GaAs MMIC Assembly and Handling Guidelines

Application Note 999

Mechanical Considerations

Because of the small size of the devices, handling should always be performed with the aid of a microscope.

There are several methods for picking up, transferring and die attaching these ICs. The most common method is with tweezers. The use of tweezers is a manual operation that is very adaptable, or product non-specific, and is also inexpensive. A difficulty in the use of tweezers is that operator skill (and training) is required to prevent damage to the GaAs ICs.

The use of an "inverted-pyramid" vacuum collet is attractive when using semi-automatic die attach equipment. This method has the potential of causing less damage to the die, but the product-specific collets are more costly than tweezers and require a several week turnaround time for their manufacture.

Grounded vacuum pencils can be used for the transfer of larger die at room temperature conditions. The vacuum pencils should have plastic tips (but care should still be taken) or they could damage the surface of the IC. Care must also be taken to insure that the IC doesn't become lodged in the vacuum tip. Advantages of vacuum pencils are their adaptability to various die sizes and their low cost.

Although alcohol-moistened Q-tips and wooden probes are commonly used for transferring devices, their use is strongly discouraged. When material such as wood and contaminated alcohol come in contact with the ICs, bonding problems may result.

Electrical Considerations

A GaAs IC can be destroyed electrically by a static (or other) discharge through the device. It must therefore be handled so these effects cannot occur. Normal electrostatic discharge (ESD) preventive measures should be incorporated into all aspects of the storage, handling and assembly of these devices. Specific measures to be taken should include:

1. Anti-static storage trays and boxes if the ICs are kept in other than the HP supplied shipping containers.
2. Grounded mats at work stations.
3. Ground straps for operators.
4. Static eliminators on compressed gas nozzles.
5. Common grounding of equipment, mats, straps, etc.
6. Wire bonding sequence should be designed to eliminate static discharges through chip.

In addition to ESD prevention measures, assembly equipment should be inspected for any power line transients that may couple into equipment that comes in contact with ICs.

Die Attach Methods

Both solder and epoxy may be used for the die attach of HP GaAs ICs to substrates and metal structures. The choice of die attach method is influenced primarily by thermal conductivity requirements and equipment availability.

Solder Die Attach

Many GaAs ICs are solder die attached. Individual data sheets may call out product specific restrictions on this method. For solder die attach, the use of AuSn eutectic (80% Au/20% Sn) is the preferred material. AuSn solder is a hard alloy and gives excellent creep resistance as well as resistance to fatigue failure, but requires a close TCE (Thermal Coefficient of Expansion) match between the IC and the underlying material (pedestal or substrate). Pedestals and other metal support structures should be fabricated from low thermal expansion materials such as molybdenum, silvar or KCW-10. KCW-10 is a sintered copper-tungsten composite available from the Kyocera Co. There are a number of other composite materials available with good thermal expansion and thermal conductivity properties. Although Kovar has excellent expansion properties, its relatively low thermal conductivity makes it an inappropriate choice for ICs which dissipate significant power.

A primary advantage of solder die attach is its excellent thermal conductivity. Where power dissipation in the IC is significant (>1/3 Watt), the use of a high thermal conductivity die attach method will result in lower junction temperatures and improved chip reliability.

Organic Adhesive Die Attach

A silver-filled conductive epoxy (e.g. Ablestick 84-1) can be used. Advantages of organic adhesive die attach are low temperature processing, ease of assembly and the ability to tolerate greater TCE mismatches than solder. The primary disadvantage is the relatively low thermal conductivity of organic adhesives.

Typically, the thermal resistance of an organic adhesive is over two orders of magnitude greater than a solder joint of similar geometry. In addition, the variation in adhesive thickness can drastically increase the thermal resistance of the joint. This increased thermal resistance will have a direct effect on IC junction temperatures and will be most significant with higher power dissipation devices. As a general rule, the mean time to failure on an IC will be cut in half for each 12°C increase in operating temperature.

Although some GaAs IC users are performing IC die attach with conductive epoxy, HP recommends that caution be exercised in selecting a die attach method, especially when the level of power dissipation is greater than 1/3 Watt.

