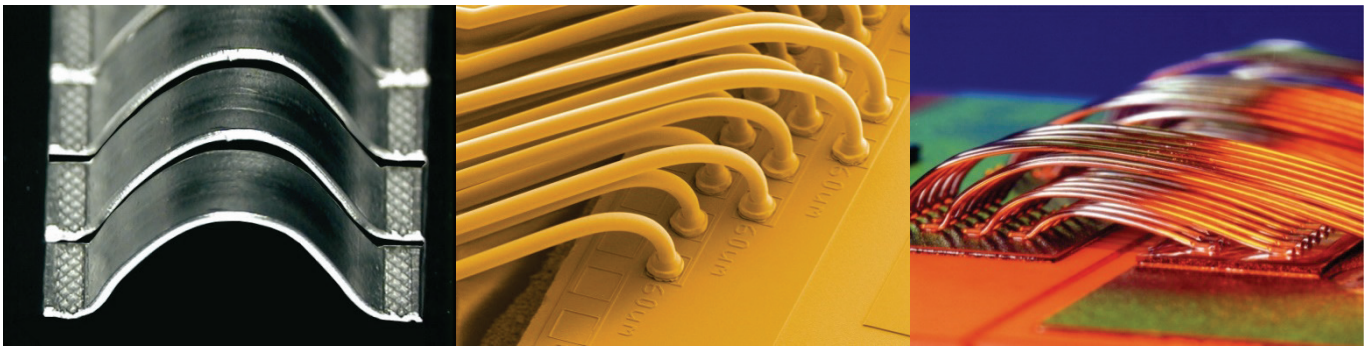
WHAT IS WIRE BONDING?

ADVANCED TECHNOLOGY FOR RESEARCH & INDUSTRY

KNOWLEDGE BASE FACT SHEET

- SCOPE: Understanding Wire Bonding Techniques and Processes for Micro Electronics Assembly Applications.



Wire bonding is the method of making interconnects between an integrated circuit (IC) or similar semiconductor device and its package during manufacturing; it is also commonly used now to provide electrical connections in Lithium-ion battery pack assemblies.

Wirebonding is generally considered the most cost-effective and flexible of the available microelectronic interconnect technologies; and finds its use in the majority of semiconductor packages produced today.

There are several wire bonding techniques, comprising:

Thermo-Compression Wire Bonding:
Thermo-compression wire bonding (combining to likely surfaces (usually Au) together under a clamping force with high interface temperatures, typically greater than 300°C, to produce a weld), was initially developed in the 1950's for microelectronics interconnects, however this was quickly replaced by Ultrasonic & Thermosonic bonding in the 60's as the dominant interconnect technology. Thermo-compression bonding is still in use for niche applications today, but generally avoided by manufacturers due to the high (often damaging) interface temperatures required to be successful.

Ultrasonic Wedge Wire Bonding:
In the 1960's Ultrasonic wedge wire bonding became the dominant interconnect methodology. Application of a high frequency vibration (via a resonating transducer) to the bonding tool with a simultaneous clamping force, allowed Aluminium and Gold wires to be welded at room temperature. This Ultrasonic vibration assists in removing contaminants (oxides, impurities, etc.) from the bonding surfaces at the start of the bonding cycle and in promoting intermetallic growth to further develop and strengthen the bond. Typical frequencies for bonding are 60 – 120kHz.

The ultrasonic wedge technique has two main process technologies:

Large (heavy) wire bonding for >100 µ diameter wires

Fine (small) wire bonding for <75 µ diameter wires

Examples of typical Ultrasonic bonding cycles can be found here for fine wire and here for large wire.

Ultrasonic wire bonding uses a specific bonding tool or "wedge," usually constructed from Tungsten Carbide (Al) or Titanium Carbide (Au) depending on the process requirements and wire diameters; ceramic tipped wedges for distinct applications are also available.

Thermosonic Wire Bonding:
Where supplementary heating is required (typically for Gold wire, with bonding interfaces in the range of 100 – 250°C) the process is called Thermosonic wire bonding; this has great advantages over the traditional thermo-compression system, as much lower interface temperatures are required (Au bonding at room temperature has been mentioned but in practice it is unreliable without additional heat).

Thermosonic Ball Bonding:
Another form of Thermosonic wire bonding is Ball Bonding (see the ball bond cycle here). This methodology uses a ceramic capillary bonding tool over the traditional wedge designs to combine the best qualities in both thermo-compression and ultrasonic bonding without the drawbacks. Thermosonic vibration ensures the interface temperature remains low, while the first interconnect, the thermally-compressed ball bond allows the wire and secondary bond to be placed in any direction, not in-line with the first bond, a constraint in Ultrasonic wire bonding. For automatic, high volume manufacture, ball bonders are considerably faster than Ultrasonic / Thermosonic (Wedge) bonders making Thermosonic ball bonding the dominant interconnect technology in microelectronics for the last 50+ years.

Ribbon Bonding:
Ribbon bonding, utilising flat metallic tapes has been dominant in RF and Microwave electronics for decades (ribbon providing a significant improvement in signal loss [skin effect] versus traditional round wire). Small Gold ribbons, typically up to 75um wide and 25um thick are bonded via a Thermosonic process with a large flat-faced wedge bonding tool.

Aluminium ribbons up to 2000um wide and 250um thick can also be bonded with an Ultrasonic wedge process, as the requirement for lower loop, high density interconnects has increased.