

## Double Side SMT and Molding Process Development for mPossum Package

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**Abstract:** 3-Dimensional System in Package (3-D SiP) structure (Amkor calls it mPossum-molded Possum) using double side Surface Mount Technology (SMT) and double side molding was evaluated in order to achieve small/thin form factor as well as good functionality by integration and double side layout. As the new platform on laminate substrate basis, molding process was challenge in mold flow balance at top and bottom side and package warpage control over the overall assembly process. There were two types of different molding process evaluated with 1) 1-step molding which was done at both side at the same time and 2) 2-step molding which was done at the conventional molding process twice. Mold simulation helped to narrow down the material selections and parameters available before actual sample build. There were many challenges for this first trial in design/ parameter and material types but optimized them to enable this structure.

**Keywords:** SiP, 3D-SiP, mPossum, double side molding, double side SMT

### 1. Introduction

Transition from wired to wireless application requires different key success factors like power, cost, size and performance. In the past wired application needs cost and performance only while wireless application should be miniaturized to carry anywhere and always-on.<sup>1)</sup> This is requiring more key success factors like size and power. That is, connectivity, wearable and IoT beyond mobile phone are driving new solutions in the package technology. System in Package (SiP) is commonly mentioned as a solution for this kind of requirements and new application.<sup>2)</sup> Along with many activities to have small form factor driven product, there have been a technical transition to a new generation beyond the limitations of traditional 2-D scaling on package and many studies have been followed up.<sup>3,4)</sup>

In this paper, 3-Dimensional SiP structure (Amkor calls it mPossum-molded Possum) using double side Surface Mount Technology (SMT) and double side molding had been evaluated. This structure can achieve relatively small/thin form factor as well as good functionality by integration and double side layout. There were different options in assembly process and technology to achieve this new structure. One step molding which molding was done at the

same time on top and bottom side and two step molding which molding was done at top or bottom side first and then the opposite side later.

2-step molding process was challenge specially to control warpage for opposite side SMT and molding. Severe warpage after first molding made 2<sup>nd</sup> molding difficult so carefully selected molding material with good flow ability and low warpage property combination. one step molding needs different mold chase which hold the substrate in the middle of mold flow. It was done by supporting block and slot design to let mold flow both top and bottom side at the same time with balance. Before actual build, mold flow simulation was done to narrow down the factors and verified through actual build. Warpage control and molding balance were important to make it successful and controlled through mold material selection and parameter optimization. For mPossum (double side SMT and molding) structure, there are special processes to reveal BGA Pin by strip grinding and 2<sup>nd</sup> ball attach. They were also verified in this report.

### 2. Experiment Procedure and Results

#### 2.1. BOM and Process Review

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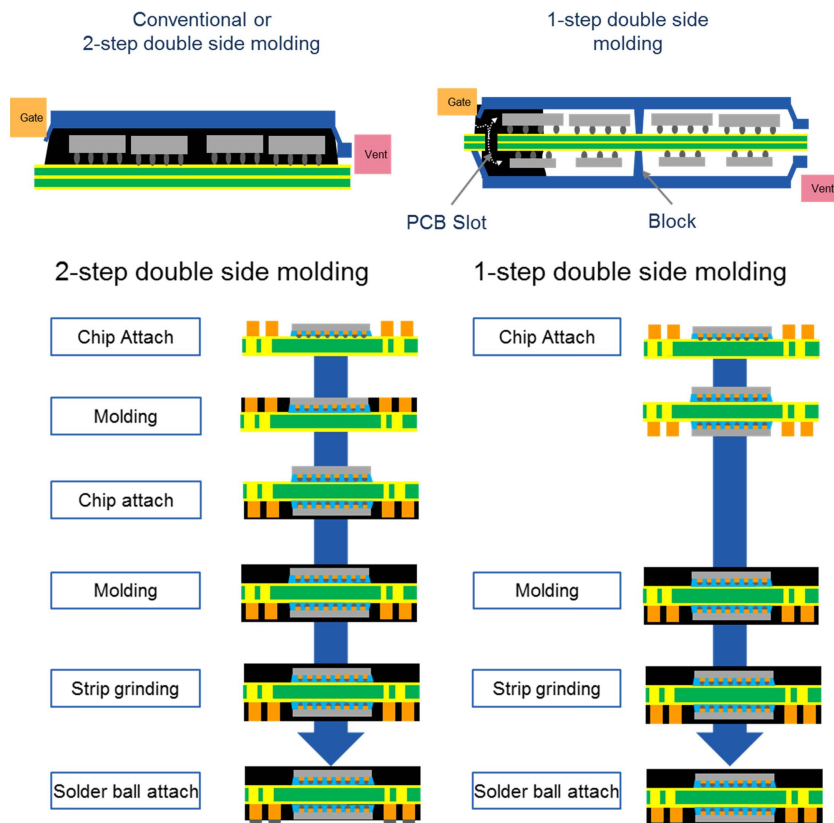
**Table 1.** BOM Description table

