Upgrading Die Attach Machine Capability for Micro Electromechanical Systems Package

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Author’s contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The paper discussed the study and challenges of the Die Attach process, the critical characteristics of the product structure and the demand for the MEMS product. Upgrading the current machine mechanical and software to improve the machine's capabilities and overcome the criticality of the product structure, such as; 30 microns Die Placement accuracy, can process Wafer with dual Die Orientation 0 and 180 degrees, capable of detecting incorrect die orientation and finally can process thin substrate with 130 microns thickness. After machine upgrades, statistical validation using Two Proportion tests was used to help validate the machine's performance efficiently. The new upgraded machine has the same capability and performance as the new die attach machine model, therefore the upgrade and enhancement on the old model Die Attach machine are effective and efficient.

Keywords: Die attach; MEMS packages; wafer orientation.

1. INTRODUCTION

MEMS stands for Micro Electromechanical Systems, which is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical devices and structures that are made using the techniques of microfabrication [1-3]. MEMS, as shown in Figs. 1 and 2, consists of ultra-compact systems composed of micro-mechanical components

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such as sensors, actuators and electronic circuits on a silicon wafer using the microfabrication technology of the manufacturing technology. Typically, the architecture of a MEMS package is composed of 2 kinds of silicon die: (1) MEMS sensor die which is fabricated with the microscopic moving parts, and (2) the ASIC die that contains the functional circuit for the MEMS. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters [4-6]. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. Due to the complexity of the package, the current Die attach machine needs to be upgraded to meet the product requirements [7-9].

Fig. 1. Cross-sectional view of a MEMS semiconductor package

![Cross-sectional view of a MEMS semiconductor package](image1)

Fig. 2. MEMS Die placement requirement

2. EXPERIMENTAL DETAILS

Due to the criticality of the product structure, most MEMS products are processed using the latest Die Attach machine model, capable of 30 microns die placement accuracy, can process wafers with double die orientation 0 and 180-degree bonding and can detect incorrect die orientation and finally process thin substrates with a thickness of 130 microns.

Fig. 3. MEMS wafer with dual orientation

![MEMS wafer with dual orientation](image2)
The older die attach machine model is not capable to process wafers with double die orientation 0° and 180°-degree bonding, which can lead to incorrect die orientation problems. The machine also needs to enhance detection capability for wrong die Orientation. Also, the machine work holder needs to strengthen the handling of a thin substrate (130 microns) to prevent damage to the substrate problem.

To meet MEMS product requirements in Die Attach, the old model Die Attach machine functionality needs to be improved and enhanced. Below are the machine activities to address MEMS criticalities refer to Table 1.

| MEMS Product Characteristic | Die Attach Machine | Wrong Die Orientation | Correct Die Orientation |
|----------------------------|--------------------|-----------------------|-------------------------|
| Die Placement Capability   | 30 microns accuracy|                       |                         |
| Die Orientation 0° and 180° bonding | Not Capable |                       |                         |
| Detection for wrong die Orientation | Not Capable |                       |                         |
| Thin Substrate             | Not Capable       |                       |                         |
| Stacked die with overhang  | Capable           |                       |                         |

![Fig. 4. Die attach machine capability assessment](image)

Table 1. Activities to overcome the criticalities of MEMS

| Criticality                        | Potential defect          | Action                                                                 |
|-----------------------------------|---------------------------|------------------------------------------------------------------------|
| Wafer die orientation 0° and 180° bonding | Wrong Die Orientation Shifted Map | • Performed machine bond head overhaul by replacing major parts & perform calibration upon re installation. |
|                                   |                           | o Installation of new BHT bond arm.                                     |
|                                   |                           | o Replacement of 24-00520 BH Y LMGUIDE 2SRS12MSSC1+220LP              |
|                                   |                           | o Replacement of 24-00519 BHZ LMGUIDE 2SRS9MUUC1E+95LPM11             |
|                                   |                           | o Replacement 12-E60686 AD838 BHT M&ENC& BF flex cable                |
|                                   |                           | o Replacement of 02-75527 BA BF 3W-VCM coil with thermal              |
|                                   |                           | o Software upgrade – CSW V 9.28.53 / VSW 3.56.47                      |
| Thin substrate 130μm              | Damaged/ crumpled leadframe | Upgrade the workholder - Installed roller at Workholder to compensate the substrate warpage. |
| Die placement < 30 microns        | Misplaced die             | • Bond head & optics calibration.                                       |
|                                   |                           | o Bond arm planarity                                                   |
|                                   |                           | o 3 pt. alignment                                                      |
|                                   |                           | o Optics calibration                                                    |
|                                   |                           | o Bond optics glass calibration                                          |
|                                   |                           | o Bond head theta calibration                                            |
|                                   |                           | o LVDT calibration                                                      |
|                                   |                           | • Performed device set up                                               |
|                                   |                           | o Teach LF indexing                                                     |
|                                   |                           | o Teach bond, Post bond & wafer, wafer alignment pt. PR                |
|                                   |                           | o Learn pick & bond level                                               |
A machine test was performed after the mechanical and software upgrade to verify the machine accuracy with respect to die placement. A separate test scenario was conducted and measures the actual die placement X and Y axis and the die theta or orientation was determined.

3. RESULTS AND DISCUSSION

After machine upgrade and enhancement were completed, a Statistical Validation was conducted using 2 Proportion Tests to verify the efficacy of the acts. The upgraded or new version of Die attach machine is capable of bonding the wafer with Die Orientation 0° and 180-degree bonding first statistical validation. The statistical result is shown at a 95% confidence level, there is a significant difference. The New upgraded Die attach machine is capable to process wafers with Die Orientation 0° and 180° bonding.

The second statistic validation allows the upgraded or new version of Die attach machine to detect the Post Bond Inspection Wrong Die...
Orientation. The statistical findings are shown at a confidence level of 95%, there is a substantial difference that the latest upgraded Die attach machine is capable of detecting Wrong Die Orientation during post-bond inspection.

Lastly, the third Statistical Validation, does the installation of an additional roller in the work holder will reduce the occurrence of damaged substrate. The statistical result is shown at a 95% confidence level, there is significant difference the new installed roller in ASM838 can reduce occurrences of Damaged Substrate.

4. CONCLUSION

The overall practical conclusion is that the upgraded and enhance die attach machine is capable to process MEMS packages, can overcome the product structure criticalities such as 30 microns die placement accuracy, can process wafers with double die orientation 0 and 180-degree bonding, can detect incorrect orientation, and finally, can process thin substrates with 130 microns thickness. The new upgraded machine has the same capabilities and functionality of the new die attach machine.
model, therefore the upgrade and enhance the old model Die Attach machine is effective and successful.

**DISCLAIMER**

The products used for this research are commonly and predominantly use 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**

Author has declared that no competing interests exist.

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