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REMOVAL OF HYBRID MICROCIRCUIT BEAM-LEAD DEVICES FOR POSTMORTEM TESTS

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ABSTRACT

Identification of the cause of a hybrid microcircuit malfunction often necessitates testing one or more of the beam-lead devices separately from the substrate on which it was bonded. This requires a removal technique that maintains the structural and electrical integrity of the device. This paper discusses a rework technique that will successfully remove beam-lead devices and do so without incurring structural or electrical damage to either the device or substrate metallization.

INTRODUCTION

The assembly of hybrid microcircuits (HMC) generally utilizes the process of thermocompression bonding to attach beam-lead components to the substrate. Several reasons may dictate the need to remove and replace one or more beam-lead devices (BLD) on a hybrid. A scrape-off technique that is generally used throughout industry to remove beam-lead devices can seldom remove the beam-lead device intact and undamaged.

This paper describes a technique that can successfully remove beam-lead devices from a hybrid and maintain the device integrity for postmortem tests, and that does not adversely damage substrate metallization or the hybrid circuit.

BACKGROUND

When production of hybrid microcircuits began the initial problem was to remove beam-lead devices and replace them. The problem was solved with the typical scrape-off technique, which involved inserting a sharp knife under the corner of a device and carefully breaking it loose. This left the beams still attached to the substrate, and the device body either broken, without beams, or both. The beams still bonded to the substrate were then scraped off using either tooling designed by the writers or commercially available equipment. This rework technique was quite adequate and successful when the only objective was to remove and replace BLD's. After the initial period of hybrid microcircuit production a need developed to know why a particular device had failed. In

almost all cases the device was destroyed during removal. The new problem was to develop a rework technique that would allow beam-lead device removal and postmortem. Figures 1 and 1A show a device that has been removed with the chip-to-beam interface intact.

Figure 1. Four-Beam Device Successfully Removed

The first approach was to use a small, very sharp knife to cut the beams between the chip and the bond. As difficult as it may seem, about 30 to 50 percent of devices were removed intact. This success

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Figure 1A. Successful Removal of 24-Beam Device

was directly dependent on the skill of the operator. Some operators could repeatably attain the 50 percent figure, while others often destroy the chip or the substrate.

DEVELOPMENT

A report by Adams and Bonham¹ states that a beam-lead bond schedule can be developed in terms of only two variables, bond force and tool temperature; these variables form a bond envelope. The other machine parameters are held constant with sufficient values to overcome machine tolerances and achieve a TC bond. A typical bond envelope is shown in Figure 2. Within this envelope the devices meet all the established criteria. In the area along line AB the force applied has resulted in excessive deformation of the beams. Pull-off testing of excessively deformed devices will result in a decrease of pull-off strength. This may be attributed to the fact that the cross-sectional zone of the heel area has been greatly decreased. A schematic of a bonded beam is shown in Figure 3. A beam with this decreased heel area characteristic will fail at the heel at a lower strength.

It was decided to test the heel failure concept for postmortem beam-lead removal, by applying a force sufficient to assure that the weak link is at the heel. One method of accomplishing this is to apply greater force, use a regular bonding tool, and make a second bond over the first.

Figure 2. Typical Bond Envelope

Figure 3. Bonded Beam-Lead Device

This method does cause the weak link to occur at the heel of the bond. However, the remaining portion of the bonded beam is so thin and well bonded that it is difficult to remove with the scrape-off tool. The next step in developing the heel-area technique was to sharpen a beam-lead bonding tool to a knife edge. The intent was to sever or nearly sever the beams at the inside (chip side) of the bond, and pull off the device. A success rate of 70 to 95 percent was attained, dependent on device size.

Two problems still required attention. Even with a sharpened tool it is not possible to completely sever the beam, especially when substrate metallization extends under the unbonded portion of the chip. Thus a very weak bond was still present, and it was still necessary to use a small microknife to break the device loose at the heel. The microknife

may damage the substrate and its use is operator-dependent. The second problem is that of being able to grind a BL tool to a sharp edge and still maintain all four sides sufficiently flat.

PRESENT TECHNIQUE DESCRIPTION

The Microswiss tool now used has a 0.001 inch wall thickness. This thickness makes it relatively easy to tool and still effectively weakens the beam. The objective is to sever the beam just inside the existing bond (Figure 4) so the device can be removed from the substrate without damaging the chip-to-beam interface. For this reason, the tools purchased from Microswiss are 0.001 inch smaller than the tool used in initial bonding. Figure 5 shows a comparison between the regular bond tool and the cut-off tool.

Figure 4. Cut-Off Tool Severing Beam

Figure 5. Comparison of Cut-Off and Bonding Tools

Beam-lead bonding to hybrid microcircuits requires a precise bond schedule that includes all bonding parameters. However, that degree of thoroughness is not necessary to determine the optimum force necessary to cut the beam for postmortem removal. To ensure maximum deformation and minimum substrate metallization damage, the applied force should be the same as the initial bonding force, because the force applied to a beam with the regular tool is different to that of

the cut-off tool. For example, beam-lead bonding of smaller devices (4-beam) at Bendix uses a force of 550 grams. When applied to a device beam with a wobble bonder and bonding on 50 percent of the beam length, this calculates as a pressure of 160,000 psi. When using the same force and a 0.001 inch wall-thickness tool, the pressure applied is 400,000 psi.

The first step in the rework technique is to perform the cut-off operation. This is accomplished by chucking the above-described cut-off tool into the tool holder of a Model 576 Kulicke and Soffa wobble bonder with the heat turned off. The hybrid microcircuit is placed on the workholder, and the beam-lead device to be removed is aligned under the tool as in initial bonding, ensuring that the inside tool edges are just inside of the initial bond. The bonder is then actuated in the bonding mode, which causes the beams to be almost severed.

The HMC is then removed from the workholder and placed on a vacuum chuck under 20 to 30 power magnification. A small microknife guided by a steady hand is used to complete severing of the beams that remain attached. Finally the device is placed on a petroleum-jelly-coated microscope slide and enclosed in a plastic container for transfer to the testing area.

CONCLUSION

In summary, a workable and successful technique for removal of beam-lead devices for postmortem has been developed. The success achieved in removing a device and placing it onto a slide without cracking the device or damaging the chip-to-beam interface is shown in Table 1.

CONTINUING EFFORT

Certain remaining disadvantages in this technique demand further work. The most obvious is the low yield of the larger devices as compared to that of the smaller devices. Efforts to improve these yields by determining the best cut-off tool size and configuration are continuing.

Most of the present effort is being directed toward eliminating the need for the microknife to complete removal. A means of pulling the device loose after cut-off is being investigated and preliminary results are promising.

Separate tooling is being developed to free the K and S 576 for use in production bonding. This tooling will allow

easy changing from one cut-off tool size to another. This work is expected to reduce capital equipment and labor costs.

TABLE 1. REMOVAL SUCCESS

Type of Device (Size in Inch)	Number of Samples	Percent Acceptable
4-beam, 0.025 by 0.025 Device A	125	99
4-beam, 0.025 by 0.025 Device B	100	90
4-beam, 0.080 by 0.080 (0.010 by 0.020 beams)	50	90
24-beam, (0.003 by 0.005 beams)	50	70

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