SOLDERABLE ANISOTROPIC CONDUCTIVE ADHESIVES FOR 3D PACKAGE APPLICATIONS

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ABSTRACT:

3D packaging has recently become very attractive because it can provide more flexibility in device design and supply chain, reduce the gap between silicon die and organic substrate, help miniaturize devices and meet the demand of high speed, provide more memory, more function and low cost. With the advancement of 3D packaging, the bump height is now down from 80µ to 10µ. When the bump diameter is 20-40µ and height 10µ, the process and reliability are obvious issues. It is well known that underfill can enhance the reliability for regular flip chip, however underfill won't help assembly process. In order to resolve some difficulties that 3D packaging faces, YINCAE Advanced Materials, LLC has developed solderable anisotropic conductive adhesives for 3D package applications. In this paper we will discuss the assembly process and reliability in detail.

Keywords: Solder anisotropic conductive adhesive, 3D package

INTRODUCTION:

Recently, 3D packaging has been increasingly implemented in the industry due to the flexibility in device design and supply chain, its ability to reduce the gap between silicon die and organic substrate, and the demands of size miniaturization, cost reduction, high speed, high memory, and multiple functions from end customers. In order to achieve further size miniaturization, higher speed, and cost reduction, 3D TSV (Through Silicon Via) package has been introduced into the packaging industry. In addition, the bump size has been reduced from 80µ to 10µ.

3D package with 10µ bumps is assembled using thermal compression bonding process, which is shown in Fig. 1. Die size is 6X6mm, 100µ pitch, copper column: 8µ, pre-Sn: 2µ. From Fig. 1, it is very easy to find that there are some process yield and reliability issues in 3D packaging.

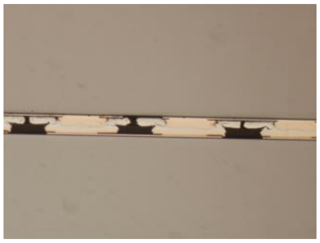


Fig. 1 Assembled chips using TCB process

In order to resolve reliability issues, YINCAE has developed a solderable anisotropic adhesive for 3D package applications. Solderable particles can solder bare copper (20µ) pads together to form reliable solder joints. Adhesive can fill the gap between two chips as soon as solder joints are formed. To evaluate the application of solderable anisotropic conductive adhesive on 3D package applications, unbmuped flip chip was used to assemble onto PCB using anisotropic adhesive.

In this paper we will discuss the assembly process, process yield, and pressure cooking and thermal cycling performance of the devices assembled using solderable anisotropic conductive adhesives.

EXPERIMENT:

a. Materials

Three different solderable anisotropic conductive adhesives have been prepared: T8 (<5µ), T6 (10-25µ) and T5 (15-35µ). All three products have the same filler load (60%).

b. Test Coupons

Substrate PB8 gold finish was purchased from Practical Components. The PB8 substrate was cut into single units using PCB cutter shown in Fig. 2 below. The single unit was used for thermal compression bonding assembly process.

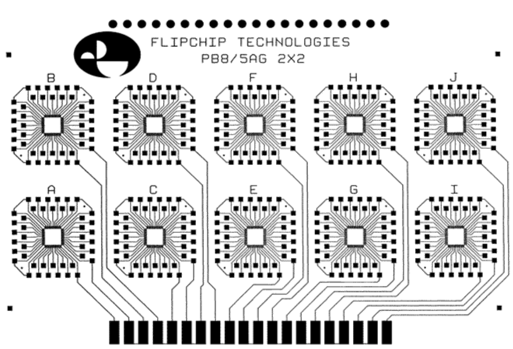


Fig. 2 Drawing of PB8 substrate

Flip chip without bumps was purchased from Practical Components, with pitch of 204um, and a body size of 5.08mm.

c. Sample Preparation

Dispensed solderable anisotropic conductive adhsives onto the footprint of PB8 single unit, then assembled chip onto PB8 substrate. Applied 15 psi onto chip and heated the substrate to 150°C, held 2 minutes until the electrical continuity circuit was formed. After this, the assembled chip was continuously cured for another 30 minutes at 150°C. The finish assumbled chip was subject to all reliability tests.

d. Pressure Cooking Test

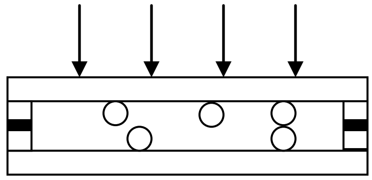
The assembled chips were inspected via C-SAM to check for voids or delamination before and after pressure cooking for seven days at 121°C and 15 psi.

