ThreeBond
TECHNICAL NEWS
Issued January 1, 1998
50

Flat Packages Mounting Adhesives

Introduction

Both consumers and industry are demanding that electronic equipment integrated with IC or LSI be made smaller and lighter, and have enhanced features. Products such as personal computers, video players, video cameras, cellular phones, and audio equipment, as well as automotive electronic products, are becoming smaller while retaining the same features, or are adding features if they remain the same size.

To make a piece of electronic equipment "lighter, thinner, and smaller," the LSI package mounted on it also needs to be smaller. As a result, the LSI package has evolved from a DIP (Dual In-line Package) with pins for insertion, to a flat package that can be installed on the board. The package has also become smaller, to match the narrow pitch of the terminals.

This issue introduces different types of flat packages, and the adhesive that Three Bond has developed to fix or connect the flat package to the board.

Contents

Introduction
1. Flat packages and connection methods 2
2. Instant adhesive and curing accelerator for temporary fixing of the flat package 3
3. BGA/CSP mounting adhesive 6
4. Flip-chip mounting adhesive 7

1. Flat packages and connection methods[1,2]

The LSI package is a metallic lead frame mounted with LSI chips, and molded with epoxy or ceramics. Epoxy-based plastic packages are prevailing in the market, because they cost less. Figure. 1-1 shows the internal structure of a flat package.

The package has changed from DIP (pin insertion type) to SOP and QFP (surface-mounting flat package), and further to thinner TSOP and TQFP. Table 1-1 shows the features of each package.

To support the increased number of pins, a new connection method that uses ball solder called "bump" instead of lead is used to connect flat packages such as BGA and CSP. Figure. 1-2 shows how packages have evolved.

Recently, a new connection method called "flip chip mounting" (or bare chip mounting) has been developed, by which bare chips are mounted without being packaged (that is, they are unmolded). This new method seems likely to prevail in the future.

Figure. 1-3 shows flat packages, the different connection methods, and the comparison of mounted IC size.

The following sections describe the Three Bond's adhesives designed for flat package installation and those designed for flip chip mounting.

