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

Mathieu Fournier[1,3], Pierre-Sylvain Alleaume[2], Alexandre Seigneurin[3], Nadjib Semmar[1, 2]
[1]GREMI-UMR 7344, CNRS Université d'Orléans, 14 rue d'Issoudun, BP 6744, 45067 Orléans Cedex 2, France
[2] Collegium Sciences et Techniques, Rue de Chartres, 45000, Orléans
[3]ST Microelectronics Tours SAS, 10 rue Thales de Milet, 37071 Tours, France

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.

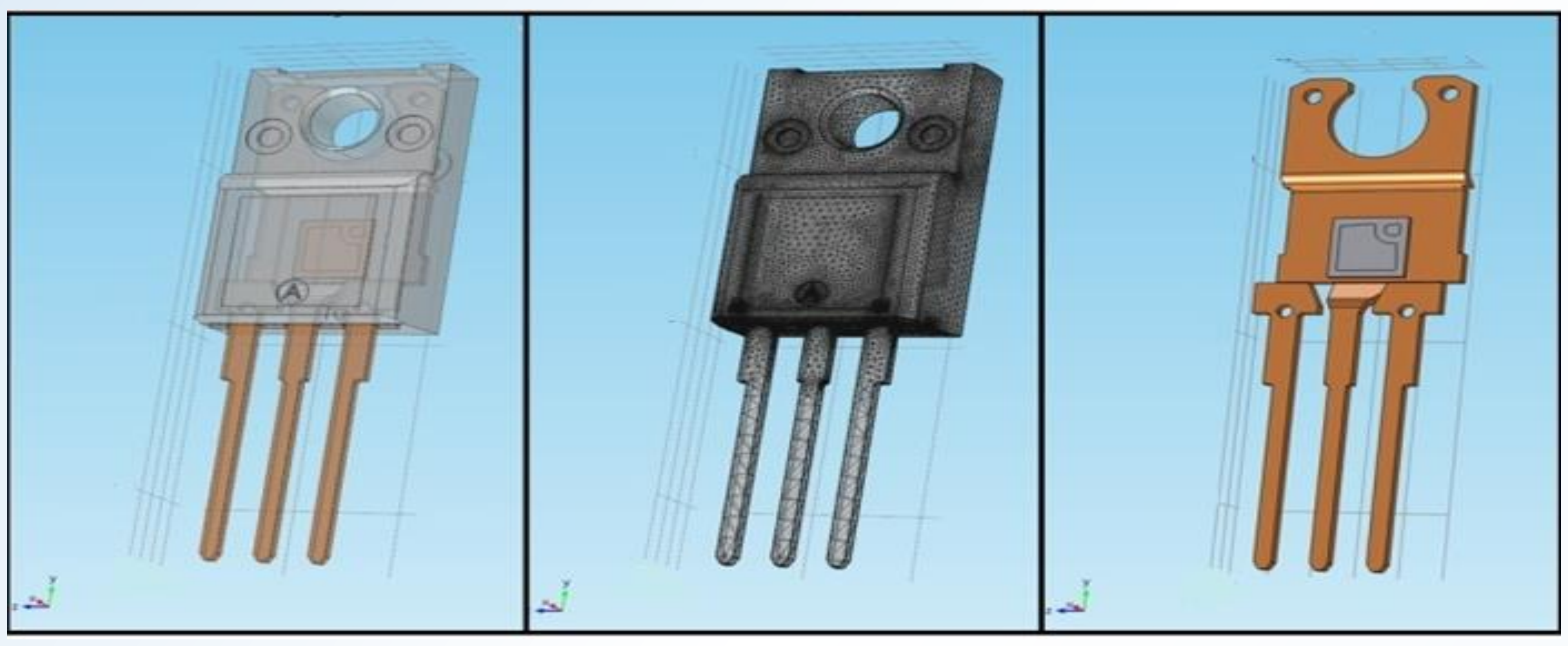

Figure 1 : View of the full system including leadframe, die and the pack (left), the system meshed (mid.), and without the pack (right)

Molding process description

The die brazed on the copper leadframe is first pre-heated at the melting temperature T_{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_{in}, then the pins are removed. Finally, we will study the cooling from T_{melt} to the ambient temperature T_{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.

