Leadframe SiP with Conformal Shield

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Abstract: System In Package (SiP) is getting popular and momentum for the recent wearable, IoT and connectivity application apart from mobile phone. This is driven by market demands of cost competitive, lighter and smaller/thinner and higher performance. As one of many semiconducting assembly products, Leadframe product has been widely used for low cost solution, light/small and thin form factor. But it has not been applied for SiP although Leadframe product has many advantages in cost, size and reliability performance. SiP is mostly based on laminate substrate and technically difficult on Leadframe substrate because of a limitation in SMT performance. In this paper, Leadframe based SiP product has been evaluated about key technical challenges in SMT performance and electrical shield technology. Mostly Leadframe is considered not available to apply EMI shield because of tie-bar around package edge. In order to overcome two major challenges, connection bars were deployed properly for SMT pad to pad and additional back-side etching was implemented after molding process to achieve electrical isolation from outer shield coating. This product was confirmed assembly workability as well as reliability.

Keywords: SiP, SiP Leadframe, packaging shield, Shield ring, Backside etching

1. Introduction

System In Package (SiP) is getting popular and momentum for the recent wearable, IoT and connectivity application apart from mobile phone. This is mostly driven by cost competitive, light and small/thin and higher performance. When it comes to integration, most of parts should be scaled down and an introduction of state-of-the-art technologies is required in material, process and package structure. So supply chain level collaboration is also important to achieve the purpose.

In package level, Leadframe product, as one of major semiconducting assembly products, has been widely used for low cost solution, light/small and thin form factor and reliability performance. But it has not been applied for SiP due to a technical difficulty by its poor SMT performance and mostly based on laminate substrate instead. And there is a layout limitation like component SMT away from package edge by tie-bar requirement for the genetic Leadframe structure. Another technical barrier to be considered is shielding capability. Shield technology is a must for future integrated products and application to minimize noise caused by nearby products/application. With this difficulties, Leadframe products have not been considered for SiP application. And some innovative structures utilizing pre-molding substrate have been developed in other way.

In this paper, how to implement Leadframe and shield technology into SiP application has been studied. In order for stable component SMT, SMT pads were designed to be connected together and then back etching process was applied to get all pads electrically isolated after mold. In the design rule, component to component and component to package edge clearances kept the same as laminate product and a new embedded shield ring was added around package edge. Especially shield technology was newly introduced to Leadframe so shield ring and pad design were carefully implemented for the sputtering method. Whole assembly process and new process like back-etching and sputtering shield were checked and reliability performance also confirmed afterward.

2. BOM and Process Review

BOM (Bill of Material) followed up a standard Leadframe product and...
frame material sets in Amkor. Leadframe thickness was 4 mil (0.102 mm) and 70×250 mm size. Solder paste was SAC305 and mold material was ≤20 µm filler size for 35 µm component standoff gap filling. Surface finish on package lead was matt Sn plating and target thickness was 200 µinch.

Assembly Process steps were based on conventional Leadframe product work flow and some additional steps like SMT, backside etching and sputtering were added (highlighted in bold color in Fig. 1). Among those additional process steps, our major developments were focused on SMT on Leadframe and sputtering for shield performance.

3. Leadframe for SMT Process and Shield Process

In order for stable SMT process, Leadframe substrate design was approached differently from a conventional Leadframe. It had tie bars all around component pads to hold frame stable. And half-etch was applied for mold locking effectiveness (Fig. 2). The Leadframe outline was surrounded by shield ring and was connected with conformal shield later. Shield ring was very critical for EMI shield performance and package singulation quality so its width was carefully designed and controlled.

4. SMT Process

After the DOE by solder paste volume, type and stencil design, we found no issue on overall STM process after parameter optimization. Solder paste was printed well on the right place and showed no exceed overflow after chip mount (Fig. 3). As for reflow parameter, peak temperature was 240°C and dwell time was 72 sec. over solder melting temperature. After reflow, solder void and stand-off height were checked by X-ray and cross section analysis (Fig. 4). There was some minor void found but no O/S failure and no negative impact on reliability result.

As shown in Fig. 4, there was very stable stand-off variation and average value was around 25 µm which was enough for mold underfill process.
5. Shield Process and Reliability

Before conformal shield, selective back-etching was done after mold to make tie-bars disconnected and enable the whole package to have electrical functions as designed. This process is well known process in the industry. Confor-

Fig. 4. view of X-ray and cross section to check void and stand-off height.

Fig. 5. view of conformal shielded sample.

Fig. 6. Reliability condition and its result.
Mal shield was done by sputtering with SUS-Cu-SUS of 3 layers and 7 µm top side thickness. For better conformal shield quality, singulation should have been done without burr so blade DOE was done and applied after parameter optimization. The sputtering performance was confirmed to be compatible with comparable laminate SiP packages by mechanical peel-off test and electrical resistance measurement through metal coating layer. Contact resistance is under 100mOhm and sheet resistance is under 50mOhm. It’s well aligned with laminate products. Fig. 5 shows package samples after conformal shield. There was neither mechanical adhesion issue with mold material nor burr on the package top surface and side wall. Cross section view shows shield image where top is 7 µm and side wall is 3 µm thickness in average.

After all assembly process, good units were inputted to MRT L4 to L2AA to check their reliability performance. As results shown in Fig. 6, Leadframe package has passed MRT L4 and even L3. It is higher performance in reliability compared with laminate product that is known as MRT L4 only available. All of failure modes were inductor inside crack as it’s known very vulnerable to a mechanical stress. It’s assumed Leadframe and mold material absorbed the stress and deconcentrated it toward the component parts mounted on it. So this result could prove Leadframe product can commit the higher reliability performance even for SiP application.

6. Conclusion

Leadframe for SiP product has been evaluated with new Leadframe design concepts and an electrical shield technology for future demand. Assembly process workability has been confirmed with several DOEs, especially for SMT on Leadframe and shield technology which are new to this industry. SMT result showed no significant issue with optimized parameters to enable minimum solder void and stable stand-off height for overmold process. Conformal shield on Leadframe product was also newly introduced and showed compatible results to laminate conditions as well. Moreover, its reliability performance was positive as it passed MRT level 4 and 3 passed better performance than comparable laminate products.

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