Bonding Methods

Thermosonic and thermocompression wire bonding are the recommended methods for electrically interconnecting to GaAs ICs. Either wedge or capillary wire bonding can be successfully used. These methods are presented below. Please note that these schedules are guidelines that have been developed for use with specific types of wire bonding equipment. Processes developed for use with your equipment may differ from these schedules.

Thermosonic Bonding

Thermosonic wedge bonding is used at HP and is the preferred method. The HP equipment is manual, but semi-automatic or automatic equipment could also be used. With the thermosonic method, bonds can be easily formed using a stage temperature of 150°C. This has particular advantage with hybrid circuits that cannot be heated to the elevated stage temperatures required with thermocompression methods. The recommended wedge and capillary bond schedules are given below.

Thermosonic wedge bond schedule:

Equipment:	MechEl thermosonic wedge bonder
Bonding tool:	Wedge, per Figure 1
Wire:	Gold wire, 0.0007" diameter, 0.5-2.0% elongation. Breaking strength 5-8 grams
Gram force:	22 ± 1 gram
Stage temperature:	150 ± 2°C
Ultrasonic parameters:	power: 60 ± 1 dB dwell: 66 ± 8 msec

Thermosonic capillary bond schedule:

Equipment:	MechEl thermosonic capillary bonder
Bonding tool:	Capillary, per Figure 2
Wire:	Gold wire, 0.0007" diameter, 0.5-2.0% elongation. Breaking strength 5-8 grams
Gram force:	30 ± 1 gram
Stage temperature:	150 ± 2°C
Ultrasonic parameters: (for bond pull on IC)	power: 60 ± 1 dB dwell: 66 ± 8 msec

Thermocompression Bonding

This method generally involves higher temperatures than those required with thermosonic bonding. Thermocompression bonds are usually formed with bonding tool temperatures of 350°C and stage temperatures of 250°C, although processes have been developed that use lower temperatures. When the hybrid circuit cannot tolerate a stage temperature of 250°C, the bonding tool temperature and/or force is increased.

Thermocompression wedge bond schedule:

Equipment:	Westbond thermocompression bonder
Bonding tool:	Small Precision Tools wedge (SPT-1002-A-W-2015-L-F)
Wire:	Gold wire, 0.0007" diameter, 3.6% elongation.
Gram force:	28-30 grams
Stage temperature:	250°C
Tool temperature:	220°C

Summary

This guideline is the result of experience gained at HP divisions that assemble GaAs ICs into hybrid circuits. It is dynamic rather than static and, by its nature will change as we gain more experience with the handling and assembly of GaAs ICs. Your insights, as the customer, are encouraged and will benefit other GaAs IC users.

Finally, this guideline does not preclude the use of any assembly methods not specifically mentioned.

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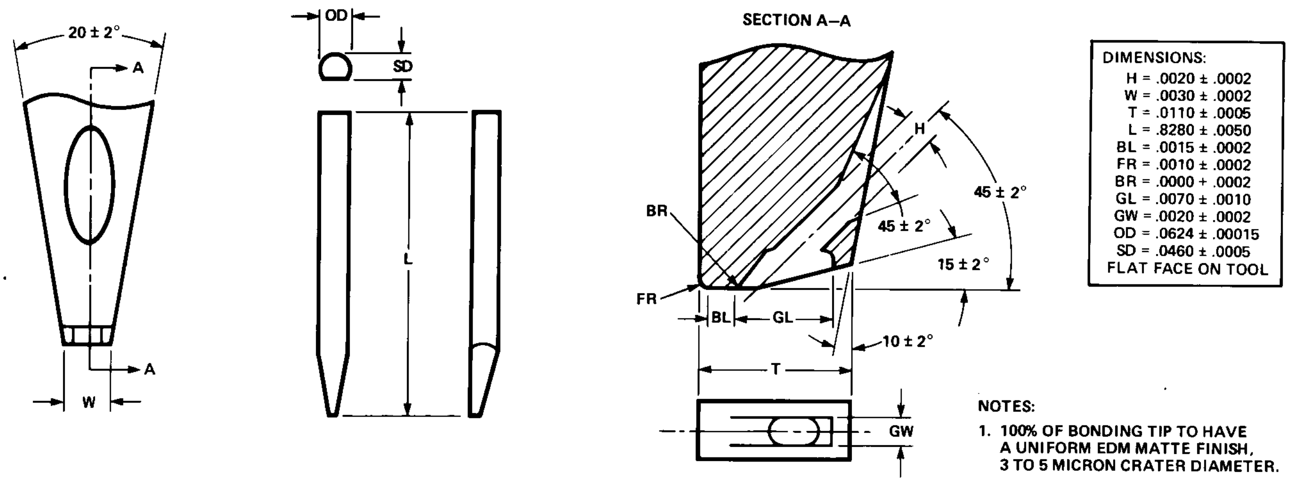

