An Innovative Reliability Solution to Interconnect of Flexible/Rigid Substrates

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An Innovative Reliability Solution to Interconnect of Flexible/Rigid Substrates

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ABSTRACT:

With the pitch size of interconnect getting finer and finer, the bonding strength between flexible and rigid (e.g. PCB, ceramic) substrates becomes a serious issue because it is not strong enough to meet the customer's requirement. Capillary underfill has been used to enhance the bonding strength between flexible and rigid substrates, but the enhancement is very limited, particularly for high temperature application. The bonding strength of underfilled flexible/rigid interconnect is dramatically decreased after being used at 180◦C, and the interconnects are weakened by the internal stress caused by the expansion of underfill at high temperatures. In order to resolve reliability issues of the interconnect between flexible/rigid substrates, solder joint encapsulant was implemented into the thermal compression bonding process, which was used to manufacture the interconnect between flexible/rigid substrates. Compared to the traditional process, the strength of the interconnect was doubled and the reliability was significantly improved in high temperature application.

INTRODUCTION:

Miniaturization is a trend in the electronic industry, which has increasingly attracted more attention. However, the manufacturing process and reliability have become more and more challenging due to miniaturization. The solder joint starts to lose mechanical strength, which not only causes issues for the drop performance, but also issues for thermal cycling performance. In order to enhance mechanical strength of BGA/CSP, POP, etc., board-level underfill has been used to fill in between solder joints, but thermal cycling performance is sacrificed. A big hurdle is the rework issue of underfill. Reworkability is particularly important during high volume production. Solder joint encapsulant only enhances solder joint strength and won't cause internal stress for solder joints because there is no adhesive between solder joints. The reworkability of solder joint encapsulant adhesive is same as solder paste. Thus, solder joint encapsulant successfully provides a low cost and high reliability solution for high volume or high reliability production.

Miniaturization not only occurs in microchips, but also in interconnects between flexible/rigid substrates. Interconnects between flexible/rigid substrates face the same issues of poor mechanical strength and thermal cycling performance as microchips. In order to resolve the reliability issues for interconnects between flexible/rigid substrates due to miniaturization, solder joint encapsulant was implemented into the thermal compression bonding process to manufacture the interconnect between flexible/rigid substrates. The implementation of solder joint encapsulant doubled the bonding strength between flexible and rigid substrates, and dramatically enhanced its reliability, particularly at high temperature application.

PROCESS:

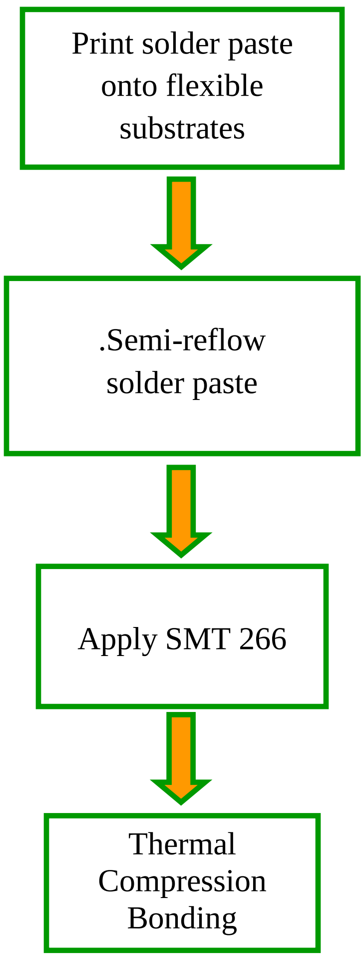


Fig. 1 Process Flow Chart

The application process of solder joint encapsulant adhesive is shown in Figure 1 above. It should be noted that solder joint encapsulant adhesives can provide advantages of simple, short and high throughput manufacturing process over traditional solder paste plus underffilling process. SMT 266 is directly applied onto semi-reflowed solder paste by brushing, soldering and curing of adhesive is combined in one step. The reflow process of solder joint encapsulant adhesive is fully compatible with the typical industry high temperature solder paste thermal compression bonding process. During solder bonding process, solder joint encapsulant adhesive SMT 266 can remove metal oxide from pads and bumps to allow solder joint to be formed, then cure with the formation of a 3-D polymer network encapsulating each individual solder joint. Between solder joints, there is no adhesive blocking outgassing channels to ensure high process yield. The Schematic SMT 266 encapsulated solder joint is shown in Figure 2 below.

