High Reliability and High Temperature Application Solution – Solder Joint Encapsulant Paste

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ABSTRACT:

The miniaturization and advancement of electronic devices have been the driving force of design, research and development, and manufacturing in the electronic industry. However, there are some issues occurred associated with the miniaturization, for examples, warpage and reliability issues. In order to resolve these issues, a lot of research and development have been conducted in the industry and university with the target of moderate melting temperature solder alloys such as m.p. 280°C. These moderate temperature alloys have not resolve these issues yet due to the various limitations.

YINCAE has been working on research and development of the materials with lower temperature soldering for higher temperature application. To meet this demand, YINCAE has developed solder joint encapsulant paste to enhance solder joint strength resulting in improving drop and thermal cycling performance to eliminate underfilling, edge bonding or corner bonding process in the board level assembly process. This solder joint encapsulant paste can be used in typical lead-free profile and after reflow the application temperature can be up to over 300□C, therefore it also eliminates red glue for double side reflow process. In this paper, we will discuss the reliability such as strength of solder joints, drop test performance and thermal cycling performance using this solder joint encapsulant paste in detail.

Keywords: Solder Joint encapsulant Adhesive Paste, SMT Adhesive, Underfill, Reflow

INTRODUCTION

With the advancements of the electronic industry, IC components become miniaturized, pitch size gets smaller, and I/O numbers increase. The interpose layer is also getting thinner due to the miniaturization. Therefore, some copper paste has been developed for some interconnect application, which is expected to tolerate at 3X lead free reflow process cycles. During SMT assembly process red glue has to be used to avoid parts falling apart during double side reflow process. In addition, lead-free Sn/Ag/Cu soldering has higher reflow process temperatures. As a result, there are some reliability issues such as poor process yield, weak mechanical strength of solder joint, and poor thermal cycling performance, which are related to warpage. To address these issues, a few methods that have been or will be implemented include capillary underfill, corner bonding, no-flow underfill, underfilm and wafer-level underfill processes.

In order to resolve these issues, the YINCAE team has successfully developed lower or normal temperature solder joint encapsulant adhesive (SJEA) paste which can solder at lower or normal temperature and service at higher temperature (300°C). In this paper, we will discuss solder joint encapsulant paste process and reliability.

PROCESS

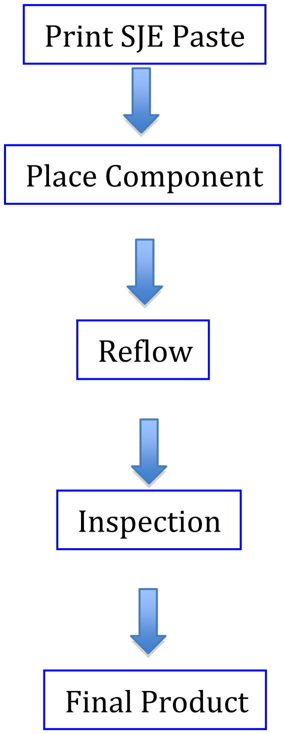

Fig. 1 Application process of SJE Paste

The application process of SJE paste is shown in Fig. 1. It is easily found that this process is the same as the application process of traditional solder paste, and there is no special or additional process step, and it is easy for mass production.

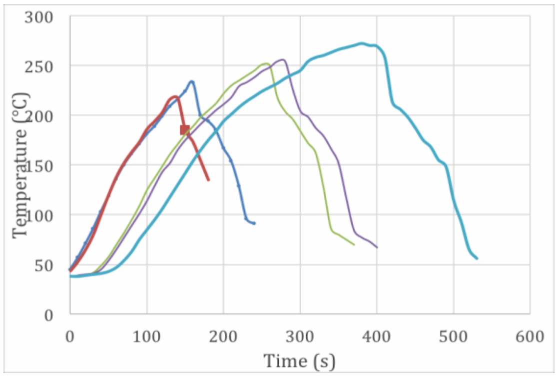

Fig. 2 Lead free reflow profiles of SJE paste

Fig. 2 shows the different reflow profiles from short to normal, to long time reflow profile. Solder joint encapsulant paste are typically compatibe with industry typical reflow profile, there is also no issue for other profiles. The nromal reflow profile is recommended for mass production process.

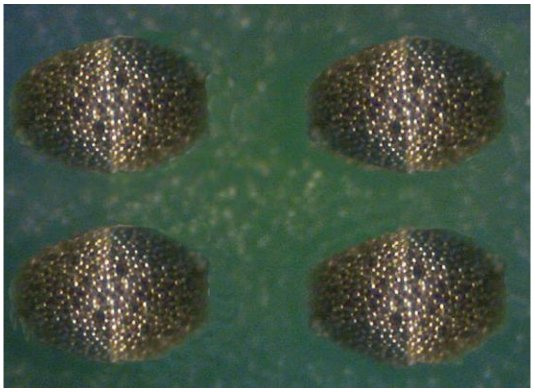

Fig.3 Printability of solder joint encapsulant paste

A solder joint encapsulant type 6 SAC paste was made. The printability was examined using 50 microns thick and 100 -150 microns pitch stencil. The printing result was shown in Fig. 3. There is no bridge, smearage and solder spatter observed after printing. The dot size of solder joint encapsulant paste released on PCB is very uniform. Therefore, solder joint encapsulant paste has demonstrated excellent printability.

