APPLICATION NOTE

APN3001: Epoxy Die Attachment for GaAs Flip Chip Devices

This application note describes the recommended method for die attachment of GaAs flip chip devices. A major concern in developing a process using epoxy as the attachment material for assembly is the exposure to temperatures and subsequent cooling during epoxy curing or the ability of the epoxy to withstand temperature cycling. All this can cause flexible PC boards to expand and contract, causing stress on the dissimilar materials of the assembly.

The epoxy to be used in the die attach process must be capable of handling these stresses; the stresses are transferred to the silver epoxy at the interface of the die and the board. The epoxy joint volume and height will determine the strain that the epoxy joint undergoes, directly affecting the reliability of that joint between die and substrate or PC board. An increase in the volume and height of the column will decrease the strains within the epoxy joint. Care must be taken with the increase in epoxy volume, as an increase in resistance may also occur that may impact electrical performance.

Dispensed Epoxy Characteristics

The first step in developing a die attach process for the flip chip devices is to select an epoxy that is capable of handling the stresses of temperature cycling and the expansion and contraction of a flexible PC board (FR-4, epoxy-glass). There are many epoxy materials available for such applications. The one recommended and used to develop the process described here for attaching the flip chip devices is Ablebond 8380 Electrically Conductive Die Attach Adhesive manufactured by Ablestik Electronic Materials and Adhesives of California. This material is fast curing and is flexible, making it ideal for high thermal stress conditions.

The epoxy die attach machines used to dispense the epoxy material typically have two arms that pivot from epoxy dispense mode to a pick and place die pick up tool. When in the dispense mode, the epoxy is dispensed from a reservoir by a fish line wire, stamping tool or nozzle, in which a 'tear drop' of epoxy is placed on the tip of the wire or stamping tool, ready to be positioned onto the substrate or PC board. The epoxy dot size is typically 0.008" in diameter and approximately 0.001" in height or bondline. This size is adequate in that it facilitates a good fillet of epoxy around the die but not enough to cause the epoxy to bridge or short out the contact pads of the flip chip device.

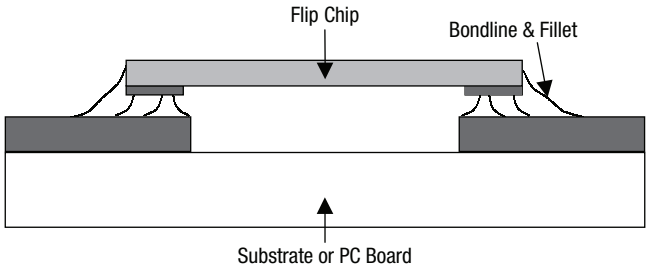

Figure 1. Epoxy Bondline Thickness and Fillet

Epoxy Cure Process

Cure epoxy material per the manufacturer's recommendations, by convection or infrared ovens. The curing ovens should be clean and not used for other purposes, or for curing other types of epoxies, as this may adversely affect the epoxy being cured. The curing process should be held as close as possible to a constant temperature. When a box oven is used for curing and the product is placed into the oven, the oven should not be opened until the cure time is reached. This will insure that the product has reached full cure time at the recommended temperature.

There are some important factors to consider when determining cure time for a given epoxy attach process. One is to fully understand and take into account the overall mass of the assembly to be cured. Next, a study of the time-to-temperature ratio of the assembly should be determined. This is to insure the assembly has reached the recommended cure temperature of the epoxy. With these factors understood, the recommended cure process may commence.

Die Shear Evaluation

A die shear evaluation was performed to determine the integrity of the die attach process after subjecting the epoxy attached assemblies to temperature cycling.

A sample of fifty flip chip devices were epoxy-attached to an FR-4 circuit board per epoxy attach recommendations. The assemblies were subjected to a visual inspection of 30x and 100x after die attach and epoxy cure, for epoxy or die fractures, with no defects observed. The devices were also electrically tested to insure continuity to the circuit board. The assemblies were temperature cycled at -65° to +125°C, no dwell, and 30 minutes at each extreme for 25 cycles.