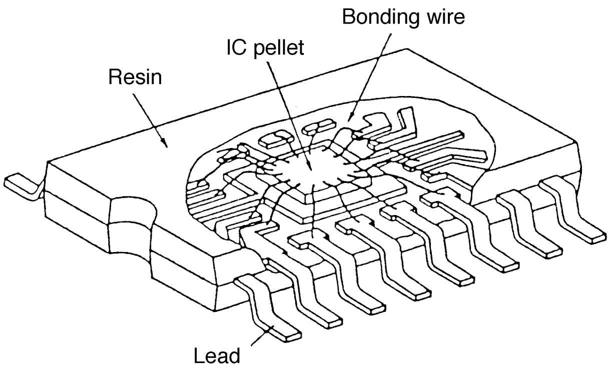


Fig. 1-1. Internal structure of a flat package

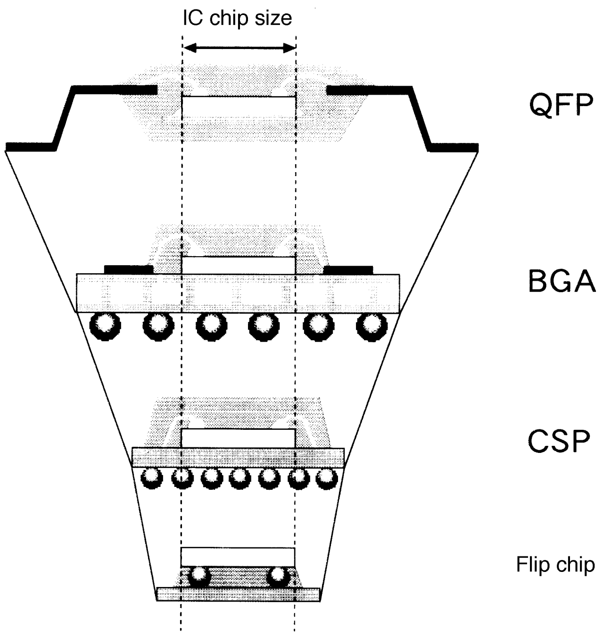


Fig. 1-3. Comparison of the areas for IC chip mounting

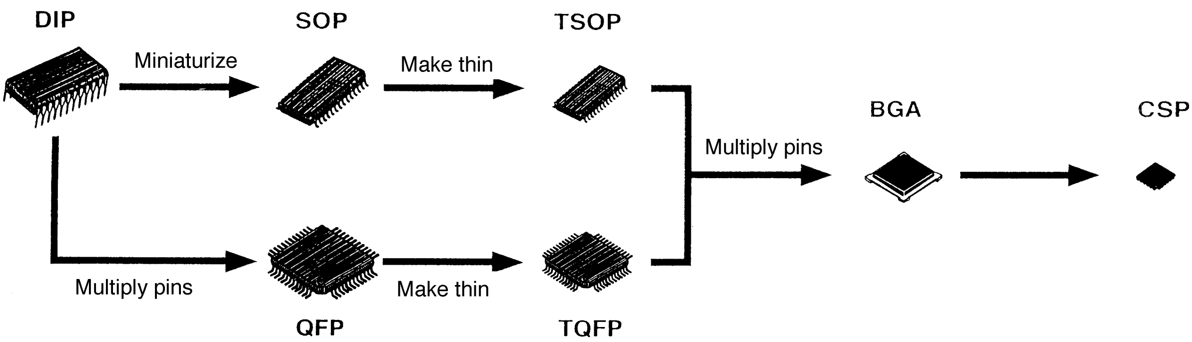
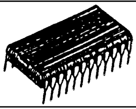
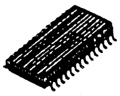
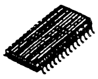
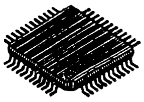
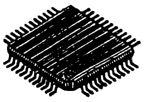
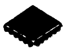


Fig. 1-2 Evolution of the outside of packages

Table 1-1. Features of each LSI package

Package	Appearance	Features
DIP		Dual In-line Package Package with leads that protrude from its two longer sides
SOP		Small Outline Package Package with leads that protrude from its two longer sides and are formed into gull-wing shape (L shape)
TSOP		Thin Small Outline Package SOP package, 1.0 mm thick
QFP		Quad Flat Package Package with leads that protrude from its four sides and are formed into gull-wing shape (L shape)
TQFP		Thin Quad Flat Package QFP package, 1.0 mm thick
BGA		Ball Grid Array Package with an array of bumps (ball-shaped solder) on its top or bottom surface
CSP		Chip Size Package / Chip Scale Package BGA package miniaturized to the size of a chip on a little larger, and having narrow-pitched bumps

2. Instant adhesive and curing accelerator for temporary fixing of the flat package

Flat packages, such as SOP and QFP, are used for double-sided printed circuit boards in audio and video equipment, such as audio and video cassette players, and in cooking equipment such as microwave ovens, electromagnetic cooking devices, and electronic pots.

The flat package must be securely fixed to the board at the correct position by the solder dip process.

ThreeBond 1738 and 1739 are instant adhesives, developed for temporary fix of the flat package. ThreeBond 1796B, 1796E, and 1796G are curing accelerators that speed up the curing of the adhesive.

Conventionally, rubber-base adhesives, double-sided adhesive tapes, or epoxy-based adhesives have been used. Rubber based adhesives, however, have low heat resistance, and often drop or move the temporarily fixed packages during the solder dip process. Double-sided tape is not practicable, because it is difficult to correct the position of a package after it is fixed to the board. Epoxy-based adhesive has to be cured in an oven, and the packages tend to move during heating. Further, the adhesive might melt and flow into the terminals, causing failures. The packages can be soldered manually with a soldering knife, using no adhesives, but this method requires skill and is especially difficult for narrow pitch terminals.

