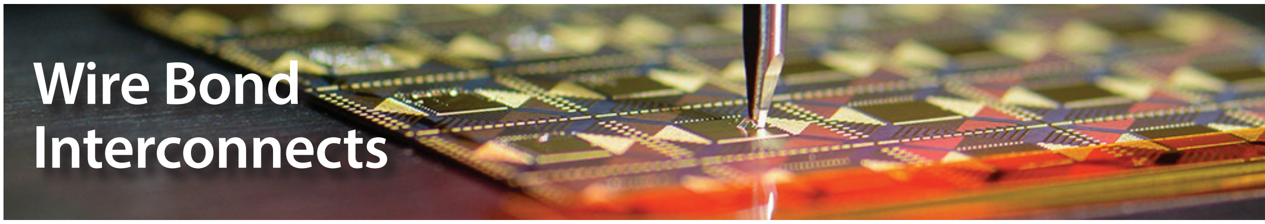

Key Insights for Achieving Success in Wire Bond Interconnect Process

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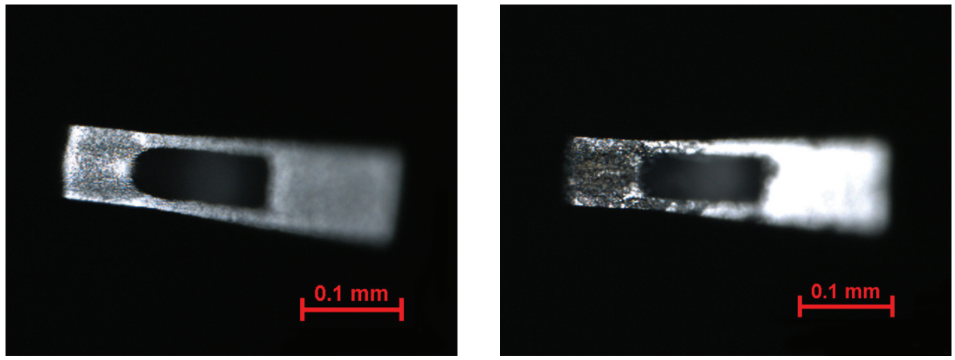
EVERY YEAR, MORE THAN 15 TRILLION interconnects are created through wire bonding. While gold ball bonds make up the majority, it's important not to overlook the significance of aluminum wedge and ribbon bonding. Wire bonding is widely regarded as a cost-effective and flexible interconnect technology, commonly utilized in the assembly of semiconductor packages. However, when wire bonding is mentioned as an interconnect strategy in a new development project, it often raises concerns. Wire bonding is a process that should not be taken lightly, as it requires a solid and robust wire bond interconnect for long-term success. Several fundamental requirements must be carefully addressed to achieve this. These requirements include proper fixturing, appropriate bond tools, reliable bond parameters and loop geometry, as well as high-quality incoming materials that are free from contamination and corrosion.

Fixturing

Fixturing plays a critical role in wire bond applications, presenting unique process challenges depending on the specific product application. Throughout years of product development, it has been observed that many wire bond challenges stem from fixturing. In most cases, a custom fixture is necessary to securely hold the parts before wire bonding can commence. The fixture must ensure that the parts remain stationary with a fixed orientation, perpendicular to the bonding tool. Any movement during bonding can absorb energy, leading to process variation or the inability to bond the parts effectively. Fixtures for gold bonding must also withstand temperatures over 100°C. It is vital for fixtures to securely hold the parts, avoid adding unintended stress, and not interfere with bond head movement. In cases where the part has a unique package design with thermal insulation, designing a fixture for gold bonding becomes even more challenging as the bond surface needs to reach the required bonding temperature. If wire bond fixtures are intended for medium to high volume manufacturing throughout the product's lifespan, they must be built with tighter tolerances and hardened for long-term wear resistance. This helps to reduce process variation over time, making thoughtful fixture design a crucial initial step.



