COMPANY
INFINEON TECHNOLOGIES ASIA PACIFIC PTE LTD

LOCATION
Singapore

SOFTWARE
AUTODESK® Moldflow®

Infineon Technologies AG: Evaluating delamination in molded packages with process simulation

Infineon Technologies AG is a world leader in semiconductor solutions. Microelectronics from Infineon is the key to a better future. In the 2019 fiscal year, the company reported sales of € 8.029 billion with about 41,400 employees worldwide.

Semiconductor and system solutions from Infineon contribute to a better future – making world easier, safer and greener. Infineon is a global electronic components supplier to leading technology companies including automotive, medical, smart homes, computers, consumer goods and power sector.

Infineon's strategy focuses on global megatrends that are fundamentally shaping the world today: demographic and social change, climate change and scarce resources, urbanization, and digital transformation. Company focus on energy efficiency, mobility, the Internet of Things & Big Data as well as security opens extraordinary growth opportunities. Infineon's vision is to be the link between the real and digital world. Artificial intelligence, Industry 4.0, deep machine learning, intuitive sensing – digital transformation is becoming reality, and the physical world is connected to the virtual world like never before.

At Infineon, success is not only defined by the targets that company achieve but also by the way it leverages with innovative approaches. Mr. Subramanian N.R *(Senior Staff Engineer-Mold Process Simulation)* explains "Product performance and yield from molding process is at the core of our thinking. Our mission is 100 percent quality, performance and reliability of our products," with everyone in Infineon keen to tackle every issue we face "we explored to query and extract flow parameter outputs from moldflow simulation to relate with the observed molding defects." Adds Subramanian this accumulated knowledge is applied in analysis using Autodesk Moldflow Software to overcome molding process challenges faced during product and mold tool development.

Over the years, Infineon has won many awards from a wide range of environmental organizations, customers, and other initiatives for its work in the area of CSR. Company work on contributing to the success of their customers in nearly all sectors and almost every country in the world.

Challenges

IC Package moldings are getting complex and now cater to high performance and non-standard design configurations with technology advancements. Also increasing yield requirements to reduce molding costs of transfer molded packages necessitate optimal spatial distribution of multitude package cavities within the molded lead frame strip and entail significant constraints on molding tool and process and impose challenges to moldability of such high density packages with minimal quality defects.

Recently, while working on an encapsulation of IC package, the Infineon team faced a delamination problem during the filling process - there was an issue in the adhesion of the mold component with lead surfaces. Having uniform adhesion at all the bi-material interfaces, such as mold component with lead frame and silica chip, is an important aspect of molding that protects it from environmental conditions as well as provide electrical insulation.

After preliminary investigation in this project, it was observed that the package geometry and tooling variations adversely impacted on the resin flow within cavities, causing a non-uniform flow rate in various sections, leading to delamination. The poor interfacial adhesion during molding could deteriorate and propagate further in the subsequent assembly process and reliability tests when subjected to thermal and moisture environment.

In this case, the team was working on a large strip molding with a multitude layout of cavities as shown in Fig. 1. The resin flow propagated from a single cull through to the main runner and further flowed to the cavities via sub-runner and gates. It was observed that the mold compound flow from the cull to the farthest cavity rows required longer transfer time, and instances of flow entry were significantly different between the cavity rows. Cavity fill time plot (above figure) showed significant time differences between the first and last rows. There was significant variation in resin dynamic characteristics during flow that was causing moldability defects in different sections of the molded strips.

