The Handling and Bonding of Beam Lead Devices Made Easy

Application Note

Introduction

Beam lead devices are particularly suited for hybrid integrated circuits where low parasitics and small size are prime requirements. Available as single units or monolithic quads, the beam lead devices have made high packing density and superior performance easily achievable in hybrid circuits. There are single beam lead devices in four different outlines—05 and 10 for Schottky diodes, 06 and 07 for PIN diodes. A picture of the HPND-4001 PIN diode in outline 07 appears in Figure 1. As typical of the single beam lead devices, this beam lead PIN diode consists of a silicon chip with coplanar plated gold tabs (beam leads measuring barely 5 mils wide and 0.5 mil thick) 9 mils beyond the edge. The detailed dimensions of outline 07 shown in figure 2 illustrate the small size of the beam lead package, which results in little space needed in a circuit. the low package parasitics allow the achievement of maximum performance for the beam lead diode.

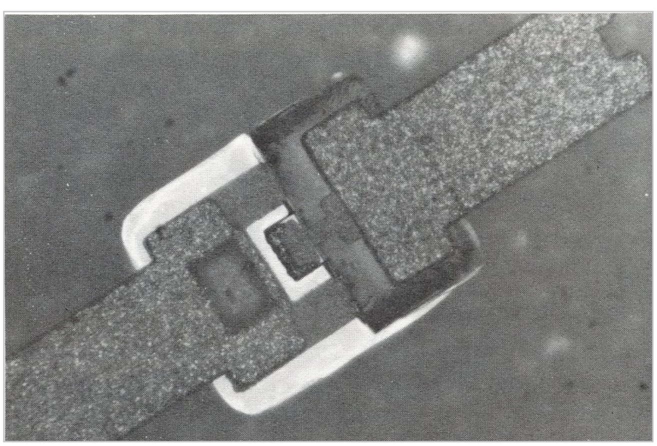


Figure 1. The HPND-4001 beam lead PIN diode in outline 07 shown here provides low capacitance of 0.07 pF and less than 0.1 nH inductance to allow the achievement of maximum isolation and minimum insertion loss at high frequencies.

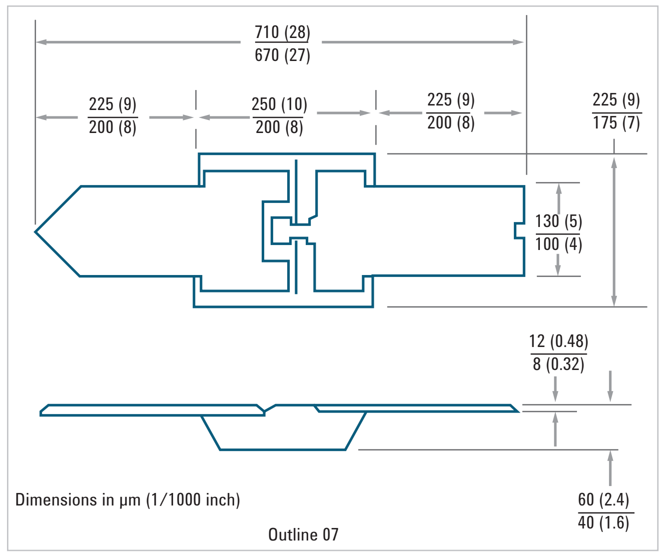


Figure 2. The dimensions of outline 07 are indicative of the small size of the beam lead package, resulting in little space needed in a circuit.

The construction of the beam lead diode is designed to offer exceptional lead strength without sacrificing electrical performance.

The beam lead ring quad as shown in Figure 3 provides four Schottky diodes connected in anode to cathode arrangement with a lead at each corner. The monolithic construction assures uniform characteristics for the four diodes—a feature that is essential for optimum performance in double balanced mixer applications. these quads are available in outlines 03 and 08. The quad shown, consisting of four Schottky diodes in outline 03, provides capacitance below 0.2 pF for high frequency applications. The small size of the quad is apparent in the detailed drawing of outline 03 shown in Figure 4. As in the case of single devices, the monolithic beam lead quads are useful in conserving space and maximizing performance in hybrid circuits.

