Agilent Beam Lead Attachment Methods

Application Note

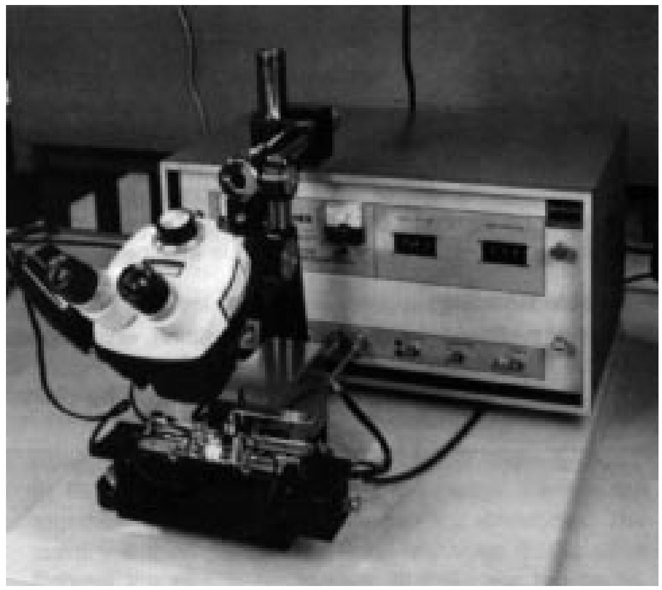


Figure 1. General setup for attaching beam lead devices

Introduction

This application note gives the first time user a general description of various attachment methods for beam lead devices. The attached table summarizes the salient features of all the methods including the advantages, disadvantages, and the associated cost of the equipment. Equipment selection as dictated by the type of substrate being used is emphasized.

Attachment Methods

Beam lead devices can be attached by any of the conventional means, but matching the method to the intended substrate, conductor metals and finish is imperative to a reliable, cost effective process. The various methods should be evaluated in light of this requirement. A general setup for attaching beam leads is shown in Figure 1. Characteristics of the various methods are discussed below.

Thermocompression bonding

Since nearly any thermocompression wire bonder can be modified for beam leads, it is a common method. A typical setup for bonding beam leads is shown in Figure 2. The wedge bonder tip contact area is 3 x 4 mils.

Because of the temperatures and pressure required, the thermocompression method should be restricted to hard substrates which won't deform or allow the conductor to move. Substrate deformation or conductor movement generally results in the beam being torn or the device broken. Seldom is a reliable bond achieved since the material is deforming under the pressure and does not allow the necessary concentrated force at the bond area.

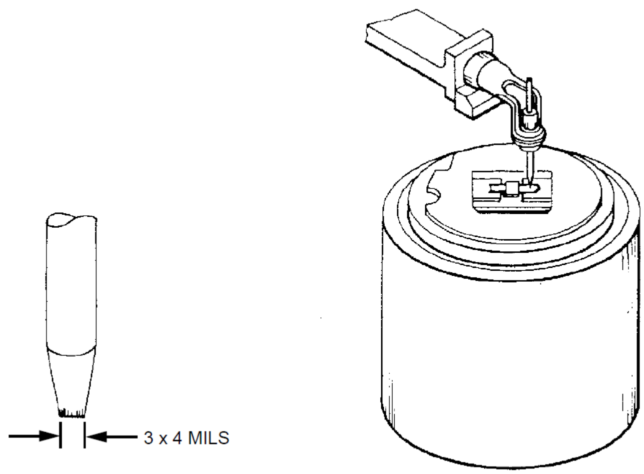


Figure 2. Typical setup for thermocompression bonding of beam lead devices

Reflow method

One alternative to the thermocompression bond on either soft or hard substrates is the reflow of either tin or solder. The conductor is prepared by plating the base metal with 200 micro-inches of bright tin or solder coating. It is difficult to control the amount of solder such that it does not alter the spacing required for the beam lead, so tin is the preferred choice. In the reflow process, the wedge bonder tip is replaced with one which has a tip of approximately 10 x 10 mils and has enough mass to act as a soldering tip. (See Figure 3.) The temperature of the electrode must be arrived at empirically since the materials being used will dictate the temperature required to reflow the tin or solder.