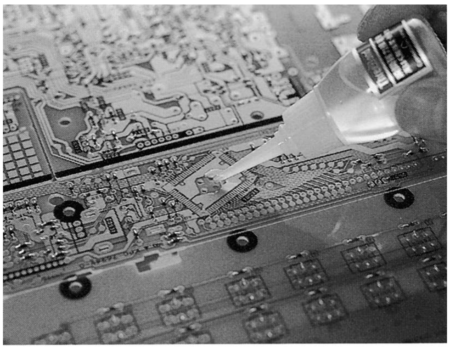
With Three Bond adhesives and curing accelerator, a flat package can be securely bonded and fixed, and the adhesive takes only a few seconds to cure. No special skill is required, and the process can be automated.

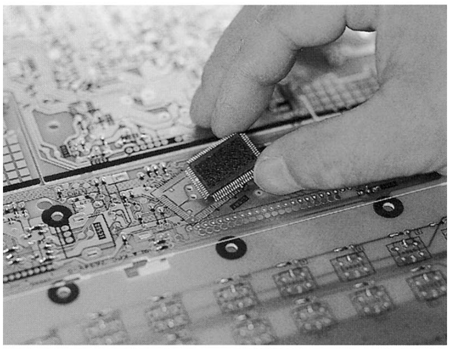
2-1. How to use ThreeBond 1738 and 1739

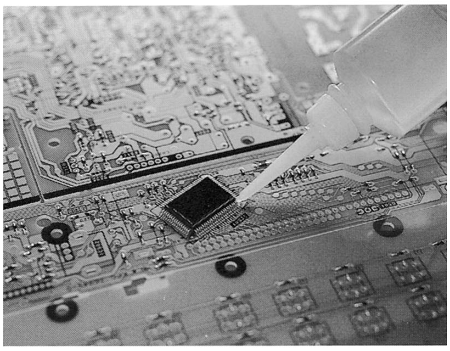
(1) Apply an appropriate amount of the instant adhesive, usually about 0.01 g, to the surface to be bonded.

(2) Place the flat package in position.

(3) Apply the curing accelerator from between the flat package and the panel. Because of the capillary effect, the curing accelerator disperses to the entire surface of the flat package, and cures instantaneously.







The solder dip process

2-2. Properties (Table 2-1)

The adhesive comes in the form of gel, and will not run down even on an inclined workbench. It has a relatively slow setting time (30 to 40 seconds), so positions can be adjusted after the adherends are positioned.

2-3. Curing speed (Fig. 2-1)

The use of the curing accelerator makes it possible to fix a flat package in 2 to 10 seconds.

2-4. Insulation resistance to moisture

Table 2-2 shows the insulation resistance measured on comb-shaped electrodes onto which ThreeBond 1738 and 1739 were applied and cured with ThreeBond 1796E.

Whether voltage is applied or not, the insulation resistance does not deteriorate even after long exposure to high temperature and humidity.

2-5. Influence of the curing accelerator on the flux

Two types of flux have been tested. ThreeBond 1796E was added to each of them by 10% in weight, and the flux impedance of them was measured after one day and again after five days at room temperature, using comb-shaped electrodes.

The color of the flux might change when the curing accelerator is added, but its insulation property remains unchanged.

2-6. Notes to remember when using the adhesive

To reduce failures, read the following before using the adhesive to fix the flat package.

Make holes in the panel on which the flat package is to be installed (see the photos in section 2-1). These holes serve two purposes: They let the excess adhesive flow to the back of the board instead of spreading over the terminals. Also they release the gas generated during the solder dipping process and prevent the flat package from floating, moving, or falling.

When you shift from a manual soldering process that does not use adhesive to the method proposed here, check the location of flat packages and peripheral parts to prevent the solder from bridging between leads during the solder dipping process.

