The Future of Solder Joint Encapsulant

YINCAE Advanced Materials, LLC WHITE PAPER

October 2015

YINCAE Advanced Materials, LLC, 19 Walker Way, Albany, NY, 12205
www.yincae.com
518-452-2880

The Future of Solder Joint Encapsulant

Mary Liu and Wusheng Yin, Ph.D

YINCAE Advanced Materials, LLC, Albany, NY
info@yincae.com

ABSTRACT:

Solder joint encapsulant adhesives have been successfully used to enhance the strength of solder joints and improve thermal cycling as well as drop performance in finished products. The use of solder joint encapsulant adhesives can eliminate the need for underfill materials and the underfill process altogether, thus simplifying rework, which results in a lower cost of ownership.

Solder joint encapsulant adhesives include: low temperature and high temperature solder joint encapsulant adhesives, and their derivatives. Each solder joint encapsulant adhesive has: unfilled and filled solder joint encapsulant adhesives, and solder joint encapsulant paste. Each solder joint encapsulant product has been designed for different applications. In this paper, we are going to discuss the details and future of solder joint encapsulant adhesives.

INTRODUCTION

With the advancements of the electronic industry, IC components are becoming smaller. This means pitch size gets smaller and I/O number increases. In addition to these factors, lead-free soldering process has to be implemented due to law requirements. As a result, there are some reliability issues such as poor process yield, weak mechanical strength of solder joint, and poor thermal cycling performance. YINCAE's solder joint encapsulant adhesives have been widely used to make billions of devices with approved satisfied performance in the customer field.

Due to the benefits of miniaturization, design flexibility, and cost efficiency, package-on-package has become an increasingly popular IC package for electronic devices. In order to address multi-core processors, higher data transfer rates, and wider bus memory architectures, POP with through-mold vias (TMV) are used in mobile devices. Like CSP/BGA, POP TMV also needs reliability enhancements to meet the end customer's needs. However, the application process is much more difficult with processes like capillary underfill, corner bond, no-flow underfill, and wafer-level underfill process to address this issue. This is especially a problem for POP with TMV, which has molded cavity surface. All the above processes result in unsatisfied process yield, reliability scarification, and lengthy application processes, among other issues. Here, we will discuss the application of a few solder joint encapsulant adhesives, the reliability in real products, and the future of solder join encapsulants.

HIGH TEMPERATURE SOLDER JOINT ENCAPSULANT

The solder joint encapsulant refers to encapsulating solder joints after soldering shown in Figure 1 below. High temperature solder joint encapsulant normally refers to high temperature lead free e.g. SAC solder joint encapsulants. Solder joint encapsulant adhesives include applications for SMT assembly, ball-bumping process, and solder joint encapsulant paste. Solder joint encapsulant adhesives for the SMT assembly process include customizable options such as different colors like black or red, and different storage temperatures such as low temperature storage, or room temperature stable storage.

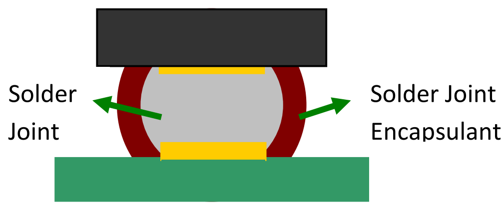

Fig. 1 Schematic solder joint encapsulant

Figure 2 shows the comparison of solder joint pull strength of POP using traditional tacky flux and solder joint encapsulant adhesive. The pull strength of solder joint is 79N using traditional tacky flux, while the solder joint strength is 400N using solder joint encapsulant adhesive, more than five times the strength of that using tacky flux. In addition, it should be noted that solder joint encapsulant adhesive not only increases solder joint strength, but also produces a smaller standard deviation.