Item	Material (2-step molding)	Material (1-step molding)
PCB	90×240.5 mm Size, Cu post	74×240 mm Size, Pre-Solder ball
Die/Component	0.06 mm thickness/0201	
Underfill (UF)	Fine filler UF or Pre-applied UF	
EMC	DOE by mold flowability, Warpage condition	
Solder Ball	Dia. 0.15 mm, SAC305	Dia. 0.25, SAC305

BOM (Bill of Material) followed up a standard Laminate material sets in Amkor. Laminate substrate thickness was 200 um with Cu Post evaluation for 2-step molding structure and 480 um with pre-solderball for 1-step molding structure. Size was chosen for both available 90×240.5 mm and 74×250 mm. Cu post diameter was 150 um and height was under Moldcap height over die to be revealed by strip grinding without die exposure. Pre-solderball size was 300 um and grinded by half for 2<sup>nd</sup> ball attach. 2<sup>nd</sup> Solder ball was SAC305 and Underfill material for Flipchip attach was chosen as fine filler type to control resin bleedout and minimize warpage influence. Molding process was a key so its materials were chosen by mold flow simulation and actual sample DOE (Design of Experiment) but basically it was <=20 um filler size for 35 um component standoff gap filling. Surface finish on substrate was OSP for flipchip

and Ni/Au for wire bonding die configuration. They are summarized in Table 1.

Assembly Process steps were different based on molding process. Fig. 1 shows its schematic view and process flow. 2-step molding structure follows up the conventional process flow but it repeats 2 times on top or bottom side separately. Sequence on top or bottom can be decided by its layout and our test vehicle was done on bottom side first due to Cu post structure. 1-step molding process is much simple and shorter than 2-step molding. Molding was done at the same time for both top and bottom size after top and bottom SMT. As a special feature to do molding at double side, support block should be designed to hold PCB for double side mold flow so there was unit loss per strip and block position and its number should be considered along with mold flow balance. In our test vehicle was designed



**Fig. 1.** Process flow.

by 1 to 3 block and found 2 block was better for warpage and mold flow balance. With pre-solderball design, pre-solder ball attach was done during bottom SMT before molding process. After molding, strip grinding was done to reveal Cu post or Pre-solderball and then 2<sup>nd</sup> solder ball was attached on it. During this process flow, our major developments were focused on molding process and strip grinding on Cu and solderball.

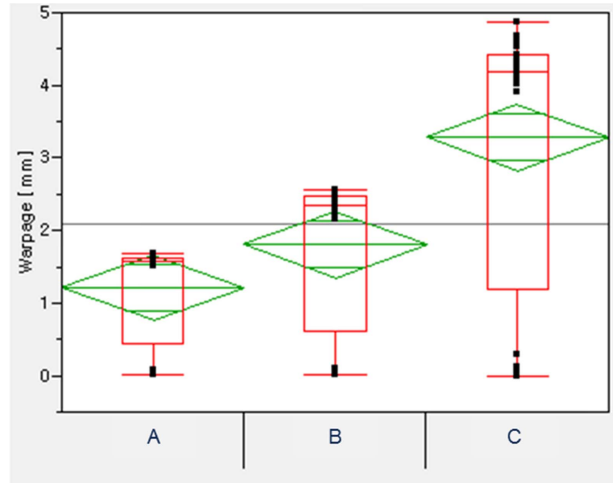
**2.2. Chip attach/Molding process with 2-step molding**

Chip attach was done by thermal compression bonding for thin die and thin substrate application rather than mass reflow. Once one side molding was done, Chip attach and SMT were challenge due to the genetic warpage by one side molded strip. So molding material and process optimization were required before going to opposite side processing.

