Keysight Technologies
GaAs MMIC ESD, Die Attach, and Bonding Guidelines

Application Note

This application note includes:

– Die attach methods
– Bonding methods

KEYSIGHT TECHNOLOGIES

1.0 ESD Considerations

A GaAs IC can be destroyed electrically by a static (or other) discharge through the device. Therefore, it must 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:

- Anti–static storage trays and boxes if the ICs are kept in other than the Keysight Technologies, Inc. supplied shipping containers.
- Grounded mats at work stations.
- Ground straps for operators.
- Static eliminators on compressed gas nozzles.
- Common grounding of equipment, mats, straps, etc.
- 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.

2.0 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 theses ICs. A 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 from their manufacture. Grounded vacuum pencils can be used for the transfer of 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.

3.0 Die Attach Methods

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

3.1 Organic adhesive die attach

Silver–filled conductive epoxies have advanced significantly in recent years (e.g., Ablestick 84–1LMI) and are becoming the preferred method for die attaching GaAs MMICs. Advantages of these organic adhesive die attach methods are low temperature processing, ease of assembly, and the ability to tolerate greater TCE (Thermal Coefficient of Expansion) 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. However, proper use of these epoxies will result in very thin adhesive thicknesses in the 12 to 20 micron range (0.47 to 0.78 mils). The thin layer results in corresponding small temperature gradients. Thick layers of epoxy can drastically increase the temperature gradient across the joint and often result in unacceptable high inductance to ground. A thick layer of epoxy 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.

3.2 Solder die attach

Many GaAs ICs users prefer solder die attach. Solder die attaching starts with a solder “preform”. The solder preform is supplied in a size that corresponds to the component being soldered. *(Note: A rule of thumb for preform sizing is roughly 75% of the die size. Actual final dimensions will depend on IC aspect ratio, and the method of scrubbing during solder attach).* The microcircuit is heated until the solder melts and bonds the two surfaces. While individual data sheets may call out product–specific restrictions on this method, 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. 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 usually results in lower junction temperatures which improves chip reliability.

Solder die attach requires a close TCE (Thermal Coefficient of Expansion) match between the IC and the underlying material (pedestal or substrate).

3.3 Pedestal mounting

Pedestals are often required to match the MMIC elevation to that of the RF substrate. Pedestals are also used when the TCE of the MMIC and substrate must be matched closely as in solder die attach. The table below gives the TCE and TC (Thermal Conductivity) of commonly used pedestal materials.

Table 1. TCE/TC

Material	TCE (PPM/°C)	TC (Watts per meter Kelvin) (W/mK)
GaAs	6.8	
Silver	6.5	153
Molybdenum	5	140
Kovar	5.2	Poor
Copper/Tungsten 80% Cu/20% W	8.5	255
Brass	20.5	
Aluminum	23	
Be Cu	16.7	
Cu	16	

Note: Aluminum, brass, copper, and copper alloys are not recommended due to the high TCE of these materials and the stresses they induce into the die attach interface.

Common practice is that pedestals are solder die attached to the microcircuit floor and then the MMIC is epoxy or solder die attached as a separate operation.

Pedestals are usually fabricated using an EDM process which is employed for small thin accurate parts such as MMIC pedestals. can supply EDM components such as MMIC pedestals on a contract basis; for additional information and support email: mmic_helpline@keysight.com.

4.0 Bonding Methods

Thermosonic wire bonding is the recommended methods for electrically interconnecting to GaAs ICs. Thermocompression bonding may be used as an alternative but care must be used to prevent the cracking of die. 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.

4.1 Thermosonic bonding

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 higher stage temperatures required with thermocompression methods. The recommended wedge and capillary bond schedules are given below.

Table 2. Thermosonic wedge bond schedule

Equipment	MechEl thermosonic wedge bonder
Bonding tool	Wedge, per Figure 1 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 ±6 msec