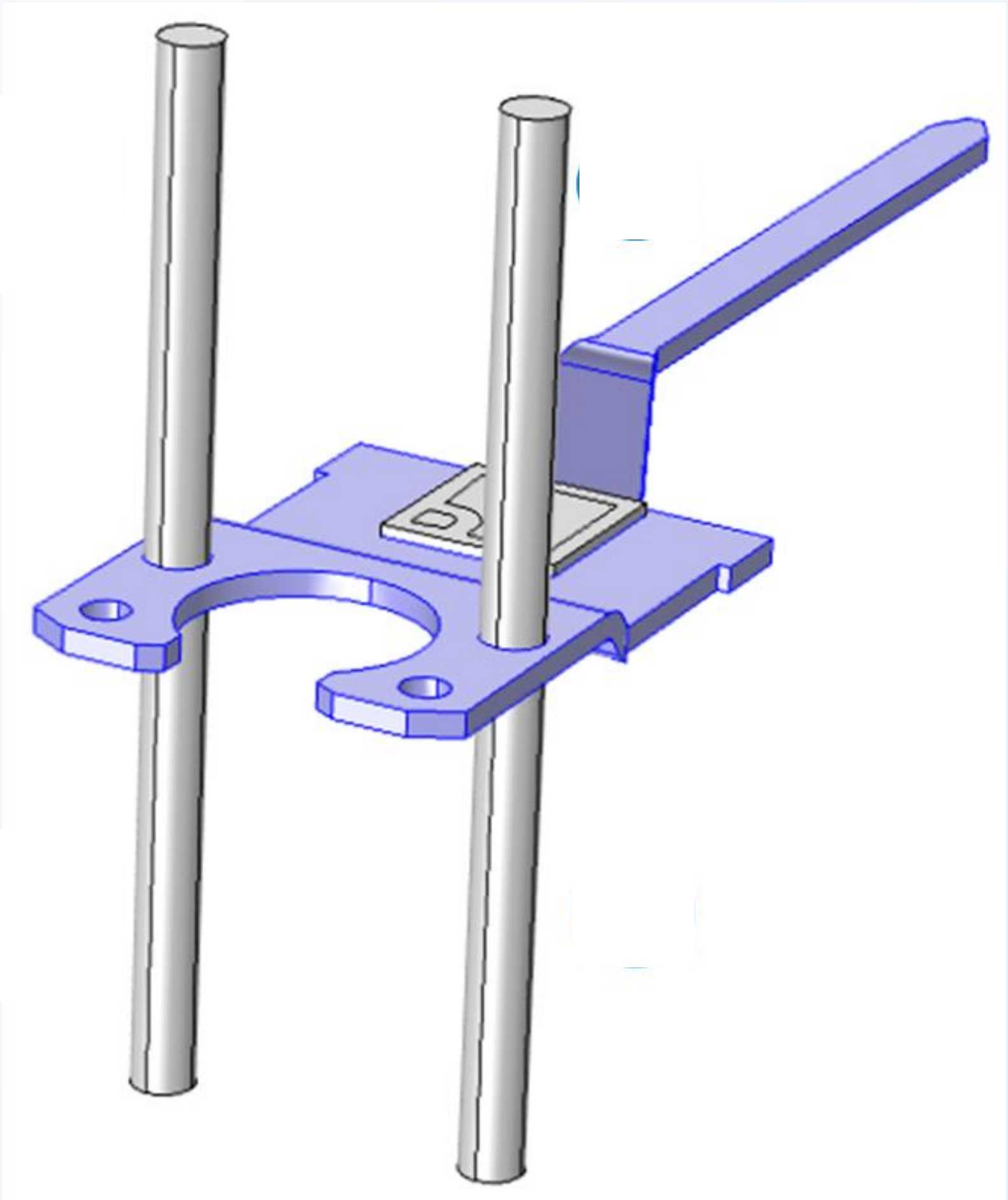

Figure 2 : View of the system with the pins

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_{melt} equilibrium temperature, and we take T_{amb} as strain reference temperature without temperature deviation.

