SAWING PROCESS STREAMLINING BY FULL CUT INTRODUCTION ON ULTRA-THIN WAFERS

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Abstract

Ultra-thin wafer has shown to be an important component of Semiconductor Assembly Manufacturers to achieve excellent thermal resistance performance of the product. But reducing silicon thickness to <50 um, plus the addition of material impurities, like oxide layers, test element group (TEG) and metallization of different chemistries alters the silicon wafer's dicing response thus imposing novel challenges to Wafer Saw application. To satisfy the separation requirements of all those materials, dicing technology employs step cutting process to control the induced stress to the workpiece by proportional sharing of loads using two individual blades, namely, Z1(blade1) and Z2(blade2) by partial (step) cutting technique. Since a complete cutting is being done in two passes, step cut reduces the sawing thruput time (or cycle time) per wafer. In effect, by straight forward calculations, the overall equipment capacity is reduced by half with this kind of Wafer Sawing set up.

The objective of this study is to define a full cut dicing that will address the high thruput time and simplify the sawing process.

This paper discussed the details and approach on how full cut or single pass dicing can be applied to ultra-thin wafers w/o sacrificing the quality of the final product thus resolving the capacity restrictions brought about by using 2-pass or step cut process.

1. 0 INTRODUCTION

Wafer sawing is the front-line process before the Assembly of RF Power devices. It is where a semiconductor wafer can be converted to thousand pieces of expensive scrap caused by instantaneous blade loading spikes which cannot be detected by in-process controls if suitable tools and parameters combinations were not correctly defined before production implementation.

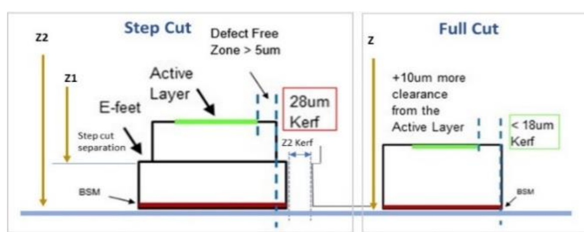
Sawing induced stress is inevitable it's a given challenge in silicon o dicing, the interaction between the materials in contact – blade and the work piece (machining and tribology) may result to large and uncontrollable sawing forces reducing the die robustness. Sub- micro level cracks may not be visible at zero-hour inspection, therefore if this condition is not known and remained uncontrollable, it could become a reliability concern when assembled on the final product.

Full cut or single pass sawing improves the thruput time by 50% but challenge the norms in dicing thin wafer since only one blade will carry the workload in a single pass cutting stroke.

1.1 <u>Step Cut Vs. Full Cut Construction Analysis :</u>

Pros and cons of comparing the two-sawing process were established using below Con Ana Illustrations.

Fig. 1a : Step Cut and Full Cut Con Ana



Step Cut Pros.

- Sawing load is proportionally shared between the two blades.
- Blade formulation matrix can be individually changed for frontside and backside dicing requirements.
- Blade RPM and Cut heights can be adjusted individually.

Step Cut Cons :

- Requires dual kerf alignments – precise centering of Z2 over Z1

- Lower thruput time
- Maintenance of 2 blades and 2 pre-cut board types

Full cut Pros :

- Faster thruput time (single pass sawing)
- Single blade and pre-cut board maintenance
- Single kerf alignment

Full cut Cons :

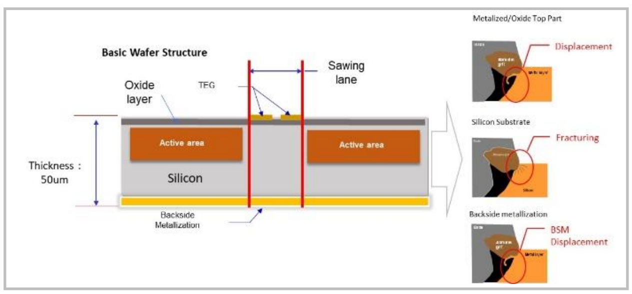
- Full sawing load is carried by single blade. ide and backside dicing requirements.
- Single blade parameter settings

1.2 Critical Blade Parameters :

Blade Parameters	Property	Function
Bonder	Hard	Strong bond
Grit Size	Optimized	Low fracturing effect
Grit Concentration	Optimized	Pocket for dispacement

