



Augmented Leadframe Design for Stable Multi-Wire Ground Bonding

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Authors' contributions

This work was carried out in collaboration amongst the authors. All authors read, reviewed and approved the final manuscript.

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ABSTRACT

Technological change has brought the global market into broad industrialization and modernization. One major application in the semiconductor industry demands safety and high reliability with strict compliance requirement. This technical paper focuses on the package design solution of quad-flat no leads (QFN) to mitigate the leadframe bouncing and its consequent effect of lifted wire and/or non-stick on leads (NSOL) defects on multi-wire ground connection. Multi-wire on single lead ground (or simply Gnd) connection plays critical attribute in the test coverage risk assessment. Cases of missing wire and/or NSOL on the multi-wire Gnd connection cannot be detected at test resulting to Bin1 (good) instead of Bin5 (open) failure. To ease the failure modes mechanism, a new design of QFN leadframe package with lead-to-diepad bridge-type connection was conceptualized for device with extended leads and with multiple Gnd wires connection. The augmented design would provide better stability than the existing leadframe configurations during wirebonding. Ultimately, the design would help eliminate potential escapees at test of lifted Gnd wire not detected.

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1. INTRODUCTION

Semiconductor advancement technology keeps cultivating essential applications varying from consumer electronics, medical, communications, and to those requiring high reliability performance such as for automotive and space applications. Its packaging design solutions mostly diversify on size, flexible form factors, scalability, and electrical characterization capabilities. It has led likewise to the development of new materials and process bricks that extended its capabilities to meet quality prerequisites.

With the new and continuous technology trends and breakthroughs, challenges in assembly manufacturing are inevitable [1-4]. On top of the technology innovation, it has been a common challenge on QFN packages the criticality of wirebonding process [5-8]. The wirebonding connection integrity becomes complex as semiconductor manufacturing continuously creates a variety of circuit and wire layout designs. Apart from its design diversity, multi-wire on single lead layout is increasingly in common on the incoming new devices which streamline the unique electrical characterization and its application. Despite the product complexity and criticality in its nature, the

process itself plays a significant factor on producing good units with good quality. Wirebonding is defined as the process making electrical interconnection between semiconductors or other integrated circuits (IC) and silicon chips using bonding wires. Moreover, it is one of the fundamental blocks in IC manufacturing. Common defects found at this process station are lifted stitch or NSOL, non-stick on pad (NSOP), presence of contamination and other consequent effects. It comes into different factor contributors that affect its wirebond performance resulting to poor quality and low yield. One of which is the leadframe bouncing phenomenon. The event would result to lifted wires or NSOL as depicted in Figs. 1-2 in the wirebond process and becomes a manufacturing issue that needs to be addressed and risk-assessed its functional and reliability impact. In some cases, if not most, test coverage is also an issue as missing wires on Gnd connections are difficult to detect during testing.

The failure mode demonstrated that the wedge fails to stick on the ring/bond finger or so-called leads during wirebonding. Like any other wirebond related defects, NSOL can be due to a variety of factors, primarily poor setup related issues or bond pad surface contamination.

