

Ensuring Reliability: A New Method for Measuring Pressure Distribution During Encapsulation

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The integration of sensors and actuators into encapsulated multi-chip modules creates formidable challenges to characterizing and controlling process pressure. However, a new measurement method developed by Fraunhofer IZM shows that pressure-indicating sensor film can fully characterize the area pressure distribution on the cavity and on substrate surfaces within a mold cavity during encapsulation.

Thermo-mechanical stress from non-uniform encapsulation pressures on flip chips, quad flat no leads, sensors, and thin substrates can lead to hidden damage or to long-term reliability problems. Until now, pressure differences during molding were assumed to be negligible, despite the presence of filler particles in the epoxy molding compound (EMC). The Fraunhofer results show that substantial pressure differences can occur, with potential damage to components and substrates.

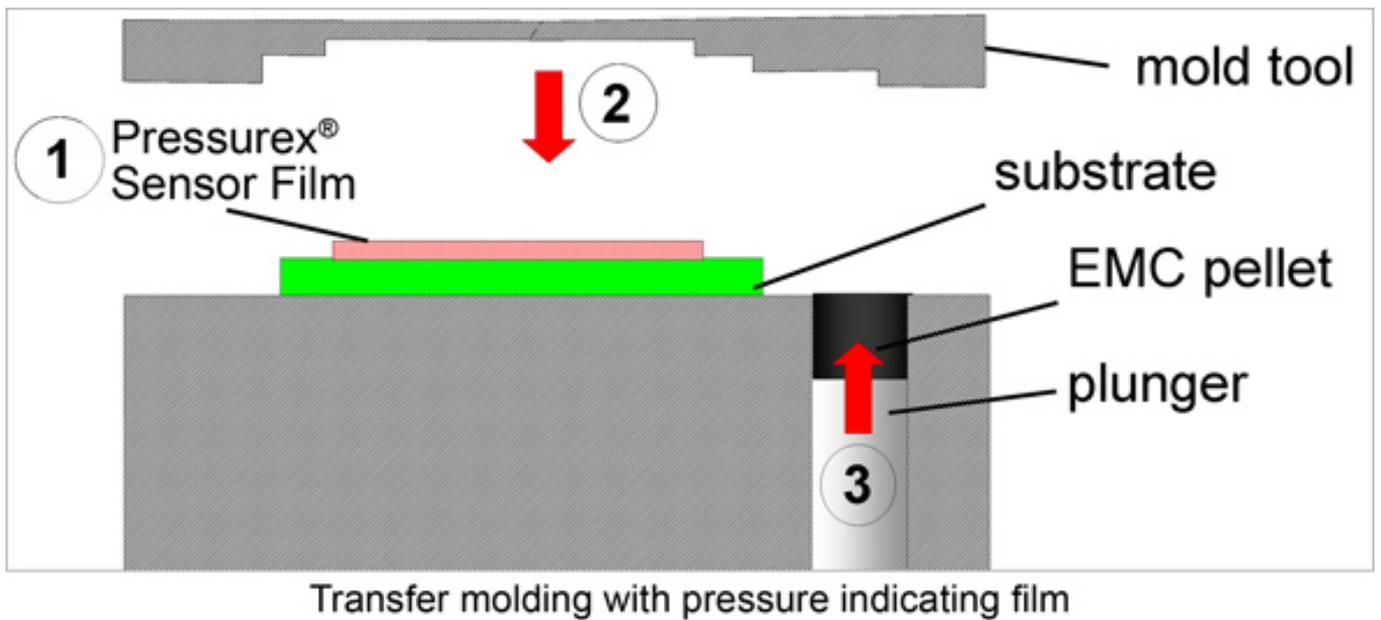
Conventional pressure sensors measure pressure at only a single point, not simultaneously across the entire area. They also require modifying the metal molding tool to bring out their data without short-circuits. Present sensors also leave markings on the device surface that can later interfere with pick-and-place assembly, or with laser labeling.

Commercially available sensor film placed within the mold cavity produces a quick, permanent image of pressure distribution across the area during the flow of the EMC. The film requires no external connections. It neither marks nor mars the device surface. When placed between contacting surfaces the film changes color in direct proportion to the actual pressure applied.

The Fraunhofer method creates a multilayer stack consisting of the Pressurex sensor film, an adhesive layer, and a protective polymer layer. The protective polymer mechanically restrains the film, preventing movement, swelling, or degassing during measurements. This restraint allows several minutes of testing at 180 °C, the maximum anticipated temperature during the exothermic cure of the EMC.