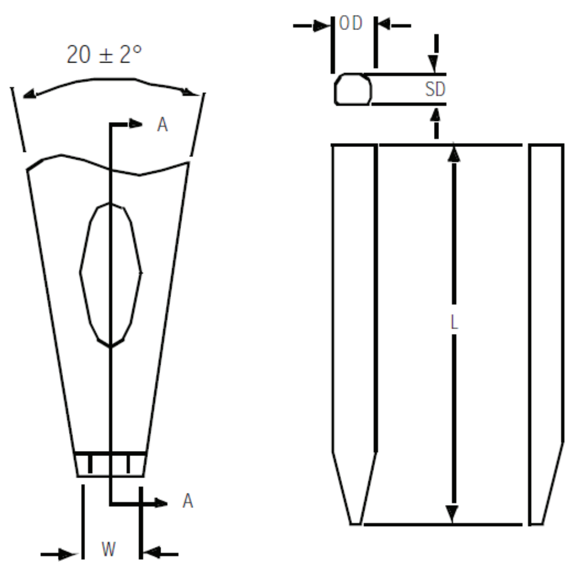

Figure 1. Wedge bonding tool

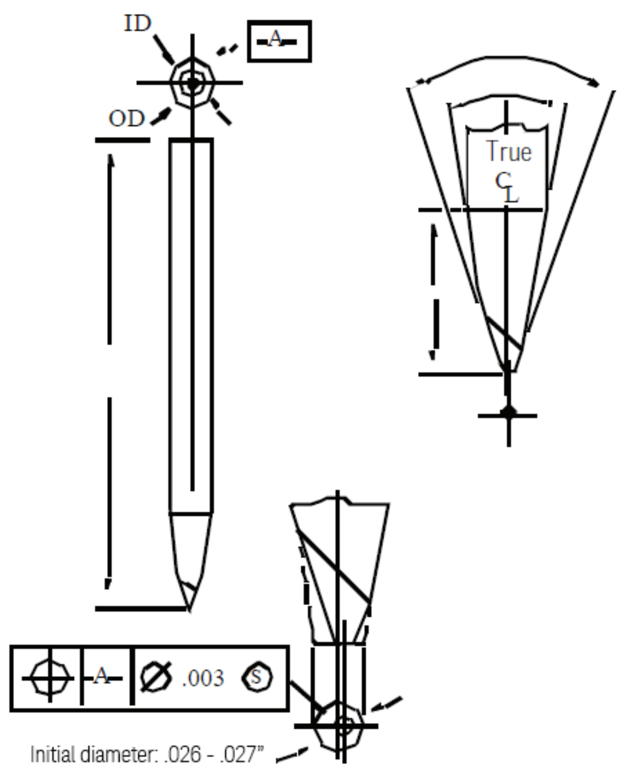

Figure 2(a). Thermosonic capillary bonding tool

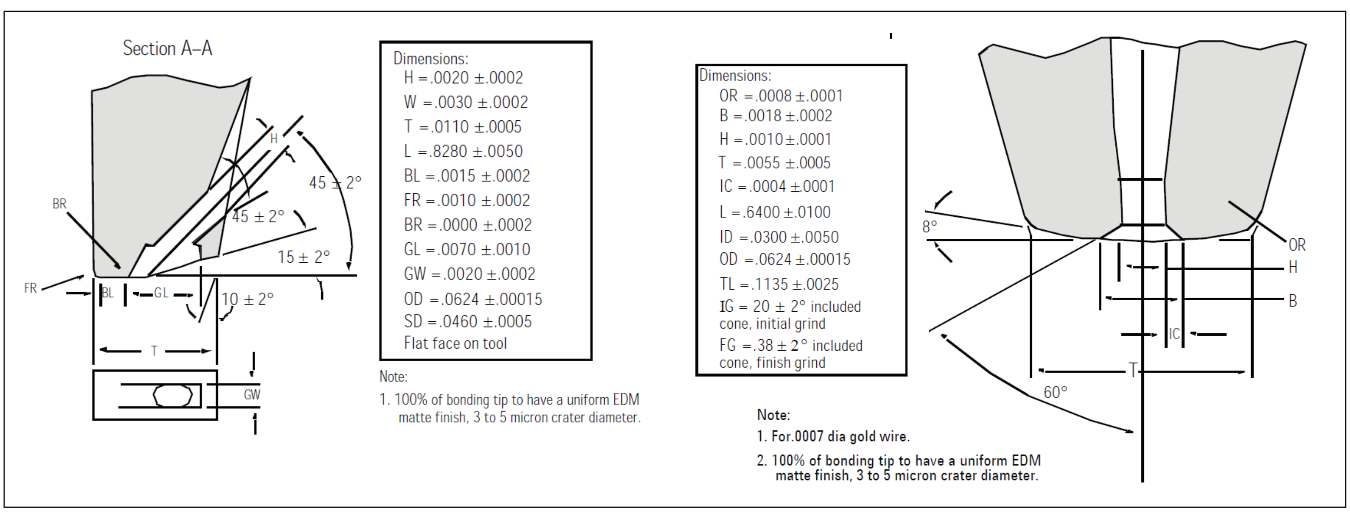

Figure 2(b). Detail of capillary

Table 3. 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 temp.	150 ±2 C°
Ultrasonic parameters (for bond pull on IC)	Power: 60 ±1 dB Dwell: 66 ±6 msec

Table 4. 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	28–32 grams
Stage temp.	250 C°
Tool temperature	300 C°

4.2 Thermocompression bonding

This method generally involves higher temperatures than those required with thermosonic bonding. Thermocompression bonds are usually formed with bonding tool temperatures of 300 °C and stage temperatures of 250–300 °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.

5.0 Summary

This guideline is the result of experience gained at facilities 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.

For additional information and support email:
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