



Enhanced Ball Shear Testing Configuration For Substrate LGA Sensor Devices

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Semiconductor assembly mass production environment has means of testing and verifying bond consistency and reliability during wire bonding. Common bond integrity assessment is ball shear testing (BST). This test enables analysis of the strength between the bond pad and a ball bond. This paper presents significant procedure on how ball shear testing parameters should be treated during wirebond integrity check. Device complexity in terms of performing ball shear testing specifically on sensor dice has different output responses. Frequent shearing on die resulted as bond pads are elevated by 30 μm (microns). To address manufacturing in-process controls challenges, shearing tool position, dage settings, and optical scopes are taken into consideration. Also, a study was performed on the execution correctness in combination with proper dage parameters was explored to meet good ball shear test process capability and break modes.

Keywords: Ball shear test; bond pad; LGA; sensor die; substrate; wirebond process.

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1. INTRODUCTION

Ball shear destructive test is a standard quality control integrity check in wirebonding. Such solder balls and wire bonds can be sheared individually using a tool accurately positioned above the substrate land grid array (LGA) sensor device's surfaces. Shear tool positions during testing are critical for accurate results. Tools and parameters are also crucial in achieving test integrity. Whenever the tool is wide, might be hitting its neighboring bumps, however, if the tool is too thin, it may cut out a channel directly through the bump. In addition, failure mode characterization is a key in understanding joint quality.

The shear force data collection of a ball bond must be correlated with its ball diameter for correct analysis of its ball shear strength. Contrarywise, the shear force reading of a wedge bond must be correlated with the tensile strength of the wire correspondingly. Assembly

manufacturing found it difficult performing the ball shear test on bottom sensor die (Die 1) since the bond pads are elevated by 30 μm as shown in Fig. 1 resulting frequent shearing on die.

The image in Fig. 2 illustrates the differentiation between good and bad sheared mode for sensor die pads. It has shown incapability to perform good ball shear break mode when using existing procedure due to narrow space in positioning shear tool.

Ball shear test or simply BST is another method for evaluating the quality of a ball bond. The bond strength and failure mode are measures of the ball bond quality. Ball shear data reflects the intermetallic formation & its coverage (IMC) of the bonds. Criteria for BST is governed by assembly work instructions [1]. Works and studies shared in [2-8] are helpful for better understanding of the challenges such as the BST and IMC of the wirebonding process.