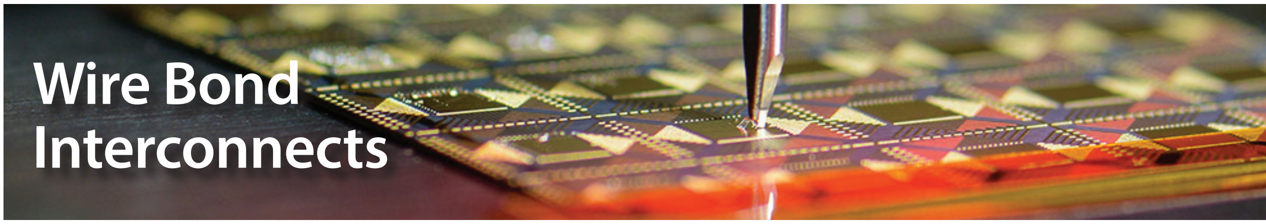
Compare the effects of a new wire bond tool (shown at left) with a used wire bonding tool with Al buildup on the left side (shown at right).

Bond Tools

Bond tools are often overlooked as a critical component of the wire bonding process. Similar to any other process tool, bond tools experience wear. During development work, wear can be extensive and rapid. The type of wire used affects how bond tools wear. When bonding with gold wire, the material on the end of bond tools can wear off, while aluminum wire bond tools may accumulate aluminum residue from the bonding process. Ribbon bonding tools tend to chip. In an established process for a specific part, it is common for process or manufacturing engineers to conduct tool wear studies to determine tool life and its impact on process stability. By employing statistical process control (SPC) techniques, upper and lower specification limits can be established for the wire bond process. As bond tools wear, the wire bond strength may drift closer to the specification limit. Once the relationship between tool wear and performance is understood, an automatic wire bonder can be set to trigger limits for a tool change. During development, tool wear and buildup are often accelerated due to over bonding. It is critical to check the bond tool before each operation change. Additionally, peripheral tool components in the bond head, such as cutters, wire guides, and set screws, should not be overlooked. These components need to be changed and adjusted as necessary. For instance, it is important to note that the set screw holding the wire bond tool in place should be changed every time the tool is changed, and it needs to be tightened to a specific torque setting. Considering these factors is essential to minimize process variation.

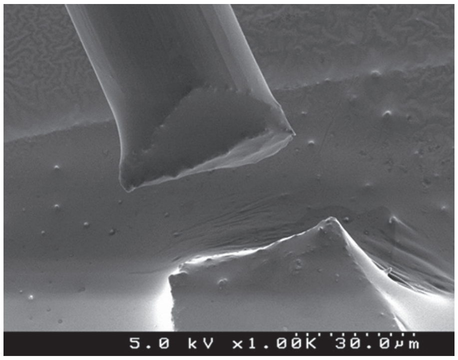
Bond Parameters and Loop Geometry

Bond parameters and loop geometry are significant factors in wire bond development. A robust wire bond weld is achieved by employing a specific design-of-experiments (DOE) approach to select critical bond parameters. The three main bond parameters that require optimization are force, power, and time. These parameters are interdependent and usually necessitate a full factorial DOE for proper resolution. Wire bond parameters must be developed for both the source and destination bonds of a given part. Loop optimization is a separate concern that relies on understanding the product's geometry limitations and its intended usage environment. Parts with unique geometries may impose limitations throughout their lifespan. If bond wires are too long, they can fail under thermal stress. Conversely, if they are too short but too tall, they can fail due to vibration, mechanical shock, or interference with other components. By comprehending loop geometry and bond head movement, an appropriate looping geometry can be designed and optimized for the product's lifespan.

