A High Thermal Conductive Solderable Adhesive

YINCAE Advanced Materials, LLC WHITE PAPER

January 2016

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A High Thermal Conductive Solderable Adhesive

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ABSTRACT:

With increasing LED development and production, thermal issues are becoming more and more important for LED devices, particularly true for high power LED and also for other high power devices. In order to dissipate the heat from the device efficiently, Au80Sn20 alloy is being used in the industry now. However there are a few drawbacks for Au80Sn20 process: (1) higher soldering temperature, usually higher than 320 °C; (2) low process yield; (3) too expensive.

In order to overcome the shortcomings of Au80Sn20 process, YINCAE Advanced Materials, LLC has invented a new solderable adhesive – TM 230. Solderable adhesives are epoxy based silver adhesives. During the die attach reflow process, the solder material on silver can solder silver together, and die with pad together. After soldering, epoxy can encapsulate the soldered interface, so that the thermal conductivity can be as high as 58 W/mk. In comparison to Au80Sn20 reflow process, the solderable adhesive has the following advantages: (1) low process temperature – reflow peak temperature of 230 °C; (2) high process yield – mass reflow process instead of thermal compression bonding process; (3) low cost ownership. In this paper we are going to present the die attach process of solderable adhesive and the reliability test. After 1000 h lighting of LED, it has been found that there is almost no decay in the light intensity by using solderable adhesive – TM 230.

INTRODUCTION:

LED industry has getting more and more attraction due to the demand of green energy. High power LED is considered to be a good replacement for our routine lighting industry. However there is a big challenging for high power LED which is how to dissipate the heat from high power LED device. There is same challenge for high power device which is how to remove the heat from high power chip device quickly and efficiently. On the other hand, the miniaturization of electronic device has led to the difficulty of dissipating heat from the smaller chip device. The development of high thermal conductive thermal interface materials becomes more and more important, also more challenging now.

In order to dissipate the heat from the device efficiently, Au80Sn20 alloy is being used in the industry now. However there are a few drawbacks for Au80Sn20 process: (1) higher soldering temperature, usually higher than 320 °C; (2) low process yield; (3) too expensive.

In order to overcome the shortcomings of Au80Sn20 process, YINCAE Advanced Materials, LLC has invented a new solderable adhesive – TM 230. Solderable adhesives are

epoxy based silver adhesives. During the die attach reflow process, the solder material on silver can solder silver together, and die with pad together. After soldering, epoxy can encapsulate the soldered interface, so that the thermal conductivity can be as high as 58 W/mk. In comparison to Au80Sn20 reflow process, the solderable adhesive has the following advantages: (1) low process temperature – reflow peak temperature of 230 °C; (2) high process yield – mass reflow process instead of thermal compression bonding process; (3) low cost ownership. In this paper we are going to present the die attach process of solderable adhesive and the reliability test. After 1000 h lighting of LED, it has been found that there is almost no decay in the light intensity by using solderable adhesive – TM 230.

EXPERIMENTAL:

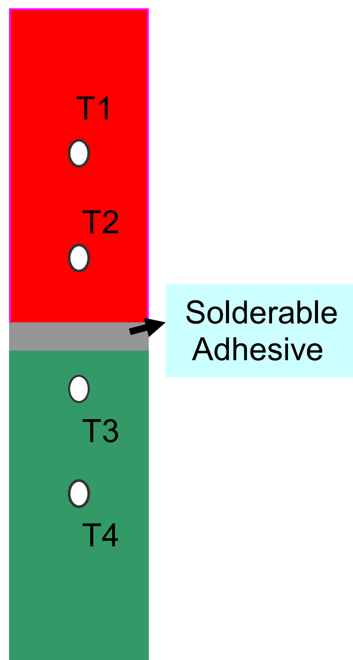


Fig. 1 Schematic Thermal Conductivity Measurement

a. Thermal conductivity and Delta T measurement:

The test vehicle is shown in Fig.1. The heat source power is 60 W and cooler substrate is kept at 25 C. The Delta T = T2-T3. The smaller Delta T, the higher thermal conductivity.