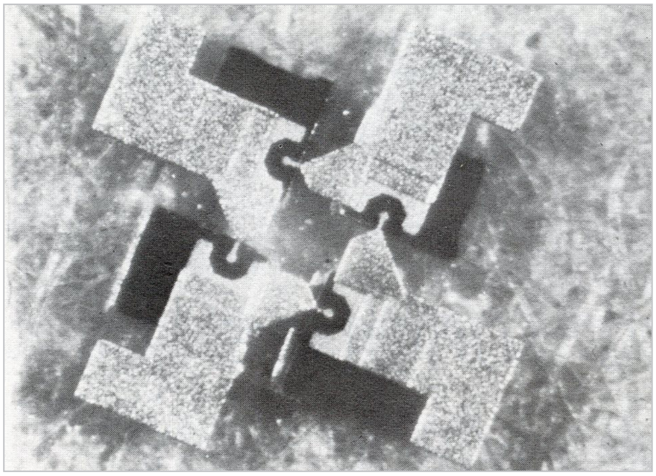


Figure 3. A beam lead ring quad of four Schottky diodes in outline 03 provides capacitance below 0.2 pF for high frequency operation.

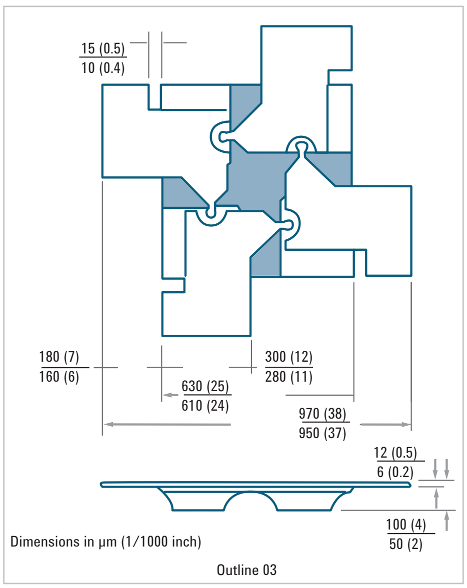


Figure 4. The small size of outline 03 would conserve space in a hybrid circuit.

Handling

In order to avoid damage to the mechanical and electrical characteristics of beam lead devices, particular care must be exercised in the handling of these devices during inspection, testing, and assembly, Although the construction of the beam lead devices is designed to have exceptional lead strength, the small size and delicate nature of the devices requires that special handling techniques be observed so that the devices would not be mechanically or electrically damaged.

Beam lead devices are usually shipped in a flat, plastic container known as a "beam pack" or gel pack" shown in Figure 5. Designed for transporting beam lead devices, this beam pack is coated at the bottom of the container with a thin layer of adhesive silicone (sylgard) to which the devices adhere. A maximum of 50 units can be placed in each container.

The devices are covered with a sheet of antistatic polyester fabric before the lid of the container is closed. This type of container has several attractive features. Each device is kept at a fixed location, apart from any other devices, therefore avoiding any damage as a result of mutual collisions.

Furthermore, the devices can be visually inspected while still in the container. Since the devices are very small, the inspection, loading and assembly processes are accomplished with the aid of magnification by a microscope.