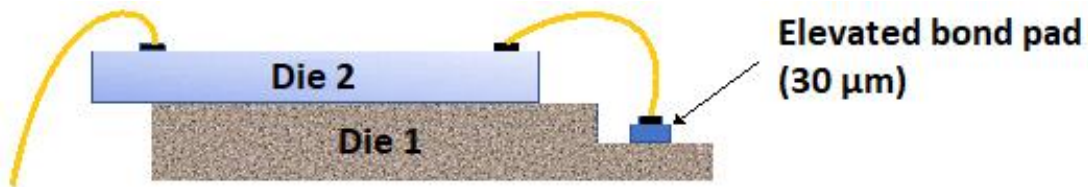


Fig. 1. Elevated bond pad of bottom die

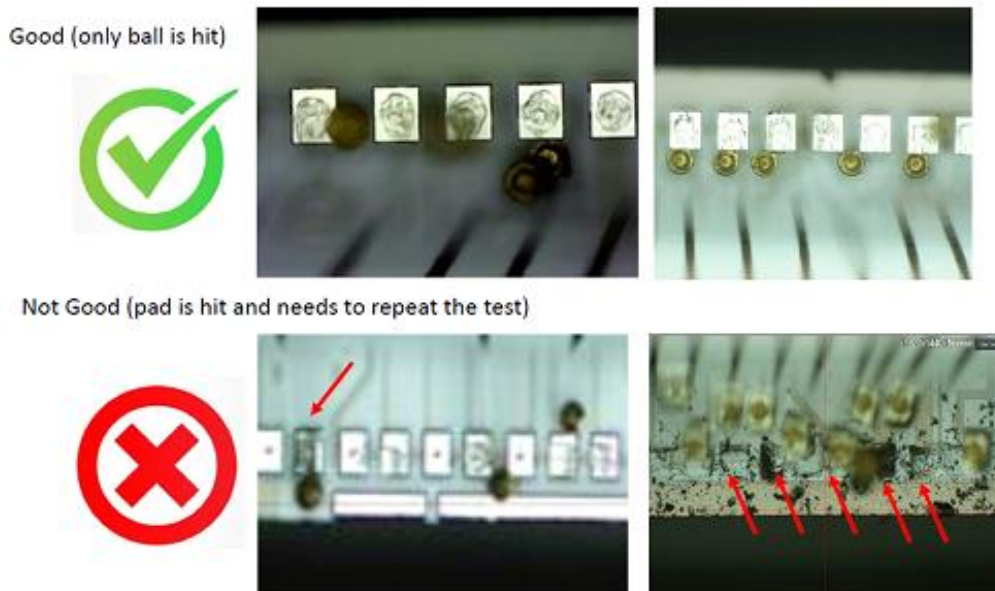


Fig. 2. Failure modes

2. METHODS AND RESULTS

A combination of systematic and parametric approach was explored during the in-process controls validation. This enhanced approach will guarantee good process capability results. The procedure are as follows and illustrated on below: 1) Locate Shearing tool at initial position and press Test button, 2) Shearing tool will touch the lower surface of the sensor die for 0 reference of shear height, 3) Shearing tool will move upward and apply 32 μm shear height to align with elevated sensor pad, 4) Dage will perform BST and Press corresponding BST break mode.

With the enhanced procedure, manufacturing operations now able to perform ball shear on sensor die with good BST break mode.

Also, scope alignment is being considered to address subjective assessment during buy-off.

Set Max test load from 100 to 30 μm
 Land speed from 500 to 1500 $\mu\text{m/s}$
 Shear Height from 2 μm to 32 μm

The paper focused on how ball shear testing will be structuralized for sensor die pads of substrate LGA packages. An enhanced procedure and Dage parameter is defined and validated. Shearing recommended position is between die edge and sensor pad edge. Key elements to arrive the best method were scope alignment, shearing tool position, dage parameters. This enabled good measurement system analysis capability.

