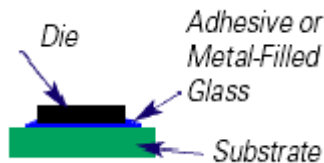


ANALYSIS OF DIE ASSEMBLY TECHNIQUES

System and board manufacturers that use bare die or flip-chip – such as National Semiconductor’s Die Products – have access to a wide variety of assembly methods that will produce high yield, high reliability systems. The following review of typical assembly techniques looks at the positive aspects and limitations of die attach, interconnect, seal, and encapsulation along with factors that are important to the process development of each method. We hope this information will aid die users in selecting the most effective manufacturing approach for their applications.

DIE ATTACH METHODS

Either an epoxy based adhesive or metal-filled glass is commonly used to attach die to a substrate.



THERMOSET ADHESIVE – Widely used for direct chip attach, multichip modules, and plastic packaging. All of National’s die can be used in this method.

Thermoset Adhesive die attach materials have a low cure temperature, low modulus of elasticity, high strength, a wide process window (bond line, cure time), and are relatively inexpensive. Their disadvantages include resin bleed, a lower level of thermal and electrical conductivity, limited reworkability, and limited internal water vapor (Residual Gas Analysis, a.k.a., RGA) performance. When using the Thermoset Adhesives, particular consideration must be given to the cure profile, bleed-out evaluation, material compatibility, design rules, pot life and storage, dispensing considerations/patterns/voiding, bond line control, and placement accuracy/planarity.

THERMOPLASTIC ADHESIVE – Used in high value modules where re-work must be an option; ideal for attachment of very large die where thermal expansion mismatches are unacceptable.

Thermoplastic Adhesives also offer a low cure temperature, a low modulus of elasticity, and are relatively inexpensive. But where there is limited reworkability with the Thermoset Adhesive, the Thermoplastic Adhesive is reworkable. Their disadvantages include limited bond strength, lower electrical and thermal conductivity, limited RGA performance, and the need for more manufacturing logistics in handling. When using thermoplastics, consider the need for greater force when attaching the die, placement accuracy/planarity/bond line requirements, and an awareness of the thermal hierarchy.

METAL-FILLED GLASS – For use in ceramic packaging that requires a high temperature hermetic seal. Many of National’s Enhanced Solutions products are qualified for high reliability applications.

When higher reliability is needed, such as in applications where there are temperature extremes or where other harsh environmental aspects must be considered, metal-filled glass is often used

for die attach. It provides high thermal and electrical conductivity, high temperature tolerance, excellent RGA, strength, and a mid-range modulus of elasticity. Disadvantages are that it adds to the cost, requires bond line control, is non-reworkable, requires fillet control, has die size limitations, and requires a high temperature organic burn-out. To take full advantage of its benefits, care must be taken to ensure bond line control, a proper OBO (Organic Burn-Out) profile, dispense control (to prevent voiding), placement accuracy, die size compatibility, and you must ensure the metallurgy of the die backside is compatible with the metal-filled glass material.

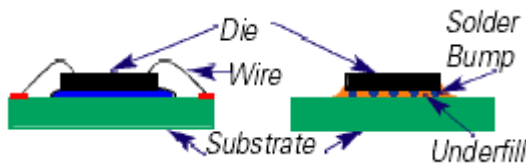
AU-Si (GOLD-SILICON) EUTECTIC – Used in high reliability hybrid packaging and ceramic packaging where a high temperature hermetic seal is needed. Here, too, National's Die Products meet the need for robust performance.

The Gold-Silicon Eutectic process is also used in the manufacture of higher reliability systems. It offers the advantages of high thermal and electrical performance, greater strength, low RGA, a high temperature tolerance, and is more reworkable than the Metal-Filled Glass material. Like the Metal-Filled Glass, the Gold-Silicon Eutectic process has a higher cost and is limited in the size die that can be used. It has a high modulus of elasticity, potential for chip damage, requires a high process temperature, and has a narrow process window. Process considerations include the process profile, an environment consisting of N₂ or N₂/H₂, die size, metallurgy (type & oxidation), voiding, and collet size/design.