Table 2 shows mold material candidates where mold material property were compared and were sorted out for best options not happening mold incomplete and severe strip warpage after molding. A-material was good for warpage control but incomplete molding issues not resolved by any mold parameter optimization. C-material with good mold flowability had no issue with incomplete mold but experienced high warpage issue. So strip warpage simulation by mold material were done (Fig. 2) and its trend was well aligned and less than 1.0 mm warpage was achieved with B-material with actual sample build. Less than 1.0 mm warpage after one side SMT/Molding was enough to

**Table 2. Mold Material Candidates**

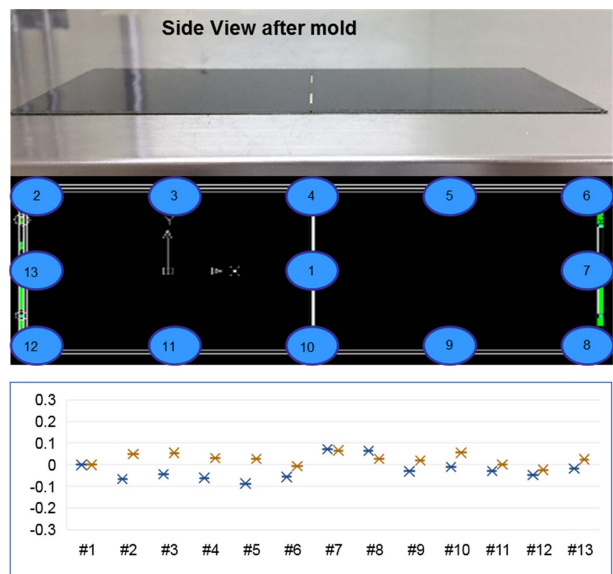
EMC	A	B	C
Max filler size (um)	32	20	24
Filler contents (%)	86	83	70
Spiral flow (cm)	150	230	260
Mold shrinkage (%)	0.3	0.17	0.6
Mold flow ability	Bad	Good	Good
Strip warpage	Good	Good	Bad



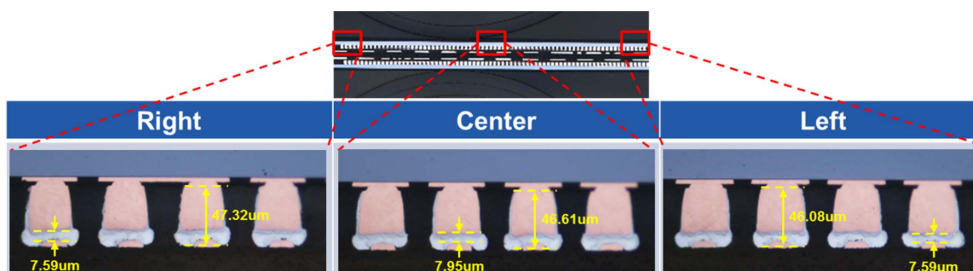
**Fig. 2. Strip warpage simulation after PMC (post mold cure) less than 0.1 mm.**

proceed next steps.

Fig. 3 is a cross section view after chip attach and under-fill process. In case of pre-applied underfill, there are no flux, underfill process and flux cleaning process. As shown in Fig. 3, wetting and interconnection were stable and bond line thickness was around 46 um and solder joint height



**Fig. 4. Strip view after double side SMT and mold.**



**Fig. 3. Cross section view after Chip Attach and underfill.**

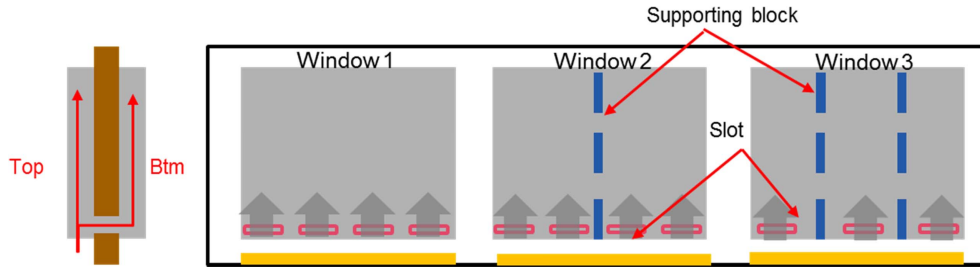


Fig. 5. Schematic view of mold flow.

was around 8 um. TCCUF (Thermal Compression Capillary Underfill) and TCNCP (Thermal Compression Non-Conductive Paste) were both available and process wise optimized but TCNCP was much preferred for shorter process time and no noise involved.

