Original Research Article

Wafer Thinning Process and its Critical Manufacturability Requirements

ABSTRACT

Wafer Thinning as a major semiconductor process step to attain miniaturization should have an excellent process and equipment to cater its criticality. Wafer back grinding up to 70um should have better wafer handling steps. Any foreign material or presence of misalignment will lead to process stability, i.e. total thickness variation, and yield problems like wafer breakage.

The paper will discussed the establishment of critical process and equipment requirements from back-grind tape lamination, wafer back-grind and back-grind tape peeling. The introduction of UV tape to ensure good cushioning during back-grind and good peeling after grinding will also be discussed on this paper. Wafer back-grind top and bottom alignment from chuck table and spindle are also covered by the study. After the evaluation, the product is the successful release and proliferation of 70um wafer thinning process to manufacturing.

Keywords: Wafer, Wafer Thinning; Back grind Tape; Chuck Table condition; Polishing Pad;

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1. INTRODUCTION

At the onset of thinner electronics packages, there were also a need of thinner architecture inside the Integrated Circuit (IC) packages. Several means were considered to attain thinner packages such as thinner substrates, mold caps, adhesive bond line and die thickness. However, ICs should be designed on a package density that can cater its application reliability requirements. Density then should consider thermomechanical strengths and in order to attain one major change should be on its die thickness.

Die thickness will be attained by the introduction of wafer thinning process. According to Zhou, et.al, in order to attain thinning wafer or silicon wafers an ultra-precision grinding machine [1] should carry it out. Nowadays, several issues and requirements faced during the process proliferation from development to manufacturing phase. The paper will discuss the several key process requirements in order to attain stress free wafer thinning to 70um and 50um die.

1.1 Wafer Thinning Process

Wafer thinning process revolves on the development of grinding wafers up to 70um and 50um final thickness. Wafer back grinding serves as the critical process of thinning were consists of three major steps: coarse grinding, fine grinding and Chemical Mechanical Polishing or CMP [2]. As described by Sandireddy, S. and Jiang T. (2005), coarse grind removes silicon faster using large diamond particle size while fine grind is a much slower rate and smaller diamond particle size, which ease up the occurrence of wafer damage. Moreover, additional step was introduce to increase die strength and decrease risk of die

crack [3]. A known additional step was stress relief called CMP or Chemical Mechanical Polishing, in which further reduces surface roughness and die related defects [4]. However, all processes have its own weaknesses. CMP, which introduced very small particles too properly, polished the silicon layer of the wafers. Critical particle control should be implemented to eliminate micro scratching and worse is wafer breakage [5]. The paper will discuss the requirements of manufacturing before and during wafer back grinding of wafer thinning process.

Auxiliary process such as back grind taping is needed for wafer thinning. BG tape laminated on top of the wafer to support cushioning during the grinding process that can induce cracks on the active layer and will affect its electrical performance. Nowadays, wafer back grinding machines are already in line with wafer mounters wherein dicing tapes or die attach films were laminated prior wafer sawing. Last process on inline grinders and mounters was the BG tape peeling, wherein BG tape was removed from the wafer front side.

2. ACTUAL EVALUATION

2.1 Materials

Wafer Thinning will focus on 8-inch wafer size using an ultrafine back grind machine. The equipment will have a full wafer back grind process: coarse, fine and CMP; and connected to a full wafer mounter process, which die attach film will be laminated on its backside then BG tape will be detape from its front side. Final wafer thickness will be 70um. Process Flow was below:

Fig. 1. Wafer preparation processes

Two different back grind tapes or BG tapes with different adhesion strengths were used: Non-UV and UV type tape. BG tapes evaluated to check if the adhesion would affect the BG tape peeling process that can lead to wafer crack.

2.1 Equipment

The equipment used was a commercially available grinder (Accretech, Model PG200). Grinding wheels was also from Accretech. The final thickness of wafer is 50-70μm.

2.2 Procedure

In order to established critical manufacturability requirements for wafer thinning, several process and equipment was studied.