SOFT SOLDER – Hybrid packaging. National provides a full portfolio of Die Products.

Like the Gold-Silicon Eutectic process, the Soft Solder process is used with hybrid packaging. It offers good thermal and electrical performance, is reworkable, and provides good matching for dissimilar TCEs (Thermal Coefficient of Expansion). However, it does require a special backside metalization. An N₂ or N₂/H₂ atmosphere is required and die placement issues (such as die movement during reflow) warrant monitoring. Process considerations include monitoring the level of O₂ in the process atmosphere, oxidation on surfaces, solder splash during placement, and voiding.

INTERCONNECT METHODS



Interconnect methods for die assembly use wires or solder bumps to electrically connect the die to the substrate.

GOLD-BALL BOND – For use in high reliability applications and plastic packaging. National supports with a full portfolio of Die Products.

Gold-Ball Bond provides high throughput, high strength, omni-directional coverage, and fine pitch capability. These advantages are contrasted with the need for an elevated temperature to perform this wire bond assembly coupled with increased material cost and the potential for unwanted inter-metallic issues. Process considerations when using this method include the high temperature, power, force, time, wire diameter and length, metallurgy issues, pitch, bonding surface conditions, and the bonding area.

ALUMINUM WEDGE BOND – Widely used for interconnects on direct chip attach

and ceramic packaging. National has a full portfolio of Die Products for high reliability applications.

While Aluminum Wedge Bond offers the advantages of room temperature processing, a lower material cost (wire), and fine-pitch capability, it is at the cost of a decrease in strength and throughput. This method is not optimum for hermetic applications. When using the Aluminum Wedge Bond method, consider these process issues: power, force, time, wire diameter, wire length, metallurgy, pitch, bond angle, forward and reverse bonding, bonding surface conditions, and the bonding area.

FLIP-CHIP EUTECTIC SOLDER – Used with modules or chip on board where traditional interconnect methods cannot provide the required electrical or physical performance. National offers eutectic solder bumps on select products for your flip-chip requirements.

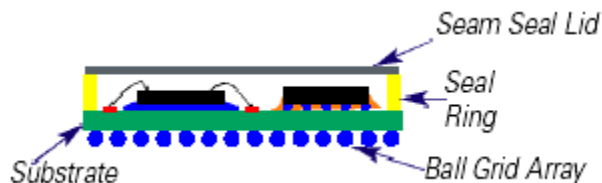
Of all of the interconnect methods, perhaps Solder Flip-Chip provides the best electrical performance, smallest footprint, and reliability. It is also reworkable. Disadvantages include the need for underfill, the requirement of high density PWB (Printed Wiring Board), and an infrastructure to support this die assembly method. When considering this process, evaluate the reflow profile, underfill approach, placement accuracy, bump/UBM metallurgy, substrate design and materials, CTE, and thermal hierarchy.

SEAL AND ENCAPULATION METHODS

In addition to the the previous die assembly techniques, the seal and encapsulation methods add a protective covering to the die.

HERMETIC – SEAM SEAL – Used in hermetic or high reliability multichip modules. National Semiconductor is a leading supplier of high-reliability Die Products.

Using this die assembly method provides a hermetic solution, large seal area, and low profile with low temperature processing and minimal manufacturing floor space requirements. Not being a batch process, low throughput is one of the drawbacks of seam seal. Process considerations include electrode design, lid design, and the need for a dry box environment.



NON-HERMETIC – GLOB TOP – Commonly used in direct chip attach applications. National provides a full portfolio of Die Products to support commercial and industrial applications.

The Glob Top process is flexible, has a low temperature cure, provides low stress, and a low profile. Its non-hermetic aspects, however, provide limited protection to the die and there is the potential for spread and wire wash. If using this method, process considerations include dispensing parameters, viscosity issues, cure time, and possible need for a dam.

