BALL BUMPING AND COINING OPERATIONS FOR TAB AND FLIP CHIP

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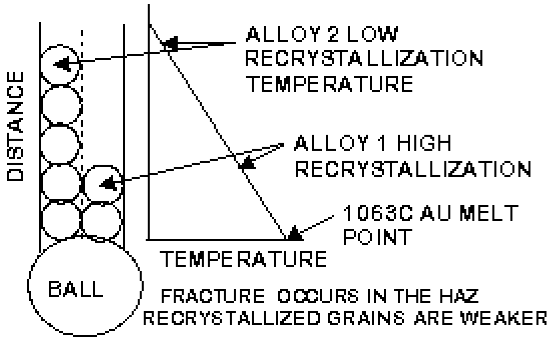
Biography

Lee Levine received the BS degree in Metallurgy and Materials Science Engineering from Lehigh University, Bethlehem, Pennsylvania, in 1972. Prior to joining Kulicke and Soffa, Mr Levine was Senior Development Engineer at AMP, Inc. and Chief Metallurgist at Hydrostatics, Inc. He has been granted three patents and has 10 publications.

Abstract:

The process of using a ball bonder to form bumps on a chip, for subsequent TAB or Flip Chip attachment to a substrate, has now reached the production stage. A number of companies are using the process for full scale production. Other companies are using the process for rapid prototyping and limited quantity production. It requires no masks, uses existing equipment, and in many cases provides the most cost effective method for depositing bumps on chips. Two process variations are prevalent.

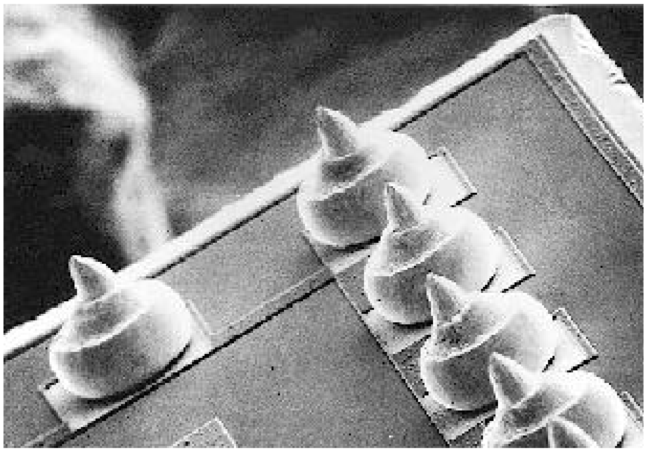
FIGURE 1. THE EFFECT OF THE RECRYSTALLIZATION TEMPERATURE ON THE LENGTH OF THE HEAT AFFECTED ZONE (HAZ).



1. Bumping and coining, is a process where a normal ball bond with a short ductile fracture tip protruding from the top of the ball is bonded to the device, then coined flat by a second stage operation. Photo 1 shows ball bumps as bonded. Photo 2 shows both ball bumps and coined bumps on the same wafer.

2. The stud bumpingprocess produces a short loop and the crescent bond is placed on the shoulder of the ball. Photo 4 shows stud bumps on a substrate prior to screen printing solder or adhesive.

PHOTO 1 SINGLE BUMPS



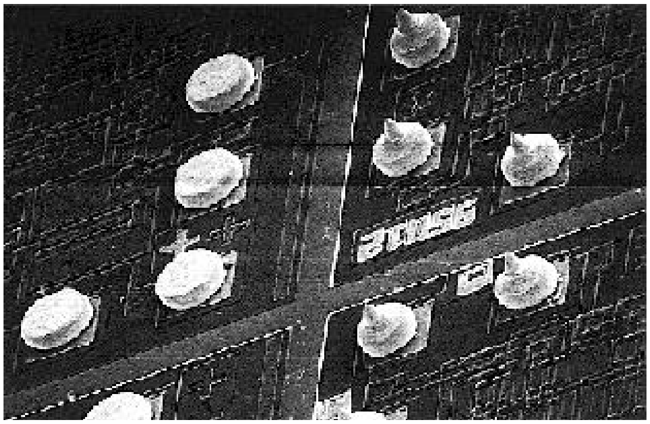
Data:

Process Description

The use of a wire bonder to produce a metal bump on a semiconductor bond pad has been available technology for several years. In this process a ball or wedge bonder thermosonically welds a metallic bump to the semiconductor bond pad. The bump may be composed of a gold alloy or a Pb based solder. It may be in the form of a ball, produced by a spark discharge from a ball bonder, or a flattened wire segment, deformed by the ultrasonic bonding wedge on an ultrasonic wedge bonder [4]. This paper will focus on the production of gold alloy balls.

