Saw Chipping Improvement to Achieve Defect Free Bare Die Products

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Abstract
In the recent years, there is increasing trend of utilizing bare die (without packaging) in many applications. For semiconductors provider, this type of business requires totally new quality expectations, because there is nothing covering the die. The die sawing process becomes very critical, as not only rejects are not allowed, but the die physical quality and appearance are also easily visible to the customers. The die saw chipping become one of the most critical issue, as its appearance can create all kind of customer concerns and complaints. One of the effective containment actions is rejecting all defective die and even those cosmetic rejects. However, this action consumes a lot of yield loss without providing real benefits to both providers and customers. In order to go for real improvements, conventional methods were verified again, follows by utilization of more comprehensive methods. One interesting finding was slower table speed did not provide better saw cutting quality, but instead much worse chipping was observed. Therefore, a new comprehensive method was required and expected analysis need to be performed with a lot of fundamental verifications. These verifications required to be performed on the material properties, blade behaviours, cutting characteristics and process parameters. From initial verification, current process window had repeatedly showing high yield loss of around 10%. With screening tests of various process parameters did not provide any significant statistical model, indicating there were more significant factors. Therefore, a new process need to be established from fundamental level, started from material properties. Due to chipping occurrence happens at the backmetal layer, the understanding of its metallization scheme was important. From previous process experience, blade cutting requirements are unique per respective metal scheme. There were several blade properties selected for evaluations, together with pre-conditioning performance (dressing & pre-cut). Surprisingly, the blade pre-conditioning played much critical role. The pre-conditioning is required to remove the blade bonding material and exposing uniform diamond grit. Only when the blade achieved ready condition, new blade features could be effective. The optimum blade features utilized balancing of grit size and concentration base on considerations of blade entry and exit from wafer. With optimum blade, several rounds of process window optimization proved that some conventional perceptions might not work well in actual process. When the optimized window was ready, robustness tests managed to confirm its performance. The last step of process development was executing effective and optimum process control to make sure successful noise prevention. When optimum process implemented in production, saw chipping was eliminated, saving yield loss of 10%. More importantly, customer quality risk was improved to zero, resulted in multi folding effect of their confidence level to the maximum level.

1. Problem Descriptions
The bare die products encountered a lot of backside chipping occurrences for certain bumped devices. Many of the affected die failed the chipping criteria of 70 um (0.070 mm) with auto vision reject rate exceeded 10%. Due to the backside surface is laser marked with relevant device name and date code, backside chipping is highly visible to the customers. Therefore, most of the affected units would need to be scrapped in production. Base on the outcome of the discussions held with the blade supplier, the sawing process was improved by converting from single pass process to step cutting method. The step cutting method utilizes Z1 blade cutting from the top surface to the certain defined depth. Then follows by Z2 blade cutting the remaining material till exiting wafer backside (into the mylar tape). In theory, additional Z2 blade can provide much better cutting quality at backside surface but the actual results did not show any significant improvement.

Fig. 1 : Backside chipping of bare die products found in production.

The chipping performance was verified again with some properly controlled engineering evaluations. It was found that backside chipping performance was slightly better than production performance. However, the overall performance was still considered bad in comparing to other normal devices. There were severe lateral and zig-zag backside chipping found at both cutting channels. Furthermore, severe side wall chipping was also found propagating from die bottom. No obvious trend was found on the affected die location, but more rejects were found at wafer centre. The evaluation was repeated with another affected device, and similar performance was obtained. Both sets of evaluation results indicated backside chipping was a common issue. Therefore, one device was selected as vehicle device, and all...
the related improvement actions will be executed on it. Upon getting good performance, improvement would be fan out to all other affected devices.

Fig. 2: Backside chipping also found in evaluation mode.

2. Analyze Opportunities

The brainstorming was performed by the cross functional team in order to identify all the possible root causes. The following figure shows the cause & effect diagram, resulted from the brainstorming session.

![Cause & Effect Diagram]

Fig. 3: Possible root causes of backside chipping.

3. Improve Performance

In alignment with the cause & effect diagram, several hypothesis were developed base on the observations of the previous evaluation findings. In priority descending order, these hypothesis include insufficient cutting power of Z2 blade (blade properties), improper blade dressing (grit exposure), improper pre-cut settings & conditions (sudden load ramping), and low robustness of the current process window.

