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STEP CUT FOR DICING LAMINATED WAFER IN A QFN PACKAGE

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ABSTRACT

Miniaturized package with thinner die requirement like Quad Flat No Lead (QFN) has led to new challenges for conventional die attach paste materials and dicing process. Die attach film (DAF) is seem to be the most potential candidate to replace the conventional die attach paste for QFN stacked die. DAF is able to replace epoxy paste in stacked packages in producing good paste bleed control, zero creeping effect and constant bond line thickness (BLT). Dicing die attach film (DDAF) will be used in this study; the laminated DDAF wafer will be diced together during wafer dicing. Laminated wafer will be cut by using step cut method. In dicing DDAF, parameter such as spindle rotation, feed speed, water flow and blade grit size will be considered. However, dicing DDAF laminated wafer is not as simple as the bare silicon wafer. Due to this reason, this paper will reveal the DDAF dicing response. Dicing responses like lateral crack, whisker formation and sidewall effect will be observed. The result shows that step cutting process gives the common dicing effect which is still in the accepted limit. In addition, the implementation of controlling dicing process parameter is crucial to obtain good dicing results.

INTRODUCTION

Semiconductor package become smaller and thinner in order to fulfill the trend of industry demand. Less power consumption, higher IO, better signal transmission and smaller space consumption lead the QFN stacked die idea to burst out. Stacked die configuration need wafer thickness which is thinner than the conventional wafer i.e. at 250um. The requirement for stacking greater than three dies stack package requires the wafers thinned down less than 100um [2]. Thinner wafer will allow more dies to be stacked into QFN packages.

Stacked die packages requires the use of film adhesive as an alternative method to the die attach. The reason of using film adhesive to avoid problems of a poor epoxy paste dispensing system that may result in excessive bleed out, die tilt, inconsistent bond line thickness (BLT) and coverage that directly affect package. There are two ways to apply the adhesive film, either by splitting coating or by laminating an adhesive film on the wafer back. In this study, the second approach had been chose.

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The adhesive film is already laminated with the mounting film; this type of film is known as DDAF. DDAF tape is functions as a support in the dicing process and also the paste at die bond. Meaning that the dicing process needs to consider two different components for the sawing process, i.e. die and die attach film. The combination of these two components makes the challenge of dicing process becomes greater.

Wafer dicing is a mechanical process which involves friction between the die sidewall with the blade edge, load carried by the blade, and stress to break the internal crystallographic bond of the wafer. This aggressive interaction during dicing process will definitely cause crack or chip to the die. A lot of studies have been carried out starting from the material, dicing parameter until to the cutting method selection. As reported by Hoh (2006), step cut method had reduced the chipping approximately 80% compared to the conventional single pass. It shows that the cutting method selection can be a major contribution for controlling the wafer damage during the dicing process.

LITERATURE REVIEW

Dicing process is the first process of assembly packaging after wafer thinning. The conventional method of wafer dicing uses a diamond tool to scribe the wafer before breaking the wafer into individual die. This method is susceptible to generating defect and bottom-side shading [4]. The current conventional wafer dicing process uses a diamond-bonded wheel to cut through the full depth of the wafer to the mounting tape [4]. Since wafer is getting thinner, it might induce more damages such as chipping and crack. It is because of the application of stress during the dicing process. Severe die chipping had been reported in [2] with the use of single-pass dicing process for DAF-laminated wafers. For the purpose of this study and paper, dual pass dicing or step cutting is used in order to reduce the stress to the wafer during dicing process.

The step cutting is normally being applied to the wafer less than 200µm in thickness. This cutting method is able to reduce the front and backside chipping. This is because it employed two different blade thicknesses and cutting height. The depth of the first cut is optimized from 25% to 75% of the wafer thickness and for this study; the depth of the first cut is set to 65% of the wafer thickness. By this cutting height setting blade penetration will not be too deep and not too shallow into the wafer. The depth of the second cut is typically 20-40µm into the tape [1]. In this study, the second cut depth is set to 25µm which is the common setting in industry. This 25µm is calculated starting from the end of the DAF layer to the dicing tape. Figure 1 shows the comparison of illustration sawn die cross section including the DAF and dicing tape layer location between the actual sawn dice.

