Saw Blade Lifetime Extension for Cost Saving and Productivity Improvement

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Abstract

This study was setup to evaluate and qualify for production the new approach of saw blade lifetime extension or extended the usable length on wafer saw blade model X that promised substantial cost reduction as compared to the original of usable length control at maximum 280 micron. Since the trend at the study plant is towards assembling memory products with thinner thickness when compared to a few years ago, i.e. the extension of usable length are evaluated especially on 170, 250 and 280 micron wafer thickness, and also gains the benefit for the increment time for machine utilization. The focus of this evaluations was on comparing the impact of the increasing of usable length of saw blade at related operations-i.e., wafer saw, die attach and test. Issues related to usage of the extended length studied included the blade properties on diamond distribution study on the blade itself as well as the Finite Element Analysis (FEA) on the blade vibration at different length. The diamond distribution showed consistency trend along the blade from the start to the end of blade. The Finite Element Analysis (FEA) result showed the shorter of blade length or the extended part of blade that was used can create smaller vibration than the original length which may infer better on saw kerf quality. Besides, this evaluation also included the kerf quality and topside chipping at wafer saw operation with various interested factors—i.e. Machines, Wear, Spindle RPM, Feed rate and wafer thickness by using Half-Fractional Factorial design. The result showed that feed rate is the most influenced factor in saw kerf quality. Confirmation runs indicate that wafer saw and die attach can achieve at 100% yield.

Keywords

DOE, Wafer saw, Saw blade

1. Introduction

Nowadays, there is a lot of competition in Semiconductor Company including IC business. Process development and cost saving are among the key factors for competence. The cost saving factor, leaded to development of this project, entitled *"Saw blade life time extension for cost saving and productivity improvement"*.

Wafer dicing in the assembly of integrated circuit packages is performed to separate the die to the specific dimension for particular die size. One of the major concerning materials for wafer dicing is the diamond blade which will be used to cut the die to the particular die size along with the street of the wafer (Refer to Figure 1).

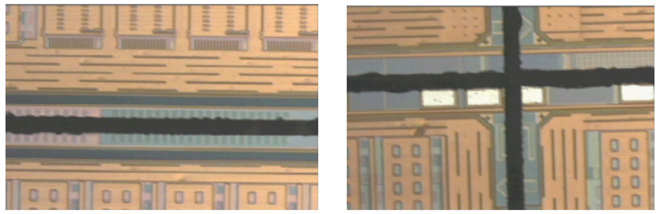


Figure 1: Example of Saw Kerf Width on the Wafer

Currently saw blade model X for wafer dicing is applied to cut the wafer in the thickness range of 6.7 mil to 20 mil. Because of the higher production volume, blade consumption is greater consequently to high cost generated. The considerations to increase the usable range of the blade were initiated for cost saving purpose and also incorporated with the wafer thickness will become thinner to support smaller area in electronic components (Karnezos M., 2004). The increasing of usable length is the way to go.

1.1 Blade Properties Study

The blade model X was used in wafer saw process by setting a wear limit (usable length) to a certain value for every wafer thickness varying from 6.7 to 20 mil. So far no quality issues related to the use of this blade type. The blade properties are one of the most important needed to be considered in this evaluation.

1.1.1 Bonding: bond is the agent that holds the grit together. Bond type and grad of hardness (holding power) are selected in accordance with the processing objectives and the characteristics of the material to be processed.

1.1.2 Concentration: concentration refers to the grit content of a blade which means to percentage base on the volume of the blade.

1.1.3 Grit size: grit size refers to grain size that expressed in terms of a mesh no# which refers to the number of meshes per linear inch e.g. #2000, 4/6 um.

1.1.4 Blade Length: blade length is the blade height which implies the usable length for cutting.

1.1.5 Blade thickness: blade thickness is the width of the blade which has to correlate with the saw street width to ensure there is no circuit damage during dicing. For this blade type, e.g the blade thickness is in the range of 1.5-1.7 mil.