e. Thermal Cycling Test

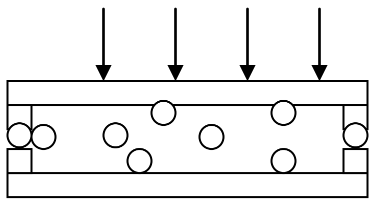
Thermal cycling test was conducted for the assembled unbumped chips. The test conditions were: -45°C to 125°C; 15 minutes each at two extreme points; 15 minutes for temperature ramping up from –45°C to 125°C, and 15 minutes for temperature cooling down from 125°C to –45°C with total time of one hour per cycle.

RESULTS AND DISCUSSION:

The chip was assembled using solderable anisotropic conductive adhesive after thermal compression bonding (TCB) process as shown in Fig. 3a, and using traditional anisotorpic conductive adhesive after TCB process is shown in Fig. 3b.



(3a)



(3b)

Fig. 3 Schematic pictures of (a) assembled chip using solderable anisotropic conductive adhesive and (b) traditional anisotropic conductive adhesive after TCB process

From Fig. 3 above, it can be seen that solderable anisotropic conductive adhesive can really form solder joints between two pads, while traditional anisotropic conductive adhesive only form physical compressed interconnect, which will easily lose connection with polymer stress relaxation. Fig. 4 below shows assembled chips using solderable anisotropic conductive adhesive. The electical continuity test will be conducted for all assembled chips.

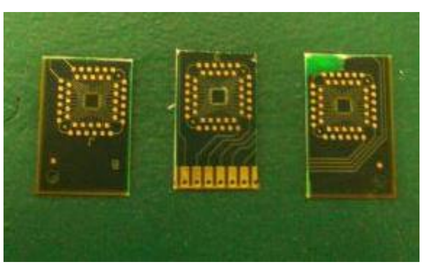


Fig. 4 Pictures of assembled chip samples using solderable anisotropic conductive adhesives

The results of the electrical continuity test is shown in Fig. 5 below. From Fig. 5, it can be seen that T8 obtained 100%, T6 31.1%, and T5 obtained 86.4% process yield. This may be because the solderable particle size of T8 is around 5 microns, which means there is more chance to have finer particles in between the pads of chip and substrate during thermal compression bonding process. Thus, this easily establishes an electronical interconnect with 100% process yield. Although it is interesting to note that T5 achieved a higher percentage of electrical continuity yield than T6, T5 contains a larger particle size than T6, so T6 should have obtained a higher electrical continuity average. This may be because during thermal compression bonding process, the larger solderable particles tends to form bridges between interconnects. In fact, this is a defect, and no truly good interconnects formed.

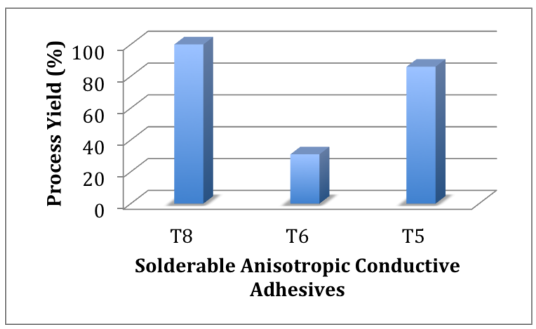


Fig. 5 Process yield of three different solderable anisotropic conductive adhesives

After electrical continuity test, the good assembled chips were moved on to the high temperature test. In the high temperature test, the chips are placed at 260°C for 30 minutes, and checked for electrical continuity afterwards. The chips that did not have 100% electrical continuity were taken out of the experiment. The results of the high temperature test are shown in Fig. 6 below. From Fig. 6, we can see that all chips passed the high temperature test. This is because during the test, the adhesive can be further cured at 260 degrees Celsius. This results in a stronger connection, thus allowing the chip and substrate to obtain a passing yield of 100%.

