WHITE PAPER: Advancing Power Electronics Prototyping

Precision Ultrasonic Wedge Bonding for SiC and GaN Power Modules

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Subject: Optimization of Thick Aluminum Wire Bonding in R&D Environments

1. Executive Summary

The transition toward Wide Bandgap (WBG) semiconductors, specifically Silicon Carbide (SiC) and Gallium Nitride (GaN), has introduced rigorous thermal and mechanical demands on lead bonding. Traditional manual bonding often fails to provide the consistency required for high-power density modules. This paper explores how the WS3100 Desktop Ultrasonic Thick Aluminum Wire Wedge Bonder bridges the gap between laboratory versatility and automotive-grade reliability.

2. The Challenge: Bonding Physics in Power Electronics

Power modules for EV traction inverters and AI data centers operate under extreme thermal cycling. The primary failure point is often the wire-bond interface.

Material Hardness: SiC and GaN metallization layers are often harder than traditional Silicon, requiring higher ultrasonic energy and precise pressure control to achieve atomic-level bonding without fracturing the die.

Current Density: High-current paths require thick aluminum wire (75µm to 500 µm). Managing the deformation of such heavy gauges requires sophisticated "Scrubbing" and pressure profiles.

3. Technical Solution: The WS3100 Architecture

The WS3100 is engineered to provide a controlled environment for these complex bonding physics through three core technologies:

A. Digital Ultrasonic Frequency Tracking

Traditional desktop bonders suffer from frequency drift as the transducer heats up. The WS3100 utilizes a high-power generator (9-30W) with Automatic Frequency Capture (≤5ms). This ensures that the resonant frequency (58.5±1kHz) is locked instantly, providing consistent energy delivery to every bond.

B. Dual-Channel Parameter Programming

Different surfaces (e.g., Die-to-Substrate vs. Substrate-to-Lead) require different energy profiles. The WS3100 allows for independent adjustment of:

- Ultrasonic Power & Time
- Bonding Pressure (30g to 1200g)
- Loop Height and Tail Length

C. Mode 2 Multi-Point Bonding

To reduce electrical resistance and improve mechanical shear strength, the WS3100 supports Dual-Point 1st and 2nd Bonds. This feature is essential for power modules where a single wire must carry significant current, distributing the load across multiple "stitches" on the electrode pad.

4. Performance Data & Specifications

The following table summarizes the operational envelope of the WS3100 for 2026 process standards:

Parameter	Specification	Industrial Significance
Wire Diameter	75-500 µm (3-20 mil)	Versatility for signal and power leads
Placement Accuracy	Computer-controlled Z/Y Stepper	Consistent loop shapes for high-frequency RF
Bonding Force	0.30-12N	Safe for fragile GaN-on-Si structures
Max Work Height	9.5 mm	Accommodates oversized power module housings

5. Case Study: Improving Yield in IGBT Prototyping

In a recent pilot study, a research facility replaced manual equipment with the WS3100 for IGBT Module assembly. By utilizing the WS3100’s Automatic Pressure Tracking, the facility reduced micro-cracking in thinned dies by 15% and improved wire-pull test consistency by 22% across a batch of 500 units.

6. Conclusion

As the semiconductor industry moves toward more complex heterogeneous integration, the tools used in R&D must mirror the precision of mass-production lines. The Jiangsu Himalaya WS3100 provides the essential accuracy, power, and programmability required to develop the next generation of power semiconductor devices.

About Jiangsu Himalaya Semiconductor Co., Ltd.

Located in the high-tech hub of Suzhou, Jiangsu Himalaya Semiconductor is a global leader in semiconductor "back-end" equipment. Our portfolio includes high-speed die bonders, wafer dicing systems, and precision ultrasonic wedge bonders.

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