The phenomenon of the blade is that while a blade is dicing a wafer, it causes wearing of saw blade, shortening the blade length. Anyway, the self sharpening by blade itself makes the blade sharpen all the time during the wearing happen (Refer to Figure 2).

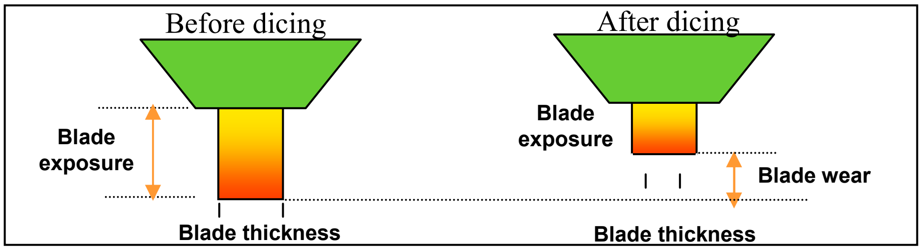
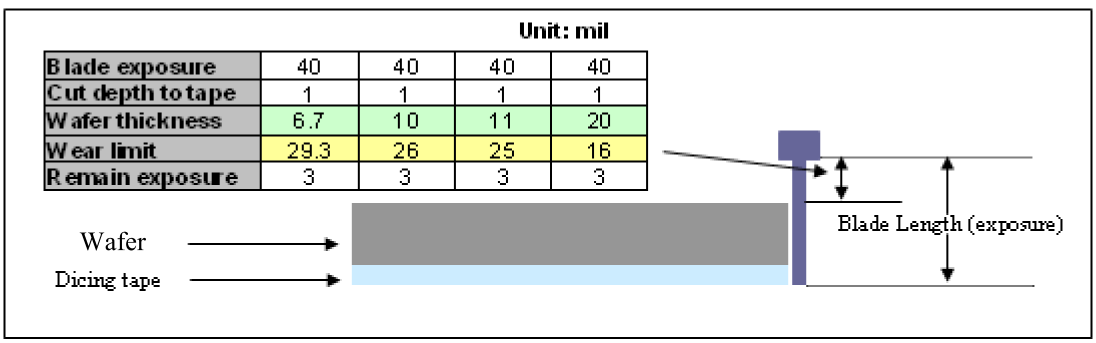


Figure 2: Phenomenon of the Blade Before and After Dicing

1.2 Opportunity for Saw Blade Life Time Extension

Saw blade is used in the wafer saw process which is the process to separate the die from the wafer but cut on the wafer which attached with the dicing tape to hold the die after dicing. Currently, the blade wear or usable length is set to a certain value to use on every package after that the saw blade will be replaced. It means that if the wafer thickness is thinner, the blade has to be replaced earlier than it should be used. Thus, there is an opportunity to increase saw blade life for the thinner wafer. The target to extend the blade life is set by referring to the remaining exposure which should have at least 3 mil from the wafer surface (Refer to Figure 3).



Blade exposure	40	40	40	40
Cut depth to tape	1	1	1	1
Wafer thickness	6.7	10	11	20
Wear limit	29.3	26	25	16
Remain exposure	3	3	3	3

Figure 3: Blade Length and Usable Length Calculation

1.3 Impact of Extension Length of Blade at Wafer Saw and Die Attach

To increase usable length or wear limit of the saw blade has potential impact on the setup, procedures and/or quality of the following operations.

1.3.1 Wafer saw/dicing: The process to separate the die to the specific dimension. At this operation, extend the blade life may have impact on.

1.3.1.1 Chipping: the diamond distribution on the blade plays a crucial role for chipping problem in case of the distribution of the diamond is not consistent through its length. Once the extension length is used, it is possible to create the chipping problem which concern to reliability issue (Refer to Figure 4).