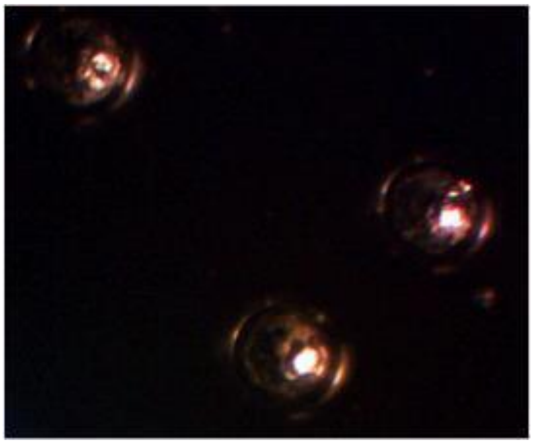

Fig. 4a Solder ball of solder joint encapsulant paste

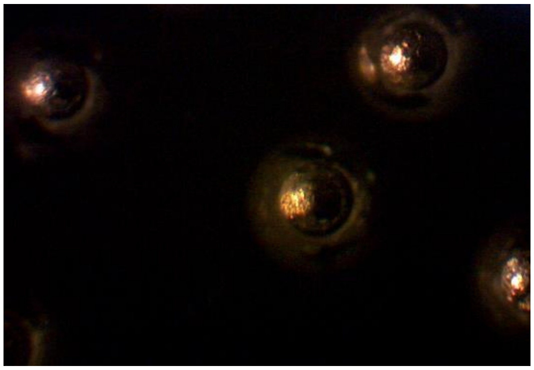

Fig.4b Solder ball of Leading SAC paste

The pictures of solder ball are shown in Fig.4a (solder joint encapsulant adhesive paste) and Fig.4b (leading SAC paste). From Fig. 4a we can see the surface of solder ball is smooth and shiny, while from Fig. 4b we can see the surface is wrinkled and less shiny. Therefore, solder joint encapsulant adhesive has demonstrated excellent solder wetting.

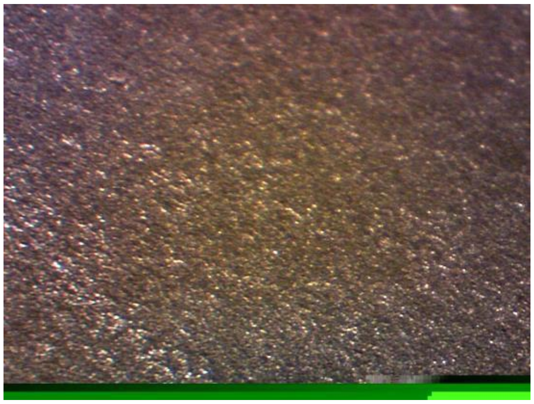

Fig. 5a Picture of void test of solder joint encapsulant paste

The voids test was conducted by peeling off copper-solder-copper sandwich structure. The sample preparation is: a) print paste onto one copper coupon then cover with another copper coupon; b) reflow using Pb free profile; c) peel off the two-copper coupon to examine solder voids. The pictures of solder joint encapsulant paste and leading SAC paste are shown in Fig.5a and Fig.5b, respectively after peeling off the two copper coupons.

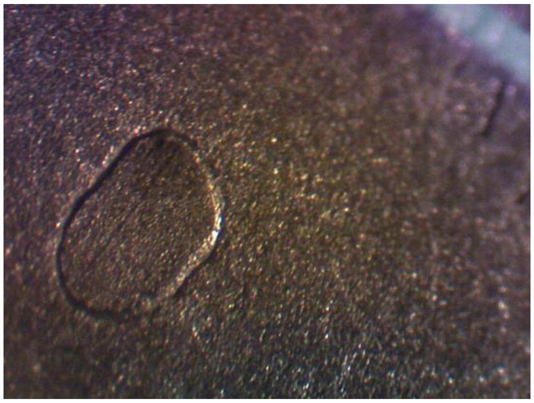

Fig.5b Pictures of voids test of leading SAC paste

Compared Fig.5a to Fig.5b, it is clearly found that there is no voids in Fig.5a, while there is a large void in Fig.5b. This result indicates that using solder joint encapsulant adhesive paste can make solder less or no voids compared to using leading SAC paste, in agreement with the previous result that solder joint encapsulant adhesive has excellent solder wetting.