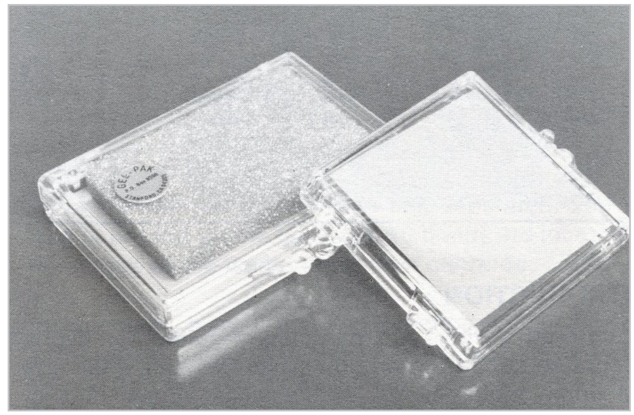
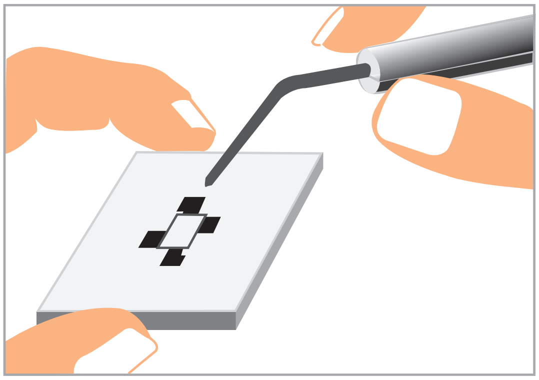


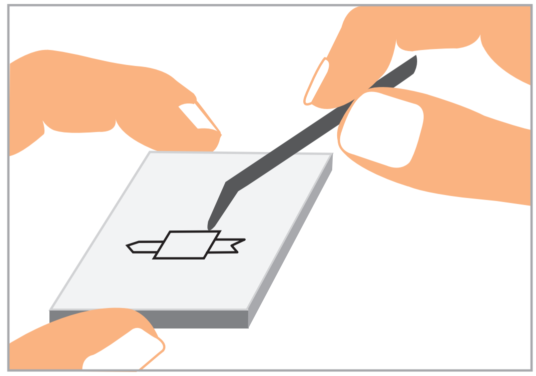
Figure 5. Designed for shipping beam lead devices, the beam pack (gel pack) contains a layer of adhesive silicone at the bottom of the container so the devices will adhere to it.

A vacuum pickup (Figure 6a) is recommended for picking up beam lead devices, particularly larger ones, e.g., quads. Care must be exercised to assure that the vacuum opening of the needle be sufficiently small to avoid passage of the device through the opening. a #27i tip is recommended for picking up single beam lead devices. A 20X magnification is needed for precise positioning of the tip on the devices. Where a vacuum pickup is not used, a sharpened wooden cotton swab (Figure 6b) dipped in iso-propyl alcohol is very commonly used to handle beam lead devices. A device will adhere to the end of the swab without danger of being mechanically or electrically damaged. It can then be placed at the designated location. An experienced operator will sometimes use a tweezer (one half of a pair of tweezers as shown in Figure 6c) to pick up beam lead devices. In this case the tweezer should be dulled and used as a probe, allowing a device to adhere to the tip. If the tweezer is used as a pair of tweezers to hold the device, the beam leads can be deformed. Another very efficient pickup tool (1) for beam lead devices is shown in figure 6d. It consists of a probe held by a handle at one end. At the opposite end is a PTFE tip, to which a beam lead device adheres.

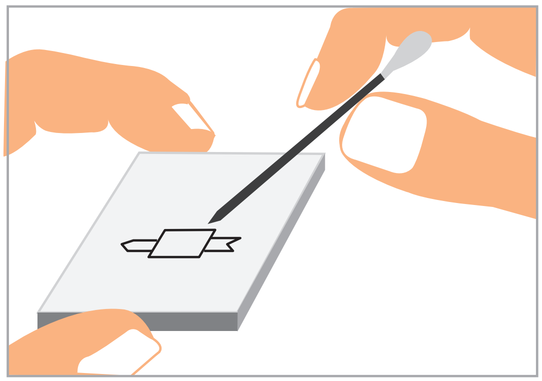
A beam lead device can be destroyed electrically by a static discharge through the device. It must therefore be handled so static effects cannot occur. Contact to the circuit should never be made with the free side of the device because this would allow static electricity from the operator's hand to flow through the device. Instead, the side of the device held should be contacted first.