1.3.1.2 Wafer scratch: the increase of usable length may impact to the wafer scratch which concern with the wafer thickness in case of load wrong wafer thickness to the machine—i.e., Operator load wafer thickness 20 mil while the remaining length is 19 mil. Once the machine start running, the wafer topside will be hit with the hub blade and make the wafer scratch happen.

1.3.2 Die attach: The process where a pick and place mechanism picks individual die off the laminated dicing tape and places them onto the epoxy coated die pad of substrates or lead frames. When using the extension length of the blade

1.3.2.1 Die crack problem : In case of non-uniformity of the diamond distribution on the blade which may create topside chipping and residue stress on the die that once process to die pick up which use ejector pin at die attach it is possible to propagate causing die crack (Refer to Figure 5).

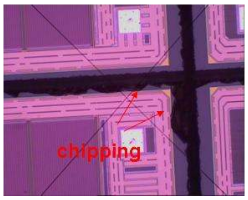


Figure 4: Wafer Chipping Photo

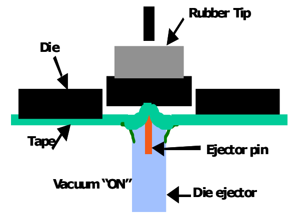


Figure 5: Die Attach Pickup Process

2. Methodology

2.1 Blade Characteristic Evaluation

2.1.1 The diamond distribution of the saw blade study

From the blade characteristic itself the diamond concentration needs to be aware of regarding its distribution on the dicing blade. To ensure that there is no problem on the extension of usable length of the blade. This diamond distribution experiment was set to investigate whether the diamond concentration is covered for all areas or not to ensure that there is no problem once the usable length has been used in dicing process refer to Table 1 and Figure 6. The data of percentage of diamond per area were collected in this experiment. The result showed in Table 2 and Figure 7 that there is no significant difference on the percentage of diamond distribution at different level of blade type at 95% confidence level. It means that the blade has the same properties on the diamond distribution.

Table 1: Factor and Levels for Diamond Distribution Study

Factor	Levels
Diamond distribution	1. Start blade 2. Middle blade 3. End blade

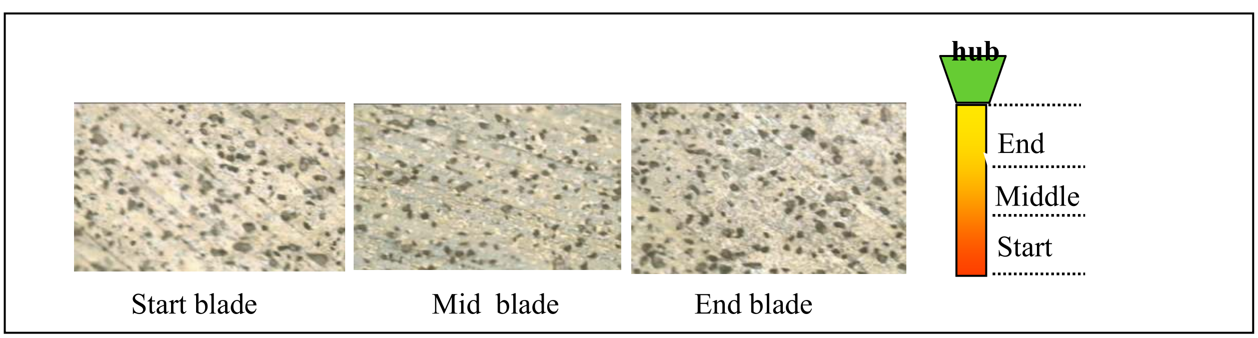


Figure 6: Diamond Distribution Photo of Each Area

Table 2: ANOVA Table of Diamond Distribution

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob> F
Model	2	20.34467	10.1723	1.4554	0.251
Error	27	188.71	6.9893		
C Total	29	209.05467	7.2088		