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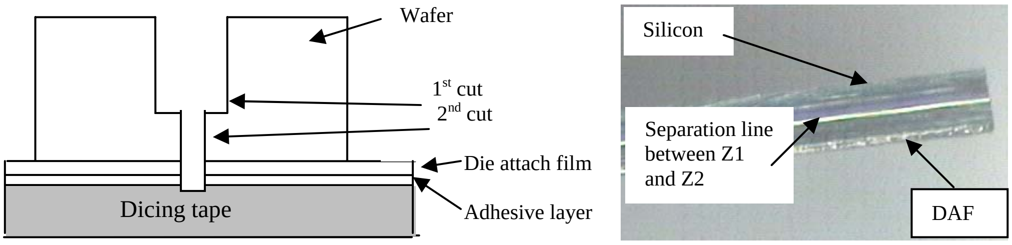
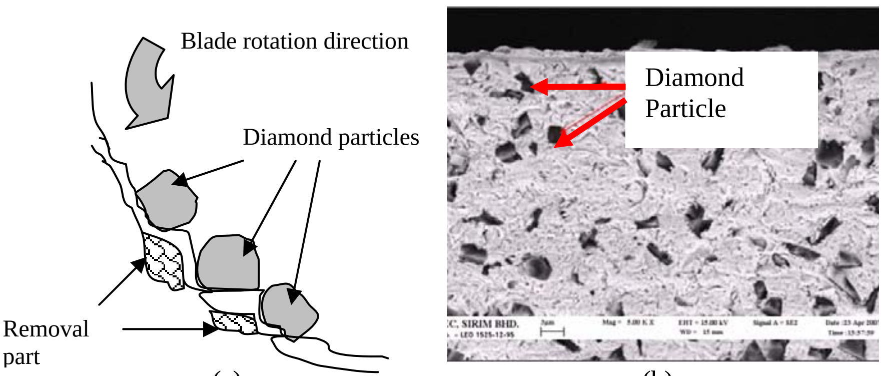


(a) (b)

Figure 1: (a) shows the illustration of the cross section of the sawn die while, (b) shows the die with the DAF layer.

The dicing DAF taped wafer is different when compared to the dicing bare silicon wafer because of the involvement of two materials with different compositions and material hardness. Wafer is made from the silicon while DAF tape is made of polymer. Silicon material is brittle while polymer has characteristic of a viscous liquids. These two materials combination makes the selection of the dicing parameter and the appropriate blade type become crucial in order to get the good dicing quality.

One of the important tools for dicing process is the dicing blade. Diamond particle functions as a cutter for the wafer while the Nickel functions as a binder to hold the diamond. Diamond blade is rotated during wafer dicing in order to shear the material away by breaking the internal crystallographic bond. In the same time, the grinding abrasive particle is worn and continually came off to keep the edge sharp [3]. Figure 2 (a) shows the diamond particle at the saw blade with the removal area to keep the blade always sharp while Figure 2 (b) shows the actual image of diamond particle inside the saw blade. For choosing the dicing blade, the size of the diamond or diamond grit size is the parameter that needs to be considered. It is because of the diamond grit size determined the load and edge quality of the saw kerf which is also which related to the chipping level.



(a) (b)

Figure 2: Illustration of the diamond particles inside the saw blade: (a) Symmetric image, (b) real image.

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Generally, larger diamond particles dig out a large portion chip of substrate material (removal zone) and the small diamond particle will proportionally dig smaller chip portion [6]. In this study only one grit size is fixed for the first cut. However, two different grit sizes for second cut will be applied. In this study, two different blade grit size blades had been used. The effect of the dicing response by using these two blades will be showed in the result and discussion chapter.

EXPERIMENTAL METHOD

Die Attach Film

Only one type of DDAF will be used in the evaluation process of a QFN stacked die. A cross section of pre-cut DDAF is shown in Figure 3. The DDAF consists of the dicing tape, the adhesive layer, and the DAF layer. The adhesive layer acts as a glue in order to stick DAF and dicing tape.

Silicon wafer had been laminated with dicing DAF at 60^0 C and exposed under UV radiation in order to enhance the adhesion between the DAF and the wafer back. UV irradiation was done with luminance over $120mW/cm^2$ and the quantity of light from 70 to $200mJ/cm^2$. The luminance level and quantity of light during UV irradiation may be different for the other different type. The two setting is given by the supplier due to the demand of their product. Poor adhesion between wafer and dicing tape can cause die displacement during dicing process. Die displacement will lead dies having chipping defect. Figure 3 shows a wafer in the dicing process.