- ✓ Wafer BG Tape Lamination
- ✓ Chuck Shape
- ✓ Grinding Spindle 1& 2 Angle
- ✓ Chuck Vacuum Condition
- ✓ Wafer Handling parts condition
- ✓ UV function
- ✓ CMP Polishing Pad

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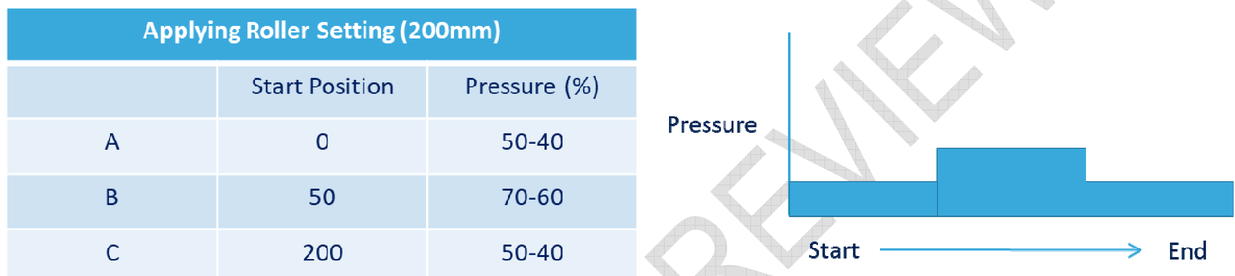
- ✓ BG tape peeling station

4. RESULTS AND ANALYSIS

4.1 Wafer BG Tape Lamination

Wafer BG Taping is one important thing to consider in handling thin wafers, specifically the Applying Roller pressure to be applied during taping process. Applying Roller Setting (200mm) is decreased by 10% of its original setting. Wafer BG tape edge cutting should also be monitored that may incur edge chippings during Backgrinding thin wafers. Dull Cutter should be replaced prior worn-out to eliminate rough edge cutting.

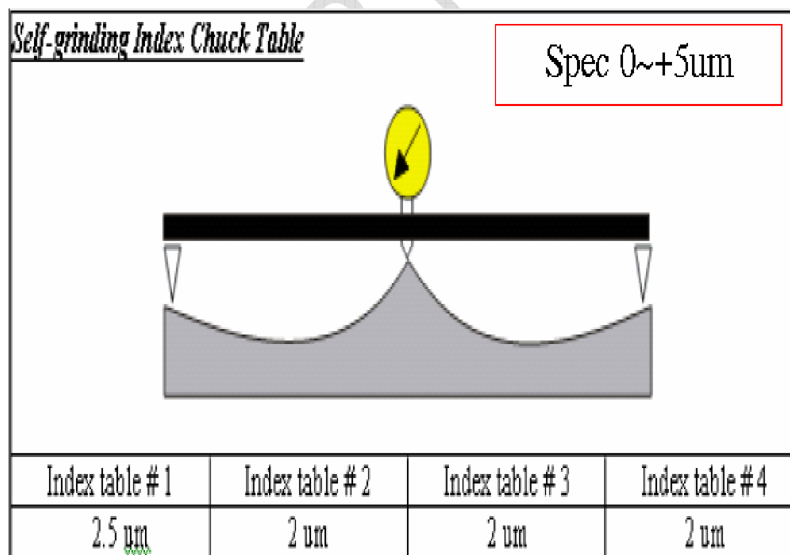


Applying Roller Setting (200mm)		
	Start Position	Pressure (%)
A	0	50-40
B	50	70-60
C	200	50-40

Figure 2. Recommended Lamination Settings

4.2 Chuck Shape

Chuck Shape is to check planarity of chuck table in order to define chuck center height difference compared to chuck edge. The characteristics will play a major role on the wafer thickness variation and planarity of the silicon wafer that to be grinded. The specification of +/-5um will define the total thickness variation or TTV requirement of wafer back grinding of +/-10um



Index table # 1	Index table # 2	Index table # 3	Index table # 4
2.5 um	2 um	2 um	2 um

Figure 3. Recommended Lamination Settings

4.3 Grinding Spindle 1& 2 Angle

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Grinding Spindle Angle adjustment is also necessary to ensure good TTV after wafer back grinding. The same as chuck shape, spindle angle is also critical since it will drive the cutting angle of the wafer thus planarity is critical to meet the TTV requirements. Based on the