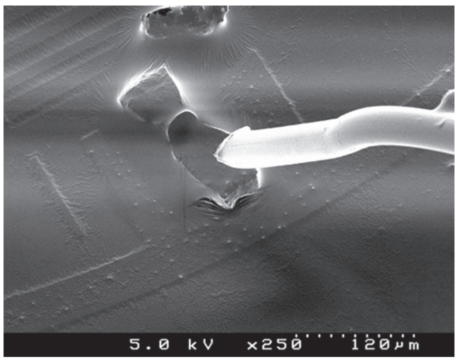


Wire Bond Interconnects

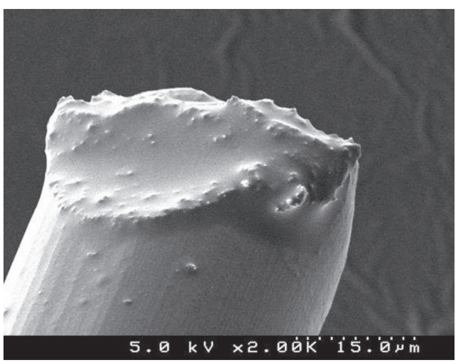
SILICON Heartland



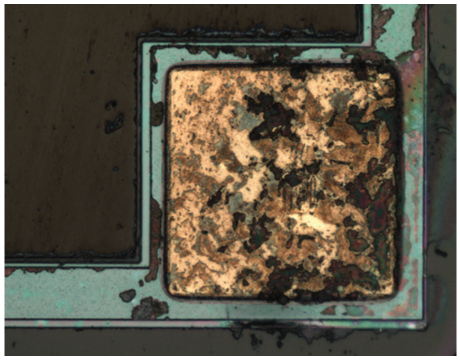
Wire bond failure from vibration.



Vibration failure with view of break at the "heel".

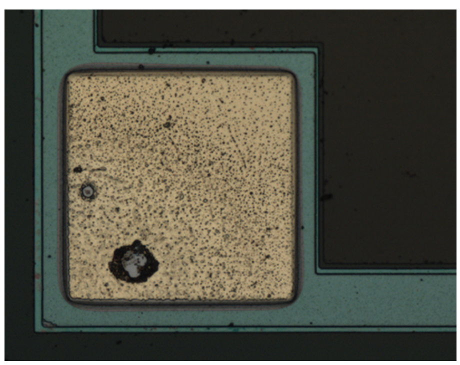


Break deformation caused by "cold working".



Gross surface contamination; pad surface is not bondable.

Unknown issue with pad metal.



Rough, dirty pad surface with handling marks.

Incoming Material

Incoming material variation is the primary cause of "non-process" related wire bond challenges and failures. In fact, it could be considered the leading cause overall. A wire bond process has only two inputs: the wire and the part to be bonded. Bonding wire from leading manufacturers is generally reliable and rarely a cause for concern. However, the incoming parts to be bonded present a different story altogether. Typically, the part to be bonded is an assembly or at least a sub-assembly, meaning there are at least two components that need to be interconnected. In the case of silicon die bonding, the production process involves chemicals, which introduces the potential for contamination and variation. The same holds true for printed circuit boards, where the plating process is prone to variation and contamination. Upstream assembly processes can also contribute to incoming material variation. For example, mounting a die on a printed circuit board can leave behind oil or handling contamination. Other common sources of contamination include residual adhesives and solder flux. Experienced wire bonding practitioners have likely encountered most root causes of wire bond failure and process variation. Utilizing statistical techniques such as "failure modes and effects analysis" or six sigma methods can effectively address these challenges. When time constraints or limited access to an established process hinder deep exploration, relying on best practices can enable the production of customer samples in the shortest time frame with the highest possible quality.

William Boyce, the Engineering Manager at SMART Microsystems, possesses a wealth of experience and a keen attention to detail. With a diverse background in automotive sensing, he has held senior engineering roles for the past 19 years. His accomplishments include the manufacturing of automotive sensors, leading new product development teams that generated over $25 million in new revenue annually, certification in EIT and Six Sigma Green Belt, recognized expertise in aluminum wire bonding, and the design and leadership of a metrology lab and machine shop at Sensata. William holds a Bachelor of Science in Engineering degree from the University of Rhode Island and has been an active member of the IMAPS New England Chapter for over 10 years.

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