Soft Solder Die-Attach

APPLICATION NOTE

Power semiconductor devices are ubiquitous in electronic equipment running over 10Watts. These power devices convert AC to DC, and vice versa; regulate voltage; switch high currents on and off; and prevent voltage spikes from damaging sensitive electronic equipment. They are found in automobiles, trains, computers and power stations. Solder is the most commonly used metal-metal joining material used in power semiconductors, because it provides the most reliable and effective means of conducting both electricity and heat.

Although flip-chip and other package types are becoming much more prevalent, semiconductor devices are still most commonly packaged as leadframe devices. Die attach is the process of affixing silicon die or chips to a leadframe or other substrate with adhesive, conductive adhesive or solder. The die-attach bond is normally between the back (non-functioning side) of the die and the metal surface of the leadframe.

Most packages are subject to extreme variations of temperature during operation. To properly dissipate thermal energy in such instances, solder is the favored material for die attach to a leadframe, especially for power devices, or for rapid mounting of inexpensive devices. The thermal conductivity of a metal solder is useful in dissipating the heat generated by power devices. Solder also provides enough mechanical strength and fatigue resistance to withstand the considerable mechanical and thermal stresses generated.

Preforms, wire or paste are the most common forms of solder used in die attach processes.

- Preforms are typically handled in a batch process where they are placed into an aluminum or graphite fixture, then reflowed in a batch vacuum oven or in-line oven.
- Solder paste is dispensed, then reflowed similarly to preforms. Usually an aqueous cleaning step is required before the device is encapsulated in molding compound.
- In the fluxless solder wire process, the wire is auto-fed into an in-line system where it contacts a preheated leadframe which melts the solder. After forming the solder deposit, a “spanker” may contact the solder to flatten it and form it into the desired shape. The wire volume is controlled via tight diameter tolerances and a precise stepper motor.

The solder alloys used in die attach usually are in the 275-345°C (liquidus) range, either to resist subsequent reflow during surface mounting, or, in the case of power devices, to allow higher device operating temperatures without joint failure. Due to the high melting temperature, solder-based die-attach processes usually require the use of forming gas, a mixture of hydrogen (typically 1-5%) and nitrogen.

Although the power semiconductor industry is trying to shift away from the use of high-Pb solder materials, the alternatives are typically either expensive or not as malleable as the Pb-bearing materials.

Alloy	Solidus (°C)	Liquidus (°C)	Remarks
96.5Sn3.5Ag	221	221	Pb-Free Alloy
65.0Sn25.0Ag10.0Sb	233	233	Pb-Free J Alloy
95.0Sn5.0Sb	235	240	Pb-Free Alloy
80.0Au20.0Sn	280	280	Pb-Free Alloy
81.0Pb10.0In	260	275	Good Thermal Cycling
92.5Pb5In2.5Ag	300	310	Good Thermal Cycling
95.0Pb5.0Sn	308	312	Good Thermal Cycling
92.5Pb5.0Sn2.5Ag	287	296	Industry Standard

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