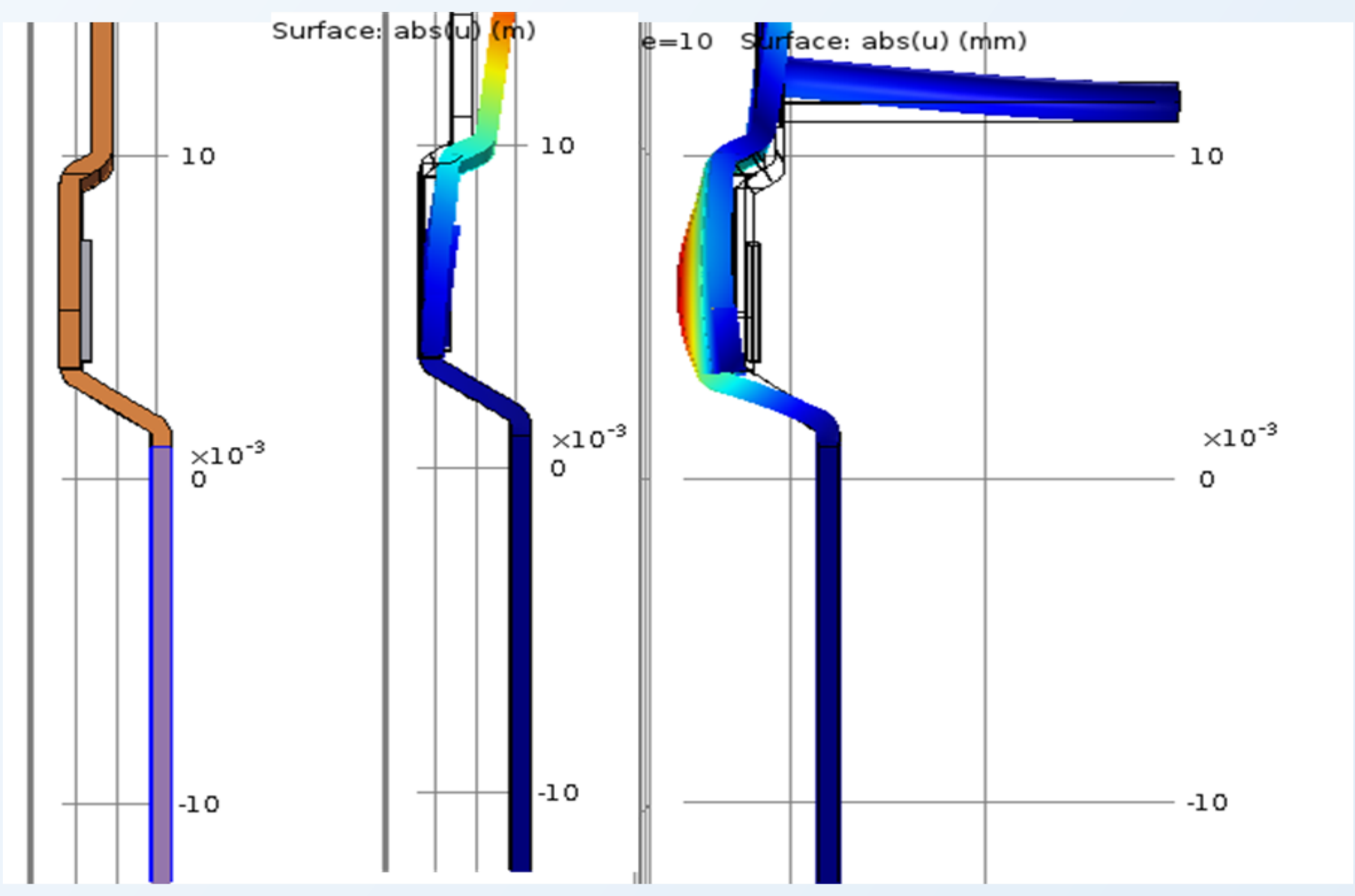

Figure 3 : Step 1, Comparison of the deformation using one (right) or no pin (center) compared to the initial position (left)

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_{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).