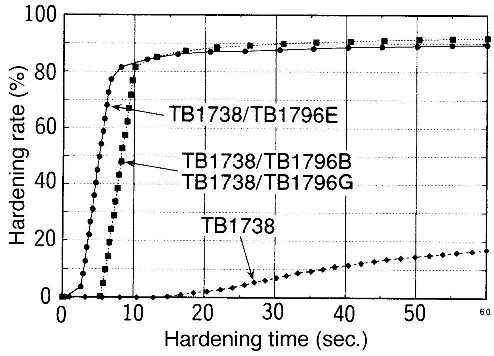


Fig. 2-1. Curing rate of ThreeBond 1738

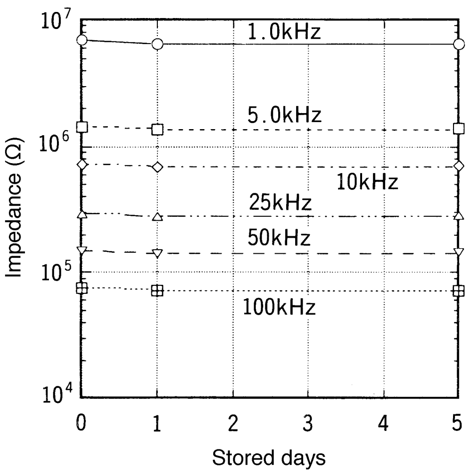
Table 2-1. Properties and characteristics of the instant adhesive and its curing accelerator for temporary fixing of the flat packages

	Instantaneous adhesives		Hardening accelerators		
	TB1738	TB1739	TB1796B	TB1796E	TB1796G
Main component	Ethyl-2-cyanoacrylate		Amine compound		
Appearance	Light blue	Colorless, transparent	Light yellow, transparent	Light yellow to Light brown, transparent	Light yellow, transparent
Viscosity mPa·s {cP}	5000 {5000}	23000 {23000}	0.9 {0.9}	0.9 {0.9}	0.9 {0.9}
Thixo ratio	5.5	4.5	——	——	——
Specific gravity	1.04	1.03	0.82	0.86	0.82
Features	• Gel-type instantaneous adhesive • No flow after application onto a vertical surface • Easy to handle	• Gel-type instantaneous adhesive • No flow after application onto a vertical surface	• High-speed curing hardening accelerator	• Super-high-speed curing hardening accelerator	• High-speed curing hardening accelerator • Not subject to the Organic Solvent Intoxication Prevention Regulations
Product shape	20 g plastic bottle	20 g aluminum tube 500 g plastic bottle	45 g plastic bottle	50 g glass bottle	500 g glass bottle

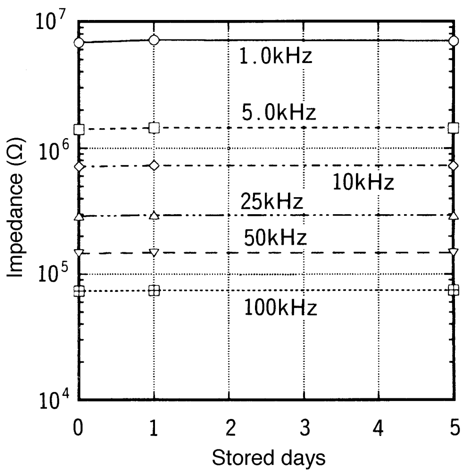
Table 2-2. Insulation resistance of the cured adhesive when exposed to high humidity environment

	Setting time at 60°C, 95% RH				Applied voltage
	Initial	24-hours	100-hours	500-hours	
TB1738/ TB1796E	$1.7 \times 10^{12}\ \Omega$	$1.0 \times 10^{13}\ \Omega$	$6.2 \times 10^{12}\ \Omega$	$1.0 \times 10^{12}\ \Omega$	None
	$6.4 \times 10^{13}\ \Omega$	$1.0 \times 10^{13}\ \Omega$	$7.3 \times 10^{12}\ \Omega$	$2.3 \times 10^{12}\ \Omega$	DC 100 V
TB1739/ TB1796E	$1.0 \times 10^{12}\ \Omega$	$5.9 \times 10^{12}\ \Omega$	$8.5 \times 10^{12}\ \Omega$	$1.2 \times 10^{13}\ \Omega$	None
	$1.3 \times 10^{12}\ \Omega$	$9.1 \times 10^{12}\ \Omega$	$3.8 \times 10^{12}\ \Omega$	$7.1 \times 10^{11}\ \Omega$	DC 100 V