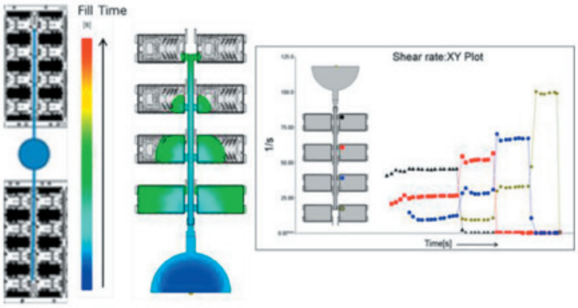

Fig. 1. High density mold strip array and cavity fill time across rows

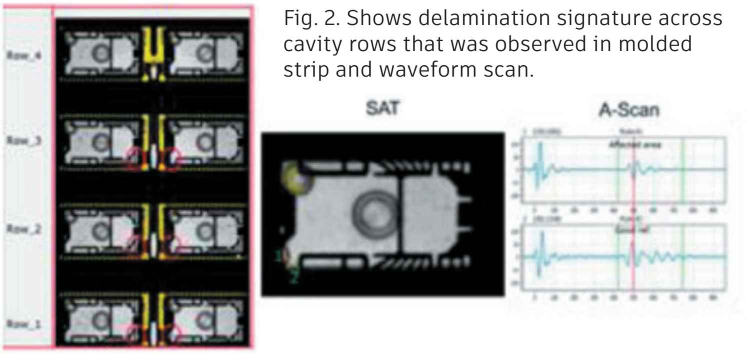

Fig. 2. Shows delamination signature across cavity rows that was observed in molded strip and waveform scan.

The Infineon team utilized Autodesk Moldflow to evaluate fill time across the rows. The shear rate at entry in the first row was significantly higher than other rows. This entry velocity was an important aspect for evaluation, as the initial resin flow state determines the adhesion developed between mold compound and the metal interface.

Also, it was seen in the Scanning Acoustic Tomography reports (Fig.2) that the filler segregation and zero-hour delamination were observed adjacent to gate entry in the first few rows of the molded strip in decreasing proportion of severity from the first row to the last row.

Solution

Autodesk Moldflow simulation is a robust molding analysis program capable of evaluating complex molding issues. The evaluation on cavity filling of large strip packages clearly showed the flow progression stages and also inquire on the flow parameters such as the resin temperature, velocity/shear rate, cure and viscosity variations in each cavity row. The data was utilized to deduce the variations in delamination observed in molded packages. Infineon also utilized Autodesk Moldflow advanced features to study filler distribution through the use of a cross-section in the vector plot, which showed filler inhomogeneity adjacent to gate entry.

The cross-section of the velocity vector plot at the gate cross-section showed rapid flow entry at gates onto adjacent die pad indicating resin flow jetting, exerting high-velocity shear flow parallel, beneath the lead surfaces. This is possible cause for inferior adhesion of the resin to the lead surfaces, increasing their susceptibility to delamination at the mold compound/lead interfaces.

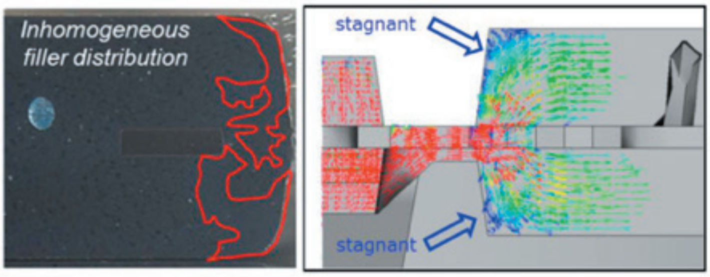

Fig. 3. Filler distribution anomaly and velocity vector plot at cross-section.

According to the simulation results and experimental verification, it was clearly seen from the low shear vectors (blue color) that at both top and bottom package edges there was an indication of stagnant flow corresponding to disproportion in filler segregation seen in the molded samples at the package edges. The non-uniform shear rate at the gate caused shear-induced migration, leading to uneven filler particle distribution and settling of particle aggregated in isolation at package edges.