b. Sample Preparation:

Dispense YINCAE solderable adhesive onto one copper coupon, then covered with another copper coupon to form sandwich structure. Put the sandwich copper coupon onto 230 °C hotplate for 60 seconds to complete the soldering and curing process. The samples prepared are for cross-section and thermal conductive performance measurement.

c. High Temperature Bonding Strength Measurement

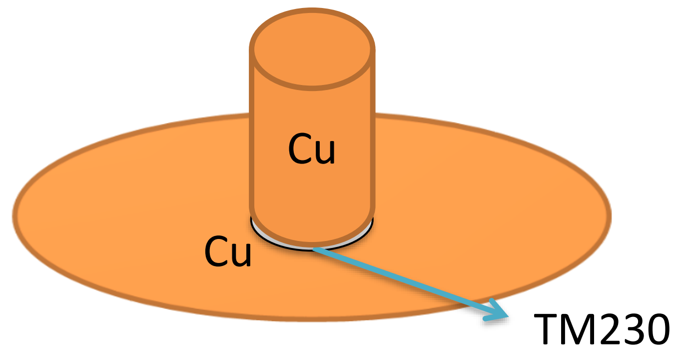


Fig.2 Schematic High Temperature Bonding Measurement

Dispense solderable adhesive TM 230 onto copper coupon and place one end of 30 mil copper wire onto solderable adhesive, then put onto 230 °C hotplate for 60 second to allow soldering and curing process. After completion of solderable adhesive bonding process, the device is heated up to 280 °C, add 5g, 10g, 15g, 20g…..onto the copper coupon, pull the copper wire up until the copper wire is broken from the copper coupon. The total weight added plus the weight of the copper coupon is the bonding strength of solderable adhesive at 280 °C.

RESULTS AND DISCUSSION:

a. Solderable Adhesive and Its Cross-section

TM 230 solderable adhesives is thermally and electrically conductive adhesive, and has higher stable electrical and thermal conductivity. During the curing process, silver is soldered together and also soldered with substrate and chip together. By comparison with

soldering materials, TM 230 solderable adhesives eliminate the outgassing from soldering process, eliminate die skewing and shifting, soldering bleed. Soldered interface will be encapsulated with the curing of TM 230 solderable adhesives, thus soldered metal interface is protected by 3D polymer network, which can tolerate harsh environmental conditions.

Fig.3 shows the schematic soldered interface using TM230 which can explain TM 230 solderable adhesive.

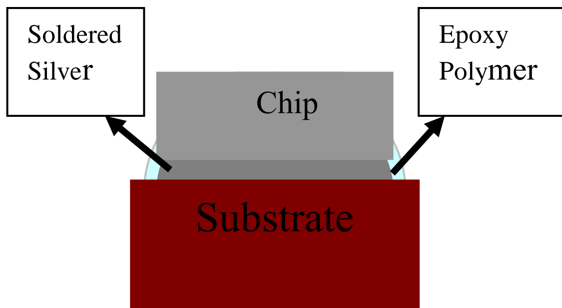
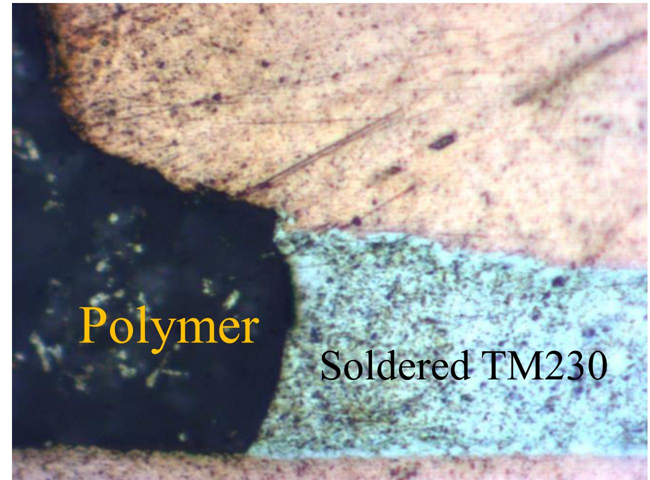


Fig.3 Schematic Soldered Interface

Fig.4 shows the cross-section picture using TM 230 for bonding two copper coupons. It can be found that all silver particles are soldered together and also soldered two copper coupons together. During the curing polymer migrate to the outside of silver soldered interface and encapsulate the interface. There is no any big silver particles found and all silver are very homogenously bonded together as shown in Fig. 4 (b).