Test sample : A comb-shaped electrode specified in JIS C 6480, type 2



Flux : CF-100VS (Tamura Kaken Corp.)
Electrode : A comb-shaped electrode specified in JIS C 6480, type 2
Measured frequency : 1.0 to 100 kHz



Flux : CF-330VS (Tamura Kaken Corp.)
Electrode : A comb-shaped electrode specified in JIS C 6480, type 2
Measured frequency : 1.0 to 100 kHz

Fig. 2-2. Influence of ThreeBond 1796E on flux

3. Mounting adhesive for BGA and CSP

The continuing need for ever smaller, more densely integrated electronic parts makes high density mounting necessary. The conventional QFP imposes limits on the possible number of pins because of its line arrangement. Also, it requires circuit boards whose surface areas may range from a few times as large, to a few tens of times as large, as that of the internal chips.

At present, the packages most widely used are BGA, and its variant, CSP, also called FPBGA (Fine Pitch Ball Grid Array). CSP is a narrow-pitch version of BGA; the packages are about the same size as the chips, or slightly larger.

BGA and CSP have several advantages over QFP:

* They require less surface area.
* They offer a larger tolerance for height variations, because the solder balls are fused for connection.
* They avoid lead deformation, which can occur in QFP mounting
* They have an effect of self-alignment, because of the surface tension of the solder balls when they are fused. By this effect, any mounting deviation can automatically be corrected up to 0.6 mm for a 1.5-mm-pitch package (Fig. 3-13).

We will not go into details here, but the mounting yield has improved and is now better than that obtained with QFP.

3-1. Sealing resin for the BGA/CSP mounting

The solder joint for the BGA/CSP mounting is small, only 0.2 to 0.5 mm in diameter. To improve the reliability of the connection against external stress, a sealant called underfill is placed between the package and the board. Epoxy resin is most commonly used for this sealant.

An underfill must have the following properties:

1. It must maintain connection reliability in repeated cycles of low to high temperature shift.
2. It must resist solder reflow.
3. It must be repairable.

For productivity, the underfill must cure at low temperature in a short time. Our recommended one-part, low-temperature-curing epoxy resin is ThreeBond 2206; its properties are shown in Table 3-1.

The conventional one-part epoxy resin had to be heated at least to 80°C for curing. ThreeBond 2206 needs to be heated only to 60°C, but still offers excellent bonding strength, for a one-part epoxy resin. The glass transition point of ThreeBond 2206 is only 107°C, but it offers sufficient reliability.

The repairability and the reliability of a bond are mutually contradictory; priority has to be carefully given to one or another. A package bonded with ThreeBond 2206 can be peeled off the board with a scraper after the package is heated to 180°C and above.

3-2. Conclusion for the BGA/CSP mounting

Because of the advantage, that BGA and CSP offer in surface area and yield, their use is sure to increase. Accordingly, the demand for improvement in the productivity and reliability will increase. Resin manufacturers must continue to develop resins for the purpose.

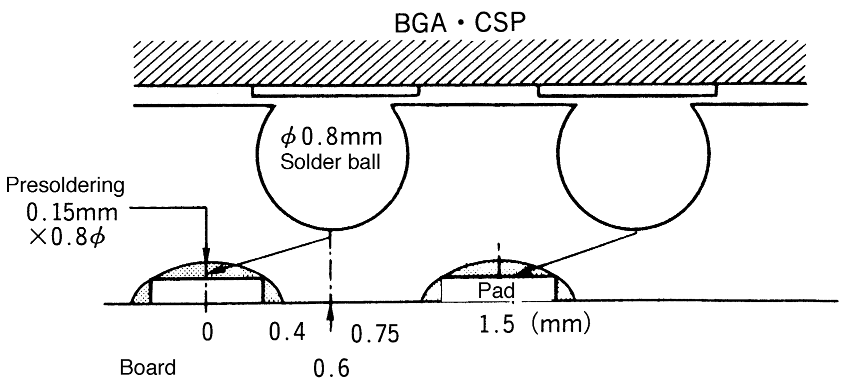


Fig. 3-1. Self-alignment effects (1.5-mm pitch)