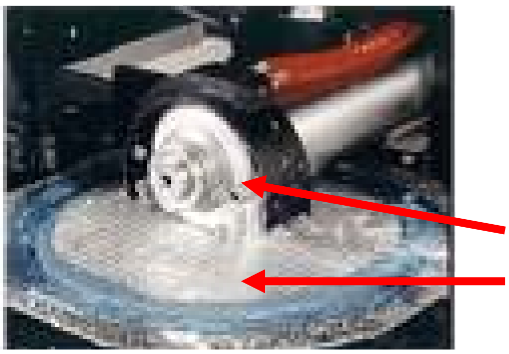

Figure 3: A wafer in the dicing process.

Table 1: Blade characteristic table.

Blade Type	*Grit Size (mesh)*	*Thickness (mm)*
Blade A	# 3000	0.030 ~ 0.035
Blade B	# 3500	0.020 ~ 0.025
Blade C	# 2000	0.025 ~ 0.030

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Three types of dicing blades will be used in the experiment. All the blades are from the same supplier but different in the grit size and thickness. Table 1 shows the value of dicing blade characteristic. Blade A was used for the first cut; or notated as Z1, while Blade B and C were used for second cut; or notated as Z2. The reason for Blade A is being used as for the first cut is because Blade A has the largest thickness among all the blades. Saw kerf of the first cut has to be wider than the saw kerf of the second cut. This also was the reason on why Blade B and C had been used for the second cut. Information in Table 1 shows that the grit size for Blade A is in between Blade B and Blade C while in term of blade thickness, Blade A is the widest. After part of the wafer thickness had been cut by using blade A, the wafer had been cut through by using blades with bigger and smaller grit size but with narrower thickness.

RESULTS AND DISCUSSION

DAF Lamination

The DAF was laminated on the 177µm thickness wafers with the condition as tabulated in Table 1. The laminated wafers were then inspected in order to verify no void occurrence between the wafer and the tape. For this reason, the presence of void in the laminated wafer could cause the die displacement during the dicing process.

Wafer Dicing

The step cutting process was evaluated in this study and it is as illustrated in Figure 4. The first cut is indicated as Z1; while the second cut is indicate as Z2. Cutting depth for Z1 is set almost to 65% of the wafer thickness, meaning that cutting height for Z1 is 177um. Cutting depth for Z2 is set to 28% of the tape thickness, excluding the DAF layer thickness. This means that cutting height for Z2 is 63.5um.

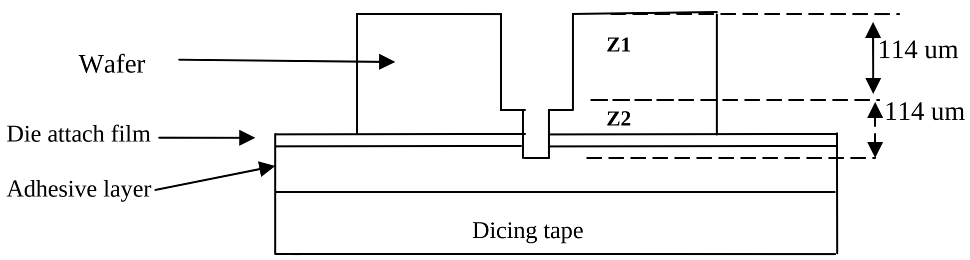

Figure 4: Illustration of the step cutting with cutting depth dimension for Z1 and Z2.