One word of caution regarding the reflow method should be noted. It is probable that the device will be under some mechanical stress when put down by this method because there is no "bugging"[1] taking place, therefore no strain relief built in. When a soft substrate, which can be flexed or which has a large coefficient of expansion is used, some strain relief must be provided by bowing the part away from the mounting point before the second lead is attached.

1. *The deformation of the beam by the bonding tool causes the gold to move into the silicon chip. The movement of this metal results in the chip lifting away from the substrate. This is commonly known as "bugging". A certain amount of bugging is beneficial for providing a resilience to the chip and substrate for protection against damaging stresses during thermal cycling in actual usage. However, excessive bugging caused by a high deformation of the beam leads could lead to unusual stresses at the interface between the beam and the chip. Failure due to peeling of the leads or fracturing of the silicon could result.*

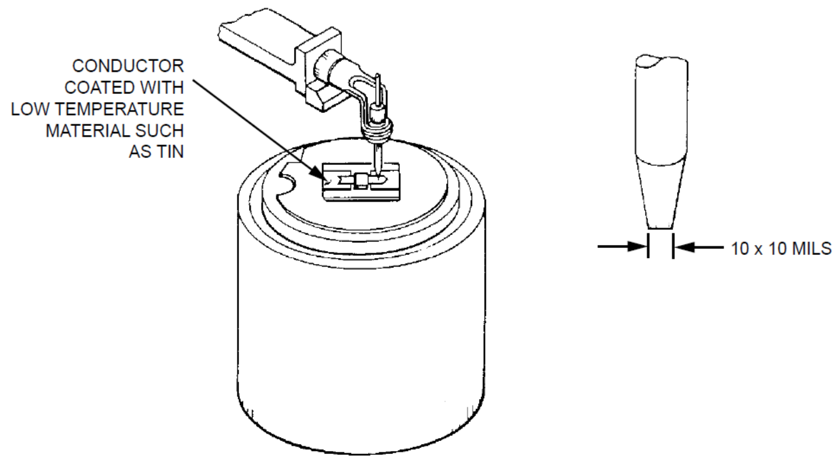


Figure 3. Typical setup for reflow of low temperature materials to attach beam lead devices

Wobble bonding

Another thermocompression bonding method, which bonds all the leads in a single operation, is shown in Figure 4. The wobble bonder allows the beam lead to be picked up by a collet which has been designed to clear the body of the part and have about 0.002″ surface width to bond the leads. This collet is then wobbled around the device with approximately a 1 degree angle with a force sufficient to bond (~ 250 grams) to the circuit materials. This method has the same problems with soft substrates as the basic thermocompression bonding method. Because of the heat and pressure required, reliable bonds cannot be made on any non-rigid substrate.

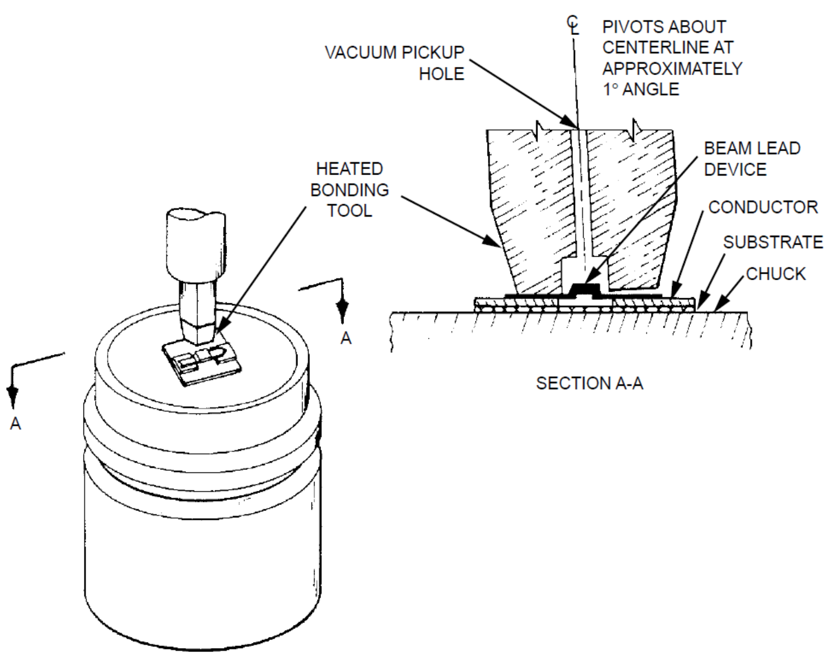
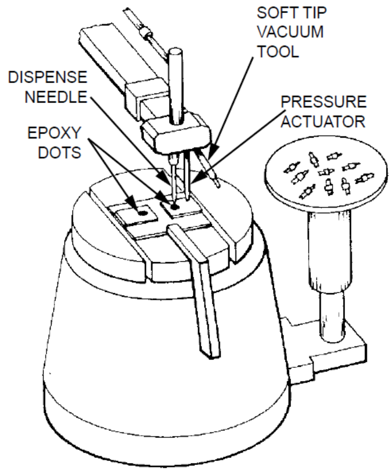