Figure 1. Wedge Bonding Tool.

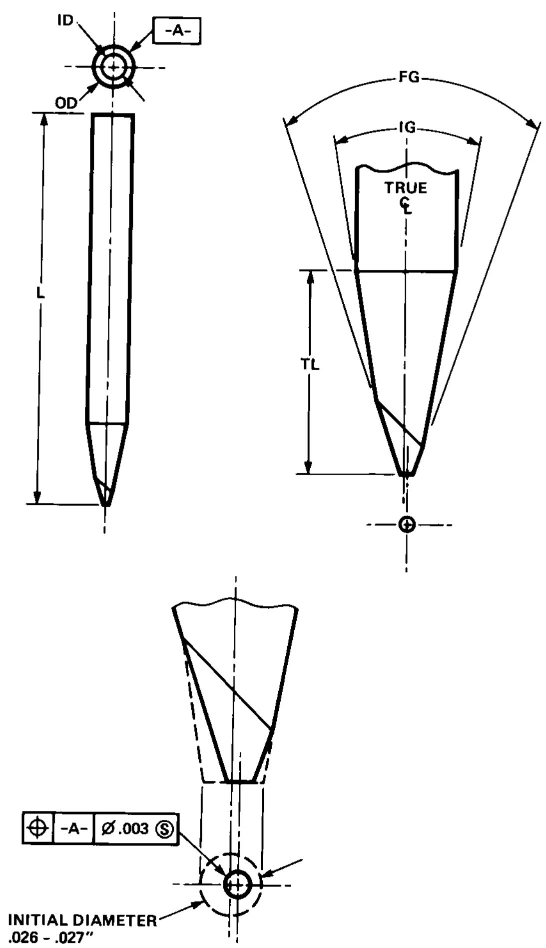

Figure 2(a). Thermosonic Capillary Bonding Tool.

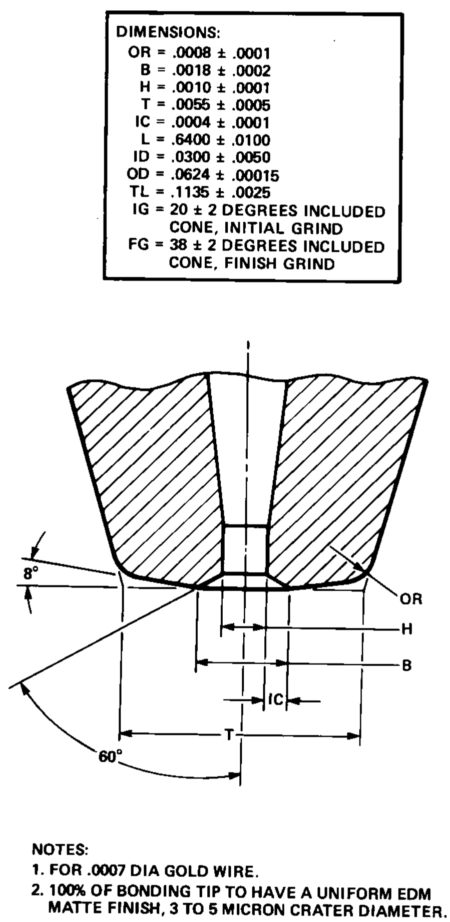

Figure 2(b). Detail of Capillary.

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Obsoletes 5091-1988E (6/91)
5964-6644E (12/95)