# Semiconductor Technology from A to Z

Assembly

# Die Attach

## Mechanical Mounting of the Die

After dicing, the individual, already identified functional dies remain on the carrier film. In the first step of the actual assembly process, each die is lifted from the film (die pick) and mechanically mounted onto its final carrier material – this process is referred to as die attach or die bonding.

Depending on the component type, different carrier materials (substrates) are used:

- Leadframe: a stamped or etched metal grid, usually made of copper or a copper alloy, which later forms the outer leads of the package
- Laminate or ceramic substrate: multilayer carrier boards with integrated wiring, as used for example in ball-grid-array packages (BGA)
- Direct chip attach: in some applications, the die is mounted directly onto a printed circuit board or another system without first receiving its own package

The die is precisely picked up by a gripping tool (die bonder), aligned, and placed onto the substrate with a defined contact force. Accurate positioning is important, since in the subsequent bonding step the die contact pads must line up as closely as possible with the corresponding connection points on the substrate.

## Bonding Materials

Various materials are used to actually attach the die to the substrate, with the choice depending on the electrical, thermal and mechanical requirements of the specific component:

- Adhesives (epoxy resins): by far the most commonly used method. The adhesive is either dispensed as a paste or applied in pre-formed film form (die attach film) between die and substrate, and subsequently cured thermally. Electrically conductive adhesives additionally contain fine silver particles to establish, in addition to the mechanical bond, an electrical connection between the backside of the die and the substrate
- Solder joints: particularly for components with high heat dissipation requirements, such as power semiconductors, the die is bonded directly to the substrate using a solder material (often gold- or tin-based). Solder joints offer significantly better thermal conductivity than adhesives
- Eutectic bonding: the die is bonded directly to a thin eutectic metal layer (frequently a gold-silicon alloy) on the substrate under the application of

heat, without requiring an additional paste-form bonding material

The choice of bonding material significantly influences how efficiently the heat generated by the chip during operation can be dissipated through the substrate – a particularly critical factor for high-performance processors and power semiconductors.

## Mechanical Stress and Quality Assurance

A key challenge in die attach is mechanical stress arising from differing thermal expansion coefficients between die and substrate. Silicon and common substrate materials such as copper or ceramic expand to different degrees with temperature changes. During curing of the bonding material, and later during operation of the finished component, this can generate stress within the die that, in the worst case, leads to cracking.

To limit this stress, bonding materials with a certain degree of elasticity are used, capable of compensating for small expansion differences without damaging either the bond itself or the die. In addition, the thickness of the bonding material layer is carefully controlled: a layer that is too thin provides insufficient compliance, while a layer that is too thick can worsen the thermal connection.

After the bonding material has cured, the quality of the die attach bond is inspected, among other things through optical inspection for voids (cavities within the bonding material) and through shear strength testing, in which the mechanical adhesion of the die is checked on a sample basis. Only after successful inspection does the die proceed to the next process step, bonding.