Improved Chuck Table Design for Silicon Wafer Defects Resolution

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Authors’ contributions

This work was carried out in collaboration between both authors. Both authors read, reviewed and approved the final manuscript.

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ABSTRACT

The paper aimed to mitigate wafer defects such as large kerf shifting issue, dice pop-out occurrence and edge cut defects in the wafer preparation or pre-assembly stage of integrated circuits (IC) assembly manufacturing. With the introduction of new wafer preparation technologies such as dicing before grinding (DBG) and laser die attach film (DAF) cut, technical challenges were encountered. The paper focused on the interaction of different glass chuck table design and laser DAF parameter in order to address the problems. Based on the evaluation and revalidation of results, it has been identified that the single hole without outer groove glass chuck table design improved the response, eliminating dice pop-out issue at laser DAF cut, as well as the kerf shifting issue and edge cut defect.

Keywords: Chuck table; wafer preparation; pre-assembly; kerf shift.

1. INTRODUCTION

Semiconductor packages with thin silicon die prefer the die attach film (DAF) technology as the die adhesive material solution [1-2]. As the wafer or die technology goes thinner, it becomes more challenging in process development, especially during its assembly preparatory stages. Critical
to note that wafer sawing process should have minimum effect on the mechanical integrity of the silicon die so as not to alter its quality.

New technologies were developed and introduced in the industry and one of this is the laser die attach film (DAF) cutting [3]. The method was developed together with dicing before grinding as a cutting medium to address potential processability problems that may occur on the standard mechanical blade saw. The development of thinner die configuration has advanced from the conventional pre-assembly or the wafer preparation process into dicing before grinding process. Conventional wafer preparation process is given in Fig. 1. Worthy to note that assembly process flow varies with the product and the technology [4-7].

Dicing before grinding was introduced to attain the required thin wafer thickness without compromising the die strength [8]. The process focused on the removal of backside chipping that may cause breakage on the silicon area of the die, thus improving its quality. However, the technology is not enough to cater the increasing demand for thinner devices. The inclusion of the DAF material attached underneath the pre-sawn grinded wafer pose another challenge for a breakthrough process development which is the laser DAF cut [3]. Laser DAF cut focus on the successive singulation of the DAF material underneath the pre-sawn wafer using low power lasers. Thus, the introduction of dicing before grinding with laser DAF cut enables the integration of the wafer thinning process and the use of DAF without compromising the quality requirement of thinner dice.

1.1 Wafer Sawing Kerf Shift/Die Alignment

An intrinsic problem encountered at dicing before grinding process is kerf shifting depicted in Fig. 2. Wafer sawing kerf shifting refers to the movement of dice induced after wafer backgrinding and mounting process. The higher tension being applied to the wafer, the higher disturbance will be applied into the sawn or singulated dice. With this, proper control of tension during the said process is highly recommended. From the tension applied during backgrinding tape lamination, stress applied in the process and even the movements of die at laser DAF cutting contribute concerns for die shifting issues.

1.2 Dice Pop-out

Silicon dice pop-out anomaly shown in Fig. 3 refers to the flying of dice after laser DAF cutting. The dice are detached from the dicing tape after laser DAF cutting. The defect could also happen prior and after wafer washing and drying.
process. Manifestation occurs when the dicing tape are disturbed when placed at the chuck table at cutting and even washing station. The die will fly once bulging happened when wafer is vacuumed at the chuck table.

Fig. 3. Dice pop-out defect

1.3 Edge Cut

Another problem encountered during the dicing before grinding and laser DAF cut introduction was edge cut. Edge cut revealed in Fig. 4 signifies the misalignment of the actual laser cut versus the defined wafer sawing kerf width. The misalignment occurred when the laser machine failed to follow the maximum wafer sawing kerf shift. In turn, the laser would hit and cut through the edge of the silicon die.

Fig. 4. Edge cut defect

2. METHODS

2.1 Materials

A 200 mm silicon wafer with a 20 µm DAF was used as carrier for the evaluation. Wafers were processed using the dicing before grinding process with 50 µm target thickness and a specified final silicon die size.

2.2 Procedure

The evaluation runs were categorized into the following legs: (1) backgrinding tape lamination tension effect validation using tension and tensionless lamination process; (2) wafer mount parameter optimization.