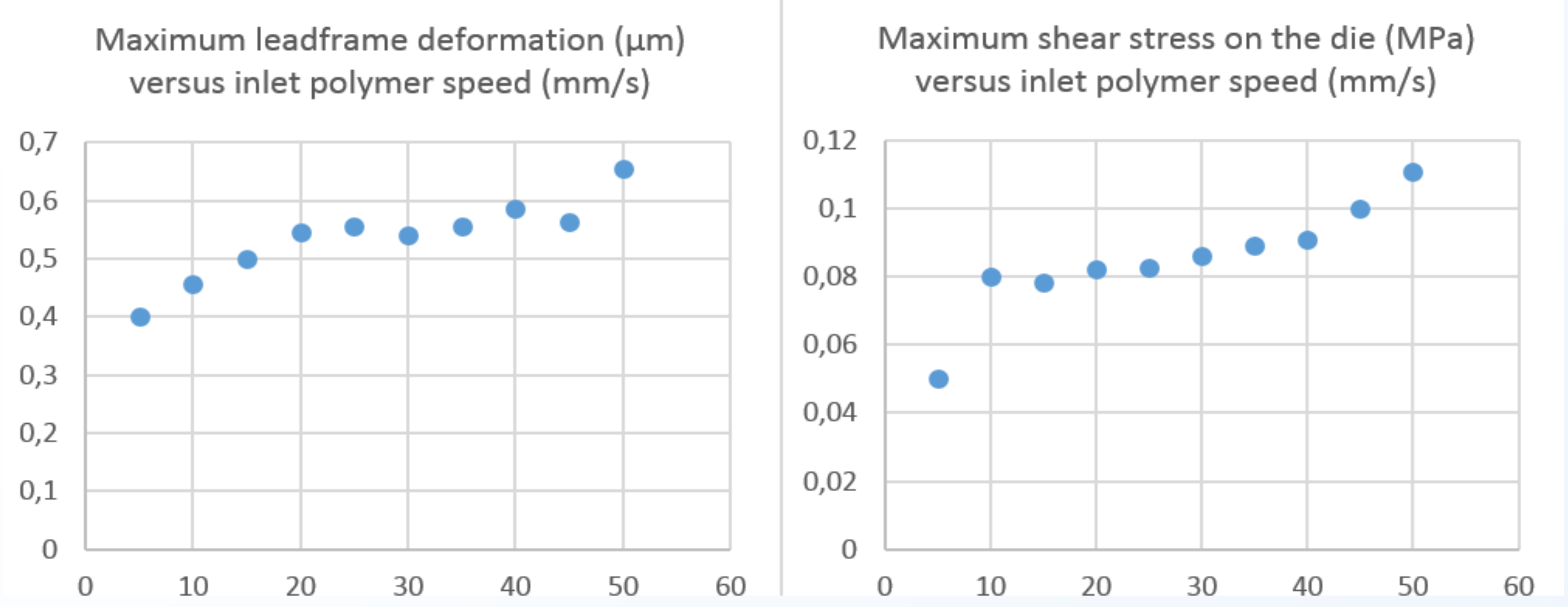

Figure 4 : Step 2, leadframe deformation and die shear stress using different inlet speed of polymer (without pin)

Step 3 : Cooling process

We performed again a thermoelasticity analysis considering that the polymer is solidificated, but here the system is at T_{amb} equilibrium temperature, and we take T_{melt} as strain reference temperature. We take as initial value a temperature deviation equals to T_{melt} -T_{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).