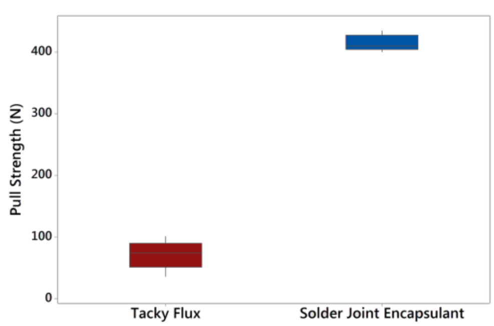

Fig. 2 Pull strength comparison

Figure 3 below shows the comparison of soldering wetting performance using tacky flux and solder joint encapsulant adhesive. It can be seen that the solder joint stand off is lower with a smaller standard deviation using solder joint encapsulant adhesive under air than using tacky flux under nitrogen. This result indicates that solder joint encapsulant adhesive has better solder wetting even under air than tacky flux under nitrogen. The reason for better wetting is that the solder joint encapsulant adhesive can form a thin liquid film to function as oxygen physical barrier during reflow process, rather than simply increasing flux activity.

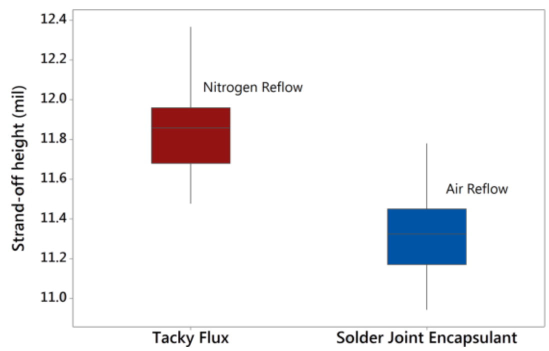

Fig. 3 Solder Wetting Comparison

Figure 4 on the next page shows the dendrite in assembled POP using solder paste and flux, which is causing the current leakage problems experienced after sales. Normally, the dendrite cannot be found immediately after manufacturing. After sale to the end user, the dendrite starts to form, resulting in higher RMA (Returning Materials Authorization), which could lead to millions of dollars lost.

Using solder joint encapsulant adhesive for POP assembly not cures to form a 3D polymer network and encapsulate solder joints, but also ensures 100% process yield. The 3D polymer network encapsulation can easily prevent dendrite formation and electromigration, as shown in Figure 5.

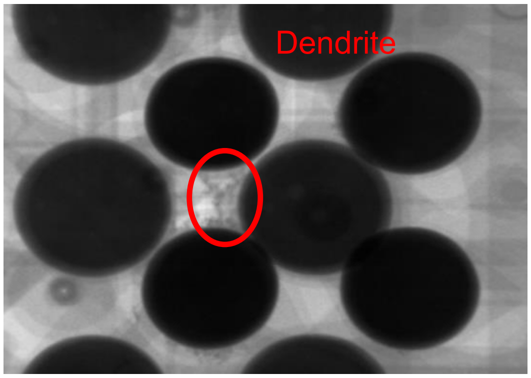

Fig. 4 Dendrite in Assembled POP Using Tacky Flux

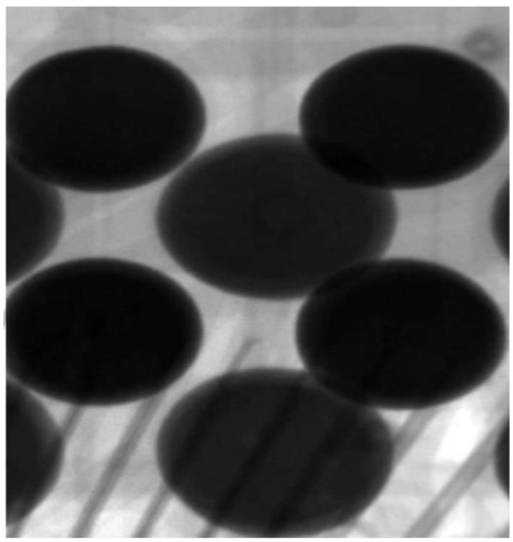
Fig. 5 X-ray image of Assembled POP using SJE

Figure 6 shows thermal cycling performance using underfill and solder joint encapsulant adhesive. From Figure 6, it can be seen that the first failure of thermal cycling started at about 500 using underfill, the first failure was significantly increased to 6000 cycles while using solder joint encapsulant. This is because the use of solder joint encapsulant adhesive only enhances solder joint strength without applying additional stress onto the joints since there is only air between the joints.

