Thermomechanical Effects of the Packaging Molding Process on the Chip in Integrated Circuits

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System description

Usually, in integrated circuits, the chip is brazed on a leadframe and then, a (black) polymer resin is molded around to create the packaging as we can see in fig.1. The molding process at high temperatures will induce thermomechanical stress on the chip, as the leadframe, the die and the braze have all different thermoelastic properties. We also considered the mechanical interaction between the fluid (hot polymer introduced in the mould) and the solid.

![Figure 1](image1.png)

**Figure 1**: View of the full system including leadframe, die and the pack (left), the system meshed (mid.), and without the pack (right)

Simulation steps with COMSOL Multiphysics®

To perform our simulation, we used COMSOL Multiphysics® tool empowered by the MEMS Module.

**Step 1**: Pre-heating process

To simulate this step, we performed a thermoelasticity stationary analysis. The system is at $T_{\text{melt}}$ equilibrium temperature, and we take $T_{\text{amb}}$ as strain reference temperature without temperature deviation.

![Figure 4](image4.png)

**Figure 4**: Step 2, leadframe deformation and die shear stress using different inlet speed of polymer (without pin)

**Step 3**: Cooling process

We performed again a thermoelasticity analysis considering that the polymer is solidified, but here the system is at $T_{\text{amb}}$ equilibrium temperature, and we take $T_{\text{melt}}$ as strain reference temperature. We take as initial value a temperature deviation equals to $T_{\text{melt}} - T_{\text{amb}}$. In addition, our polymer has a glass transition temperature at which its thermal properties change. We simulated and compared 3 different polymer used in the industry (fig. 5).

![Figure 5](image5.png)

**Figure 5**: Step 3, leadframe deformation and die shear stress for different polymer

Molding process description

The die brazed on the copper leadframe is first pre-heated at the melting temperature $T_{\text{melt}}$ of the polymer. Before the resin injection, some steel pins are used to maintain the leadframe during the process (see fig. 2). Then the polymer is introduced for about 10s at an inlet speed $V_{\text{in}}$, then the pins are removed. Finally, we will study the cooling from $T_{\text{melt}}$ to the ambient temperature $T_{\text{amb}}$.

As main results we look for an estimation of the shear stress on the die, to determine if it could break. But we are also interested in the value of the leadframe deformation to see for example the utility of our 4 pins.

![Figure 2](image2.png)

**Figure 2**: View of the system with the pins

**Figure 3**: Step 1, Comparison of the deformation using one (right) or no pin (center) compared to the initial position (left)

**Step 2**: Liquid polymer injection

For this step, we used the fluid-structure interaction node from the MEMS module. The whole system (system + liquid polymer) is at $T_{\text{melt}}$, so there is here no thermal or thermomechanical effects on the system. For the two first steps we were able to choose how many pins we are using during the process (fig.3).