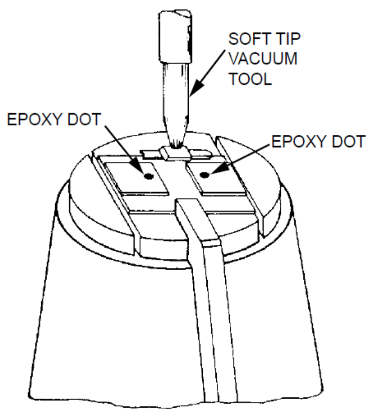
Figure 4. Thermocompression wobble bonder for attaching beam lead devices

Epoxy attach

It is possible to use epoxy to attach beam leads to soft or hard substrates. With the very pure materials available good results can be achieved. Equipment is available to dispense very small dots of epoxy and then pick and place the beam lead onto the epoxy. These setups are shown in Figures 5 and 6, respectively. Solder paste can also be used in place of the epoxy. By using a good quality low temperature solder (180 °C), it can be used on most substrates.



(a) Dispensing the epoxy



(b) Picking and placing the beam lead device onto the epozy

Figure 5. Setup for epoxy attach of beam lead devices

Figure 6. The machine shown above automatically dispenses small dots of epoxy and picks and places the beam lead devices onto the epoxy dots

Resistance welding

Resistance welding is a very effective beam lead bonding method which can be used with nearly any substrate material and most conductors. Constant voltage power supplies are available which reduce the possibility of damage to the semiconductor by overvoltage. Weld heads are available which can apply the very light pressure needed with good repeatability. If work is being done with a variety of substrate materials, conductors, and finishes, this method is the most versatile and predictable. There are a number of ways of using pulsed power to create fused bonds. All of these methods are useful, but when working with parts as small as a beam lead device, one should be careful about the method used. These methods and the difficulties encountered are described below.

a) Parallel gap

A parallel gap welding system is shown in Figure 7. In this case, the electrodes are bonded together with an insulator between the electrodes. The current is then passed from one electrode to the other through the part to be welded, in this case the beam. The energy required to fuse the bottom conductor must be generated at this interface. The spacing between the electrodes is critical to achieving success in this process. Because of the beam size and the problem of aligning these electrodes to the beam, this method is not recommended if many parts are to be bonded.

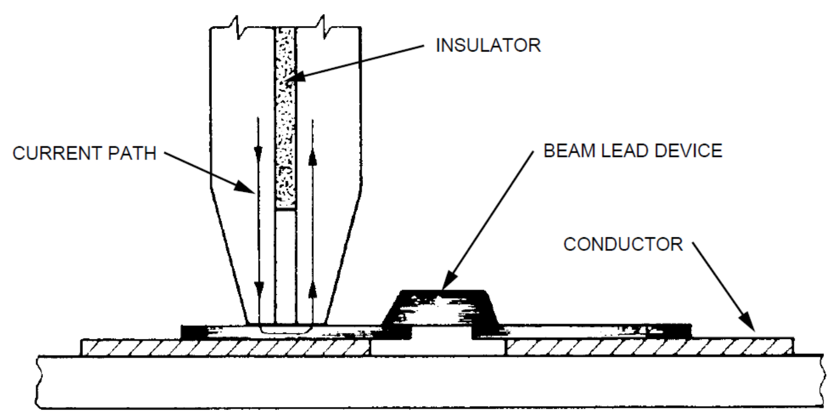


Figure 7. A parallel gap welding system

b) Step gap

The electrodes for the step gap method are much the same as above, but are free to move vertically independent of each other. This allows one electrode to contact a beam and the other to contact the conductor. The problems with this method are the same as the parallel gap, but, in addition, the pressure is difficult to apply at the right contact point without having too much on the beam. The weld electrodes require continual maintenance to provide a consistent contact surface area.