Table 3-1. General properties of ThreeBond 2206

	Unit	ThreeBond2206	Test method
Appearance		Black liquid	3TS-201-02
Viscosity	Pa·s {P}	100 {1,000}	3TS-210-05
Specific gravity		1.20	3TS-213-02
Standard hardening conditions		60°C × 180 min. or 70°C × 50 min. or 80°C × 20 min.	
Storage stability	Month	5	Stored in a refrigerator
Peeling adhesive strength	N/m {kgf/25mm}	785 {2.0}	3TS-304-21
Glass transition point	°C	107	3TS-501-05
Dielectric breakdown voltage	kV/mm	20	3TS-406-01
Water absorption rate (%, 1h)	%	+2.9	Conforms to JIS K 6911

Hardening condition 70°C × 50 min

4. Flip chip mounting adhesive

One of the technologies that support making mobile information equipment thinner and lighter while adding new features is the density in which semi-conductors can be mounted. The flip chip mounting method is especially noteworthy. It uses adhesives resulting in short connection passes and excellent frequency characteristics.

To fix a bare chip (an IC chip that is not packaged) by flip chip connection (mounting the semiconductor circuit face down) using an adhesive, equipment manufacturers have developed and reported their own unique methods, described in Fig. 4-1.

Three Bond has developed and marketed some underfill agents of the pressure-bonding type, used as described in Figure 4-1, b and e, as well as electrically anisotropic paste used as shown in Figure 4-1, d. These applications are described below.

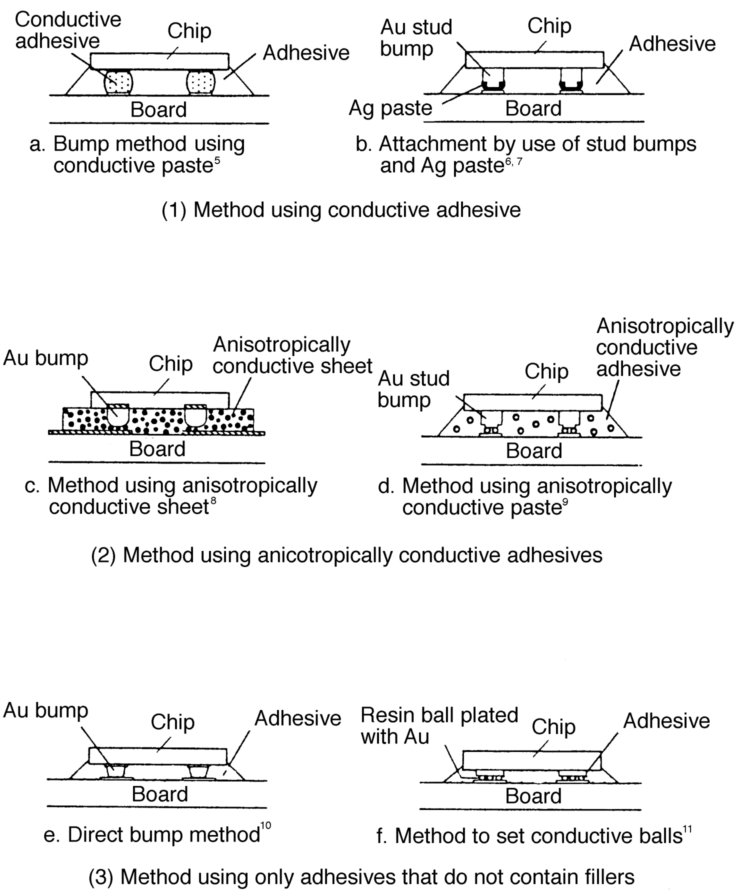


Fig. 4-1. Different methods of bonding bare chips by flip chip connection

4-1. Pressure-bonding underfill agent

A few different methods are available to make electric connection for the flip chip mounting. As was explained in the section about the underfill agent for the BGA/SCP mounting, underfill agents are also indispensable for flip chip connection, to maintain the reliability after mounting. Today, Three Bond offers three products--ThreeBond 2271, 2271B, and 2271C--for pressure-bonding an underfill agent. Each of these has a different viscosity and filling agents, for different applications. Table 4-1 shows the general properties and characteristics of these three products.