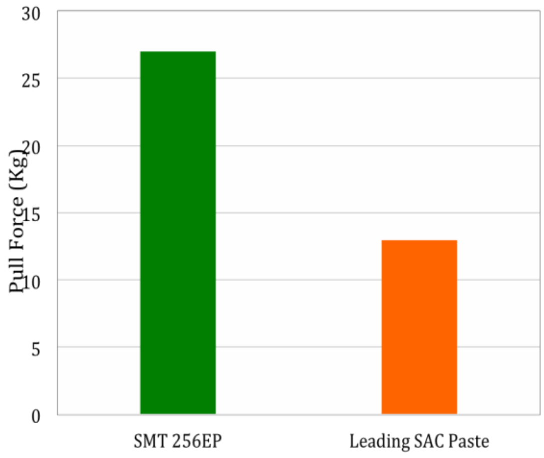

Fig.6 Pull strength of SJE paste and Leading SAC paste

The pull test was conducted by pulling copper-solder-copper overlap structure. The sample preparation is: a) print paste onto one end of copper coupon; b) overlap one end of another copper coupon on the top of paste, c) reflow using lead free reflow profile; d) pull test after reflow. The pull test results are shown in Fig.6. From Fig.6 we can see the pull strength was 27kg for solder joint encapsulant paste while only 13kg of pull strength was for leading SAC paste. This result indicates solder joint encapsulant adhesive paste can enhance the strength of solder joint.

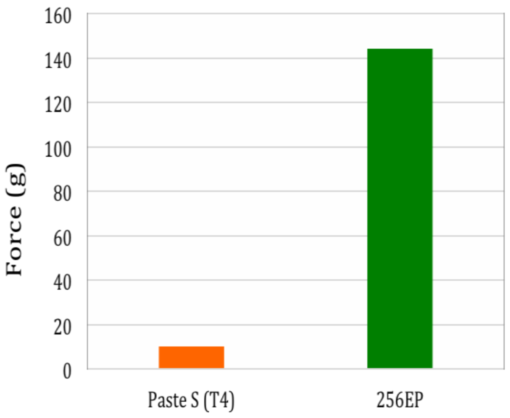

Fig.7 Pull strength of SJE paste and Leading SAC paste at 285 □C

The high temperature pull test was conducted by pulling copper-solder-copper overlap structure at 285 °C. The results of high temperature pull strength are shown in Fig. 7. It is very obvious to see there is no strength for leading SAC paste because SAC becomes liquid, while there is 200g of pull strength for solder joint encapsulant paste (SMT 256EP) at 285 °C because solder joint encapsulant adhesive still has adhesion strength. This indicates solder joint encapsulant adhesive paste can be soldered at lower or normal temperature and serviced at higher temperature (300°C).

DROP TEST

With the miniaturization of devices, the mechanical shock of SAC solder joint become an issue. The results of the drop test of solder joint encapsulant adhesive paste and leading SAC paste are shown Fig. 8.

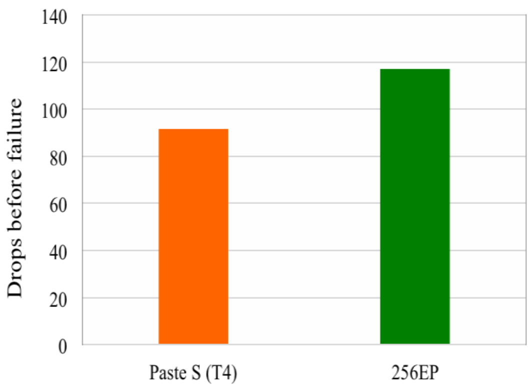

Fig.8 Drop Test of Leading SAC paste and solder joint encapsulant adhesive paste

Figure 8 shows the drop test performance of SMT 256EP solder joint encapsulant paste and traditional leading SAC solder paste. The drop test conditions are: six feet drop height and concrete floor. It can be seen that SMT 256EP has around 40-50% better drop performance than traditional leading SAC solder paste, which means solder joint encapsulant paste not only enhances solder joint strength, but also increases ductility.

THERMAL CYCLING TEST

The thermal cycling test was conducted from -45 to 125°C, one hour per cycle. The results are shown in Figure 9 below. It is clear that there is no first failure before 1500 cycles using SMT 256EP, but first failures at 1000 cycles using traditional leading SAC solder paste. This indicates that using solder joint encapsulant paste could significantly improve the reliability of solder joints.

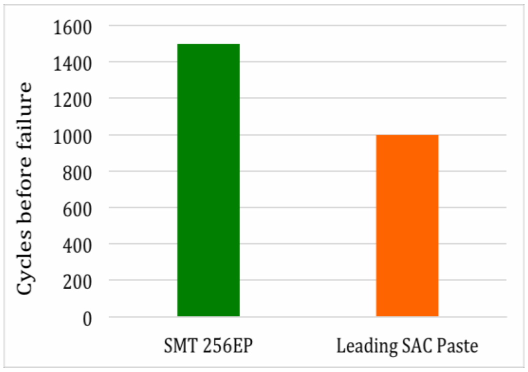

Fig.9 Thermal cycling performance of SMT 256EP and leading SAC paste (0.5mm pitch, SAC305, I/O 208)

CONCLUSION

A solder joint encapsulant adhesive paste has been successfully developed, which has demonstrated good printability, better solder wetting, less solder voids and stronger solder joint strength by comparison to traditional leading SAC paste. The solder joint encapsulant paste not only has better drop and thermal cycling performance, but also can solder at typical Pb free temperature and demonstrated high pull strength at 285°C. This provides the solution of lower temperature soldering and high temperature service to the industry miniaturization.

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