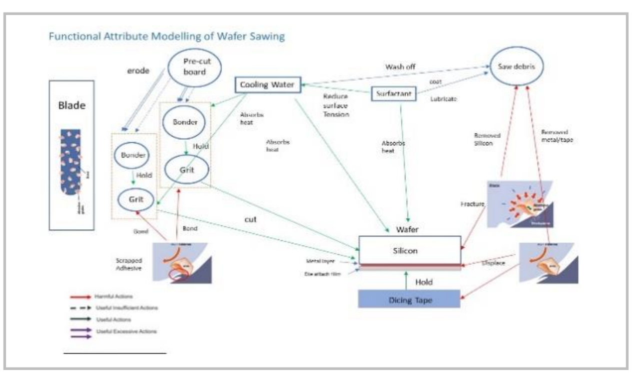
Since the workpiece involve in this study has thick layers of oxide layers and interval TEG on top and metallization layers at the backside, the major considerations are the behaviors of these materials on micro-fracturing and metal displacement as illustrated in fig. 1b.

Fig. 1b : Material Response in Dicing



Relating the above-mentioned dicing characteristics to blade's selection matrix, the main blade parameters into considerations are blade bonder types, abrasive (grit) size and concentration and the kerf to ensure chip size will not extend up to the active part of the die. The bonder and grit integral functions in dicing process are illustrated by functional attribute diagram shown in fig. 1c.

Fig. 1c : Functional Attribute Diagram



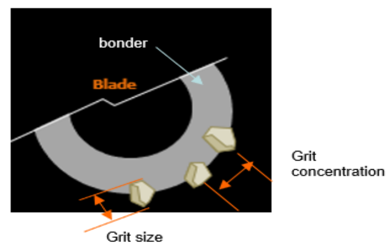
In full cut stroke, the grit function is to completely dice the workpiece and compensates the harmful effects of material displacement while the bonder should be strong enough to hold the grits (in full load) during the cut engagement. Table 1 summarizes the function requirement for each critical blade parameter.

Table 1: Blade Characteristics and Functions

1.3 Blade Characteristic Definition

Below illustration shows the major blade characteristics that are in consideration to this study.

Fig. 1d : Blade Characteristics



- Bonder : material that holds the grits, it also forms the blade's dimension (OD,ID and Thickness).
- Grit : Synthetic diamond, hard and brittle abrasives doing the cutting
- Grit concentration : determines the amount of grits in the blade

2. 0 REVIEW OF RELATED WORK

Reference to blade's kerf delta report (this report describes the optimized thickness difference between Z1 and Z2 step cut blade), low grit concentration performs the efficiently in terms of saw adherents flushing because of its wider chip pockets therefor reduces the loading effect. While grit size application literature showed that finer grits reduce the chance of side cracking performs better on chip formation on workpiece edges. Combining these parameters to blade thickness and grit velocity (RPM), below blade selection table was defined as reference starting point in defining the Full Cut Process.

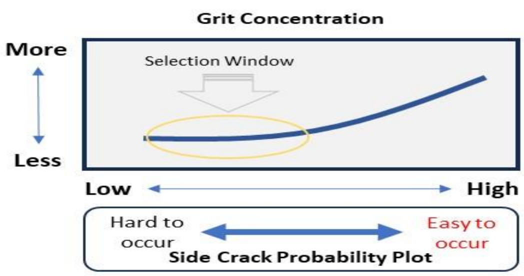
Table 2: Full Cut Blade Selection Reference

Blade Characteristics	Selection	Reference	Remarks
Bonder Type	Hardest bond	Metal bond	Stable at high RPM
Grit size	Crack/ chipping control	Mesh Grade Selection	Less chance of side cracks
Thickness	Thinniest possible capable at high RPM	<22um	Attain dicing stability, 18um kerf test cut resulted to blade loading
Concentration	Crack/ chipping control	> Chip pocket	Less chance of blade loading
Grit velocity (RPM)	High RPM	Kerf to Exposure Ratio	High dicing power (Max RPM from K/E Ratio)

The maximum RPM is defined based from the kerf to exposure table provided by the blade's manufacturer. The higher the ratio, the higher the RPM, therefore higher dicing power which better suits the full cut process.

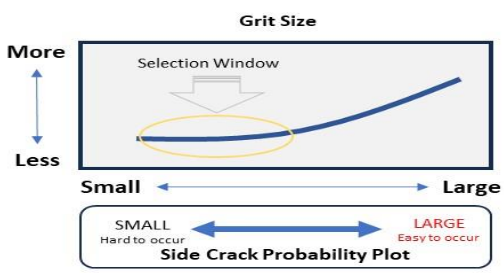
Technical references for blade selection describe how critical characteristics can be varied to achieve the target quality response of the output.