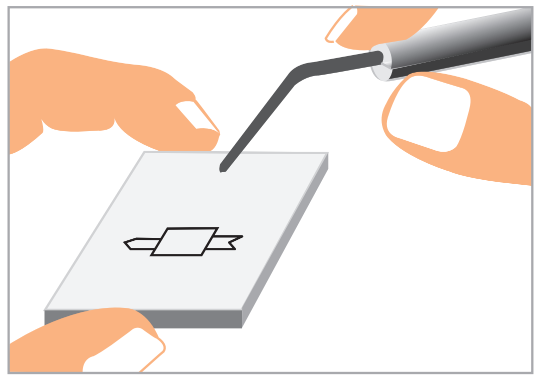
(a) Vacuum pickup is suitable, particularly for larger beam lead devices, e.g., quads.



(c) An experience operator will sometimes use a tweezer.



(b) A cotton swab dipped in iso-propyl alcohol is very commonly used in industry.



(d) A very efficient commercially available pick up tool has a PTFE tip to which the device adheres.

Figure 6. Suitable tools for picking up beam lead devices (not drawn to scale)

If there is any chance that the two circuit attachment points are at different potentials, they should be shorted together with a grounding lead before contacting the device. If tweezers are used, they must be electrically grounded to the point where the device is to come in contact. Schottky beam lead diodes are generally susceptible to damage by static discharge. Care in their handling should therefore be exercised. PIN beam lead diodes are not easily damaged by static electricity, so that no additional handling or assembly precautions need be taken except for the usual limitations imposed by the maximum voltage, power, and temperature ratings.

A controlled environment is an important consideration during the storage, handling, and bonding of beam lead devices. Contact metals may be contaminated by impurities in the air. Figure 7 shows the use of a plastic box to provide a pure environment for the storage of beam lead devices. A continuous flow of nitrogen assures an inert atmosphere. Bonding activities should ideally be located under a laminar flow hood as shown in figure 8 to keep the work area clean. Unidirectional filtered air flow is provided by the hood to maintain a controlled environment of less than 100 parts per cubic foot of particles greater than 5 micrometers in diameter.

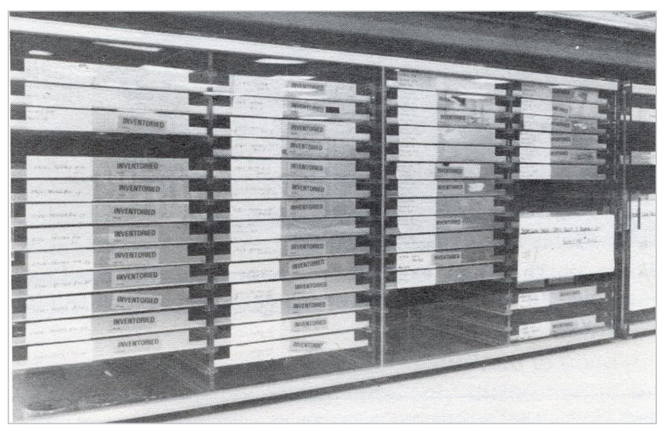


Figure 7. A plastic box is used to provide a controlled environment for the storage of beam lead devices.

Figure 8. A laminar flow hood keeps the work area clean for the handling and bonding of beam lead devices onto circuits.

Bonding

Thermocompression bonding is recommended for the beam lead devices. Parallel-gap welding can also be used. In either method, the device is positioned face down as illustrated in figure 9 with the beam leads resting flat on the metalized contact areas of the circuit and bonded using either a heated wedge (thermocompression bonding) or parallel-gap (welding) technique.

Heating of the wedge may be continuous or pulsed. When continuous heating is used, the bonding tool is heated to 300 degrees Celsius and the work stage to 220 degrees Celsius maximum. The pressure applied is 0.024 grams per square micrometer (15 grams per square mil). The bonding time should not exceed 3 seconds for Schottky diodes and 10 seconds for PIN diodes. For pulsed operation, a narrow high current pulse is used to raise the wedge to the required temperature. In the parallel-gap method, current is passed through the substrate metallization and the device lead. The generation of heat is concentrated at the interface between the two, where it is needed to achieve the bonding.