Once temperature cycling had been completed, the assemblies were visually inspected (30x and 100x) and electrically tested with no defects observed. All fifty flip chip devices underwent shear testing according to MIL-STD-750, Method 2017 with the results shown in Table 1.

Force/Code	Force/Code	Force/Code	Force/Code	Force/Code
300 g/1	150 g/1	100 g/1	350 g/1	200 g/1
100 g/1	200 g/1	150 g/1	400 g/2	200 g/2
300 g/1	200 g/1	150 g/2	200 g/1	150 g/1
200 g/1	200 g/1	100 g/1	100 g/1	250 g/1
300 g/2	200 g/1	100 g/1	450 g/2	250 g/1
400 g/2	350 g/1	100 g/1	200 g/2	350 g/2
100 g/1	150 g/1	150 g/1	250 g/1	250 g/2
250 g/1	100 g/1	200 g/1	100 g/1	400 g/2
150 g/1	200 g/2	100 g/1	250 g/1	100 g/1
350 g/1	300 g/1	150 g/1	250 g/1	200 g/1

Die Shear Code
1 = Die break leaving 100% residual GaAs material on surface of substrate.
2 = Die lift leaving no residual GaAs material on surface of substrate.
Minimum force for GaAs material is one half (1/2) that of silicon.
Code 1: Minimum force 100 grams.
Code 2: Minimum force 200 grams.

Table 1. Die Shear Data

Temperature Cycle vs. Die Shear

The purpose of this evaluation was to determine if multiple temperature cycling would degrade the mechanical integrity of the epoxy die attach. A sample of thirty flip chip devices were epoxy attached to FR-4 boards using Skyworks Solutions' epoxy attach process recommendations described above.

The format for this evaluation was to run a series of temperature cycles (-65° to +125°C, no dwell, and 30 minutes at each extreme) for a total of 150 cycles. All assemblies were visually inspected at 30x and 100x and electrically tested for continuity before and after each set of 25 total cycles. Die shear tests were performed on groups of five (5) flip chip devices after each 25 cycles for a total of 150 cycles for the final five flip chip assembles. The conclusion of the 150 cycles showed no degradation in die shear.

Number of Cycles	Sample Number	Force/Code
25	1	100 g/1
	2	150 g/1
	3	100 g/1
	4	150 g/1
	5	300 g/2
50	6	200 g/1
	7	300 g/1
	8	200 g/2
	9	150 g/1
	10	100 g/1
75	11	150 g/1
	12	250 g/1
	13	100 g/1
	14	150 g/1
	15	150 g/1
100	16	200 g/2
	17	100 g/1
	18	200 g/1
	19	100 g/1
	20	300 g/1
125	21	200 g/1
	22	250 g/1
	23	300 g/1
	24	200 g/1
	25	150 g/1
150	26	200 g/1
	27	350 g/2
	28	100 g/1
	29	100 g/1
	30	100 g/1

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Table 2. Die Shear vs. Temperature Cycling (150 Total Cycles)

Conclusion

The epoxy die attach process outlined for the Skyworks Solutions' GaAs flip chip devices and the use of Ablestik Ablebond 8380 stress absorbent conductive epoxy should produce a consistent process and reliable bond.

1. Cleanliness: It is a good idea to clean flexible or hard substrates to free them of contaminants before epoxy die attachment takes place.
2. Epoxy Storage: Adhesive should be stored per the manufacturer's recommendations.
3. Epoxy Dispensing: Dispensed epoxy dot size approximately 0.008" and a bondline thickness of approximately 0.001" between die and substrate.
4. Die Attachment: Align bond pads of device to dispensed dots, using even force of approximately 30 grams of bond force.
5. Epoxy Curing: Cure per manufacturer's recommendations. Once product is placed into curing operation, product in process should not be disturbed.
6. Attachment Quality: The strength of the die attachment can be verified by stressing the attachment joint to failure by performing die shear test on a sample basis. The force of the shear test equipment on the die is increased until the component pops from the surface of the circuit recording a gram force value at the time of fracture from substrate. This value for pass or fail criteria is based on the contact bond pad size of the die and compared against MIL requirements.