Semiconductor Technology from A to Z

Assembly

Bonding

Electrical Contacting of the Die

After the die has been mechanically attached to the substrate through die attach, it still needs to be electrically connected to the substrate connection structures. This process is referred to as bonding. Electrical contacting is achieved in about 90% of cases via wire bonding, while the mechanical attachment of the chip – as described in the previous chapter – is mainly carried out by bonding with epoxy resins.

In wire bonding, thin wires made of gold or aluminum are used, which are cold-welded to the contact pads of both chip and substrate. Three common variants are distinguished:

- Thermosonic ball-wedge bonding
- Ultrasonic wedge-wedge bonding
- Thermocompression ball-wedge bonding

In all three methods, a small ball first forms at the end of the wire, created by locally melting the wire tip. Due to the strong surface forces of the molten gold, the melt solidifies into a ball whose larger diameter compared to the bond wire ensures a more reliable mechanical and electrical connection.

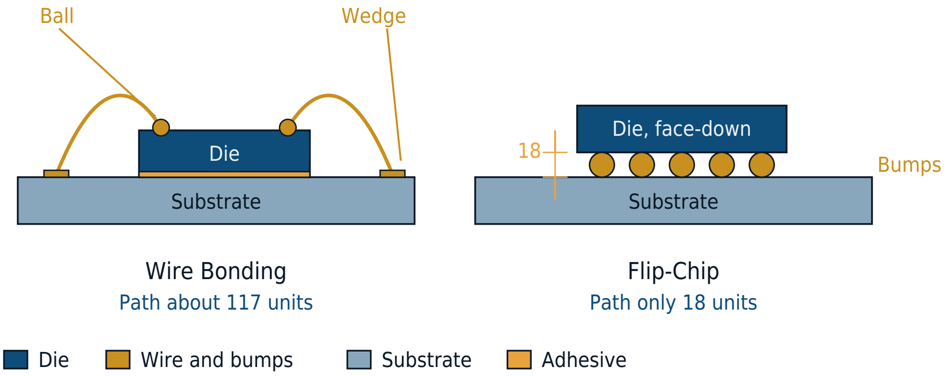
Flip-Chip Technology

In addition to classic wire bonding, flip-chip technology offers an alternative method that requires no long bond wires at all and represents the most compact form of connection between chip and substrate.

To create a flip-chip connection, small solder bumps must be present on the chip and/or the substrate. To form the connection, the chip is placed face-down, but with very precise alignment, onto the substrate. During a subsequent reflow process, the bumps melt and simultaneously form a mechanical and electrical connection between chip and substrate.

Wire Bonding and Flip-Chip

The length of the connection path determines inductance and heat



The bond wire is roughly 6 times as long as the path across a bump. Short paths mean less parasitic inductance and better heat dissipation – both favor flip-chip technology.

The key advantage of flip-chip technology lies in the very short connection paths from chip to substrate via the solder bumps – in contrast to the comparatively long wire bonds used in classic wire bonding. This reduces parasitic inductance and capacitance in the connection, which is electrically advantageous at very high signal frequencies.

Since a flip-chip connection typically leaves an air gap between chip and substrate, it is usually necessary to additionally introduce a so-called underfiller. This fills the remaining gap between chip and substrate and compensates for mechanical stress arising from the differing thermal expansion coefficients of the two materials.

Requirements and Heat Dissipation

Regardless of the bonding method chosen, the electrical connections between chip and substrate must meet a number of fundamental requirements: low electrical resistance, high reliability over the component entire service life, and good mechanical adhesion even under thermal cycling.

An increasingly important aspect of bonding is heat dissipation. As the power dissipation of modern chips continues to rise, removing the resulting heat becomes a very important consideration throughout the entire packaging and interconnection process. Short conduction paths and materials with good thermal conductivity are indispensable for this. This is precisely where flip-chip technology offers advantages over classic wire bonding, since the short connection paths via the bumps are also more favorable for heat dissipation than long bond wires.

Once bonding is complete, the chip is fully electrically connected to its substrate. The next step in assembly is to protect this sensitive connection, as well as the die itself, from external influences through suitable encapsulation.