Should We Pull Test and Shear Test Fine-Pitch Wedge and Ribbon Bonds?

By Lee Levine, Contributing Editor

The wire bond pull test and shear test are widely used to evaluate and control the quality of ball bonds—fine pitch and otherwise.

The shear test is the only method that adequately evaluates the strength of the weld. The pull test cannot test the weld because the welded cross section is normally significantly larger and stronger than that of the wire.

The dominant failure mode during pull testing is fracture in the HAZ, the weakened section of the wire above the ball. (The HAZ is the portion of the wire next to the ball that has been annealed and recrystallized by the heat needed to melt each new ball during its formation.)

The pull test does provide a meaningful look at second bonds, however and is still an important acceptance criteria for both ball and wedge bonding.

Shear testing is not commonly used to check the strength of wedge bonds. I believe, however, that as fine-pitch wedge bonding increases, both the shear test and the pull test must be employed to ensure high-quality results.

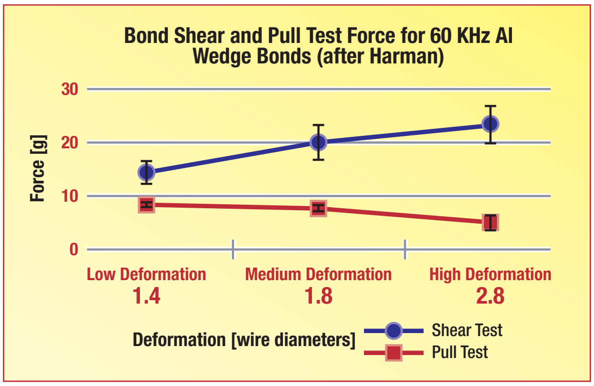
Obviously, standards and metrology will have to be established, as they were for ball bonding, to provide benchmarks and guidance for testing.

Reliability Studies

In ball bonding, long-term reliability studies have shown that at a strength level of 84 MPa (5.5 g/mil^2), ball bonds maintain high strength through 1000 hours of thermal storage at 175°C.

Lower-strength bonds degrade and are unacceptable. Although wedge bonding offers a long history of high reliability, to date no studies have been published correlating strength levels of gold wedge bonds with intermetallic coverage and long-term reliability.

Shear testing cannot be a stand-alone test for wedge bond quality. The graph demonstrates the reason why shear testing and pull testing must both be used: As wedge bonds are increasingly deformed, the cross-sectional area increases and the shear strength increases proportionally.



This graphic demonstrates why shear testing and pull testing must both be employed. (After G. Harman, *Wirebonding in Microelectronics*, McGraw-Hill, 1997, p. 105.)

However, when deformation increases beyond an optimum, the cross section just behind the bond, the "heel," is reduced to below that of the wire and the pull strength drops.

If a process engineer only optimizes shear strength, over-bonding results in reduced pull strength. Conversely, optimizing pull strength limits shear strength. Truly optimum bond quality can only be achieved by optimizing both methods.

With the advent of high-frequency ultrasonic bonding (>100 KHz), the deformation levels needed to achieve high-strength bonds has decreased.

Although the graph shows a deformation level of 1.8X as optimum, this level was typical for 60 KHz bonding. Equivalent high-frequency (100-120 KHz) wedge bonds achieve optimum strength with lower deformation than 60 KHz bonds, at approximately 1.25X the wire diameter.

Lower Deformation

The lower deformation provides one of the major benefits of high-frequency ultrasonics. It is still possible, however, to over-bond and reduce the cross section of the bond heel, as shown on the graph, by the drop in the pull strength with high deformation.

Two items to watch for: Will wedge bonding take the lead in fine-pitch wire bonding? And will the application of standards, equivalent to those used for ball bonding, drive the implementation of new reliability testing methods such as the shear testing of wedge bonds?

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