The 1st evaluation was designed base on the possible improvement of sawing quality by proper selection of blade types and properties. The focus was on the grit size and balancing with grit concentration. With increment of grit size, cutting impact/amount will increase accordingly, and cutting line will be clean. Meanwhile, blade with lower concentration can promote more self-sharpening effect, providing consistent protrusion of diamond grits. However, a new blade does not have any effective properties until completing the preparation actions. The blade initial condition is crucial to ensure consistent cutting effect. From the blade manufacturing process, diamond grits are sealed inside the bonding material. Therefore, blade preparation is required, normally by coupling blade dressing and then activating the pre-cutting mode. The blade dressing is performed by cutting the blade on either dressing board or mirror wafer to remove the blade bonding material and exposing the embedded diamonds (grit). Furthermore, the dressed blade will be used to cut actual production wafers with slower and staggering feed rate set (pre-cut mode). The slow ramping cutting speed will ensure steady and uniform grit exposure, hence achieving consistent cutting effect.

The combined factors exhibited very positive results, whereby there was no occurrence of severe backside chipping. With details measurement, all backside chipping sizes was less than 15um.

Fig. 4: Cutting impact comparison between small and large grit blade. (courtesy of Disco)

Fig. 5: Readiness of diamond exposure. (Courtesy of Disco)

Fig. 6: Results of wafer sawing with combination of new blade and new readiness method.
The 2nd evaluation was intended to explore whether conventional solution of lower feed speed can help to resolve the backside chipping issue. The evaluation results showed that slower feed speed actually caused worse backside chipping. It was concluded that slower feed speed could not help improving the backside chipping.

![Fig. 7: Results of wafer sawing with slower feed speed.](image1)

On the automatic wafer sawing machine, cutting is being done by blade. The cutting location is based on the image captured by machine camera and processed by vision system. The software alignment is important to determine accurate distance offset between blade and camera. For DISCO sawing machine, there is a function that automatically checks the cutting (kerf) position during wafer sawing process. This function can correct any misalignment and ensure kerf position is always accurate. It is executed on the machine, by executing the Kerf Check Function, alignment is then automatically corrected.

![Fig. 8: Automatic kerf check function.](image2)

However, kerf check function becomes more complicated for step cutting method running with 2 different blades. If the grooving is performed with both blades, Z1 and Z2 blades, they would make a full cut on the same line. In such occasion, kerf of narrower blade (Z2) could not be recognized. Therefore, machine spindle#2 will not able to obtain effective alignment with the camera.

![Fig. 9: Kerf check difficulty in step cutting method.](image3)

The machine supplier recognized the kerf check difficulty of step cutting method, and then developed special kerf function. With this improved function, Z1 and Z2 blade would make separate physical cut lines and follow by respective alignment.

![Fig. 10: Kerf check function for 2 different blades used in step cutting method.](image4)

It was suspected that kerf check function of step cutting method could become one of the factors in causing backside chipping. The Z2 blade was in contact on the top surface during the kerf checking process, possibly causing unnecessary metal build up or loading to the Z2 blade. When the metal loaded Z2 blade cutting through the die, it can cause intermittent backside chipping. The kerf check function was theoretically only needed to be performed once per setup or once per wafer in order to avoid unnecessary blade loading.

![Fig. 11: Kerf check on top surface (metal area) could cause Z2 blade build up.](image5)

All the optimum factors were combined to execute confirmation runs, results are shown in the following figure. The achieved improvement was excellent, it was estimated that new process can achieve 6 sigma performance level.

![Fig. 12: Performance comparison (backside chipping) of optimum run & control run.](image6)
4. Control Performance

Upon completion of all the engineering evaluations, the large size confirmation run was performed with minimum 10 wafers per each device. All the verifications showed positive results. Furthermore, the optimum material and settings are easily available and achievable in production mode. All the changes went through proper qualification process (with full reliability tests) and successfully implemented in production mode. No occurrence of any abnormal quality issue and backside chipping reported after completion of all the improvement actions.

5. Conclusion

With the implementation of the new optimum process window, bare die production has not encountered any backside chipping issue. The yield performance of the affected devices improved from 90% to 99.5%. There was no loss in capacity and cost, while achieving excellent quality performance.

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References

None