Once double side molding was done, strip warpage was very stable less than 0.1 mm (Fig. 4) as expected by contribution of well-balanced structure.

**2.3. Chip attach/Molding process with 1-step molding**

For 1-Step molding process, special features are required in mold chase and substrate accordingly. During molding, substrate should be held upward to let mold flow through top and bottom side at the same time so Mold block was designed to support substrate. The test vehicle was designed by 0, 1 and 2 blocks at each mold window and checked mold flowability. Another one to be considered for 1-step mold is slot in substrate which is a kind of gate for mold flow through opposite side. Slot length and width and position were studied through simulation along with mold material and parameter. Fig. 5 shows schematic view of Test vehicle which has different chamber size by supporting block and mold flow through slot.

1-step molding is less sensitive on warpage but need

more flowability. C-material was best in mold flowability based on given material property Table 2 so it was chosen as simulation and actual sample build DOE. Fig. 6. Shows mold flowability simulation where mold melting front advancement is quite different by component layout, Mold-cap height and mold parameter. Fig. 6-A is bottom view of mold melt front end advancement and Mold flow at top side is move faster than at bottom side. When it reaches the end with this difference, mold at top side pushes down PCB and PCB bending happens. Fig. 6-B is another case to keep mold flow balance at both top and bottom side. With this simulation and after all adjustable conditions were narrowed down to get the similar mold flow at top and bottom.

Based on this simulation, slot size range from 0.8~2.0 mm and mold chase temperature 165~185°C and filling time 15~30 sec adjusted depending on device specific. Even it's not reached to no bending condition but assembly manufactural. Fig. 7 shows the cross section view of actual sample build where PCB bending is shown Max. 30 um.

**2.4. Strip grinding and 2nd ball attach**

By structural features, BGA land should be revealed by strip grinding for 2<sup>nd</sup> ball attach. Strip grinding is well

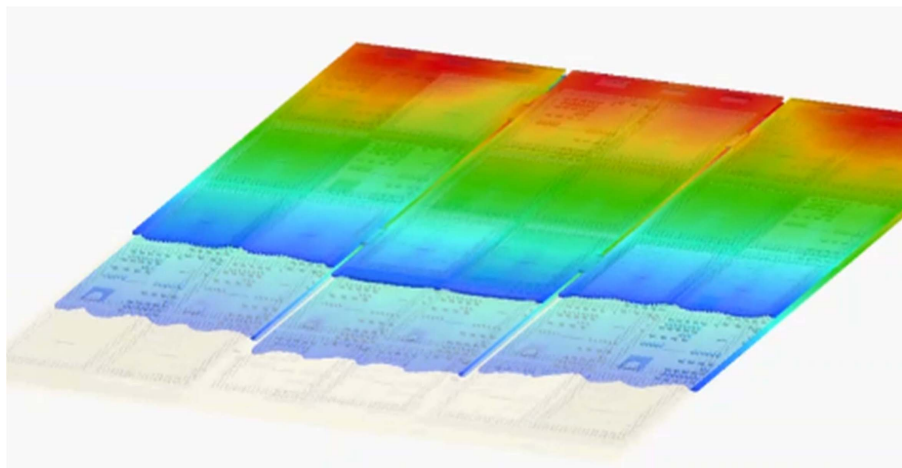


Fig. 6-1. Top side mold flow faster than bottom.

