Making the connection with wire bonding

Wire bonding will remain as the predominant means of first-level interconnect in the next millenium because there is a substantial infrastructure consisting of equipment, supporting materials, and process expertise in place to support an efficient wire bonding operation.

Wire bonding is a means of first-level interconnect, which is the initial interconnection to the actual die surface or the logic on a device. This interconnect takes that logic, or the power of the chip and connects it to the outside world. Other methods of first-level interconnect include flip chip and tape automated bonding (TAB). However, wire bonding is the predominant means of interconnection with more than 90 percent of total first-level interconnects. Of this figure, gold wire bonding represents approximately 90 percent of the interconnects while the remainder is aluminum and other noble or near-noble metals.

**Wire bonding types**

Wire bonding is done to interconnect a chip to a substrate, substrate to a substrate, or substrate to a package. Two types of wire bonding is currently used—ball bonding and wedge bonding.

Gold-ball bonding is the most popular method. In this process, a melted sphere of gold bonds a length of wire down as a first bond. Then a loop drawn out from the first bond connects the wire (the second wedge bond) down by means of a crescent and then reforms another ball for the subsequent first ball bond. Gold-wire bonding is characterized as a thermosonic process, meaning that heat (typically 150°C), ultrasonics, force, and time are all used to effect the bond.

The second method of wire bonding is the wedge bonding process. This process is primarily used with aluminum wire but also can be used with gold wire. Usually performed at an ambient temperature, wedge bonding involves putting two wedge bonds down. No ball is formed in this process. This aluminum bond process is characterized as an ultrasonic wire bond, meaning only ultrasonic energy, force, and time are used to create the bond.

The use of these types of processes depends on the specific type of application. For example, gold-wire bonding is used in most high volume applications because it is a faster process. Aluminum-wire bonding is used in situations when packages or a PCB cannot be heated. In addition, the wedge bonding process can attain a finer pitch than gold-wire bonding. Presently, the pitch limits of gold-wire bonding are as fine as 60µm. Aluminum wedge bonding with fine wire can be performed at pitches finer than 60µm.

**Applications**

The applications for wire bonding are diverse. The source of products that these eventually end up in range from PCs, to video cassette recorders, automobiles, aircraft, and microwave ovens. The automatic wire bonder industry has matured considerably in the last 20 to 25 years. The speed and

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“Wire bonding is still the most flexible for performing first-level interconnects.”

- Bruce Hueners

The wire bonding of hybrid circuits, MCMs, and similar packages have some special requirements that are not found in monolithic devices. Primarily, the unique challenges for these types of products are custom handling with large area and deep access requirements. When there are step heights within a product, such as bonding to die, substrate, package pins, a rectilinear Z-drive bond head has the capability to address bond surfaces over a range from 0mils to 250mils or greater with a single setup.

With hybrids and MCMs, the other special requirements include the variety of chips that are contained in the packages and the particular properties of each of the surfaces. This requires capability within the bonder for programming force, time, and ultrasonic parameters for each bond. Also, special looping capability for forming the shape of the wire interconnecting first and second bond is necessary. In microwave applications, the shape of the loop is critical for tuning of the circuit.

**Evaluating wire bonder**

When purchasing a wire bonder, you need to determine several things. Will the bonder build the required product? You would normally submit an application to be performed by the supplier. The wire bonder supplier has to know not only how to make the application run, but also understand metallurgy and electronic manufacturing.

You also need to determine the reliability level of the equipment and the degree of support that will be provided at installation and subsequently when the machine is put in production. In general, problems to be aware of with wire bonding fall into three categories. First is material and whether it is suitable for a high-yield wire bonding process. Gold-wire bonding, for example, requires smooth, clean bond surfaces. Typically, gold wire is bonded to an aluminum pad on the die and thick- or thin-film gold metallization on the substrate. The cleanliness of the substrate affects the reliability of the bond.

Gold-wire bonding is one of the most sensitive processes in microelectronic assembly. It could be characterized as a “litmus test”, which determines if materials and processes are under control. If they are not, there likely will be problems with the wire bonder.

Material problems can range from organic to inorganic contamination of the bond surfaces to micro cracks in the die structure. You can usually remove organic contamination with a cleaning process, such as argon plasma cleaning. Other material problems usually need to be solved in one or more upstream processes, such as die and substrate fabrication.

The second area where problems may occur is in the manner in which the bonding process is performed.