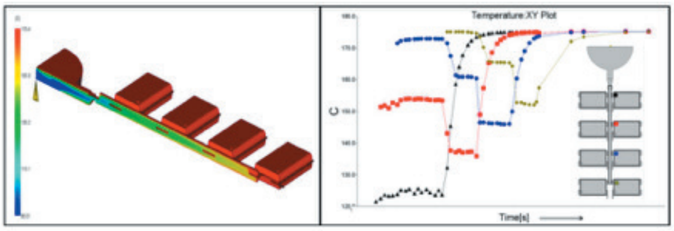

Fig.4. Runner cross-section temperature plot, Temperature XY plot near gate in all cavity rows.

It was also noticed that the temperature variation (Fig.4) was showing dynamic results along the runner sections and across cavity rows. The XY plot of resin temperature queried at the first lead in each of the rows showed that melt temperature in the first row was significantly lower and colder than other rows. It also showed the temperature falls initially in all rows, as fresh flow enters from runner and later builds up due to heat of the mold wall as the cavities are getting filled.

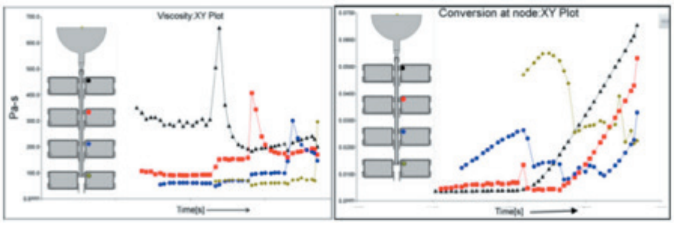

Fig. 5. Dynamic viscosity and melt conversion XY plot across cavity rows.

Consequently, the viscosity and cure degree (Fig. 5) were also influenced by temperature with proportional correspondence in each cavity row. It was noticed that velocity and viscosity can both impact on the adhesion of mold compound to lead. In the first row, high viscosity and high velocity shearing (by the mold compound over the lead surfaces) both have a bearing on the inferior adhesion developed. These two factors have a combined effect on the filler distribution anomaly and delamination seen more pronounced than other rows.

From the results it was clearly seen that the flow parameter dynamic variations are significantly different in each cavity row depending on the resin state, and can impact the moldability and quality variations seen in many molded package samples. As flow shear rate and viscosity are significantly high with low conversion rate in the first molding rows which proportionately affect the adhesion developed during cavity transfer, alternative plunger profiles were utilized to control these flow parameters for minimizing the delamination defect.

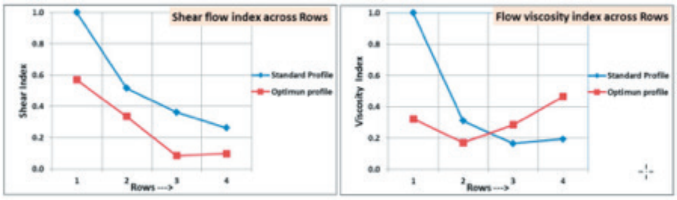

Fig. 6. Normalized XY plot of shear and viscosity index variation in rows.

An optimized plunger speed profile with increased transfer time was considered and the flow parameters variations were plotted (Fig. 6) as normalized index comparisons from first to last cavity rows. With the optimal profile, significant reduction in shear rate and viscosity in the first rows alter the adhesion characteristics of the resin with leads and die paddle edges, and overcome the delamination seen with the standard profile. Molded samples with optimal profile also showed minimal filler segregation and diminished deadhesion zones.

Results

Autodesk Moldflow technology enabled Infineon to identify real challenge faced due to flow parameters that significantly impacted on the filler homogeneity and adhesion developed by a mold compound with lead interfaces. Dynamic variations of shear, viscosity, conversion, and temperature of the melt during resin transfer at various sections of interest were extensively queried from simulation. “Autodesk Moldflow simulation gave us a holistic view of what’s happening, we were able to overcome delamination issue by testing all types of cases and scenarios virtually and analyzed data for different types of packages and evaluate optimized package and tool designs to enhance moldability,” concludes Subramanian.

Reference: “Evaluating delamination in molded packages with Process Simulation” 2018 IEEE 20th Electronics Packaging Technology Conference (EPTC), pp811-814.

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