c) Series welding

This method shown in Figure 8 uses a single electrode to make contact to the beam and the power supply return makes contact to the conductor by means of a cover plate or probe which has been fixtured to provide a low resistance path close to the point of the weld. The weld current is passed through the beam to the conductor to the power supply return electrode.

The concentration of the current at the interface between the beam and the conductor causes the materials to fuse. The use of a single electrode is a major advantage since it is not necessary to align the device to the electrode. A satisfactory electrode has a 7 mil diameter tip. This method also works well for reflow attachment to surface materials such as tin. Fixturing with a material such as copper with a nickel strike and then gold plating in the area of contact to the circuit is important in order to concentrate the weld energy at the desired point. The required energy should be from 0.1 to 0.15 watt seconds to bond beam leads to materials such as gold, tin, nickel, and alloy 42. If the level required to weld exceeds this, the fixturing should be considered suspect.

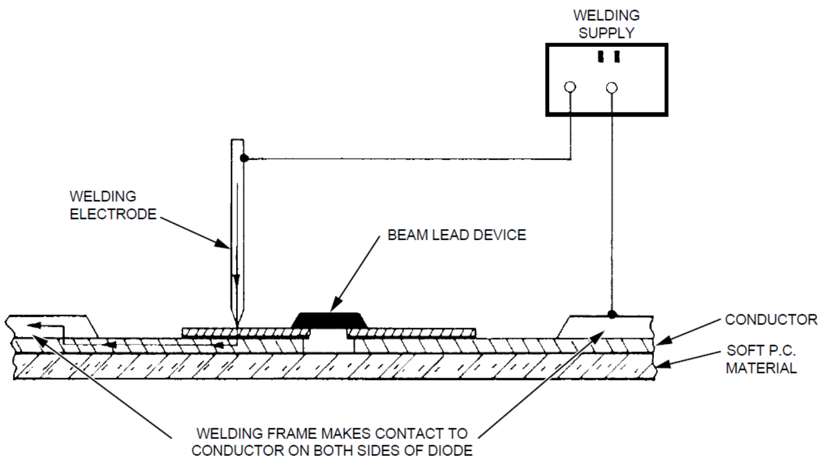


Figure 8. A single electrode series welding system

Summary

Table 1 summarizes the characteristics of the various beam lead attachment methods. The major advantages, disadvantages, and associated cost are included. It should be noted that either the thermocompression or the resistance weld equipment can be adapted for the reflow method. The wobble bonder is basically a thermocompression bonder. Besides cost effectiveness and other considerations such as automation flexibility, the selection of the method is primarily determined by the type of substrate used for the circuit.

Table 1. Beam lead attachment methods

Resistance weld		Thermocompression		Epoxy attach	
Manual	Auto	Manual	Semi-Auto	Manual	Auto
Hard substrates	N/A	Hard substrates	Hard substrates	Soft substrates	Soft substrates
Soft substrates		Lead frame		Hard substrates	Hard substrates
Lead frame		Packages		Lead frame	Lead frame
Packages				Packages	
Estimated UPH 200	-	200	120 - 180	180	1000
Major advantages		Major advantages		Major advantages	
Low temperature		Many equipment vendors		Any substrate	
Low pressure		Low cost		Most finish metals OK	
Wide range of metals		Semi-auto available		Automation	
Easy to use & low cost		Minimum maintenance		Excellent bond strength	
Simple maintenance		Excellent bond strength			
Excellent bond strength					
Disadvantages		Disadvantages		Disadvantages	
Cannot automate		Cannot use soft substrate		Not widely accepted	
Have to fixture		Requires heat & pressure			
		Limited range of finish metals			

Notes

This application note was formerly labeled as Application Note 992. The technical content has not been updated since 1993. Product specifications and descriptions in this document subject to change without notice.

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