Common characteristics:

1) Long potting life:
   8 hours at 25°C
2) High reliability:
   -40°C to 125°C for 1,000 cycles or over
3) Low concentration of chlorine ion:
   10 ppm or below

Table 4-2. General properties of pressure-bonding underfill agent

Item	Unit	ThreeBond2271	ThreeBond2271B	ThreeBond2271C	Test method
Appearance	——	Light yellow liquid	Light yellow liquid	Light yellow liquid	3TS-201-02
Type of filler		Silica	Alumina	Alumina	——
Viscosity	Pa·s {cP}	17 {17000}	12 {12000}	4 {4000}	3TS-210-05
Thixotropy		1.0	1.0	1.0	
Specific gravity of hardened substance		1.47	1.65	1.47	3TS-213-03
Glass transition point	°C	120	125	125	3TS-501-05
Thermal expansion coefficient α1 α2	ppm/°C	50 130	52 130	55 150	3TS-501-05
Impurity ion density Cl Na K	ppm	< 10 < 10 < 10	< 10 < 10 < 10	< 10 < 10 < 10	3TS-511-01
Shearing adhesive strength	MPa{kgf/cm^2}	> 9.8 {100}	> 9.8 {100}	> 9.8 {100}	3TS-301-11
Standard hardening conditions temperature time post-cure		150 ~ 180°C 30 ~ 120 sec 150°C 2 hours			

4-2. Microencapsulated anisotropically conductive adhesives

Microencapsulated (MC) anisotropically conductive adhesives are designed for fine-pitch connection, low connection resistance, and simple mounting. A conductive Ag filler dispersed in the epoxy-based adhesive gives it anisotropically conductive features. The Ag filler is covered beforehand with a layer of insulation resin about 1,000 Å thick. Only the MC fillers that are pressed between the bump and the electrode become conductive, because the pressure breaks the insulation layer. The MC fillers between the electrodes receive no pressure, and they maintain insulation even if they are in contact with one another. After pressure is applied, the adhesive is heated until it is cured. As it cures, it shrinks, securing the IC chip on the board and maintaining electric conductivity.

Characteristics

1) Fine pitch connection supported

Over 10^{10} Ω has been recorded in an insulation test by use of a comb-shaped electrode with gaps of 10 µm.

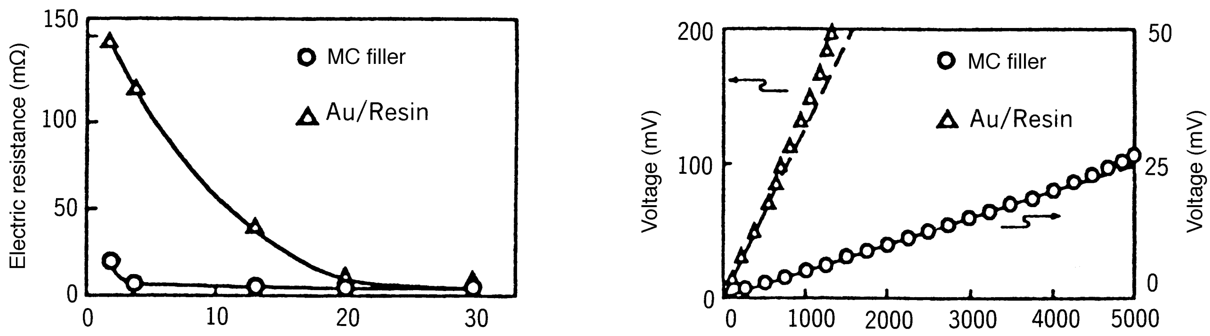
2) Low resistance

The electrical resistance of anisotropically conductive adhesive with conductive resin particles coated with gold (Au/resin) was compared with that of the anisotropically conductive adhesive with MC fillers in Fig. 4-2. As you see, the resistance recorded for the adhesive with MC fillers was 2 to 3 mΩ, 1/10 to 1/50 that of the Au/resin adhesive. Also, critical current, which is the maximum electric current that can flow through the connection point without changing the resistance, is 4,000 mA, 8 times the value for Au/resin.

