Semiconductor Technology from A to Z

Assembly

Encapsulation

Purposes of Encapsulation

After bonding, the die is fully electrically connected to its substrate but still lies exposed and unprotected. In the final major step of assembly, the die is therefore embedded in a protective molding compound – this process is referred to as encapsulation or molding.

As part of the overall packaging process, encapsulation fulfills several fundamental purposes:

- Protecting the circuit from external influences such as moisture, dust and mechanical damage
- Routing the sensitive on-chip contacts out to robust, manageable external connections
- Supplying the circuit with electrical power via the package leads
- Dissipating the power loss generated during operation
- Distributing signals and data between the chip and the surrounding circuitry

The trend in packaging technology is toward increasingly smaller and thinner packages (chip size package, CSP), in which the finished package is only marginally larger in length and width than the actual chip, typically by a factor of around 1.2.

Materials and Methods

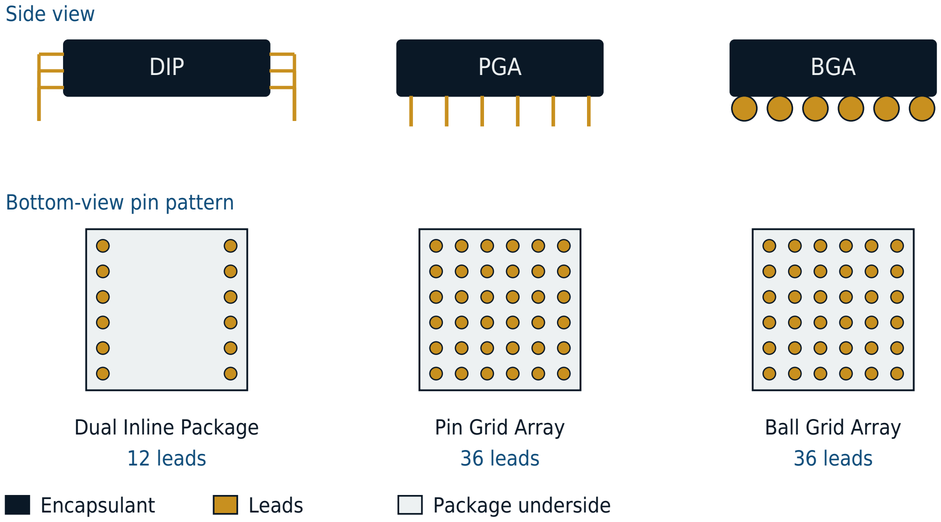
The most widely used method is molding, in which the die, together with its bond wires or bumps, is injected into a thermoset plastic compound. This molding compound cures under heat and subsequently forms the actual, solid package of the component.

Well-known package types produced this way include, for example:

- DIP – Dual Inline Package
- PGA – Pin Grid Array, commonly used especially for processors
- BGA – Ball Grid Array

Package Types

Leads along the edge or across the whole area



On the same footprint, the area array carries 3 times as many leads as two rows along the edge. That's why PGA and BGA prevail wherever many contacts are needed – for example in processors.

For components with particularly high heat dissipation requirements, such as power semiconductors, packages made from highly thermally conductive materials such as metal or ceramic are used instead of plastic. However, these materials are considerably more expensive than plastic, which is why mass production predominantly relies on plastic packages.

In the flip-chip technology described earlier, a classic full package is often omitted entirely: here, the underfiller already introduced during the bonding step takes over part of the protective function, while the chip itself remains exposed on the substrate.

Heat Dissipation and Final Quality Inspection

As the power dissipation of modern chips continues to increase, heat dissipation is one of the most important considerations when selecting package type and molding material. Short conduction paths and materials with good thermal conductivity are indispensable for this. For particularly high-performance components, additional heat dissipation measures are therefore frequently integrated into the package design, such as exposed metal areas on the underside of the package (exposed die pad) or dedicated thermal paths within the substrate.

After the molding compound has cured, the package is given a unique marking, typically via laser engraving, which carries manufacturer information, type designation and, where applicable, the result of the preceding binning step.

This concludes the actual assembly process. The fully encapsulated chip subsequently undergoes the final functional test described earlier, before being packaged for shipment to device manufacturers.