Fig. 2a : Grit Concentration Curve Vs. Crack



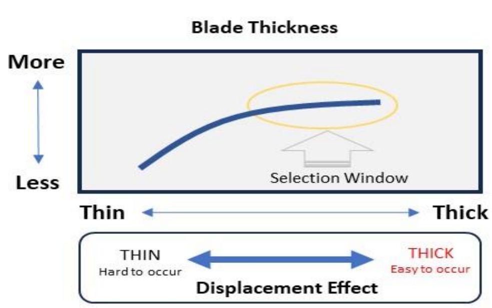
Side crack is a manifestation of sawing force build up, therefore the stable curve region is the key consideration for selecting the grit concentration suitable for the target output response.

Fig. 2b : Grit Size Curve Vs. Crack



For the blade's grit size, the stable crack response is at smaller grit size window but take note that this selection is for ultra-thin wafers only. Thicker types with thickness of above 120um have different crack response for side cracking.

Fig. 2c : Blade Thickness Curve Vs. Displacement



The sweet spot for displacement stability is at thicker curve region. It follows that a thicker tool has more grits at the cutting tip (sharp edge) therefore more abrasives are sharing the sawing load to control the displacement effects.

3.0 METHODOLOGY

Given the blade selection guidelines from the previous sections (Introduction and Review of Related Works), blade formulation matrix was defined – fine grit, low concentration and relatively thicker than Z2 blade from the present step cut set up, refer to tab. 3a below.

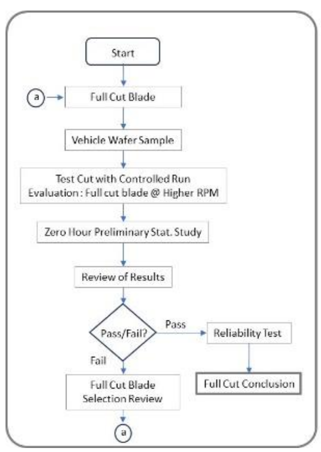
Tab. 3a : Full Cut Blade Formulation Matrix

Blade Characteristics	Selection	Parameter	Remarks
Bonder Type	Hardest bond	High Strength H1 coded bond	Stable at high RPM, wavy cut control
Grit size	Small	Mesh Grade #4xxx	Less chance of side cracks
Thickness	Thinniest possible capable at high RPM	<22um	Thickness in between Z1 and Z2 Step cut blades
Concentration	Low	50%	Less chance of blade loading
Grit velocity (RPM	High	Kerf to Exposure Ratio	High dicing power (Max RPM from K/E Ratio)

After full cut tool selection, test cut followed using metalized ultra-thin wafer as vehicle item.

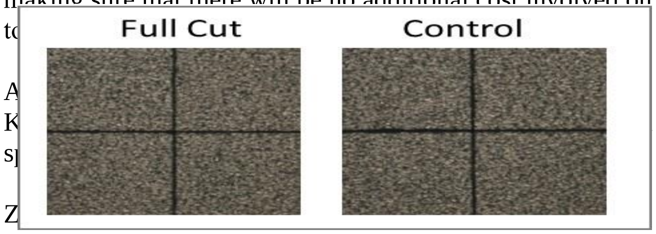
3.1 Experimentation Methodology

The flowchart below describes the framework of experimental methodology.



- Follow standard Pre-Cut procedure
- Feed rate parameters are blocked
- Full cut height is the same with Z2 setting
- Kerf check every 30 cutlines

Blade formulation matrix is also based on manufacturability, making sure that there will be no additional cost involved on t



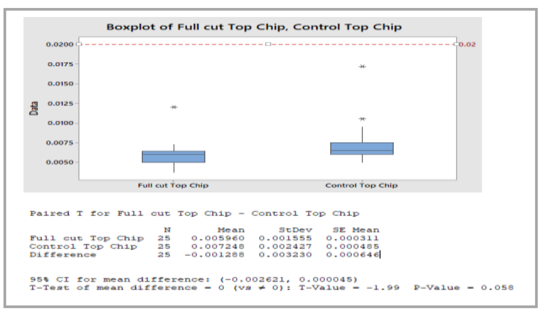
comparative analysis on top and back chipping, kerf and descriptive analysis on kerf finish morphology (sidewall crack raiser check).

4.0 RESULTS AND DISCUSSION

4.1 Zero Hour Preliminary Statistical Study on Top

Top chip plot comparison showed < 2 um cut deviation from the kerf line, although the control is showing some spikes closer to the reference line, T -test P value resulted >0.05 therefore top chip for both full cut and control (Step cut) are off the same performance level.

