

Considerations in selecting electrically conductive epoxies for die bonding*

Epoxy die bonding is a relatively new technology rapidly gaining in popularity over conventional eutectic die bonding in micro-electronics applications. This technique basically involves depositing a small, controlled amount of an electrically conductive epoxy on a substrate. A chip is then placed into the mound of epoxy and cured in an oven at low temperature. Conductive epoxies can be used to bond chips of all types: resistors, capacitors, transistors, LSI, MOS, C/MOS, ICs, LIDs, and LEDs. Both silver and gold-filled epoxies have been used successfully in a wide variety of commercial and military applications.

In selecting the proper gold or silver epoxy for your particular application, several factors must be considered. First, it is extremely important that the epoxy selected contain no solvents or thinner. The biggest problem with a system containing solvents is outgassing. In addition, solvents produce several other undesirable side effects. For example, solvent bubbles trapped beneath a chip expand when heat is applied to the chip during thermal compression wire bonding. This, in turn, can cause a significant weakening of the bond between the chip and the substrate. The thermal resistance of such a bond is also poor.

Another problem can occur when an epoxy system containing a solvent is used in screen printing. Evaporation of the solvent makes it considerably more difficult for the conductive epoxy to pass through the screen and onto the pad being screen-printed. Even when a pad has been screened with an epoxy containing a solvent, care must be taken that the chips are placed on the pad at once. Otherwise the solvent will evaporate and skinning will occur on the surface, making die placement difficult and time consuming. Of course, in many applications it is not possible to put the chips in place immediately—and this constitutes another major disadvantage of epoxies with solvents.

Conductive silver or gold epoxies should be of a soft thixotropic nature designed for use with epoxy dispensing machines and/or screen printing. These are the two most frequently used techniques in production applications.

High electrical conductivity that is fully reproducible and does not change with time is another important requisite of conductive epoxies. Typical values for conductive epoxies used in chip bonding are as follows: one-component silver, one-component gold, and two-component silver: 0.0001 to 0.0005 ohm-cm; two-component gold: 0.0005 to 0.0009 ohm-cm.

Ideally, conductive epoxies should be cured at low temperatures and as quickly as possible. Two-component epoxies can be cured very rapidly at elevated temperatures or more slowly at very low temperatures. One-component systems, on the other hand, cannot be cured at low temperatures. However, a one-component system does not re-

quire weighing and mixing and offers a longer pot life. Thus, one might say that in deciding between a one- or two-component epoxy, one should be prepared to make trade-offs among curing, ease-of-use, and pot life factors. Some typical curing cycles for one- and two-component epoxies are as follows: one-component silver and one-component gold epoxies: 1 hr at 120°C or ½ hr at 150°C; for two-component silver and two-component gold epoxies: 5 min. at 150°C or 30 min at 100°C or 12 hr at 50°C.

Any conductive epoxy selected must be capable of withstanding both ultrasonic wire bonding or thermal compression bonding in the 300° to 400°C range.

Since chemicals and solvents are involved in the production of circuits, it is vital that any conductive epoxy be resistant to such materials. The epoxy should be able to withstand high humidity environments. Another important guideline to the proper selection of conductive epoxies is that it must be able to pass thermal shock testing in the -65° to 200°C range.

At the present time, one-component gold and silver systems are in greater demand than two-component epoxies, probably because they are somewhat more convenient to use. Even so, there are some special points that must be considered in selecting one-component systems. First, the matter of storage. A number of one-component systems on the market require refrigerated storage and must be specially packed and shipped under refrigeration. Some of these systems must be discarded and replaced with new epoxy when left in an epoxy dispensing machine for as little as a one-week period. Not only does this constitute an unnecessary inconvenience, but it is also costly for the user.

There are available in the marketplace, however, modern one-component systems that overcome these problems. These epoxies are stable at room temperature for as long as six months, can be left in a dispenser for protracted periods, and can be shipped anywhere in the world without the necessity of refrigeration. Thus it is no longer necessary for users to provide special storage facilities for one-component gold or silver epoxies.

After all of the above factors have been weighed, there is one additional consideration: reliability. Find out as much as possible about past performance of the epoxy in similar applications, and check to see if the manufacturer has any reliability data on his products. Also, determine how long the product has been on the marketplace, since usage over a considerable period of time can be an indicator of a product's reliability. Some epoxies have been known to provide good performance for a few months and then break down unexpectedly. •

* Courtesy F. W. Kulesza, Epoxy Technology, Inc.