Laser DAF cut process is necessary to singulate the dice with DAF configuration. Another observation regarding the large wafer sawing kerf shift and dice pop-out issue is related to the disturbance of the dicing tape when placed into the chuck table at laser DAF cutting.

One factor seen was the effect of glass table design type. The glass table design type in Fig. 4 defined the flow of vacuum applied into the dicing tape to have a smooth and planar placement prior Laser DAF cutting process. This helps eliminate the effect of bulging and latter dice pop-out.

Results of the experiment were assessed based on the following criteria: (1) any occurrence of large kerf shifting; (2) dice pop-out and (3) edge cut or misalign cut. Moreover, these criteria for assembly rejects and visual inspection are governed by internal specifications and work instruction documents [9-10].

Fig. 5. Glass table design type
Table 1. Wafer mount parameter optimization

| Wafer mount parameter | Kerf shift | Dice pop-out | Edge cut | Remarks |
|-----------------------|------------|--------------|----------|---------|
| Roller pressure       | Pass       | Present      | Pass     | Fail    |
| Lamination speed      | Pass       | Present      | Pass     | Fail    |
| Chuck table height    | Pass       | Present      | Pass     | Fail    |

Table 2. Chuck table design effect validation

| Chuck table design | Kerf shift | Dice pop-out | Edge cut | Remarks |
|--------------------|------------|--------------|----------|---------|
| Design 1           | Present    | Present      | Present  | Fail    |
| Design 2           | Present    | Present      | Present  | Fail    |
| Design 3           | Pass       | Pass         | Pass     | Pass    |

Table 3. Validation response

| DAF type          | Response | Kerf shift | Dice pop-out | Edge cut |
|-------------------|----------|------------|--------------|----------|
| DAF A with 20 µm  | thickness| Pass       | Pass         | Pass     |
| DAF B with 25 µm  | thickness| Pass       | Pass         | Pass     |
| DAF C with 30 µm  | thickness| Pass       | Pass         | Pass     |

3. RESULTS AND DISCUSSION

The experiment results were analyzed on the different evaluation runs.

3.1 Wafer Mount Process Parameter Optimization

The focus for the wafer mounting parameter optimization was on the dice pop-out anomaly, with the evaluation performed on the following parameters given in Table 1. DAF lamination speed was reduced from 30 mm/s to 20 mm/s, to lessen the horizontal pressure during the lamination. Roller pressure was also reduced to lower the downward vertical pressure, which in turn help reduce the movement of dice during lamination.

The two different adjusted parameters showed no significant effect in terms of kerf shifting and edge cut problems. However, dice pop-out was existent after three different adjustments, signifying that the control of tensions during DAF lamination will not suffice to correct the dice pop-out issues.

3.2 Laser DAF Cut Glass Table Design Type

After the evaluation performed at backgrinding tape lamination and wafer back grinding shows that there is no significant effect on the dice pop-out issue, the next evaluation was focused on Laser DAF cutting process specific to the glass chuck table design. The evaluation in Table 2 focused on the effectiveness of the vacuum application using three different glass chuck table design.

The evaluation runs showed that the single hole design help ease up the placement of dicing tape into the glass chuck table without disturbing the dice during laser DAF cut process. With the application of tensionless backgrinding tape lamination and single whole glass chuck table at laser DAF cutting process, the risks of wafer sawing kerf shift, edge cutting and dice pop-out issue were addressed.

3.3 Revalidation of Result

To check the effectiveness of the appropriate glass chuck table design plus the tensionless back grinding tape lamination, revalidation was performed on different DAF tape with different thicknesses but the same wafer configuration. Below are the results.

The validation runs showed that there is no significant different between the result of three different DAF thicknesses. This only validated that the one hole glass chuck table design eliminated the kerf shifting, dice pop-out and edge cutting problems.

4. CONCLUSION

In this study, it is identified that the single hole without outer groove glass chuck table design (Design 3) eliminates the dice pop-out issue at laser DAF cut. The design resulted to appropriate
vacuum control at laser DAF cut, which is critical in attaining zero dice pop-out process. With the application of tensionless backgrinding tape lamination from other study [11] and the single hole glass chuck table at laser DAF cutting process, the risks of kerf shifting, dice pop-out, and edge cut issues were mitigated. For further improvement, tensionless backgrinding tape lamination and low lamination pressure at DAF mounting process would improve the wafer sawing kerf shift control.

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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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