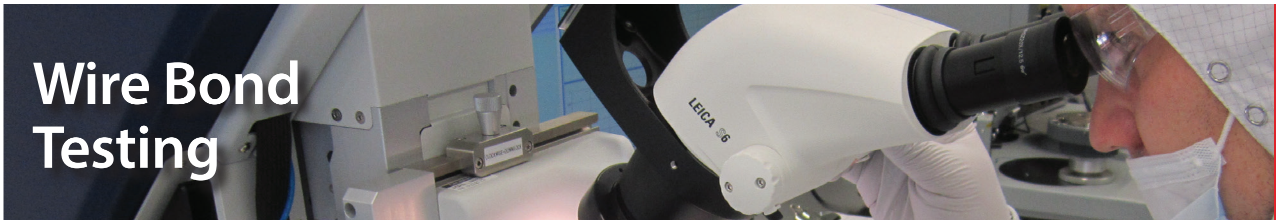

Wire Bond Testing

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Destructive Wire Bond Testing: Advancing Development and Production Processes

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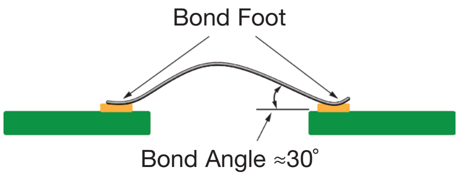
WIRE BONDING STANDS OUT AS THE most cost-effective and flexible interconnect technology, widely utilized in assembling semiconductor packages. Astoundingly, wire bonding forms over 15 trillion interconnects annually. However, this interconnect method has long posed challenges for process and manufacturing engineers. The development process involves extensive effort, including destructive pull and shear testing, along with multifactorial design of experiments. Once the process is ready for manufacturing, the responsibility falls on the manufacturing engineering teams to maintain process integrity within specified parameters, which often necessitates further destructive testing.

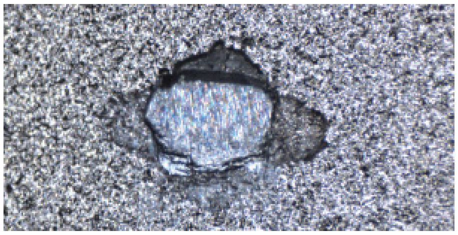
Ironically, destructive testing only applies to a fraction of the bonds tested, as only the untested bonds are shipped to customers. This raises a question: How does wire bonding continue to be a robust process, enabling the creation of low-cost and dependable electrical interconnects for microelectronic components and mechanical package assemblies? One possible answer lies in the implementation of a rigorous statistical process control method.

Wire bonding is a process that involves the joining of two metals through the application of force and vibration. It requires meticulous engineering and development efforts. Once the design phase is complete, including the selection of wire size, materials, and loop geometry, the focus shifts to creating a strong and high-quality weld between the wire and the base metal, known as the bond foot.

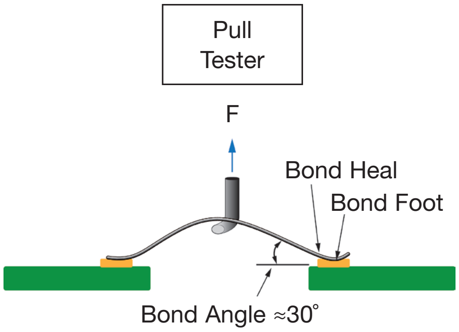
Destructive shear testing emerges as the most effective means to determine the strength and proper formation of the weld joint. This testing method involves using a blade to completely shear through the wire bond foot, measuring the force required to break the welded joint. Additionally, careful examination of the failure mode and the remnants left behind after shearing is conducted. By analyzing the maximum shear value obtained, one can assess the overall strength and establish objective data points for further analysis and statistical process methods. Evaluating the remnants provides insights into potential weaknesses in the weld and suggests ways to enhance the wire bond weld. In the process of developing wire bonding, destructive shear testing remains an invaluable tool.



Example of wire bond showing location of bond foot.



Example of a sheared bond foot.



Wire bond pull test configuration.

After achieving an optimized wire bond weld within the designated process window through shear testing, the focus shifts to optimizing the wire loop formation. This optimization is typically carried out through destructive wire bond pull testing. The bonding wire comes with a certification indicating its tensile ultimate strength, which allows for the calculation of the theoretical pull strength based on the bond and loop geometry.