(a)



(b)

Fig. 4 Cross-section of Copper Coupon Bonding with Solderable Adhesive (TM230): (a) Central Section; (b) Edge Section.

b. Thermal Performance Measurement

All thermal materials are put in between two copper coupons to prepare sandwich test sample with 2 mil thickness according to the application instruction of each material. The Delta T was measured and shown in Fig.5. It should be noted that Delta T for TM 230 and TM 150 is lower than Au80Sn20, SAC or Ag glue. These results indicated TM 230 and TM 150 have higher thermal conductivity than Au80Sn20. It is well known that the thermal conductivity of silver is about 400W/mk. Solderable adhesive is to make silver solder together by forming metallic bonding, so TM 230 and TM 150 easily reach higher thermal conductivity and permanently keep the performance stable.

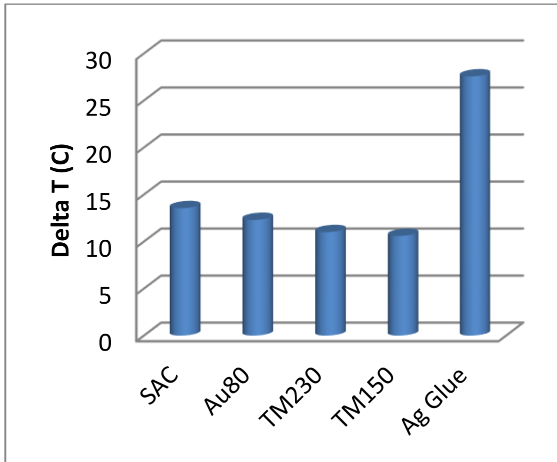


Fig. 5 Delta T for different thermal materials

Normal silver glue is to make silver physically forced together by the mechanical stress from cured polymer, so the thermal conductivity is low and unstable due to the relaxation of polymer chain. Au80Sn20 is to make chip and substrate solder together by thermal compression bonding process which is shown as follow:

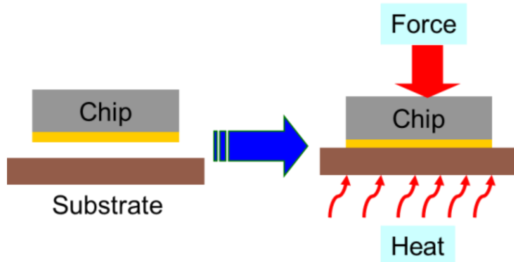


Fig.6 Thermal Compression Bonding Process for Au80Sn20

From Fig. 6 it can be seen that the thermal compression bonding process can make metallic bond for the interface which can provide high thermal conductivity, but will easily lead to product defect than the process without stress onto chip, particularly true for very thin chip.

From Fig. 7 it can be seen that Au80Sn20 needs 300 °C to form metallic bonding using thermal compression bonding process. The high temperature process usually also leads to product defects. While the process temperature for TM 230 and TM 150 is lower and almost the same as normally SMT assembly reflow process temperature which normally doesn't have the problem for electrical components.