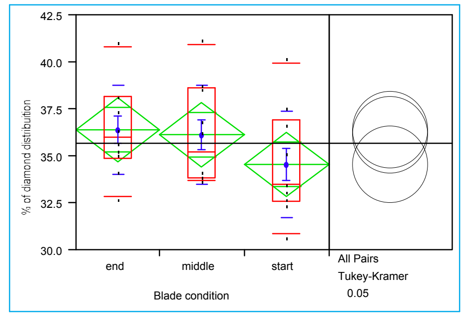


Figure 7: ANOVA Result of Diamond Distribution

2.1.2 Finite element testing on the vibrated distance from different blade exposure

One of the key issues is on the vibration of the blade. The vibration of the blade will effect directly to the saw kerf quality. Saw kerf width and topside chipping will be higher if more vibration was created during sawing wafer. This evaluation was applied by using Finite Element Analysis (FEA) to compare the vibration of the blade at different length. For this case, the longer blade length and the shorter blade length were selected to compare on the vibrated distance. The vibration of the blade showed that the vibration will be generated highly at the end of the blade especially on the longer blade length. Consequently, saw kerf width and chipping may be higher for longer blade length. From the Finite Element Analysis model, it can be inferred that dicing blade can be extended and has possibility to improve in saw kerf quality due to smaller vibration (Refer to Figure 8).

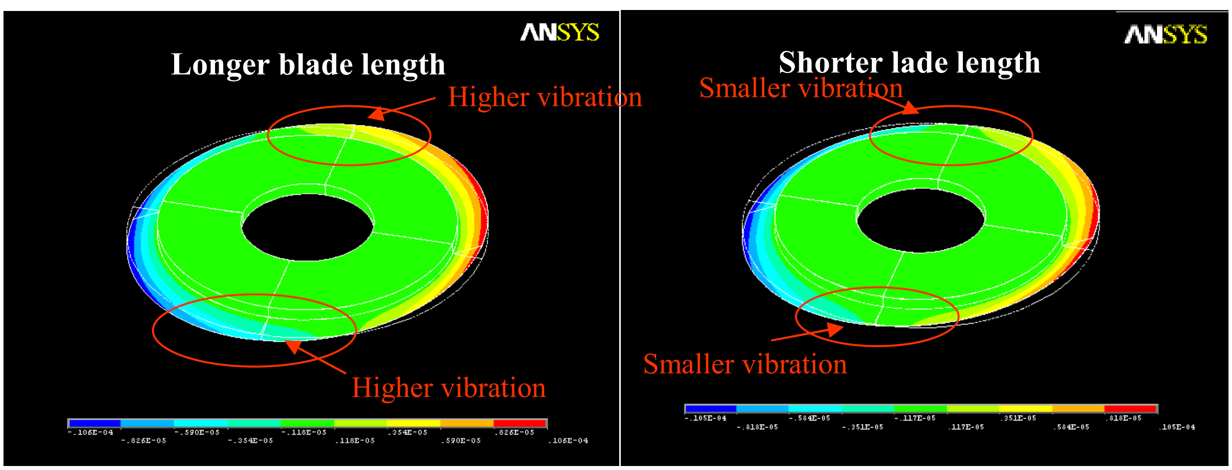


Figure 8: Finite Element Analysis Model

2.2 Saw Kerf Quality and Chipping Evaluation

2.2.1 DOE & analyses saw kerf quality & chipping

This part focused on the impact of the propose to increase usable length more than current value using at the wafer saw operation, and more particularly on the saw kerf quality and chipping issues. To evaluate the kerf quality and any chipping at the dicing the list of factors and levels are identified in Table 3 below (Weisshaus I. and Weisman G., 2003). The appropriated parameter set will be gained from this experiment to use in the real production. The experiment was performed with half-Fractional Factorial design (Montgomery, D.C., 2001 and Hicks, C.R. and Turner K., 1999). This design is a powerful tool for understand the complex process for describe factors interactions up to 2 factors interactions. The applied of fractional factorial experiment was performed with 2 replicates in each run. The responses of this experiment consist of Maximum saw kerf width (Wmax), Topside chipping (TSC) and Backside chipping (BSC).