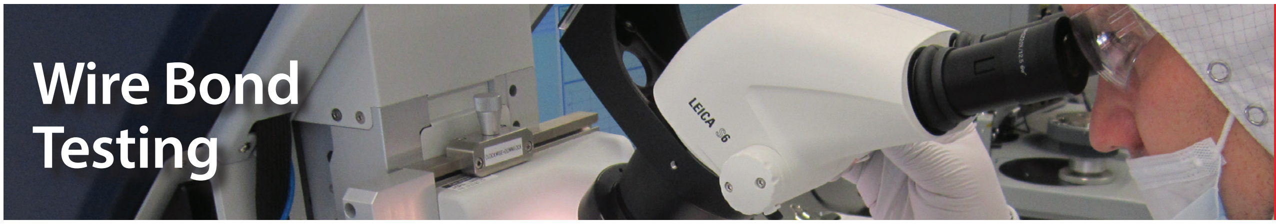
During pull testing, the test specimen is securely fastened to the base of the pull tester. A hook is positioned beneath the bond wire, and a pull force is applied until the wire fails under tensile load. The maximum tensile value obtained from this test is collected and serves as an objective data point for analyzing the overall strength and employing statistical process methods. Failure modes are also documented to ensure a comprehensive understanding of aspects like heal formation and wire strength.

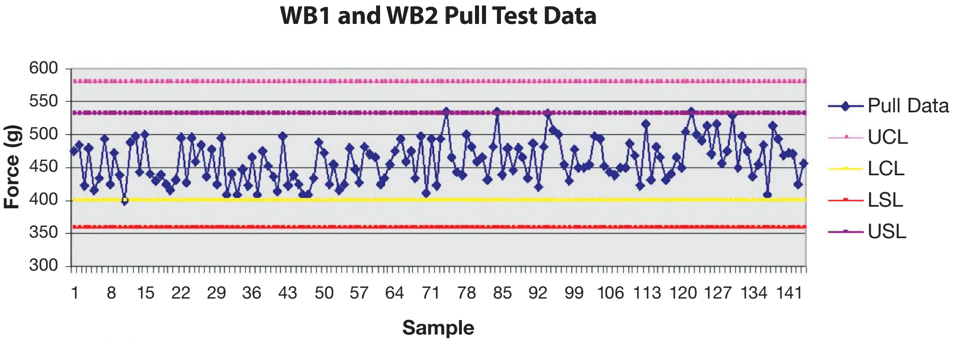
When joining metals, it is essential for the weld joint to be stronger than the components being joined. Therefore, instances where the wire lifts off the bond pad or the plating (if present) separates from the bond pad should not occur. The weakest element of the interconnect should always be the wire's heal formation, making heal break the most frequent failure mode.

Once the product is released for production, pull testing becomes a crucial indicator of bond tool wear for manufacturing engineering. It is important to note that the overall pull strength of the bond loop is influenced by the loop geometry, not solely the tensile strength of the wire. The bond angle determines the required pull force to reach the wire's tensile strength. Consequently, if the loop formation lacks tight control, the results of the pull test can be perplexing in some cases.

Once the wire bond process has reached its full development stage, undergone thorough documentation, and been released for manufacturing, the manufacturing engineering teams shoulder the responsibility of maintaining control over the process. As mentioned earlier, it is impractical to test every bond destructively, yet developing confidence in the process necessitates testing. Therefore, process monitoring and control are typically achieved through the implementation of statistical process control (SPC) methods.

A testing plan is devised, specifying the number of wire bonds to be pulled and sheared per material lot, and the collected data is recorded





Wire Bond SPC Pull Test Data.

on a running chart. This approach to statistical process control minimizes the extent of testing while ensuring product quality remains within the defined process parameters. Furthermore, it serves as an alert mechanism for the manufacturing engineering team, notifying them if the process deviates from control.

Certain manufacturers rely on Mil Std 883 as a reference for guidance on wire bond pull strength and testing. However, at SMART Microsystems, we prefer utilizing published wire strength and analytical data to establish our minimum wire bond tensile and shear strength. We employ shear testing as the primary source of objective data for assessing wire bond weld strength, while pull testing is employed to evaluate loop formation, loop geometry, and the overall health of the formation process.

When products are ready for production, rigorous in-process SPC shear and pull testing becomes indispensable. No substitute exists for this meticulous testing approach to ensure product quality and process integrity.

WILLIAM BOYCE is the Engineering Manager at SMART Microsystems. Mr. Boyce earned a Bachelor of Science in Engineering degree from the University of Rhode Island and has served in the field for over 20 years as a mechanical design engineer, process engineer, team leader, engineering Manager, and Global Engineering Director. In addition to his current role at SMART, he has held positions at General Dynamics, Texas Instruments, Sensata Technologies and TT Electronics. Mr. Boyce has also been a member of the IMAPS New England Chapter for over 10 years as a session chair. He is EIT certified, a Six Sigma Green Belt, and an industry recognized expert in Al wire bonding.