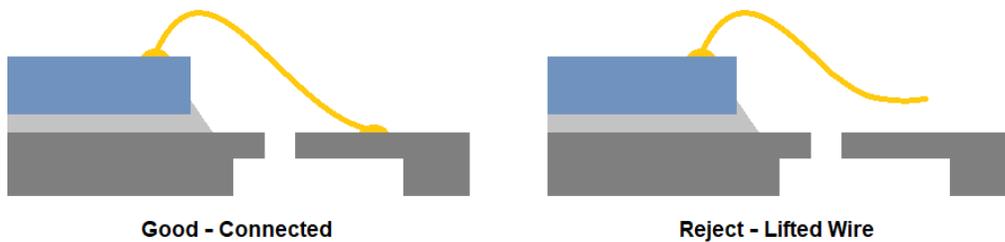


Fig. 1. Visual criteria

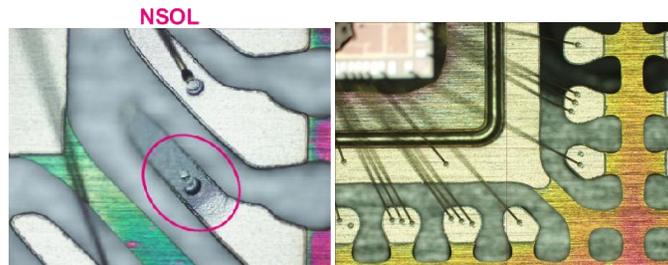


Fig. 2. Failure mode

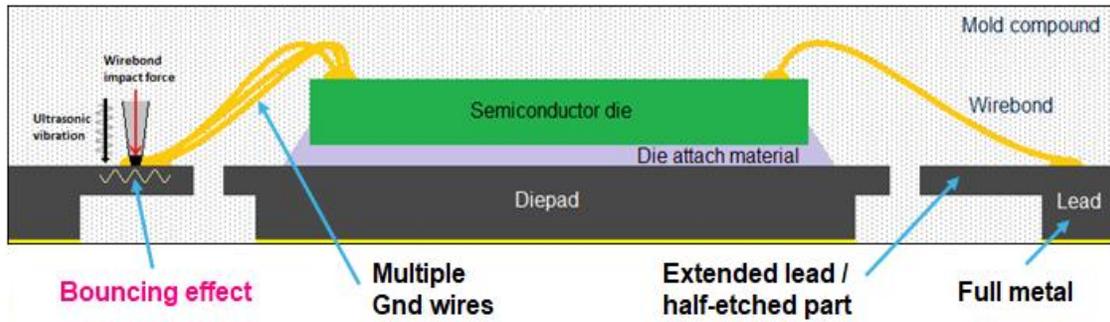


Fig. 3. Package cross-sectional view

Table 1. Test coverage simulation, for lifted wire detection

Signal	Configuration		
	A	B	C
1 Voltage supply	Detected	Detected	Detected
2 I/O	Detected	Detected	Detected
3 I/O	Detected	Detected	Detected
4 Voltage supply	Not detected	Not detected	Detected
5 Ground	Not detected	Not detected	Not detected
6 Voltage supply	Detected	Not detected	Not detected
7 Ground	Not detected	Not detected	Not detected

Leadframe bouncing effect is mainly repetitive and inherent with the QFN wirebonding, causing some instability issue in second bond deformation. A package cross-section representation is shown in Fig. 3 with the bouncing effect on the extended leads during wirebonding process.

Actual evaluation build with simulated no-wire on a 3-wire Gnd connection resulted to a Bin1 (good) at test instead of Bin5 (open) as shown in Table 1. Configuration A means that the first wire is intentionally not connected on a multi-wire signal pin. Most of the missing wires were detected, however, the test machine has issues with wires on some pins especially on Gnd pins. This has become the motivation to come-up with a robust package design catering multiple ground wires on a single lead.

2. PACKAGE DESIGN IMPROVEMENT

A new design of QFN leadframe package with lead-to-diepad bridge-type connection was conceptualized for QFN device with extended leads for multiple Gnd wires connection to address leadframe bouncing during wirebonding. Note that the focus of the augmented design as

shown in Fig. 4 is for Gnd signals only and not including the voltage supply signals since the die paddle (or simply diepad) where the lead is to be bridged is usually connected to ground and used as a ground and thermal pad. The new design would provide better stability than the existing leadframe configurations during wirebonding and succeeding processes such as tape frame attach and molding processes.

The proposed design would offer stable wirebonding and no bouncing effect in particular to Gnd signal connections. The leadframe design is comparable to the package design with chip support and grounding structure in [9], but this time the focus is the robustness for multiple wirebonding of Gnd signals. Herewith in Fig. 5 demonstrating the cross-sectional view of bridge-type connection.