3) Simple mounting

The process of electric connection and resin sealing is completed by pressurizing and heating the chip after it is aligned.

An anisotropically conductive adhesive of this type can be adapted to users' needs by altering the resin sealant (the base), the diameter of the MC fillers, and the amount of filler to be added. Table 4-2 shows the general properties of prototype 33A-469B, an adhesive of this type.



(a) Relation of pressure to electric resistance (b) V-I characteristic

Fig. 4-2. Electrical properties

Table 4-2. General properties of 33A-496B

Item	33A-496B	Test method
Appearance	Gray liquid	3TS-201-02
Viscosity	24 Pa·s {24000cP}	3TS-210-05
Filler	Silica	
Conductive filler	5 ~ 10 µm Ag 5 vol% Coating with thermosetting resin	
Electric resistance	< 10 mΩ	
Dielectric resistance	> 10^{10} Ω	DC 10 V
Shearing adhesive strength	> 6.9 MPa {70 kgf/cm²}	3TS-301-11
Standard hardening conditions temperature time post-cure	 150 ~ 180°C 30 ~ 120 sec 150°C 2 hours	

4-3. Future issues

The flip chip mounting with adhesive depends heavily on the method of each equipment manufacturer. The chip, the boards, and the mounting conditions differ and are customizable. This method is still in development, and needs a series of technical breakthroughs. Both the underfill agent and the anisotropically conductive adhesive need further improvement, to meet various users' requirements, such as other mounting methods.

A problem not yet solved is how to repair failures found after the mounting. This problem must be approached by developing adhesive chemistry as well as controlling mounting conditions.

Three Bond Co., Ltd.
Research and Development Division
H. Mikuni
T. Haijima
K. Kuboyama

References

1) Collection of Precision Bonding Techniques (Latest Version), Comprehensive Technology Center Inc.
2) Road Map for Semiconductor Packages, The Electronic Industries Association of Japan, Electronic Device Department.
3) E. Hagimoto: "All about the CSP Techniques," p. 26
4) T. Satoh: "Bonding Technique for the Anisotropically Conductive Adhesive," The Journal of the Institute of Circuit Mounting Technology Vol. 10, No 6, (1995).
5) R. Estes: "Polymer Flip Chip PFC: A Technology Assessment of Solderless Bump Processes and Reliability" Proceedings of the Adhesives in Electronics 94, Berlin, November2-4,1994.
6) Y. Matsumoto, A. Fujii, K. Kakui, Y. Kamiya, Y. Sasaki, H. Kira: "Solderless Micro Bonding," Japan Welding Society, Micro-Bonding Research Paper MJ-230-94 (1994-9)
7) Y. Tomura, Y. Bessho, M. Ono, K. Tsukamoto, T. Ishida, K. Omoya, T. Kobayashi: "Flip-Chip Mounting Using Anisotropically Conductive Adhesive," Electronic Materials, No.9 (1994), 22
8) T. Tsukakoshi, A. Nakajima, H. Kobayashi, K. Ueno: "Current Status of High Density Mounting Using Ansotropically Conductive Film," MES '95 reports, pp.139-142(1995-4)
9) H. Date, Y. Hozumi, H. Tokuhira, M. Usui, E. Horikoshi and T. Satoh: "Anisotropic Conductive Adhesive for Fine Pitch Interconnections", Proc. of ISHM Fall Meeting 1994(1994-11)
10) K. Hatada: "Bump Direct Connection," Circuit Mounting Institute, Study Group, Fluxless Soldering Technique and Trend of the Solderless Bonding Technique, pp 29-33, 1995.3.
11) T. Nukui: "One Method of Low-Temperature Solderless Bonding: Elastic Method," Low-Temperature Bonding and Solderless Bonding-Advanced Mounting Research Report, Print Circuit Institute, Advanced Mounting Research Department, pp 68-75, (1993-7)

ThreeBond
TECHNICAL NEWS
THREE BOND CO., LTD.
1456 Hazama-cho, Hachioji-shi, Tokyo 193-8533, Japan
Tel: 81-426-61-1333