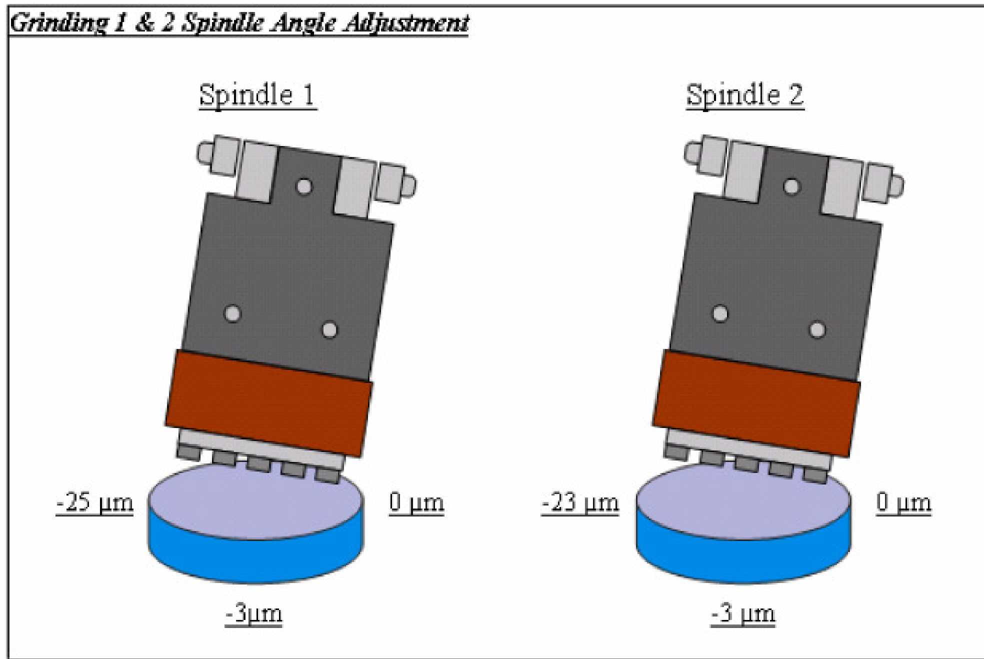

Figure 4. Grinding Spindle Angle Adjustment

Before the spindle angle adjustment, -4 and -25 angles have 6um difference on both Spindle 1 and 2 grinding wheels. Adjustments, described on Table 1, there were no differences on both spindle in which the grinding angles for both spindle will have the same removal rate for coarse and fine grinding. Lastly, no differences between spindle angles will eliminate potential TTV impact on final wafer thickness.

Table 1. Before and After Grinding Spindle Angle Adjustment

Adjustment	Grinding Spindle 1			Grinding Spindle 2		
Before	0	-10	-25	0	-4	-19
After	0	-3	-25	0	-3	-25

4.4 Chuck Vacuum Condition

After ensuring the top and bottom surface alignment, next will be the wafer handling areas. The most critical wafer handling part will be the chuck table, in which wafer sits during wafer back grinding. Chuck table is normally on porous form wherein vacuum will ensure covers the completely back side. One critical characteristics of chuck table is its vacuum condition. It defines the wafer suction power of the chuck table