The bridge-type connection between the lead and the diepad would ensure no leadframe bouncing during wirebonding process and succeeding processes. Wirebonding at leads (second bond) could now be done within the stretch of the extended lead for multiple Gnd wires configuration.

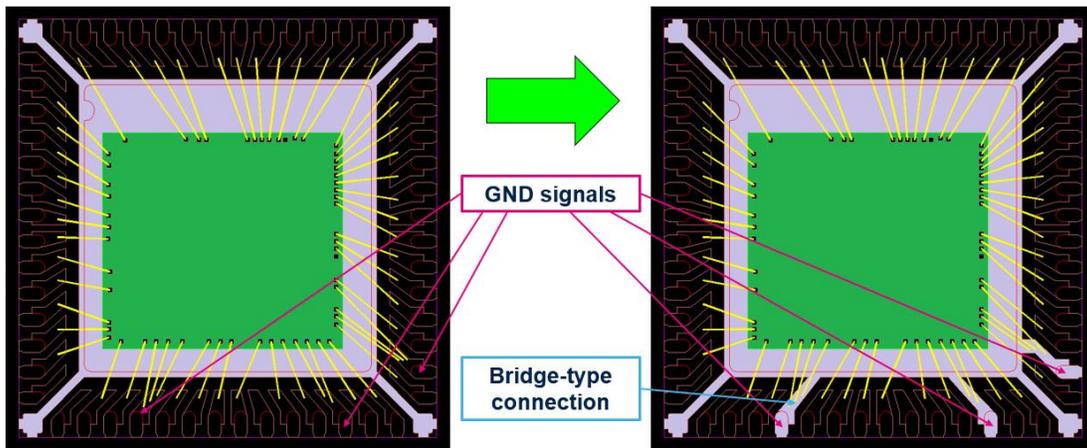


Fig. 4. Package top view, with the augmented leadframe design

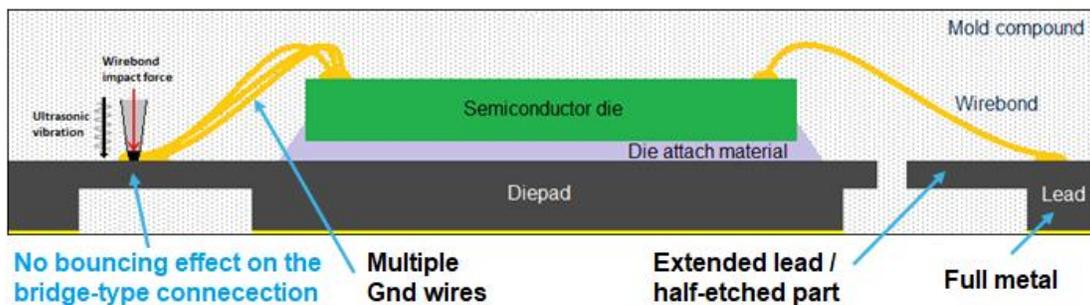


Fig. 5. Package cross-sectional view showing no bouncing effect

3. CONCLUSION AND RECOMMENDATIONS

An improved QFN leadframe design was presented with the specialized lead-to-diepad bridge-type connection for Gnd signals. Leadframe bouncing on extended leads during wirebonding on second bond induced lifted wire and/or NSOL on multi-wire connections especially Gnd signals. The new design would provide stable wirebonding due to no bouncing effect and offer robustness during the critical processes. The design would also eliminate potential escapes at test of lifted Gnd wire not detected on a multi-wire configuration.

Though the paper focused on the improvement in the wirebonding of multi-wire configuration, continuous process and design improvement is imperative to sustain high quality performance of semiconductor products and its assembly manufacturing. Prototypes are helpful for future works to validate the efficacy of the augmented leadframe design on actual devices. Comparison

of existing works and other studies should also be included for added analysis. Discussions and works shared in [10-12] are useful in reinforcing robustness and optimization of package design and assembly processes particularly at wirebonding process.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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