Fig. 4a : Top Chip Box Plot (Full Cut Vs. Control)



4.2 Back Chip Inspection Results

Optical inspection using High Power Soce was used to gauge the back chip performance for both full cut and control following the standard quality criteria. Both runs yielded 100%, see table below.

Tab. 4a : Back Chip Inspection Table (Full Cut Vs. Control)

Wafer Technology	12NC Description	Wafer Scribe Number	Sawing Process	Qty	Back Chip Count	Yield
Ultra -thin	VL1XXX AH 515	FBXXXX-X1	Control	2950	0	100%
Ultra -thin	VL1XXX-AH 515	FBXXXX-X2	Full cut	2954	0	100%

High magnification photos on backside also showed smooth corner finish, see below photos.

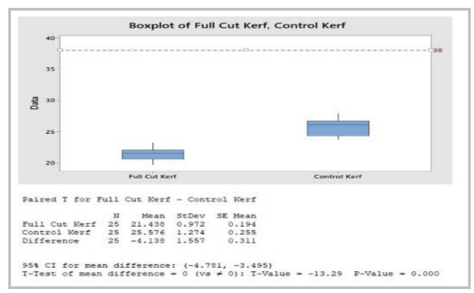
Fig. 4b : Back side Photos (Full Cut Vs. Control)

Manifestation of metal displacement on corners is minimal, therefore comparable base chip performance.

4.4 Zero Hour Preliminary Statistical Study on Kerf

Kerf box plot comparison showed narrower width on full cut process, this this reasonable since kerf is a direct function of the tool thickness where in this case Z1 (step cut blade) is one notch thicker than the full cut blade. Also, the P-value is <0.05, therefore kerf performance of the two- sawing process are significantly different for this measurable.

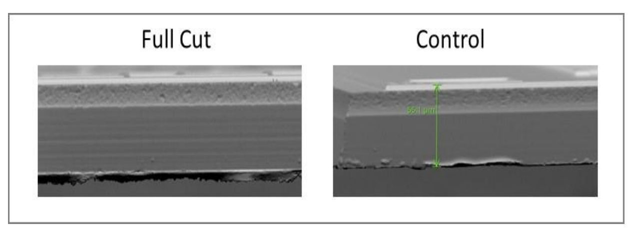
Fig. 4c : Kerf Box Plot (Full Cut Vs. Control)



4.5 Cut Finish Morphology Results

Cut finish (Cut cross section) showed minimal backside metal displacement, grit marks were all defined with no sign of crack raisers for both full cut and control samples.

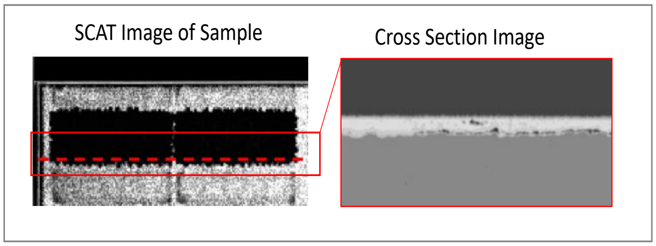
Fig. 4d : Cut Finish Morphology (Full Cut Vs. Control)



4.6 Reliability Results

To further confirm the integrity of sawn dice from full cut run, sample was submitted for 1000 cycles TMCL, no sign of stress raiser on side wall, see below cross section result.

Fig. 4e : Cross Section of Full Cut Sample after 1000c TMCL



5.0 CONCLUSION

Based on the results – Zero hour Preliminary Statistical Study (PSS) and Reliability test, Full Cut Sawing can be concluded as comparable to Step Cut Process on product quality responses, but since sawn thru is achieved by a single stroke, full cut simplifies the dicing system in terms of efficiency (thruput time) and kerf alignment easiness (single blade alignment only), eliminating the precision requirement of dual blade centering therefore, wafer saw streamlining can be achieved by employing this application in replacement of the current step cut process.

6.0 RECOMMENDATIONS

Qualification of full cut process on other wafer technologies like the deep trench capacitors (DTC) with die attach film at the backside.

Software upgrade of Dicing equipment to interlock Spindle load profile on sawing process control with data logging capability.

High speed sawing study (3x-5x faster than full cut federate) to further improve the dicing efficiency.

7.0 ACKNOWLEDGMENT

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8.0 REFERENCES

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9.0 ABOUT THE AUTHORS

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