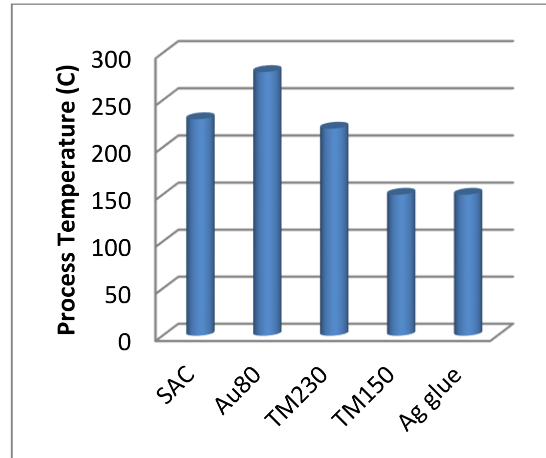


Fig. 7 Process Temperature For Different Thermal Materials

From Fig.8 it should be noted that the service temperature of TM230 and TM150 is up to 300 °C with 80g bonding strength which is higher than that of Au80Sn20, SAC and Silver glue. TM230 and TM 150 not only have metallic bond but also have non-melting glue bonding, while Au80Sn20 only has metallic bond. The metallic bond will lose the strength as soon as the service temperature is close to the melting temperature, while glue bonding won't lose the strength until the occurring decomposition. So TM 230 and TM 150 have demonstrated higher service temperature. The performance of silver glue will decrease with increasing temperature due to the relaxation of polymer chains.

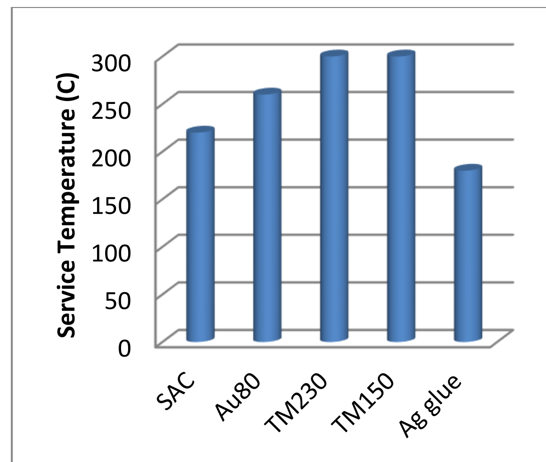


Fig. 8 Service Temperature of Different Thermal Materials

From Fig. 9 it can be seen that after 1000 hours lighting the leading competitors' thermal material led to the light intensity decrease a lot,

while TM 230 almost kept the light intensity same as the initial intensity. TM 230 has higher thermal conductivity and can dissipate the heat from the chip quickly and efficiently so that the active layer of LED chip won't decrease, which is in agreement with the results from the thermal performance measurement.

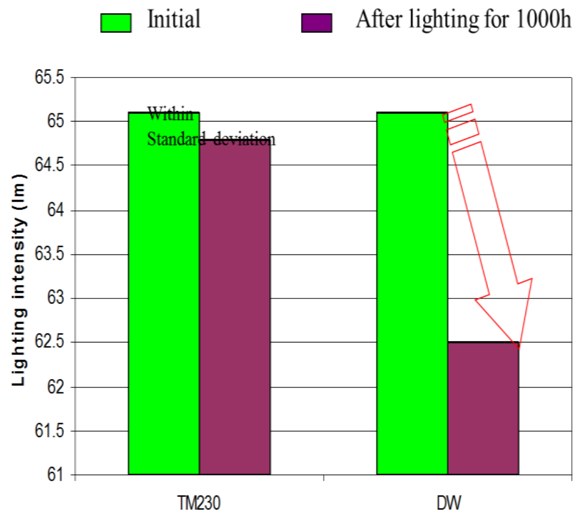


Fig. 9 Light Intensity Deceasing With Lighting Time

CONCLUSION:

- TM230 Solderable Adhesive has been designed to combine the advantages of pure solder materials and silver adhesives, to overcome the disadvantages of these two systems;
- TM230 Solderable Adhesive has higher thermal conductivity than pure solder alloy;
- TM230 Solderable Adhesive has lower process temperature, and higher application temperature;
- Unlike solder paste or preform, TM230 Solderable Adhesive can be used for bare die attachment;
- TM230 Solderable Adhesive has eliminated out-gassing issue for soldering and cleaning process after soldering.

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(WP-1011-01/2016)