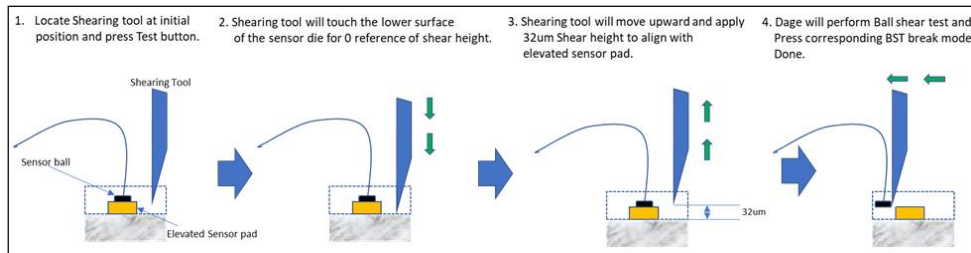


Fig. 3. Sensor pad BST sequence

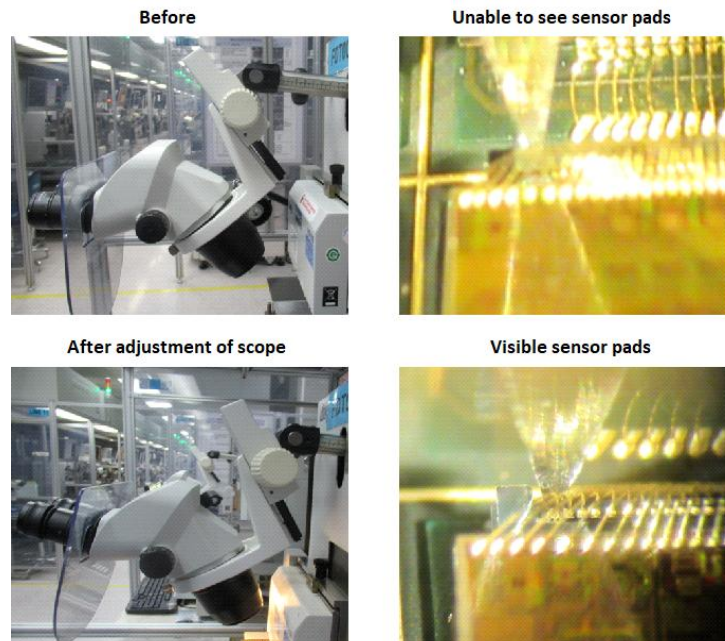


Fig. 4. Optical scope position

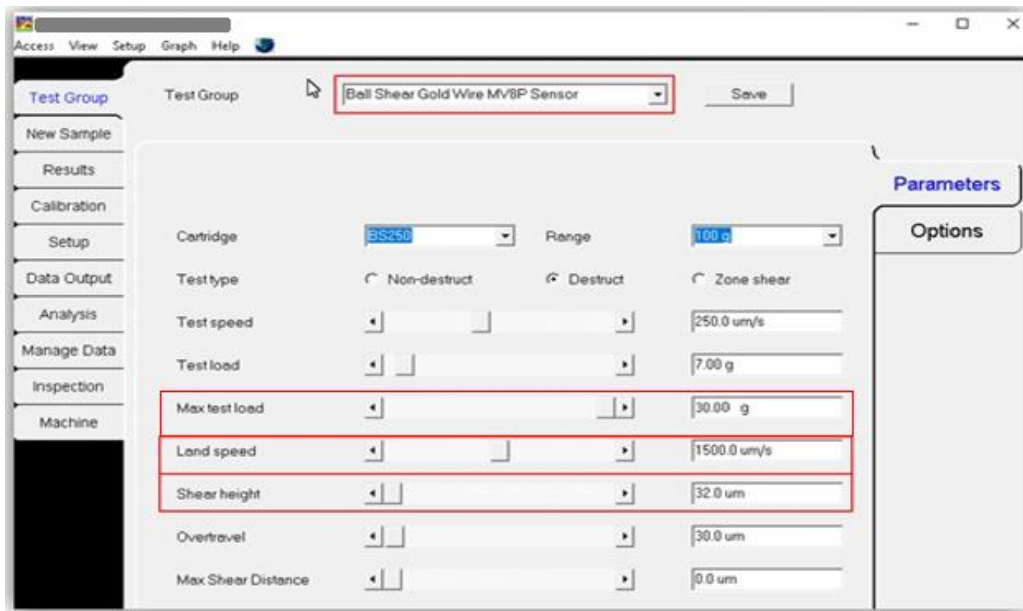


Fig. 5. Modified parameter settings of bond tester machine

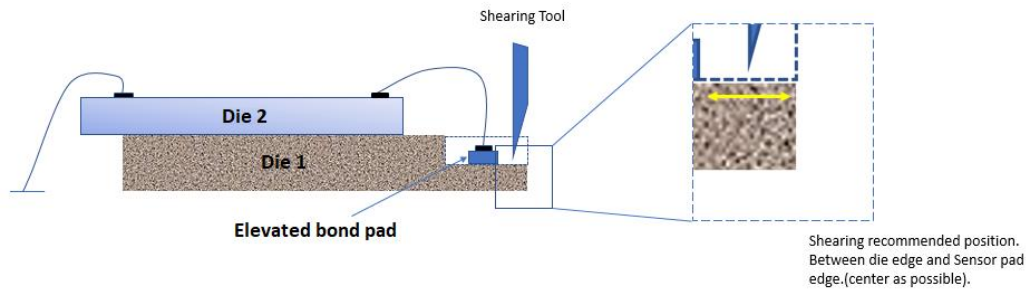


Fig. 6. Initial shearing position

3. CONCLUSION AND RECOMMENDATIONS

Ball shear testing results do not just depend on the defined machine parameters defined. The very first factor in analyzing the result is the measuring procedure, corresponding to what type of samples to be measured.

In this study, to have the realistic BST result, the shear tool height must be defined based on the pad height, including the appropriate tool position. Also, a good visual using the built-in scope of the shear tool tip and the ball to be tested will help to prevent hitting adjacent balls.

With the various new developed wafer from different wafer fabrication sites, there is a potential different die pad configuration and

thickness could be released. Therefore, it is recommended to acquire its actual pad height prior device qualification in semiconductor manufacturing site. Shear tool height must be defined according to the given pad height.

For future works, the enhanced BST configuration could be applied on semiconductor devices with similar die technology. Learnings from this paper combined with the studies earlier mentioned and additional works in [9-12] are helpful to further improve the wirebonding process.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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