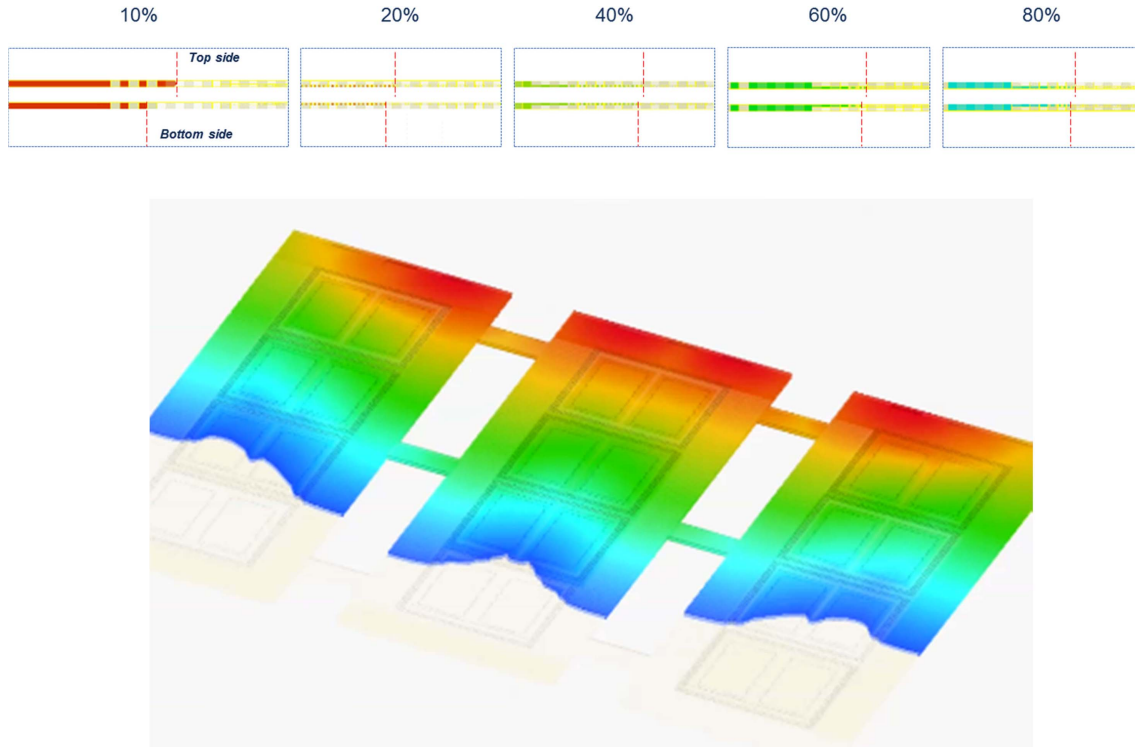


Fig. 6-2. mold melt front advancement well balanced.

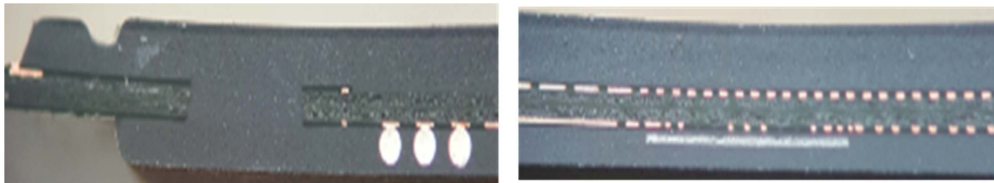


Fig. 7. Cross section view of sample build with 1-step molding process.

known process for wafer level fan-out product and PoP<sup>5)</sup> but fine mesh is required to grind different material surface like mold, Cu post or Solder ball at the same time. As shown in Fig. 8-A, Cu smear by strip grinding was less than 5 um. Fig. 8-B is the top and cross section view after

2<sup>nd</sup> ball attach process. Coplanarity was stable with Avg. 40 um.

Fig. 9 is cross section view of assembled package with 2-step molding and 1-step molding process respectively. Cu post structure can deliver the fine ball pitch platform while

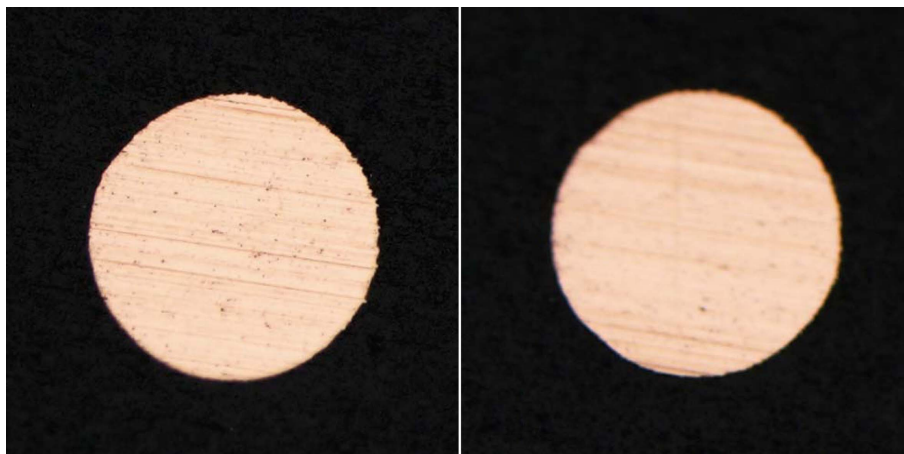


Fig. 8-1. Strip grinding for land reveal (Cu post and Solder ball).