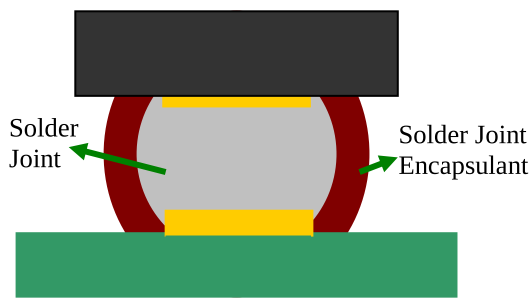


Fig. 2 Schematic cured SMT 266 encapsulated solder joint

UNDERFILLING INTERCONNECTS OF FLEXIBLE/RIGID SUBSTRATES

The Schematic bonding of flexible/rigid substrate is shown in Figure 3 below. High temperature solder paste was used in the thermal compression bonding process. After thermal compression bonding, five different underfills were used to underfill these interconnects of flexible/rigid substrates.

Fig. 3 Schematic of Flexible/Rigid bonding

After underfilling and curing of these interconnects of flexible/rigid substrates, the pull test was conducted and the test is shown in Figure 4 below.

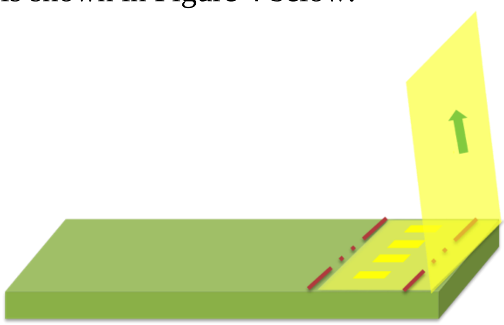


Fig. 4 Pull Test Schematic

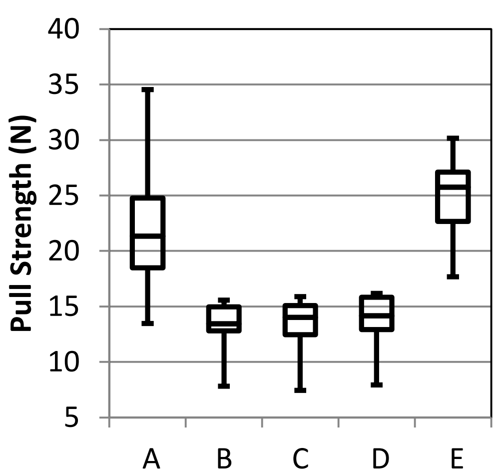
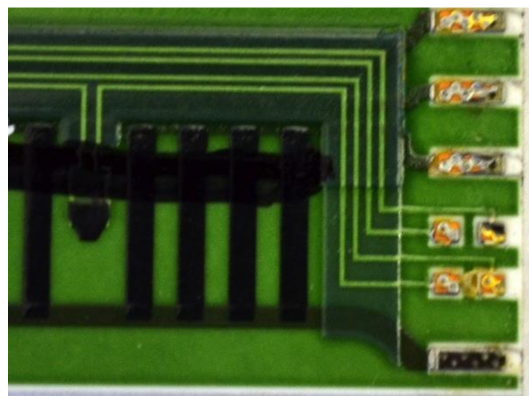


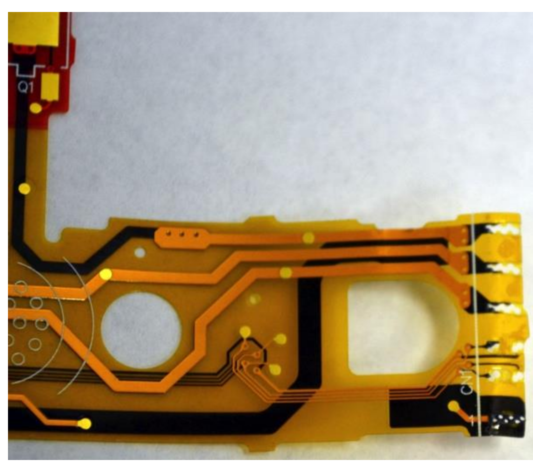
Fig. 5 Pull strength using different underfills

The results of pull strength versus different underfills were plotted and shown in Figure 5. From Figure 5, we can easily see A and E underfills have demonstrated good adhesion in between flexible and rigid substrates. These underfilled interconnects were subject to a high temperature storage test later.

The photos of the substrates after the pull test are shown in Figure 6 below. From Figure 6, it can be seen that the pads were peeled off from flexible substrates, which means that before high temperature treatment, the adhesion and soldering strength were very good.



(a) Ceramic substrate



(b) Flexible substrate

Fig. 6 Photos of (a) ceramic and (b) flexible substrates after pull off

After the underfilled interconnects rigid/flexible substrates were stored at 185°C for 40 hours, the results of the pull test are shown in Figure 7 below. From Figure 7, it should be noted that the pull strength was significantly decreased compared to that before high temperature treatment and all of them failed because the pull strength was less than 10N. There are two factors contributed to the dramatic decrease in pull strength after high temperature treatment. One is that the flux residue becomes soft or semi-liquid, which weakens the adhesion from underfill. Another contributing factor is that high CTE of underfill at high temperature causes large internal stress for solder interconnects, which weakens the strength of the interconnects of rigid/flexible substrates.