In dicing process, an adequate torque will be applied to the blade. The torque is given by setting the rotation of the spindle. Z1 spindle rotation is set to 45k rpm while Z2 spindle rotation is set at 30k rpm and 45k rpm. This is to see any over load during dicing experienced by the wafer at this spindle rotation rate. Over load experienced by the wafer can be detected by the existance of crack and chipping on

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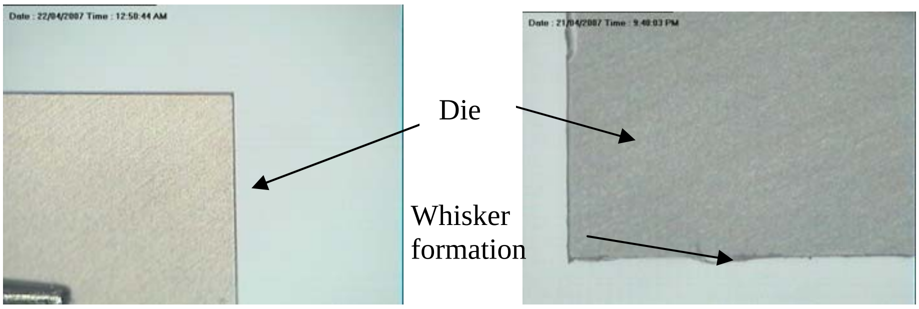
the die.

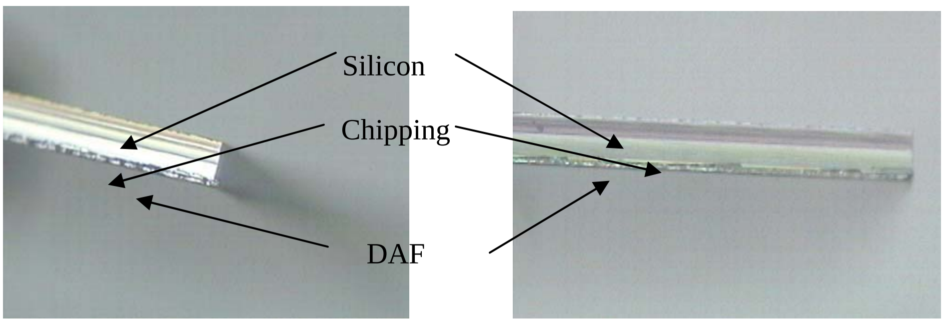
Feed rate or saw speed at 1 and 2 inch/sec was evaluated for dicing laminated DAF. In this experiment, dicing response like front, backside and side wall chipping, saw kerf width, flying die and as well as whisker formation will be observed. Whisker refers to any polymer residue from the DAF material left on the die. Figure 5 shows the comparison between the good dicing quality and the die with whisker formation defect.

Defect like side chipping also had been detected from the sawn die. Figure 6 (a), (b) and (c) show, the respective image when observing from the side view, can be seen that at the bottom side; after DAF layer exist small backside chipping. The chipping is nothing more than 35% of the die thickness. Generally, the backsides chipping accepted criterion is less than 50% of the wafer thickness but control limit is around 25% to 35% of the die thickness.



(a) (b)

Figure 5: (a) Die with good cutting quality, (b) Die with whisker formation.



(a) (b)

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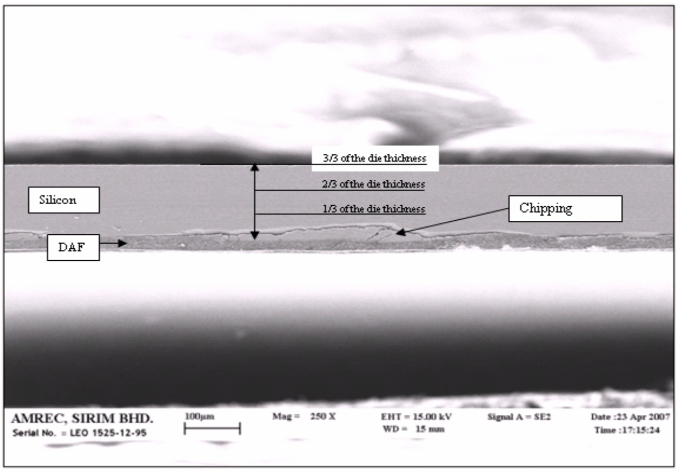

(c)

Figure 6: (a) and (b) was snapped under the low microscope while in image, (c) taken by using Scanning Electron Microscopy (SEM). Indicated in the image is the approximate level of the die thickness and clearly it can be seen clearly that the chipping is less than 1/3 of the die thickness.

