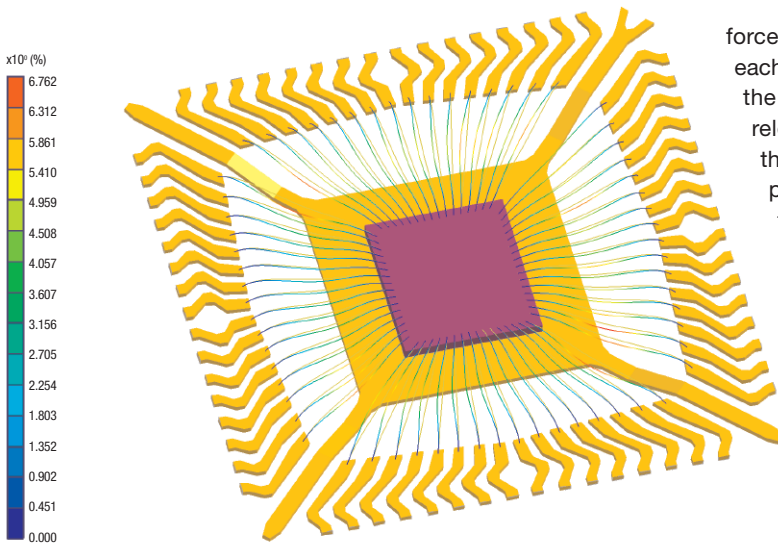
Among these defects, wire sweep and paddle shift in particular are caused by fluid-structure interaction problems. Gold wires are common IC package components used for transferring the electronic signals and power between the die and the leadframe contacts. During the encapsulation process, the melted resin flow exerts drag force on wires, which causes them to deform. The amount



Moldex3D simulation results showing the melt front advancements, colored by elapsed time, at a level of 45 percent filled. The die (pink, center), leadframe (salmon, extending outward) and gold wires of the package are also displayed.

of wire deformation, or sweep, during encapsulation is affected by the resin viscosity, wire mechanical properties, package dimension and process conditions. If wire deformation exceeds the limit, it can cause wire breakage or adjacent wires to touch, and the package will subsequently fail. The paddle, on the other hand, is the flat base of the leadframe and is used to support the chip. Usually, the paddle is connected to the leadframe by long and thin metal leads, which give the paddle system a quite flexible structure during mold filling. Uneven resin flow in the cavity, however, can apply unbalanced loading on the paddle system and, hence, deform or shift the paddle. When the amount of paddle shift is too large, it will significantly reduce the thickness of the cavity, further resulting in excessive wire sweep or exposing the die.

Applying the conventional trial-and-error method to resolve these problems is difficult and costly because of the complex interactions among fluid flow, heat transfer, structural deformation and polymerization of the EMC. However, through the coupling of Moldex3D® from Coretech System Co. and



Wire sweep simulation result showing the original and deformed wires colored by wire sweep index (WSI). The WSI distribution is the maximum deformation divided by the projected length of each wire. A high WSI value indicates the potential failure of adjacent wires touching or wire breakage.

force distribution can be calculated along each wire. With a single click in Moldex3D, the drag force, boundary conditions and relevant mesh data are then exported to the ANSYS Mechanical solver, which performs the deformation calculation transparently in the background for each wire at the instant when the melt touches it. After the analysis in ANSYS Mechanical is completed, the wire deformation result can be checked either in Moldex3D or in ANSYS post-processors. As to the paddle shift problem, Moldex3D outputs the spatially and time-varying pressure loads on the leadframe directly to ANSYS Mechanical, which then performs steady-state simulations based on the data for each instant of time. For the wire formation calculation, both Moldex3D and ANSYS Mechanical

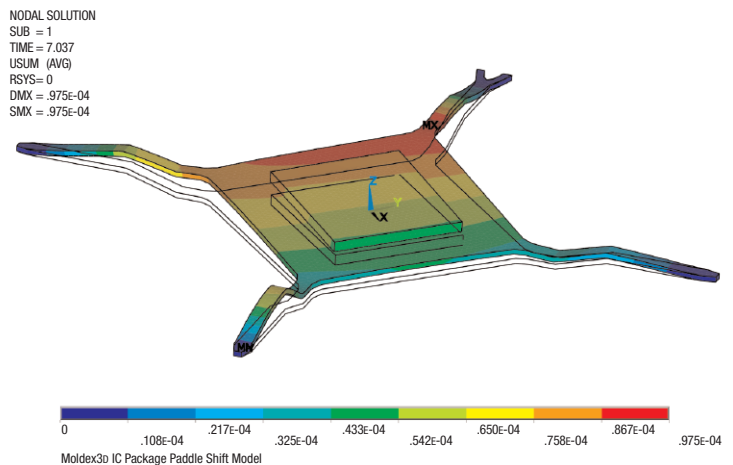
ANSYS Mechanical simulation software, engineers can analyze the complicated physical phenomena inherent in the encapsulation process and further optimize the package design. The nonlinear capability of ANSYS Mechanical technology is critical for wire sweep and paddle shift simulations, since the deformation of wire or paddle could be quite large.

The IC Package module of Moldex3D is a fully integrated analysis environment connecting pre-processing, post-processing, mold filling and structural analyses for microchip encapsulation simulation. One of the major challenges of three-dimensional modeling of microchip encapsulation is generating a suitable mesh for analysis. In the Moldex3D pre-processor, an efficient volume mesh generator with high-quality and arbitrary grid type (for example, tet, hex, wedge, pyramid or boundary layer elements) allows meshing of the package geometry with minimal model simplification. Furthermore, a parametric capability can assist in creating wires, thereby greatly reducing meshing effort. In the mold-filling stage, Moldex3D can calculate the resin flow considering nonlinearities such as viscosity change and the curing reaction of the EMC. Engineers can thus predict how the mold will fill, identify potential air traps and weld lines positions, and evaluate the runner and gate design.

Having obtained the local flow field from the mold-filling analysis, the drag

can display the paddle shift results.

The combination of Moldex3D and ANSYS Mechanical software provides a promising simulation solution for the microchip encapsulation process. By using the integrated analysis, molding defects can be easily detected and moldability problems can be improved efficiently to reduce manufacturing cost and design cycle time. These reliable and powerful simulation tools can help IC package designers to meet the difficult demands from legacy devices to tomorrow's innovative packaging solutions. ■



An example of a total displacement distribution, measured in centimeters as shown in the ANSYS Mechanical post-processor. This paddle shift is caused by the unbalanced pressure loading during mold filling.