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Tutorial 83 - - April 2008

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Soldering Stud Bumps

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Aluminum stud bumps. Copper stud bumps. Gold stud bumps. Which one is best? The answer depends on what you are trying to do. CVInc has developed a practical method to convert stud bumps to solder bumps, using a wide variety of conventional and lead-free solders.

Bumping single die is often preferred in flip chip assemblies for both product development. prototypes and for low-rate production. The premature expense of full-wafer bumping is difficult to justify before a proven design with full-rate production potential is realized.

CVInc has developed a wide range of single die stud-based solder bumping approaches, including include aluminum, copper, and gold stud bumps, as well as modified "barrier bumps" with a variety of solders.

Gold Stud / No solder

Gold stud bumping serves over 97% of the present stud bump market. Gold stud bumps require no special die surface treatment or under-bump metal (UBM). They are formed with a modified wire bonder, on any surface that is wire-bondable. After placing the ball portion of a gold wire bond, the wire is severed, leaving behind a gold stud. (Figure 1) Gold stud bumps can be planarized by coining, to assure uniform bump heights. Gold stud bump reliability is well documented, with many years of data.

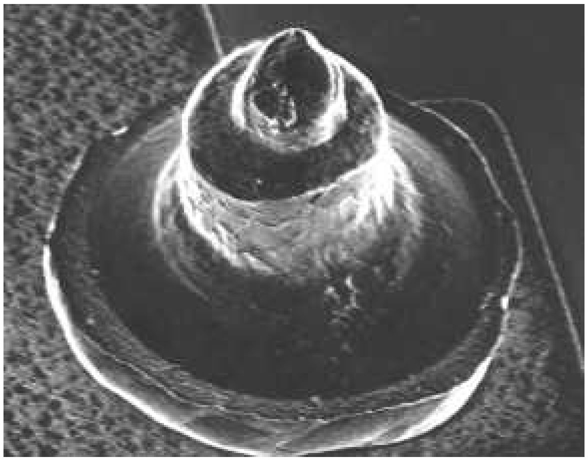

Figure 1. Conventional gold stud bump with trimmed tail, prior to adhesive bonding.

Unfortunately, gold stud bumps have several limitations for single-chip bumping. Most flip chips are intended for solder assembly onto boards or in packages. The electrical, mechanical, and thermal characteristics of gold stud bumps differ from those of solder bumps, adding a risk factor to prototype device performance evaluation. Gold stud bump connections use specialized attachment methods, such as conductive adhesives, requiring different materials, equipment, and process flows from solder attach in a standard board line. An alternative is to use a stud bump for attachment to untreated die pads, and cap it with solder for the board connection.

Aluminum Stud / Tin Solder

We found that the wedge portion of an aluminum wedge bond could be used as the "stud" foundation for a solder bump. Like a gold stud, the aluminum wedge is created with a wire bonder, so it provides electrical contact without requiring UBM. Depositing a solder sphere over the wedge provides solder-bump assembly.

However, the wedge bond base could be a reliability concern, as the dragging motion of wedge bonding can damage low-k materials. Also, wedge bonds are not consistent and repeatable in size, so the solder bumps formed on them may not have uniform heights.

Gold Stud / Indium Solder

We developed a process for converting gold stud bumps to solderable flip chip bumps using Indium-based solders. InPb has the advantage that the reflow temps are similar to eutectic SnPb solder. InAg is a lead-free, lower temperature alternative. Indium excels in temperatures ranging from room to cryonic, ideal for medical and cryonic applications.

However, indium solders in direct contact with gold cannot operate continuously at temperatures above 125C. At higher temperatures, Indium consumes the gold and will over time embrittle the solder joint.

Copper Stud / Tin solder

Another option is to use a solderable copper stud bump. Copper has the advantage that tin can be applied directly to the copper without the detrimental effects of even a small amount of gold in the tin.

However, copper stud bumping requires special processing, and there is yet no long-term reliability data for the Cu/Al intermetallics. Undesirable CuSn intermetallics might also be formed. Over repeated reflows, tin solder can consume the copper, although it is unlikely that the entire solder ball would be consumed. Each successive reflow consumes more of the copper, increasing the reflow temperature of the solder. The result could be a brittle solder alloy, leading to poor wetting and joint dissociation.

Barrier Bumps / Any Solder

CVInc has developed a simpler, faster, and lower-cost process to combine the advantages of stud bumps and solder bumps. A Ni-Au barrier layer is formed on the copper or stud as protection. The barrier layer, applied to either copper or gold stud bumps, prevents intermetallic formation between the tin and the copper or gold bump, providing a more reliable and dependable solder joint. Figures 2 through 4 show several stages of the process.

Figure 2. Gold stud bump with Ni coating. The tail was left on to show the original stud bump. Notice the relatively high bond pad after coating.

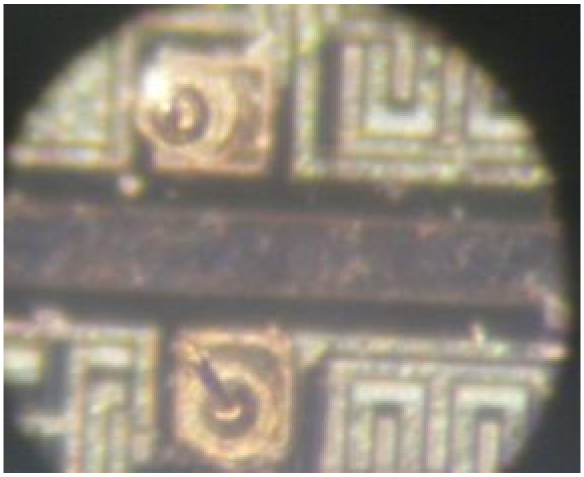

Figure 3. Ni-coated gold stud bump on aluminum pads

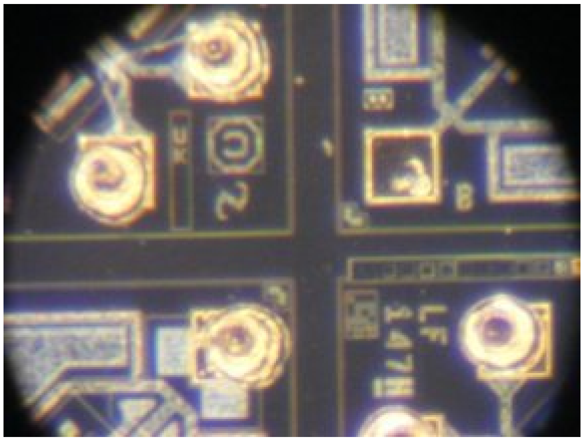

Figure 4. Ni-Au stud bumps on aluminum pads, with gold also visible on the pads

Conclusions

Solder attachment of gold stud barrier bumps streamlines the attachment process by eliminating an additional process step. Soldered barrier bump die can be placed and reflowed with the other components on the board. A thin gold contact layer for the solder alloy allows almost any solder to be used. To verify the process, CVInc has deposited a variety of In, Sn, Au and Pb alloys on the bumps.

As an extension of this proprietary technique, a similar barrier layer can be added not only to stud bumps, but also to thick film gold paste and to the sputtered metal on substrates traditionally used for wire-bonded RF components.

For More Information

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