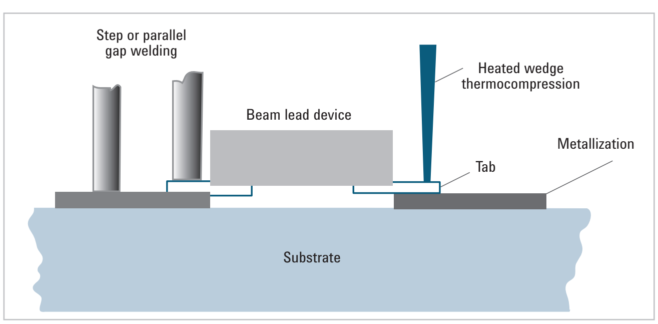


Figure 9. The bonding of the beam lead device is achieved using either a heated wedge (thermocompression bonding) or parallel gap (welding) technique.

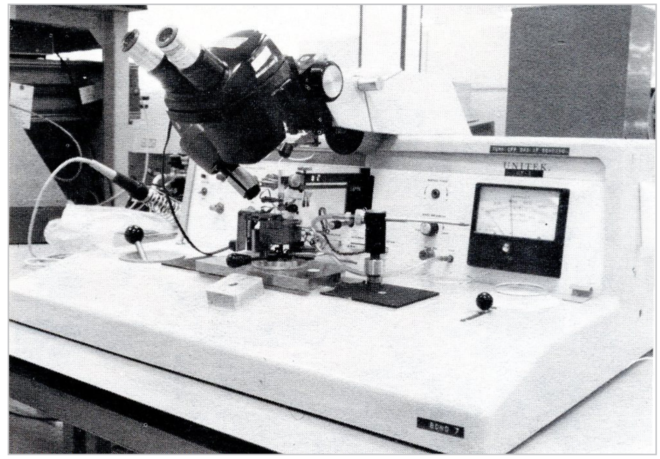


Figure 10. The Unitek Model 8-150-02 bonder is adaptable for the thermocompression bonding of beam lead devices.

The major advantage of pulsed heating techniques is that a cold substrate can be used, generating only localized heating in the vicinity of the bond itself. The electrodes (or wedge) can be placed on the device lead when the bond area is cold and can maintain a constant force through the heating and cooling cycle.

Many commercially available bonders are specifically designed or can be adapted to bond beam lead devices. Shown in figure 10, is an example of one such bonder which is the Unitek Model 8-150-02 bonder (2). This bonder is used for wire bonding. However, with slight modification, it can readily be adapted for thermocompression bonding of beam lead devices. Precise control of heat, pressure, and time provided by the equipment is essential in this type of operation. Figure 11 represents a close up view of the accessory equipment (3) used with the Unitek bonder for thermocompression bonding of beam lead devices. The heat and pressure are applied through use of a silicon carbide tip with a radius of two to three mils.

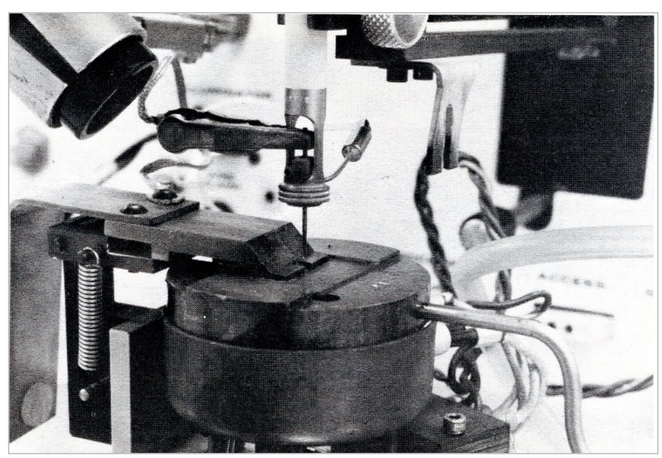


Figure 11. This is a close up view of the equipment used with the Unitek bonder for the thermocompression bonding of beam lead devices.