Table 3: Factors and Levels for Saw Quality Study

Levels	Factors				
	Machine	Wear	Spindle RPM	Feed rate	Wafer thickness
Low (-1)	BB	Low	Low	Low	Low
High (+1)	AA	High	High	High	High

The interactions plots have been done for each response and the results were summarised in the Table 4, 5 and 6.

Table 4: Wmax Parameter Setting

Wmax Influenced factors	Best setting
RPM and feed rate	RPM = high Feed rate = low
Wear and feed rate	Wear = high Feed rate = low
Machine and thickness	Thickness both high and low on machine BB

Table 5: TSC Parameter Setting

TSC Influenced factors	Best setting
Machine and Thickness	Thickness at low level on machine BB and Thickness at high level on machine AA
RPM and Thickness	RPM =high on both low and high level thickness
Machine and RPM	RPM =high on both machines AA and BB

Table 6: BSC Parameter Setting

BSC Influenced factors	Best setting
RPM and Feed rate	RPM = high Feed rate = low
Machine and Thickness	Thickness at low level on machine BB Thickness at high level on machine AA
RPM and Thickness	RPM =high on both high and low level wafer thickness

At the higher RPM, normally the blade will wear faster and also the feed rate at the lower level will have an impact on the throughput. Also in the normal production, both machine types are required to support production. Thus, another evaluation was performed to find out the parameter for each machine. The new evaluation will fix the spindle RPM to a certain value to prevent the higher wear rate and also another set of feed rate which increase from the result got from the first evaluation was used. The experiments conducted for each machine type were shown in Table 7.

Table 7: Factors Summary for Saw Quality for Each Machine Type

Levels	Factors		
	Wear (F)	Feed rate (G)	Wafer thickness (H)
Low (-1)	Low	Low	Low
High (+1)	High	High	High

The interaction and main effect plots were performed and the result of best parameter setting was shown in Table 8.

Table 8: Best Parameter Setting for Each Machine Type

Machine	Responses	Thickness	Feed rate	RPM
AA	Wmax	Low	Low	Fix
		High	High	Fix
	TSC	Low	No effect	
		High		
	BSC	Low	Low	Fix
		High	Low	Fix
BB	Wmax	Low	Low	Fix
		High	Low	Fix
	TSC	Low	No effect	
		High		
	BSC	Low	Low	Fix
		High	Low	Fix

The settings for the experiment were determined by choosing the best solution. However, a conflict existed with the feed rate on AA machine. The results were appropriate at two levels. However, the result of backside chipping did not show different when compare at both levels. Thus, Feed rate at higher level was chosen due to the increment of throughput. Confirmation run with the appropriated setting above were tested on 10 different runs and the result showed acceptable with all of the responses (Wmax, TSC and BSC) including the die pick up at die attach were in the target.

3. Conclusion

This study is aimed to identify and determine parameters which affect the saw quality once saw blade life is increased. Its investigation involves main factors such as wear, machine, RPM, feed rate and wafer thickness. The data of each factor has been collected and tabulated using the half fraction factorial design with 2 replicates in each run for 1st screening and full factorial design by machine model with 2 replicates in each run for finalizing the best parameter setting for each machine. In conclusion all of samples are pass the target value. The best set of parameter and average responses of saw quality from each machine are as following:

AA machine used feed rate at low level for low level of wafer thickness and high level for high level of wafer thickness by fixing the spindle RPM at certain value.

Maximum saw kerf width average = 1.865 mil
Topside chipping average = 0.381 mil
Backside chipping average = 0.753 mil

BB machine used feed rate at low level for both low and high level of wafer thickness by fixing the spindle RPM at certain value.

Maximum saw kerf width average = 1.843 mil
Topside chipping average = 0.398 mil
Backside chipping average = 0.842 mil

4. References

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