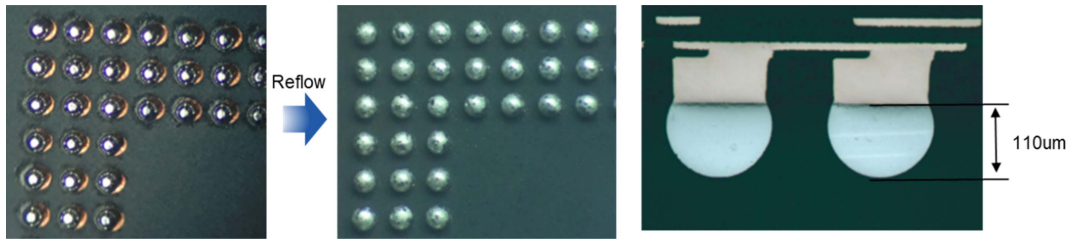


Fig. 8-2. 2<sup>nd</sup> Ball attached on revealed Cu post.

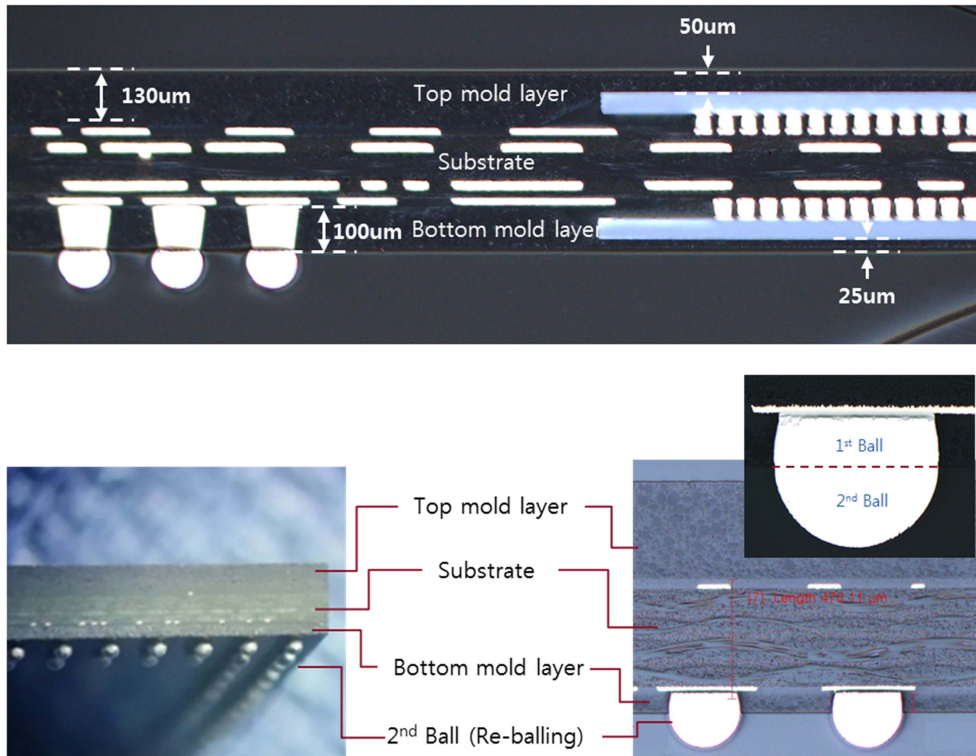


Fig. 9. Cross section view of assembled package.

solderball can be flexible on expensive substrate technology. mPossum package with double side SMT and molding is a stable structure and shows good reliability performance.

### 3. Conclusion

3-D SiP structure (Amkor calls it mPossum-molded Possum) using double side SMT and double side molding has been evaluated for small/thin form factor as well as good functionality by integration and double side layout. In this evaluation, two molding processes were confirmed its feasibility with different molding material, layout and land reveal options. With this structure, warpage control as well as mold flowability were very important to enable this platform. Its key factors were screened first by strip warpage and mold flowability simulation and compared with actual sample build. As a 3-D integration, its reliability performance also is compatible with 2-D SiP structure.

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