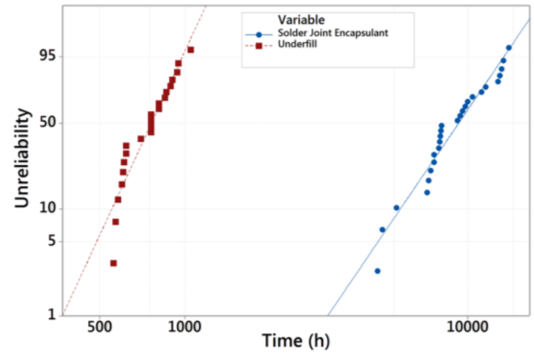

Fig. 6 Thermal cycling performance using underfill and solder joint encapsulant

Figure 7 below compares the pull strength of solder joint encapsulant paste and normal solder paste. Solder joint encapsulant paste and normal solder paste are reflowed under the same reflow profile e.g. typical lead-free reflow profiles. We can see the pull strength of solder joint encapsulant paste is two times better than that of normal solder paste. The increase of pull strength not only comes from the adhesion strength of solder joint encapsulant but also from excellent solder wetting due to the oxidation barrier of solder joint encapsulant adhesive during reflow process.

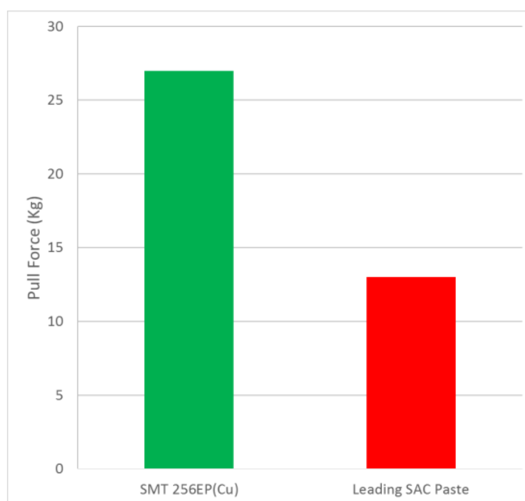

Fig. 7 Comparison of pull strength between solder joint encapsulant paste and normal solder paste

Figure 8 below compares high temperature (285°C) pull strength between solder joint encapsulant paste and normal solder paste. It is well known that when the temperature increases to 285°C, SAC alloy has no strength at all. However, when the solder joint is encapsulated by epoxy polymer after reflow using solder joint encapsulant paste, the pull strength of solder joints is still up to 200g force. This will open the door for lower temperature soldering and can be used for high temperature applications.

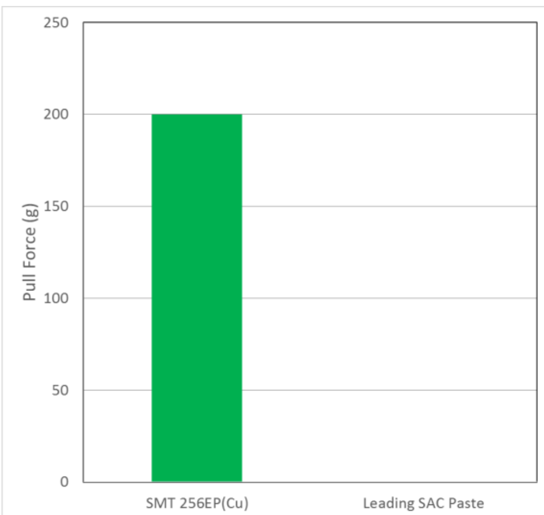

Fig. 8 Comparison of high temperature pull strength between solder joint encapsulant paste and normal solder paste

LOW TEMPERATURE SOLDER JOINT ENCAPSULANT ADHESIVE

Low temperature lead-free solder alloys, such as SnBi, are attracting the attention of the electronic industry. However, low temperature lead-free solder alloy has some reliability issues. In order to overcome these reliability issues, low temperature solder joint encapsulant adhesives and their pastes have been successfully developed.