Gold alloy ball bumping on a wire bonder can be accomplished with two modifications of the standard wire bonding process. First the wire bonder requires software developed specifically for the bumping process. This software eliminates the motions associated with the formation of the loop and crescent bond and enables the bonder to form the ball and bond it in one operation. All of the unnecessary motions associated with normal wire bonding are eliminated, significantly improving the bond cycle time.

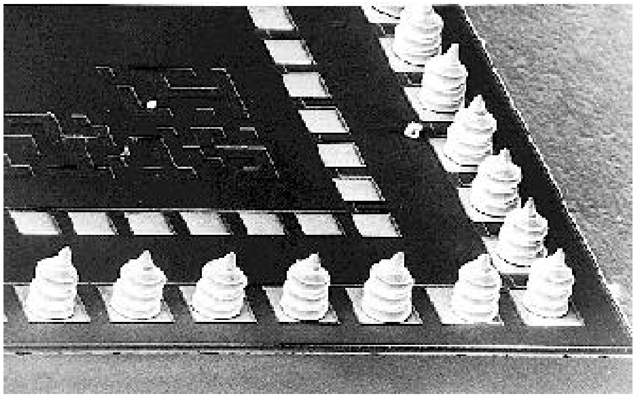
PHOTO 2 BUMPED AND COINED WAFER



The second process modification is the introduction of specially formulated wire alloys. The control of the Heat Affected Zone (HAZ), the recrystallized segment of wire directly above the ball, is most successfully accomplished by controlling the wire composition. Palladium, a common gold alloying element, has a strong effect on increasing the recrystallization temperature of the alloy[1,2]. Figure 1 illustrates how increasing the alloy recrystallization temperature has a direct effect on the length of the HAZ. This length defines the location where the wire will break during the motion of the wirebonder from the top of the ball up to the height of the EFO electrode where a new ball will be formed. Standard 99.99% Au bonding alloys, with a low recrystallization temperature, will have a longer HAZ length, increasing the variability of the break location. This variability will result in the formation of non uniform balls and in the EFO failing to discharge because of insufficient wire. The bumps in photos 1-4 are formed from a 99% Au-1% Pd alloy wire, it produces high quality, repeatable bumps.

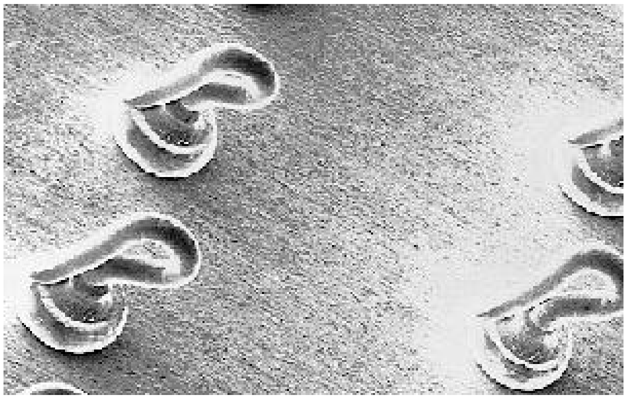
Bumping is normally the first part of a two stage process. The next stage, coining, is also accomplished on a wire bonder, using the same software as for bumping but with the ball formation motions eliminated and the bonding wire removed. Photo 2 shows gold ball bumps and adjacent coined bumps. A special, flat faced, tool is used to coin, achieving a consistent flat top surface with a repeatable height. This provides a stable surface for subsequent TAB or Flip Chip Bonding. Attempts at TAB inner lead bonding, without prior coining, have proven unreliable. The tape has a tendency to be deflected by the bump and fails to form a good bond.

PHOTO 3 STACKED BUMPS



Coined bumps have been shown to provide a good interconnection method. Interconnection by direct attachment of gold plated tape using a single-point TAB Bonder, screen printing of the bumps with solder for Flip Chip bonding, and use of Z axis conductive adhesives have all been shown to provide acceptable, commercially viable methods for attaching Ball Bumped devices.

PHOTO 4 STUD BUMP



Bumps can be stacked, to generate a significant stand off, and improved the thermal cycling life expectancy. In a 1993 paper researchers at NEC showed that the thermal cycling life expectancy of Flip Chip devices to an alumina ceramic substrate could be improved by an order of magnitude by developing a three bump stack structure [8]. A similar stack structure can be easily generated with Ball Bumps by bonding a three bump stack.

Another variation of ball bumping , the stud bump, was developed more recently. It uses the same Pd alloy wire but uses standard wire bond software. By choice of programmable parameters a cotter pin shaped bump can be generated. Photo 4 shows an example of the stud bump. It has been used commercially along with screened and reflowed solder paste for Flip Chip applications. [7].

Conclusion:

The ball bumping process is a variant of the wire bonding process that has now become a fully qualified manufacturing process. It has demonstrated reliability, high yields and low manufacturing costs. It uses available equipment and provides a versatile and flexible method for forming bumps on a chip.

References:

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