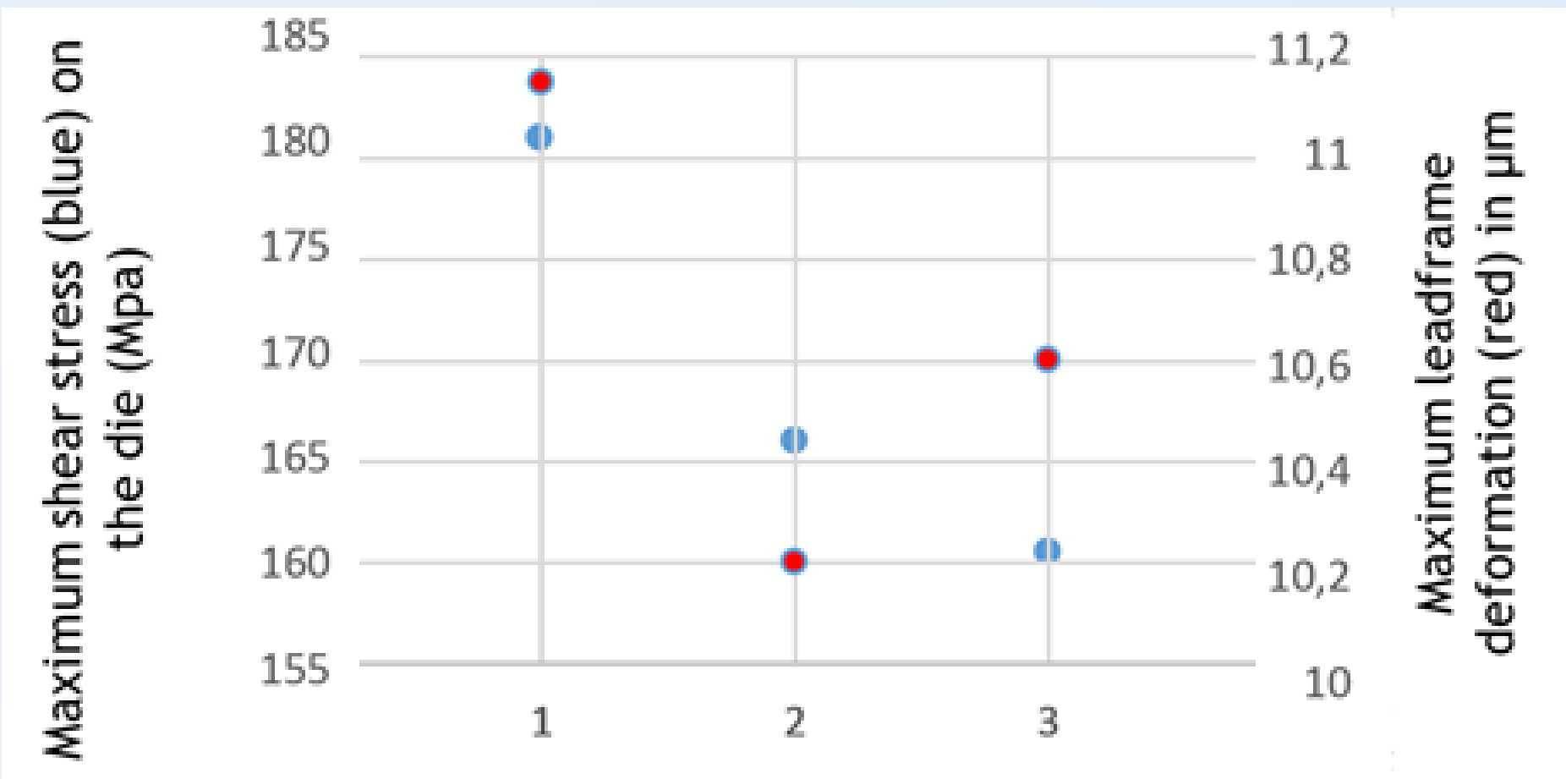

Figure 5 : Step 3, leadframe deformation and die shear stress for different polymer

Excerpt from the Proceedings of the 2014 COMSOL Conference in Cambridge