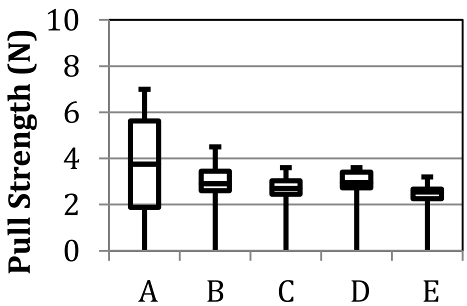


Fig. 7 Pull strength using different underfills after high temperature treatment

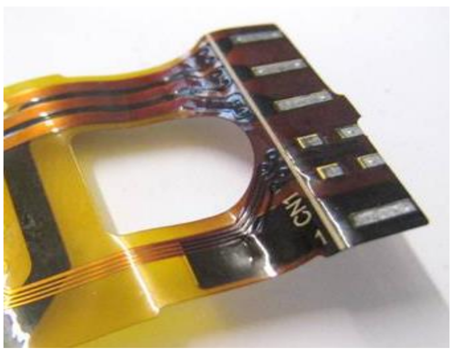


Fig. 8 Photo of flexible substrate after high temperature treatment and pull test

After high temperature treatment, a pull test was conducted on the underfilled interconnects. The photo of the flexible substrate is shown in Figure 8. It is very interesting to note that the failure occurred in the solder interconnects and there was no underfill left on the flexible substrate after high temperature treatment. This is in agreement with the dramatic decrease in pull strength after the high temperature test.

SOLDER JOINT ENCAPSULANT ADHESIVE USED IN INTERCONNECTS

Solder joint encapsulate adhesives was used to replace traditional flux during thermal compression bonding process to form interconnects between rigid and flexible substrates. The results of pull test are shown in Figure 9 below. It should be noted that using solder joint encapsulant adhesive (SMT 266) passed the pull test 100% of the time, while using traditional flux passed only 67% of the time, even before high temperature treatment (185°C for 40 hours).

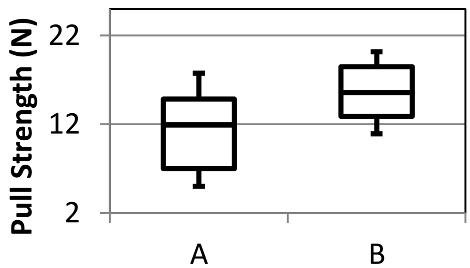


Fig. 9 Pull strength of interconnects using A- traditional flux and B- SMT 266

Like the underfilled interconnects, these interconnects, which were made using flux and solder joint encapsulant adhesive, also underwent high temperature treatment (185°C for 40 hours), followed by the pull test. The results of pull test are shown in Figure 10 below.

From Figure 10, we can see that the strength of interconnects using flux decreased dramatically and failed the pull test almost 100% of the time after high temperature treatment. Pull strength of the interconnects also dropped while using solder joint encapsulate adhesive SMT 266, but passed the pull test 100% of the time. It is also interesting to note that the strength was still almost double of the strength using traditional flux. It is most important to note that using solder joint encapsulant adhesive also leads to a much smaller standard deviation than that using traditional flux.

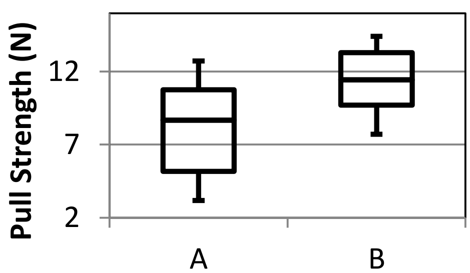


Fig. 10 Pull strength of the interconnect using A- traditional flux and B- SMT 266 after high temperature treatment

CONCLUSION:

With increasing miniaturization in the electronic industry, the strength of solder joint or interconnects presents a challenging issue. Underfilling the interconnects of rigid/flexible substrates does not solve the problem. Solder joint encapsulant adhesive (SMT266) provides a reliable solution to the interconnect of rigid/flexible substrates. Using solder joint encapsulant adhesive not only doubles the strength of the interconnect compared to using traditional flux, but also ensures 100% manufacturing process yield. Solder joint encapsulant adhesive is used in line process, thus shortening the manufacturing process.

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8. Mary Liu and Wusheng Yin Presented " World First Solder Joint Encapsulant Adhesives" in Shenzhen (China), NEPCON, August 31, 2010

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