A standard miniature weld head can be used to supply the required tip travel and apply the proper pressure. A heated wedge shank held in the weld head holds the tip and supplies heat to it. The wedge shank is heated by an AC power supply.

The D.P. Veen Model 1250 bonder shown in Figure 12 is typically used for eutectic die attach. Its capabilities include die pick up and place, and manual or automatic scrub. Epoxy or preform die attach can also be performed by this type of bonder. With slight modification it can be adapted for thermo-compression bonding of beam lead devices. As illustrated in Figure 13, the D.P. Veen bonder can accept a variety of stages to accommodate various package types, including alumina or copper clad circuit boards. The stage can be programmed to perform customized functions such as automatic indexing.

A basic understanding of the capabilities and requirements of the bonding equipment that is used an careful application of the techniques recommended are necessary for the achievement of the type of bonds that will not present any ongoing or short term problems to compromise device performance.

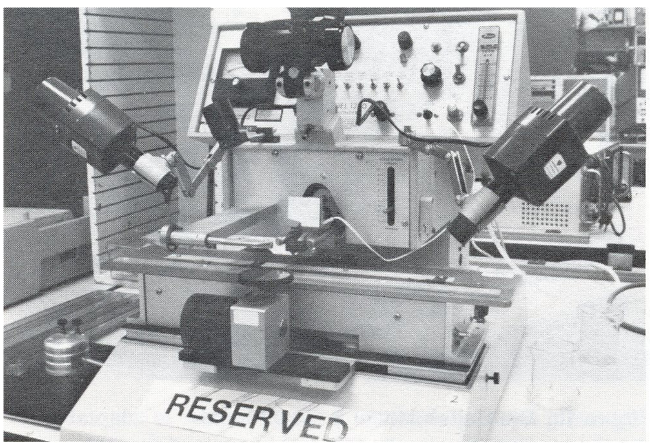


Figure 12. The D.P. Veen Model 1250 bonder can also be adapted for the thermocompression boding of beam lead devices.

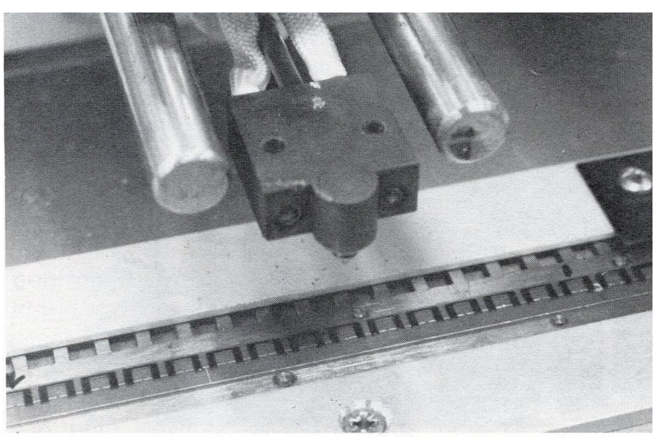


Figure 13. The D.P. Veen bonder can accommodate various package types and circuit boards and perform customized functions such as automatic indexing.

The following examples will serve to illustrate these points. In Figure 14, where the HPND-4001 beam lead PIN diode in bonded in package C-2, is an example of a good bond reflecting proper use of equipment and techniques. The beam leads of the diode are flat against the contact metallization of the package. The bond is centered on each beam lead with sufficient indentation to effect a strong bond.

