PROCESS AND DESIGN OPTIMIZATION OF LEAD-FRAME PACKAGES FOR MOLDED UNDERFILL PROCESS THROUGH MOLD FLOW SIMULATION

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ABSTRACT

Molded Underfill (MUF) is a very challenging process with the aim to optimize throughput and cost, by using a single step transfer pressure to fill tight gaps underneath flip-chip die. With the introduction of advance leadless lead-frame packages, some of the difficult challenges faced are void entrapment under die and incomplete fill due to complicated lead frame design that induce uneven mold flow. To address this concern, several interactive aspects including design, process, material, and equipment interaction have to be jointly analyzed to reduce process defects and achieve high yield. 3D mold flow simulations can be coupled with pilot runs, process builds, materials characterization and design optimization to jointly optimize the design and process.

In this study, Grid Array Quad-Flat No-Leads (GQFN) is used as the test vehicle. GQFN is an advance leadless leadframe package with broad design flexibility that allows interconnects trace routing and multi-row I/O pad configurations. The package is able to support stacked die, passive integration, System in Package (SiP) using flip chip and wirebond interconnection. Unlike conventional QFN packages GQFN requires a double molding process, specifically on the top side and insulation molding at bottom side after leads etching. In addition to void entrapment under the die at top side molding, there is also a risk of imbalanced mold flow and void entrapment between leads due to the tight clearance of the insulation mold and irregular shaped I/O pads.

Firstly, 3D flow simulations are completed according to the actual mold process, leadframe and mold tool design parameters to evaluate mold process experimental study. Mold results are analyzed to validate the simulation results or define parameter changes for further study or DOE optimization. Void locations, size and ratio from mold experiments are captured by SAT and parallel-lapping evaluations. Through experience our simulation results are typically in good agreement with the experimental data of the actual molding process studies. With

validated 3D flow simulations critical parameters affecting void trapping such as lead frame design, bump pitch/height, die thickness, filling time, and die orientation can be optimized were then quickly validated through simulation studies. Unbalanced flow between top and bottom of the die is usually inevitable; hence the main objective is to minimize the risks and improving the process margin. Parameters which can be easily varied in simulations are lead frame design, die thickness and die orientation. With optimized parameters as guidelines from simulation, experimental test were carried out and quickly correlated. This study showed that simulation is helpful in both lead-frame design and molding process optimization to bring new GQFN packages to market quicker and more cost effectively.

This paper shows good correlation between the predicted void location results with the actual voids from various experiments done. Key learnings from this study can be used to formulate database and guidelines for upfront product enhancement, reduce the design-to-implementation cycle time, identify key problems before fabrication and troubleshooting during production. This collaborative approach using 3D mold flow simulation can save time and resources, hence increasing efficiency and reducing cost as well as design-to-implementation cycle time.