Figure 9 compares the drop test performance of low temperature solder joint encapsulant paste and normal solder paste.

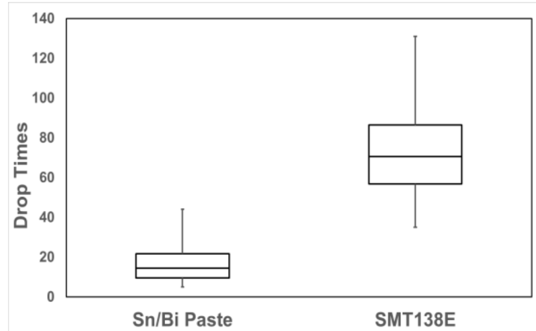

Fig. 9 Drop test performance of solder joint encapsulant paste and Sn/Bi paste

From Figure 9 above, it can be seen that solder joint encapsulant adhesive (SMT 138E) has much better drop test performance than that of Sn/Bi paste due to the enhancement of low temperature solder joint encapsulant adhesive. Low temperature solder joint encapsulant adhesive not only lowers the soldering temperature and saves a lot of energy, but also resolves a lot of industry issues such as warpage, open solder joints, etc.

Figure 10 compares the pull strengths of low temperature solder joint encapsulant paste and SAC solder paste.

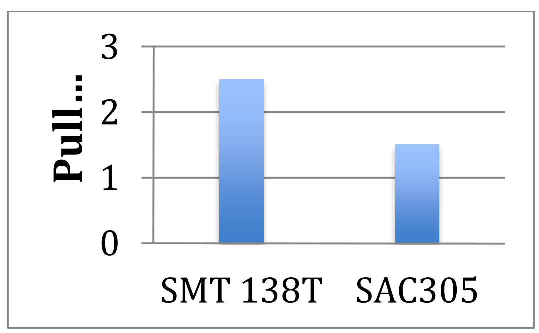

Fig. 10 Pull strength comparison between solder joint encapsulant paste and SAC305 solder paste

From Figure 10, it is very interesting to see that the pull strength of low temperature solder joint encapsulant paste is higher than that of SAC305 solder paste. In order to achieve high reliability solder joint, one option is to modify low temperature solder alloy, and another is to use solder joint encapsulant adhesive to enhance solder joint strength. We will continue to develop new solder joint encapsulant adhesives in the future to achieve low temperature lead-free processes to be implemented in the entire electronic industry.

CONCLUSION

A large family of solder joint encapsulant adhesives and their derivatives have been successfully developed for different applications. All solder joint encapsulant adhesives have been designed to enhance solder joint strength, resolve some manufacturing issues, and shorten the manufacturing process. The most interesting products include low temperature solder joint encapsulant adhesives and the solder joint encapsulant paste, which are lead-free, and with the solder joint reliability equal to or better than the high temperature SAC reliability. The implementation of low temperature lead-free solder joint encapsulant and its paste will significantly benefit the electronic industry in the future.

REFERENCES:

1. Mary Liu and Wusheng Yin presented " A First Room Temperature Stable and Jettable Solder Joint Encapsulant Adhesive" in IMAPS New England - 38 the Symposium & Expo, May 3, 2011

2. Mary Liu and Wusheng Yin had technical poster" A First Individual Solder Joint Encapsulant Adhesives" in Raleigh NC, IMAPS, November 3, 2010

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

4. Mary Liu and Wusheng Yin presented " A First Individual Solder Joint Encapsulant Adhesives" in San Francisco, SEMICON West/IMAPS, July 14, 2010

5. Mary Liu and Wusheng Yin presented "Solder Joint Encapsulate - Miniaturization Solution" Las Vegas, Nevada, APEX , March 25- 27th, 2014.

6. Mary Liu and Wusheng Yin presented "An Innovative Reliability Solution to Interconnect of Flexible/Rigid Substrates." Rosemont, IL, SMTAI, September 30th to October 1st, 2014.

For additional information Contact:

YINCAE Advanced Materials, LLC
19 Walker Way
Albany, NY 12205
(518) 452-2880
http://www.yincae.com/
info@yincae.com

WP-1008-10/2015