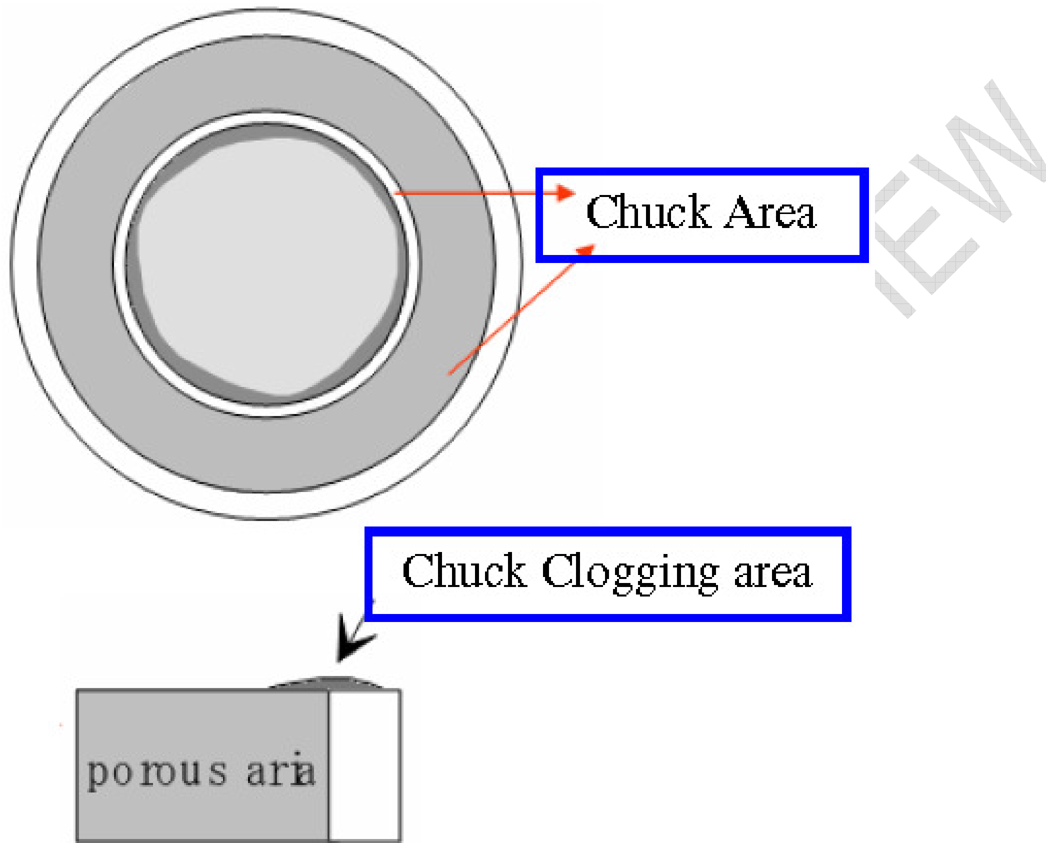

Figure 5. Chuck Table Condition

The in-line equipment typically have 4 chuck tables to have at least one wafer on each part of the wafer back grind process. Based on the assessment, chuck table has a clogged area wherein cleaning is necessary to ensure vacuum coverage and will eliminate detached wafer during back grinding process.

Table 2. Before and After Grinding Spindle Angle Adjustment

Chuck Table	Vacuum	Release
1	90% good	Good
2	Good	Good
3	Good	Good
4	Good	Good

4.5 Wafer Handling Parts Condition

Another critical handling part was the spinner chuck table, in which table sits during wafer cleaning after the back grind process. After the assessment, the spinner table have damage on the wafer edge surface that may incur wafer breakage during spinning process or H2 place to spinner station, specifically for thinner wafers after polishing.

