Contacts:

Joseph S. Bubel
President
Hesse & Knipps, Inc.
408-436-9300
bubel@hesse-knipps.us

Lee Levine
Consultant
Process Solutions
Consulting, Inc.
610-248-2002
levilr@ptd.net

Dana Baedke
Key Marketing
Communications
267-263-2513
dana@keymarketing.biz

Why Wedge Bond?

By Joseph S. Bubel and Lee Levine

In the past, ball bonding has dominated the interconnect market because of its high speed and capabilities. But now as interconnect density is becoming greater (the ITRS roadmap predicts that we are heading towards 20 µm pitch) ball bonding is reaching its limits. Wedge bonding, because it can produce a smaller full strength weld than ball bonding, has the potential to dominate the market in ultra fine-pitch devices.

Wire bonding is a welding process and ultrasonic welding is accomplished by deforming the wire and the substrate together, forming them into an alloy of the two constituents. Ultrasonic energy enhances the process by lowering the flow stress and allowing easy slip mechanisms for dislocation movement (deformation occurs by the movement of dislocations). Wedge bonding, because it directly deforms the wire without first forming a ball, is capable of producing a weld with less deformation than ball bonding. High quality welds can be produced with bond width 20-25% larger than the wire diameter. This size is significantly smaller than the minimum size that a ball bonder can produce for the same wire diameter. Figure 1 shows the common bonding processes and compares their deformation as a function of initial wire diameter for an optimized process.

In order to achieve finer pitch capabilities all bonders must reduce wire diameter. For ball bonders, reducing the wire diameter allows ball formation and subsequent deformation with a smaller final bond diameter. However, as wire diameter is decreased conductivity and strength are also reduced. Many new devices require more current and the smaller diameter wire required by finer pitch devices has a negative impact on performance and reliability. Wedge bonding has an advantage, because it can achieve equivalent pitch with a larger diameter wire, or finer pitch with the same diameter wire as ball bonding.

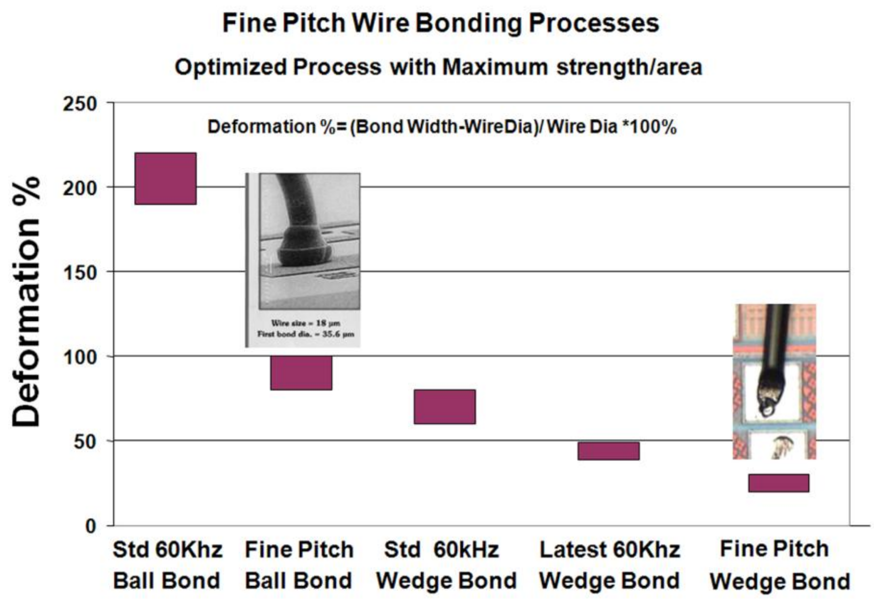
New wedge bonders have many new capabilities:

- They are much faster than previous generation machines, and now are capable of bonding more than 6 wires/second. > VIDEO: BONDHEAD AND MACHINE SPEED DEMONSTRATION
- New constant loop height and constant loop length algorithms achieve optimum control of electrical properties (impedance, capacitance). > VIDEO: PROGRAMMABLE LOOPING PARAMETERS

- Low loop capability is superior because there is no ball adding to the bond height and the low take off angle of the wire naturally tends toward lower height. New looping motion algorithms provide the lowest loops achievable. > VIDEO: LOOP HEIGHT AND WIRE LENGTH PROGRAMMING & DEMO
- In 8 die stacks wedge bonds have been shown to achieve a 32% decrease in cross section and a 20% decrease in total stack height compared to standard ball bonded devices. This provides an inexpensive alternative to TSVs in 3-D packaging.
- Bond placement accuracy has improved. New machines are capable of 1µm bond placement repeatability @3σ. Improvements in V groove and oval hole tools in conjunction with bonder advances have significantly improved bond placement enabling them to achieve the finest pitch available for any wire bonding process.

With the continuing drive toward finer pitch and the trend toward higher power devices wedge bonding will become the leader in ultra fine-pitch interconnection.

Figure 1. Wire Bonding Process Capability



 For more information, please visit the company's website at www.hesse-knipps.com, e-mail info@hesse-knipps.us or call Joe Bubel at 408-436-9300.

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Headquarters
Hesse & Knipps GmbH
Vattmannstraße 6
33100 Paderborn
Germany
Phone: + 49 52 51-15 60-0
Fax: + 49 52 51-15 60-97
E-Mail: info@hesse-knipps.com

The Americas
Hesse & Knipps, Inc.
2305 Paragon Drive
San Jose, CA 95131
USA
Phone: +1 (408) 436-9300
Fax: +1 (408) 436-2822
E-Mail: info@hesse-knipps.com

Asia Pacific
Hesse & Knipps Asia Limited
Unit 1605, 16/F, Westin Centre
26 Hung To Road, Kwun Tong
Hong Kong
Phone + (852) 2357-9400
Fax: + (852) 2357-4700
E-mail: info@hesse-knipps.com.hk