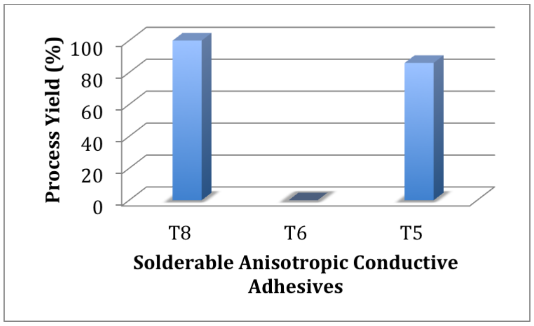


Fig. 6 Process yield after high temperature test

After conducting the high temperature test, the assembled chips underwent the cooking test. The results are shown in Fig. 7 below. All assembled chips passed the pressure cooking test up to five days. T8 still has 100% yield after seven days of pressure cooking test, which means the assembled chips using solderable anisotropic conductive adhesives have good reliability as soon as real solder joint was formed as in T8 .

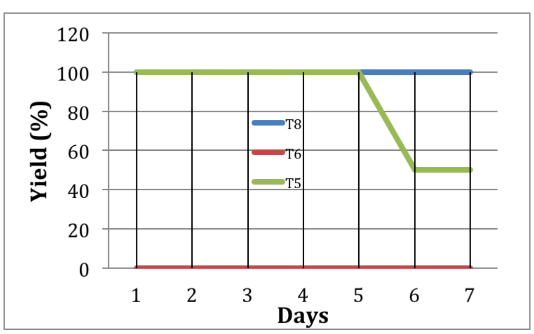


Fig. 7 The yield of assembled chips after pressure cooking test

After the pressure cooking test, the C-SAM was used to detect voids and delamination, and to compare with the results before PCT. During the thermal compression bonding process, the underfilling and soldering processes were completed at the same time. Fig. 8 below shows the images of C-SAM before and after PCT. From Fig. 8, we can find that there are no underfill voids in assembled chips before PCT, and no delamination and voids in underfilled chips after PCT. All these results have shown that anisotropic conductive adhesive has not only good adhesion, but also good moisture resistance.

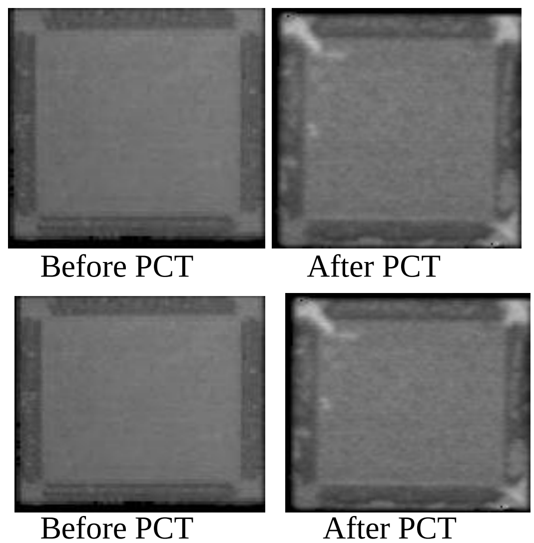


Fig. 8 C-SAM images of assembled chips using anisotropic conductive adhesives after PC

The thermal cycles for the first electrical failure has been used for evaluation for reliability of assembled chips. All the reliability data is shown in Fig. 9 below.

The first failure was observed for traditional anisotropic conductive adhesive at 200 cycles, while the assembled chips starts to fail at 1000 cycles. Solderable anisotopic conductive adhesive (T8) is much better than the traditional anisotorpic conductive adhseive. This is because solder joint has been really formed using solderable anisotropic conductive adhesive during thermal compression bonding process. This indicates T8 is good for 3D package application.

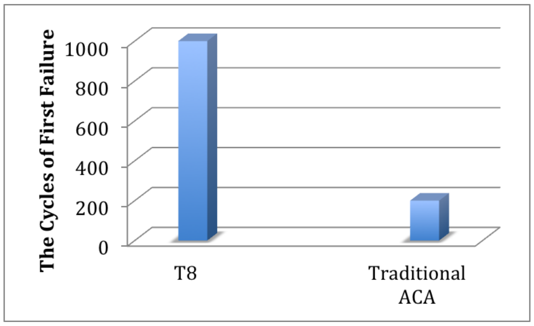


Fig. 9 First failure of anisotropic conductive adhesive in thermal cycling

CONCLUSION:

Solderable anisotropic conductive adhesives have been successfully developed and investigated. It has been found that T8 had the best performance because it contains the finest solderable particles. T8 passed all the reliability tests and also had much better thermal cycling performance than traditional anisotropic conductive adhesive due to the presence of solder joints formed in solderable anisotropic conductive adhesive. All data have demonstrated T8 is good for 3D package applications.

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