The chip is intact and there is good continuity between the chip and the beam leads. (The porous material underneath the contact metallization is the ceramic in the package viewed under approximately 150X magnification.) An example of a poorly bonded beam lead diode is shown in Figure 15. The diode is misplaced in the gap. At the cathode end the beam lead is folded over. At the anode end the bonding tool slipped and twisted the beam lead, causing excess strain on the metal to silicon contact and resulting in a separation at the interface. Another example of a poor bond is shown in Figure 16. At the cathode end the bonding tool slipped and smeared, resulting in excess strain on the metal to silicon contact and causing the device to buckle.

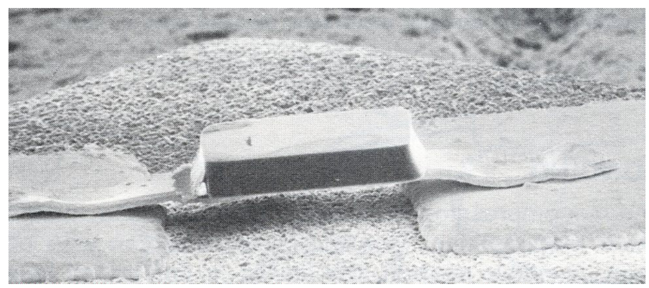


Figure 14. The HPND-4001 beam lead PIN diode bonded in package C-2 shown here is an example of a good bond. The beam leads are flat against the package contact metallization. The bond is centered on each lead with sufficient indentation.

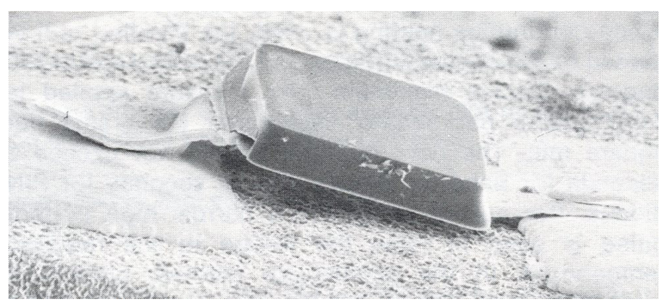


Figure 15. This is an example of a poorly bonded beam lead diode. The cathode lead is folded over, the anode lead is twisted, and the chip is separated from the lead.

In the last two examples, the reliability of the devices is questionable. Beam lead quads are not any more difficult to bond than single beam lead devices. The only difference is that there are more points to contact. Identical equipment and techniques can be used to bond single and quad beam lead devices.

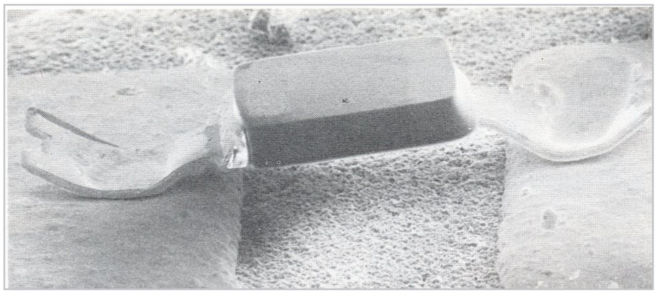


Figure 16. This is another example of a poor bond. The excess strain from bonding tool slippage caused the device to buckle.

An example of a good bond for a beam lead quad is shown in Figure 17. The beam leads are flat on the package leads. The bond is centered on each lead with sufficient indentation. There is no sign of tool slippage or excess strain. This is an outline 03 beam lead quad bonded in package C-4. The 5082-2280 Schottky quad is an example of this combination. An example of a poorly bonded quad is shown in Figure 18. The quad has been pushed to the left. The upper right lead is torn and its diode fractured. Another example of a poor bond is shown in Figure 19. The quad is twisted so badly that the bottom lead has separated. The top lead is not flat on the package. All bonds are located on the edges of the leads rather than centered.

