Application Note

Handling Gallium Arsenide Die

Rev 1

INTRODUCTION

Gallium arsenide die have physical properties that require special care in assembly to ensure high yields and good reliability. A few simple precautions in the die mounting and wire bonding operations will result in a smooth prototype or production flow. This note discusses handling, assembly procedures, visual inspection criteria, and electrostatic discharge precautions. The recommendations given in this document are meant as references and may vary depending on specific equipment and application.

DIE MOUNTING

Crystalline GaAs used as a substrate for microwave integrated circuits is brittle and is susceptible to chipping and cracking. In addition, high performance GaAs ICs have unique elements, known as air bridges, on the top surface. Air bridges are small structures used as interconnect crossovers and are constructed with plated gold. There is no support along the span of the air bridge, although there is a passivating layer underneath, which prevents shorting. This causes them to be very malleable and subject to physical damage from tweezers or shear forces in die mounting, which can result in open circuits.

The ANADIGICS die has no back metallization and must be epoxy mounted. A good thermally conductive, silver filled epoxy should be used. It is also important that the epoxy have good mechanical characteristics at temperatures as high as 200^{o} C. An epoxy that meets these criteria is the two part EPO-TEK H-20S epoxy, having a cure temperature of 100^{o} C for 45 minutes, or Ablestik 84-1LMI.

A soft silicon/rubber tip collet or pyramidal collet should be used for die mounting, although tweezers can be used with extreme care. If a soft tip collet is used, be careful to keep the tip clean. Picking up at the edge of a die or picking dirty die can leave dirt on the tip of the collet that could scratch the die picked from there on. If a pyramidal collet is used, be careful about aligning the die accurately before picking it up. A misaligned pyramidal collet will cause the die to chip, crack or possibly shatter.

Equipment maintenance is important to any die attach operation. Excessive use of oil on moving parts could lead to oil flowing into the collet air line, causing oil to be deposited on the die. This oil can cause several problems later, from poor bond adhesion to package sealing problems.

It is critical that only the lightest pressure possible is applied to the die both in the pick up and mounting operation. Too much pressure can crush or tear the air bridges. Some slight deformation of the air bridge is allowable, but seriously deformed or broken air bridges should be screened at post die mounting visual inspection. Therefore, it is recommended that GaAs die be pressed into mounting epoxy by the sides of the die, not by applying pressure on the top surface of the die.

When pushing the die into the epoxy, a minimum of three (3) corners of the die should be surrounded by epoxy. The epoxy should not come more than half way up the side of the chip and at no time encroach the top of the die. The epoxy fillet should be inspected to ensure that all the epoxy is relatively void free. It is also important to observe that manufacturer’s recommended cure cycle.

WIRE BONDING

Ball bonding is recommended at a stage temperature of 150^{o} C with 1.3 mil gold wire, but wedge bonding can be used. Power, time, pressure and temperature settings are dependent upon the type and manufacture of the wire bonder. Care should be taken to characterize the wire bonder and setup using optimum parameters. Due to the brittle nature of GaAs, the substrate is subject to damage under the bonding pad. This can cause bond pad failure if too much force or too much ultrasonic energy is used during bonding.

A good combination of force and ultrasonics will make the bond in the shape of a Hershey's Kiss or a rain drop. If too much force is used, the bond will be large and flat, if too little is used the bond will be small and drawn up. After the force is set, adjust the ultrasonics to the point where the bond does not stick. Then increase the ultrasonic energy up slowly until the bond sticks well for your application. When building hybrids with both Si and GaAs die, it is recommended to bond the die with the first bond. This will simplify your setup since the first bond is the easier one to control.

Care should be taken when setting up the desired connections to the die so as not to contact the exposed air bridges, which may cause shorts. If using wedge bonding ensure that the first bond tail does not touch any circuit traces. If a second bond is used to make connection to the die ensure that the tear cycle does cause the wedge to cut across circuit traces. This may tear air bridges or otherwise damage the circuitry.

THERMAL CONSIDERATIONS

It is good practice to provide a good thermal path for any semiconductor device. This includes using a thermally conductive epoxy and a good thermally conductive mounting surface, such as alumina or metal. It is important that the thermal coefficient of expansion of the mounting surface is not greatly different from that of GaAs (TCE value of approx. 6×10^{-6} K^{-1}). Ceramics such as alumina or beryllium oxide are good, and some metal alloys such as kovar or alloy 42 are acceptable.

VISUAL INSPECTION

Visual inspection of the die is recommended upon receipt of a die shipment and after wire +bonding. A stereo microscope at 30X is recommended. At this magnification, shipping or assembly related defects can be detected. Inspection at higher magnification is performed by ANADIGICS to detect any process related defects that could result in reduced reliability or electrical performance.

Parts should be inspected for foreign matter, bent or broken air bridges, scratches and chips or cracks in the body of the die. Foreign matter that cannot be easily cleaned may cause shorts between air bridge lines. Broken air bridges usually suggest open circuits. Bent or otherwise disfigured air bridges can be allowed in most applications.

Because of the brittle nature of GaAs, some chipping of the edges of the die is normal. If these chips are confined to the edge of the die and do not touch active element of the device, they are acceptable. Chips may be caused by the die separation process, abnormally rough shipping, or almost any assembly procedure, particularly when handling with tweezers. Cracks that lie in the active region of the die may propagate with time and cause a failure. Exceptions can be made for chips or cracks that touch a bond pad. Reliability testing at ANADIGICS has shown cracks of this type do not cause reduced MTTF (Mean Time To Failure).

Scratches in metalization traces may suggest poor handling procedures and may disqualify a die for extremely high reliability level, but may not affect the electrical performance of the device. Scratches on the edge of a capacitor are of some concern, since this may cause the capacitor top plate to short against the bottom plate. The bond pads will have scratches caused by circuit testing, These scratches are normal and are not cause for rejection.

After mounting and bonding, parts should be inspected to ensure good epoxy fillets around the edge of the die. Large voids in the epoxy should be deterred, as well as, die that do not sit reasonably flat in the package. Wire bond sites should be inspected for short circuits and damage to traces or air bridges. Bond heels should also be inspected for proper deformation.

STATIC SENSITIVITY

All semiconductor devices are sensitive to electrostatic discharge. Often static induced failures are latent in nature, and sometimes the only indication of damage is just poor yields. Therefore, it is prudent to assume that all integrated circuits, including GaAs integrated circuits, require static controlled work stations. Operators should wear dissipative wrist straps and work over dissipative table mats. Finished work should be kept in dissipative packaging.

It is worth repeating that static failures are often not obvious. Semiconductor devices can be repeatedly handled without causing immediate failures. It should be noted that many kilovolts can be delivered with a simple touch causing a failure that may not show up for months. Therefore it is good practice to take all possible precautions during handling and assembly.

SUMMARY

Handling GaAs die encompasses many of the same concerns as any semiconductor device. General cleanliness and static protection practices are applicable as required by the desired screening level. A few allowances must be made to compensate for the brittleness of the material and the exposed air bridges. Often it helps to reduce the cycle speed of automated equipment. It also is important to pay close attention to the forces of die mounting and wire bonding, also the energy level of the ultrasonics during wire bonding. Inspections are necessary in keeping qualified processes from shifting and keeping quality levels high. Once these conditions are met, GaAs integrated circuits can be assembled with high yield and reliability.

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