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• Inventors of the Ceramic Capillary •

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Ultrasonics in Wire Bonding

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Part I of II

In The Beginning, Thermocompression

From the historical standpoint, Au-Al semiconductor wire bonding was done only by heat and pressure (thermo compression), which provided a metal to metal weld. This was an acceptable process for some years but the 300ºC+ temperature and relatively high bonding parameters (force, time) became a problem with thinner devices, device sensitivity, lead frame oxidation, etc. In addition, low cost trends invited more plastics and lower temperature assembly materials and less use of ceramic packages.

The Addition of Ultrasonics

Around 1979, some thought that adding an ultrasonic vibration to the capillary along with the usual parameters that the "scrubbing" action of the metal surfaces would improve the bond reliability. (Ultrasonic "wedge" bonding at room temperature has and is currently being used for Al-Al metal system). As luck would have it. It also lowered bonding temperature requirements and created better Au-Al reactivity.

The actual bond mechanism is chemical reactivity at the interface forming strong Intermetallic compounds. The available vibrating devices were 60 kHz frequency and most process were designed around this frequency form many years and still remain so, even today.

The Advent of High Frequency

In the late 1980's, however, a group of bonding scientists working at major multinational semiconductor company based in Dallas, Texas pioneered a revolutionary improvement in the ball bond process by increasing the transducer frequencies beyond the standard 60 kHz. Along with this, more precise power controllers and more efficient transducers were developed which further improved process capabilities.

Capillaries were also modified to better utilize the necessary changes in process design as well as being tuned to the higher frequency transducers.

Exactly, then, what is *high* frequency (HF)? Frequencies beyond 90-100 kHz are considered HF. This represents an apparent threshold where significant changes in bond quality and overall process improvements began to occur.

In reality, optimum HF frequencies processes are in the 120-140 kHz range. The advantages observed with a fine-tuned HF process are stronger bonds due to better metal reactivity, shorter bond times, lower forces, and a significant improvement in temperature reduction.

In fact, reported data has indicated gold ball bonding on Nickel (Ni) at room temperature with a frequency of 240 kHz, a difficult bond under any conditions. Process improvements on other hard to bond surfaces such as, flex, rubbery, soft and very hard have been achieved with well designed processes.

Wedge bonding, though not as widely used with HF, shows improved results with normally difficult surfaces. It should be pointed out that the lower the frequency, the more "scrubbing" or actual physical displacement of the tool tip occurs, which is not desirable. Increasing frequency eventually results in acoustic energy transfer that actually increases chemical activity with virtually no scrub.

Coming Next: Part II - Ultrasonics in Wire Bonding

Happy Holidays!!!