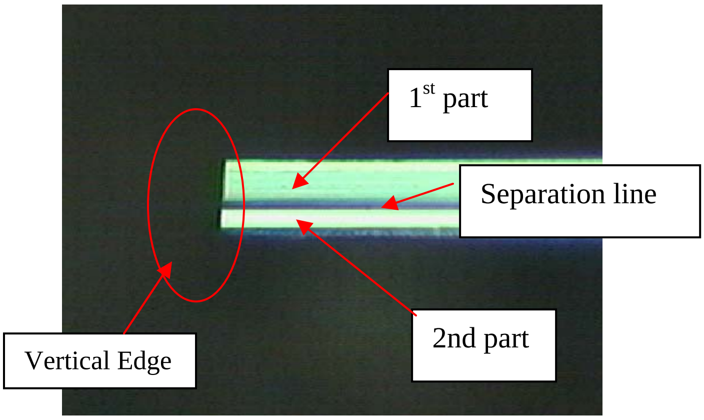

Figure 7: Image of the die edge.

The separation between the first cut and the second cut can be seen clearly in Figure 7. There is a horizontal line parallel along the die edge, the top part is the first cut and the bottom part in the DAF layer is the second part. The top part of die was more than 50% thicker when compared to the bottom part. In the image had been indicated a slight step line at the vertical side of the die edge. The step line is almost a continuous line along the cutting line from Z1 and Z2. The step line exists because of the different blade thickness of first cut and second cut. Blade A had been used for the first cut while Blade B and C were used for the second cut. As Blade B and C have a small difference in the blade thickness about 0.005 mm, the cutting quality for these two blades were not so much different. The step line of the first cut and the

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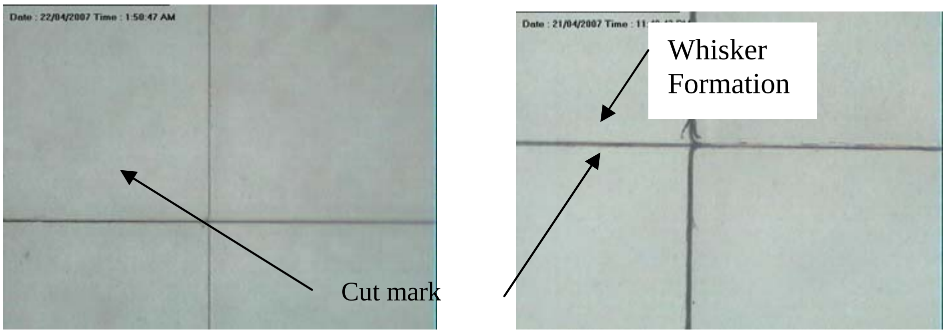
second cut is almost being a continuous line rather as big step line is because of the difference of the first cut blade and second cut blade is small. Blade A and C is about 0.01mm, while the difference of thickness for Blade A and B is 0.005 mm.

Defect like severe backside chipping can be detected from the wafer remnant. When there is silicon remaining on the wafer remnant, this shows that the die is having a serious backside chipping defect. The entire wafer remnant, from the experiment done shows there is no silicon remaining left on the wafer remnant. This shows that step cutting give no serious backside chipping defect. Whisker formation defect normally can be observed at the side of the die, top surface and also wafer remnant so wafer remnant from the entire experiment had been observed. Observation result also shows that some whisker formation was detected on the wafer remnant.



(a) (b)

Figure 8: (a) shows the wafer remnant of a clean cut, (b) shows a wafer remnant with whisker formation.

Generally, the accepted criterion for whisker formation is not more than 30% of the wafer thickness. Whisker formation in this experiment is still under the accepted condition. In dicing process the most critical defect is top chipping. This is because of the active area is on the top wafer surface. From all the experiment done, none of the result shows front chipping or crack at the top surface.

CONCLUSION

The objective of this paper was to study the step cutting method for the laminated DAF wafer. The specific outcome was also to identify the variety of responses from the dicing parameter that being used for the DDAF evaluation. The result showed that the step cutting method is suitable for dicing DAF. The difference in blade grit size was likely does not affect the sawing quality, as long as the blade thickness of the second cut blade is smaller than the first cut blade thickness. Several common dicing DAF defect were observed during the experimental results runs and it is also to be the best dicing quality. The defect and the criterion also had been discussed. Continuity of this study can be carried out in order to focus on the optimization of the dicing parameter for higher throughput with a good yield performance.

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