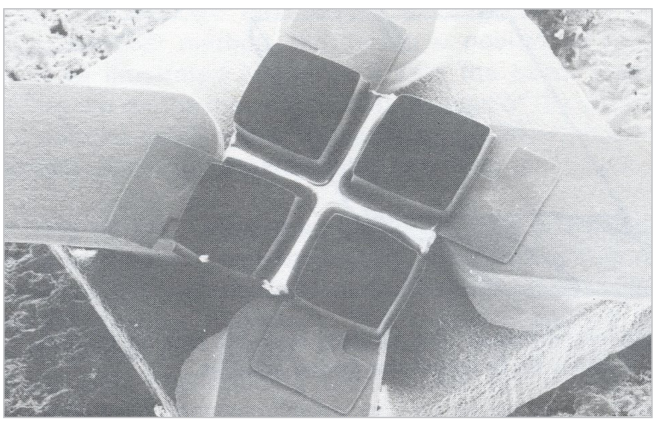


Figure 17. This is an example of a good bond for an outline 03 beam lead quad bonded in package C-4. The beam leads are flat on the package leads. The bond is centered on each lead with sufficient indentation.

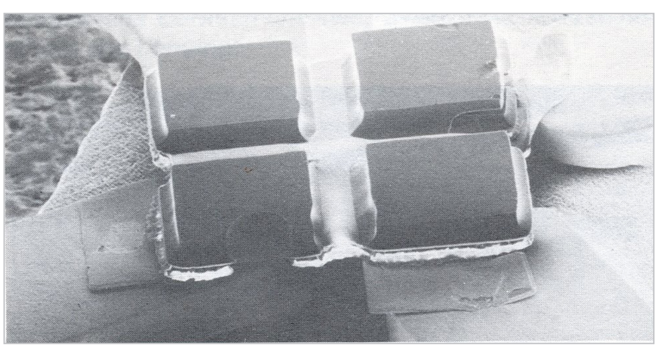


Figure 18. this is an example of a poor bond. The quad has been pushed to the left. The upper right lead is torn and its diode is fractured.

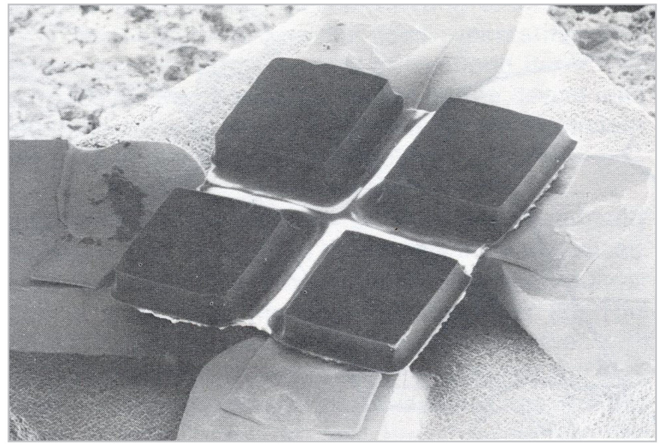


Figure 19. This is another example of a poorly executed bond. The quad is twisted so badly that the bottom lead has separated.

In summary, proper bonding practice will insure the achievement of good bonds on beam leads. The bonds should be centered on each lead with sufficient indentation for achieving a strong bond. The tip of the bonding tool should be oriented perpendicular to the lead to prevent an twisting and damaging of the lead. There must be flexibility in the bonding conditions to meet the needs of a particular circuit. For example, to avoid pressing the beam leads into a soft circuit board, a reduction in bonding pressure and stage temperature would be appropriate.

Conclusion

Beam lead devices are particularly attractive for hybrid circuits because of their low parasitics and small size. The availability of equipment and techniques specifically designed for their small size has facilitated the handling and bonding of these devices. With properly trained assemblers, beam lead devices permit a rapid and inexpensive assembly procedure. The only sophisticated pieces of equipment needed are a microscope and a thermocompression bonder.

Notes

(1) The pick-up tool is manufactured by: Tak Products, Inc.

(2) Other manufacturers of similar types of bonders include Hughes, Kulicke & Soffa, Westbond, and Tanaka.

(3) Possible sources for the accessory equipment include Unitek Corporation, Tempress Research Co., and Small Precision Tools.

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