FINE WIRE BONDING EXPLAINED

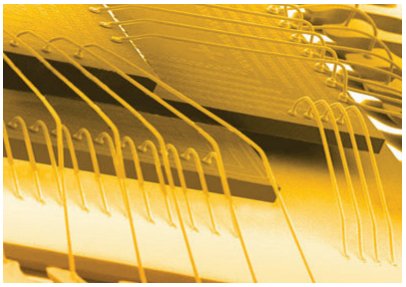
ADVANCED TECHNOLOGY FOR RESEARCH & INDUSTRY

KNOWLEDGE BASE FACT SHEET

- SCOPE: What is fine wire bonding and how does it work?

Fine Wire bonding Process:

Wire bonding is the process of providing electrical interconnects between an Integrated circuit or component and the external leads of its packaging such as a lead frame or PCB with very fine bonding wire (<75 micron diameter wire).



Gold Ball Bonded Stacked Die Package

The materials of the wire used in wire bonding are usually made of gold (Au), aluminum (Al) or increasingly copper (Cu). In fine wire bonding there are two main process variations: Ball bonding and Wedge bonding.

Ball Bonding:

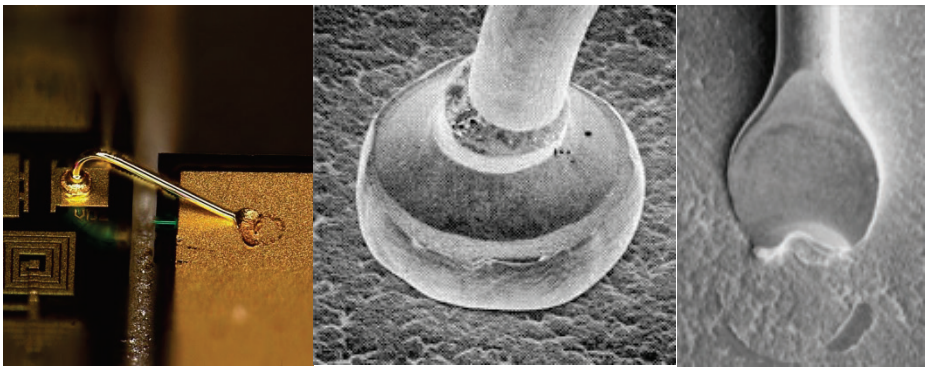
During the ball bonding process, the wire is thread through and held by a bonding tool known as a capillary. The end of this wire is then melted by means of an EFO (Electronic-Flame-Off) to achieve a free-air-ball roughly 1.5-2.5 times the size of the wire diameter used. The free-air-ball size is controlled by the energy provided by the EFO and also the length of the wire provided (known as the tail).

The free-air-ball is brought into contact with the bond pad, coupled securely by the capillary. Pressure, heat and ultrasonic energy are then applied to the ball for an amount of time, forming an intermettalic weld between the ball and the bondpad. The ball is deformed during this process to a shape defined by the dimensions and geometry of the capillary tip (note: bond parameters will also have an effect on the final bond geometry).

The wire is then guided to the next bond position, where the wire is brought into contact with the package interconnect pad underneath the capillary, the wire is guided through the capillary during this movement making a loop of wire between the two bond locations. Controlling this movement can help determine the shape, height and length of this loop.

Pressure, heat and ultrasonic energy are then applied to the wire to create the second bond (Sometimes referred to a ‘stitch’ or ‘fish tail’ bond). The process is completed by means of breaking the wire in preparation for the next wire bonding cycle, by clamping the wire and raising the capillary.

Ball bonding can be used to bond both Au and Cu wire, as Cu wire is considerably harder than Au, increased parameters and harder materials are needed for the capillary along with a localised inert atmosphere for the EFO, in order to prevent oxidization during the creation of the free-air-ball.



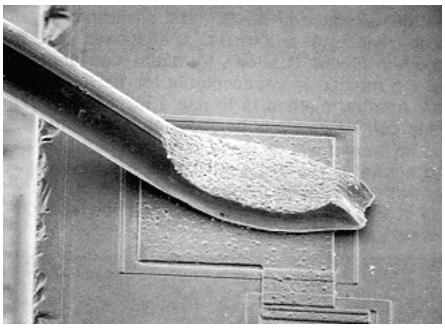
Gold Ball Bond: Complete Wire, 1st Ball Bond & 2nd Bond

Wedge Bonding:

During wedge bonding, a clamped piece of wire is coupled under a bonding tool (referred to as a wedge) and a bond pad. Pressure and ultrasonic energy are applied for a given period of time forming a first wedge bond. The shape and dimensions of this bond are determined by the dimensions of geometry of wedge (note: bond parameters will also have an effect on the final bond geometry).

The wire is guided through the wedge during this movement making a loop of wire between the two bond locations. Controlling this movement can help determine the shape, height and length of this loop. The wire is then guided through the wedge tool to the second bond location and the pressure and ultrasonic energy are applied again to form the second bond location. The process is completed by means of breaking the wire in preparation for the next wire bonding cycle, by clamping the wire and movement of the wire.

Wedge bonding can be performed using Al, and Au wire with the addition of heating the bonding surface and modifications to the wedge tools material construct and tip shape. Al wire will use a concave tip shape made from tungsten carbide while Au wire will use a cross-groove tip shape made from Titanium Carbide.

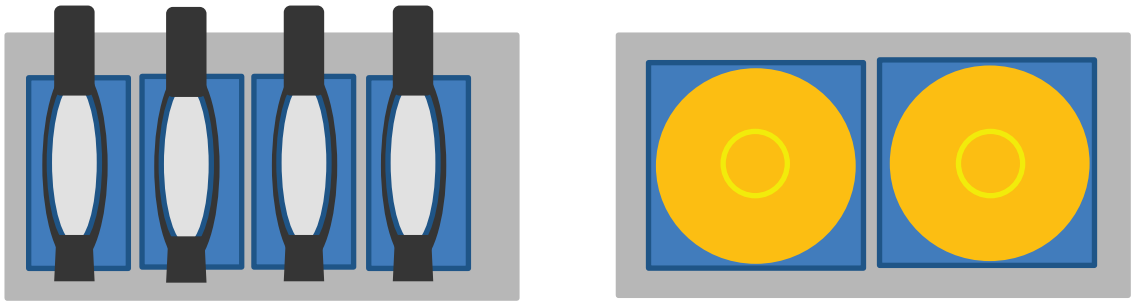


Aluminium Wedge Bond

Comparison:

Ball bonding is non-directional unlike wedge bonding which is uni-directional which makes ball bonding a much faster process than wedge, as the part being bonded does not to need to be aligned to the path of the wire and tool.

Wedge bonding has the advantage of been able to bond to pads with a smaller pitch compared to ball bonding. Wedge bond footprints are considerably narrower as there is no need for a free-air-ball to be created.



Wedge Bond versus Ball Bond Pitch Comparison

Unlike gold ball and gold wedge bonding, which require an elevated temperature (typically 125-150 degrees Celsius), Aluminium wedge bonding is performed at ambient temperature and can therefore be used where devices / materials are temperature sensitive.

The elevated temperature required for bonding wire gold wire helps ‘soften’ the bond pad surface and introduce more energy into the bonding junction, as well as help remove organic contaminates off of the bond pad surface; widening the process window.