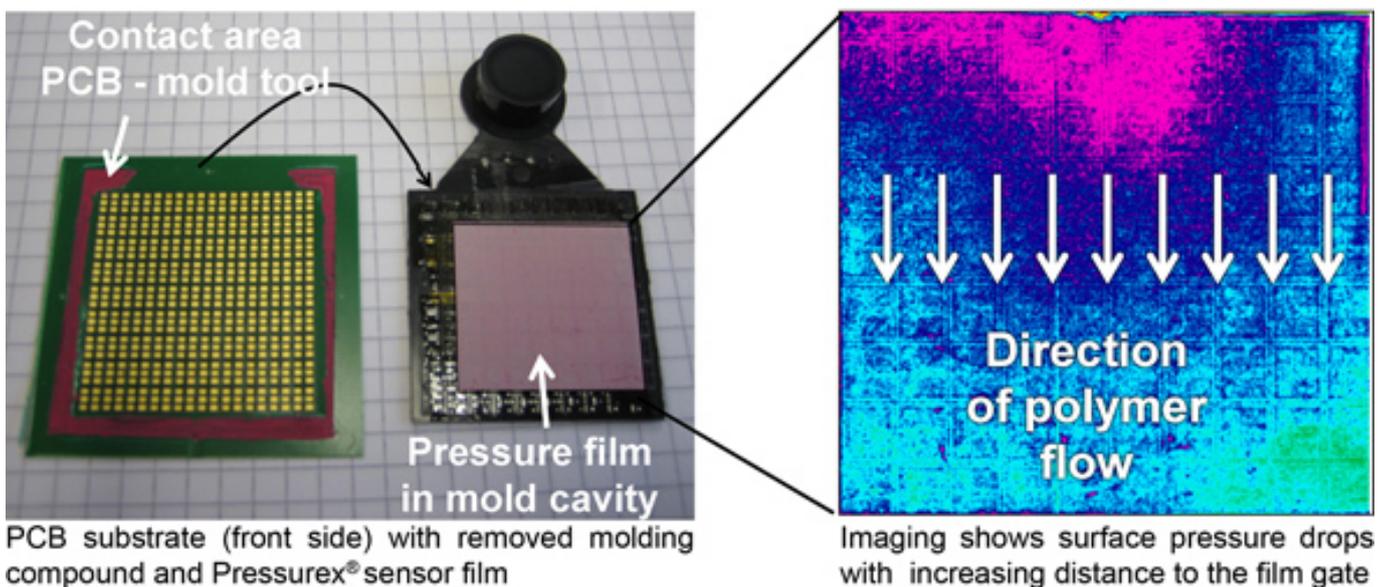
Figure 1 shows the pressure indicating film positioned on the top surface of the PCB. The top surface location measures the cavity pressure distribution. Separately, the pressure indicating film may be placed on the top or bottom of the substrate to measure mold wall contact pressure.

Three steps are involved in transfer molding with pressure indicating film, as described below.

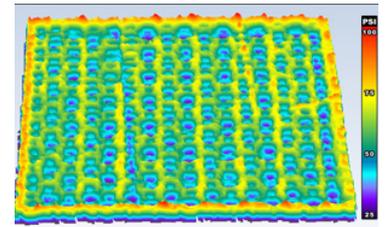


- Step 1: Mount the multilayer stack on the PCB and insert it into the mold cavity
- Step 2: Close the mold cavity and preheat the PCB and the EMC pellet
- Step 3: Depress the plunger to press the epoxy molding compound into the cavity.

For cavity pressure measurements, injecting the polymer on top of the multilayer causes immediate, permanent pale red color changes on the pressure-indicating film. These color variations can be compared to a color calibration chart to determine their psi and kg/cm² equivalents. Digital scanning with software processing is also available to convert the differing intensities of red on the film to a spectrum of colors corresponding to the local pressures. The digitally processed film (2b) shows a uniform cavity pressure distribution between 120-140 bar. Only areas distant from the gate show pressures below 100 bar.



For mold wall-to-substrate pressure measurement, the sensor film placed on the upper or lower surface of the PCB measures the contact pressure between the upper or lower mold walls and the PCB. Frictional movements



Pressure distribution over the bottom side of the substrate & its bond pads

between the top mold wall and the PCB leave red markings directly on the PCB surface. These verify the complete uniform contact needed to prevent the EMC from flowing out upon the substrate, causing what is referred to as “mold flash.”

Although no polymer is injected below the PCB, controlled pressure is required there to avoid damage to the solder pads. Figure 3 shows that no solder pads rise above the solder-resist surface. As the measured pressure is lowest at the top of the pads, the mold tool is not contacting the pads, only the solder resist between the pads.

In summary, Pressurex sensor film is now proven to be appropriate for characterizing the encapsulation of microelectronic systems. Correct characterization of this process is essential for further quality and reliability improvements. The methods presented here allow developing and monitoring stress-minimized encapsulation processes. They provide a firm basis for enhancing the reliability of polymer encapsulated microelectronic and micro-electromechanical (MEMS) systems.

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