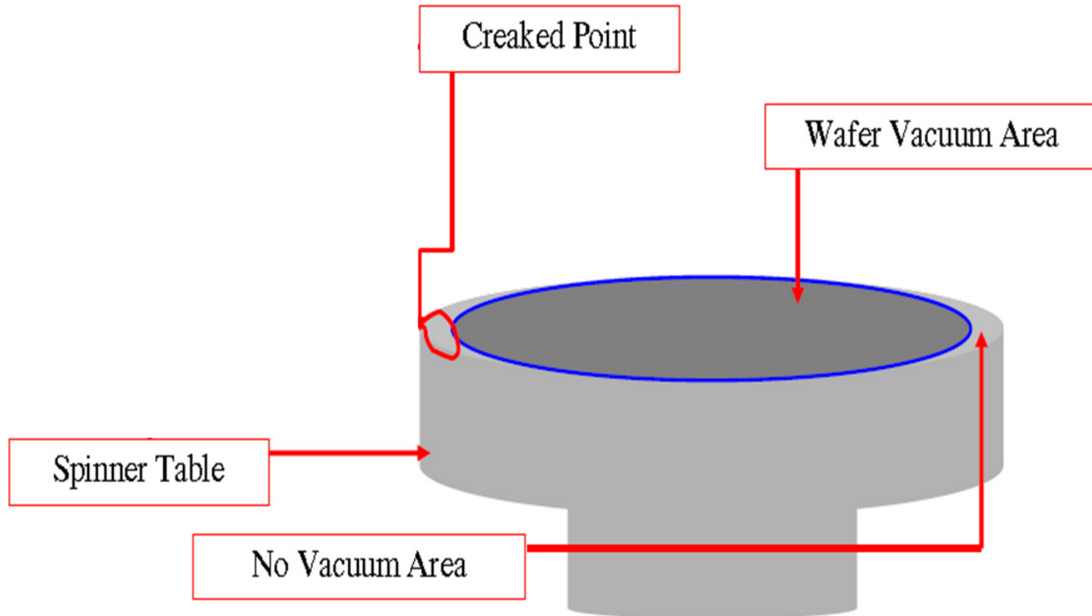

Figure 6. Spinner Chuck Table Condition

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4.6 UV Function Condition

UV Condition is important to ensure detaping process is effectively performed, given that ASIC die is using an UV type BG tape. After the assessment, UV type BG tape is needed for wafer thinning process due to higher adhesion strength during wafer back grind. The adhesion strength will ensure the cushioning of wafer thus will eliminate the wafer detachment during grinding

4.7 CMP Polishing Pad

The third back grinding process is highly critical since the thickness is already below 75um, thus a need of good process handling is necessary. CMP uses polishing pads and slurry to attain mirror finished back grind. After the assessment, polishing pad to be used should not have slurry slot that could lead to stocking of hardened slurry and will incur foreign material or worst wafer breakage, as shown in Figure 7.

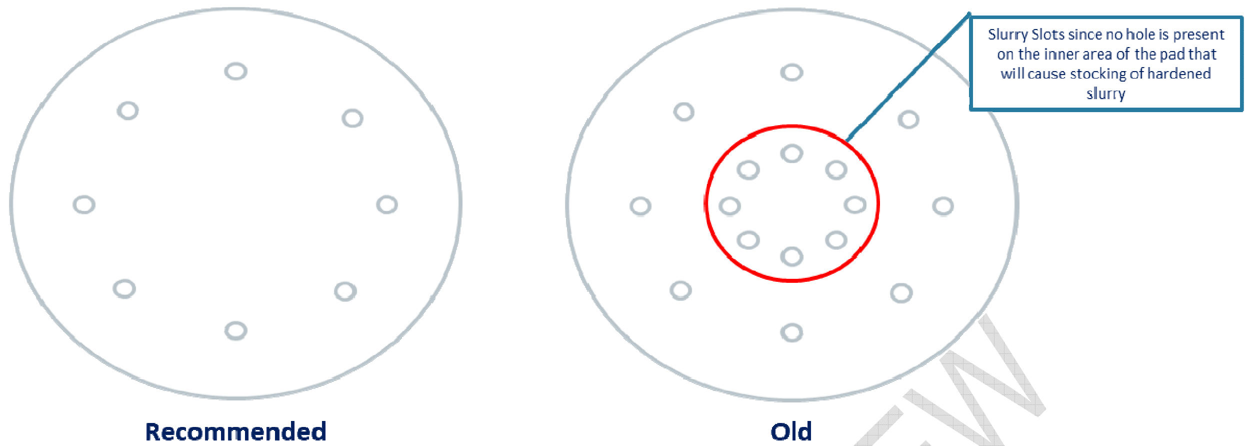

Figure 7. Polishing Pads Condition

4.7 BG tape peeling station

Last step for in-line back grind and mount equipment is the BG tape peeling station. Since we are dealing on removing BG tape on top of a very thin wafer. Even though the UV BG tape has very light adhesion after radiation, handling will still be carefully established. After the validation, the peel roller defines the evaluation shows that the success of the peeling and elimination of dislodge of wafer. The phenomena is that the BG peel tape should exactly touch the edge of the thin wafer and not to touch the dicing tape or die attach film that can dislodge the wafer during peeling.

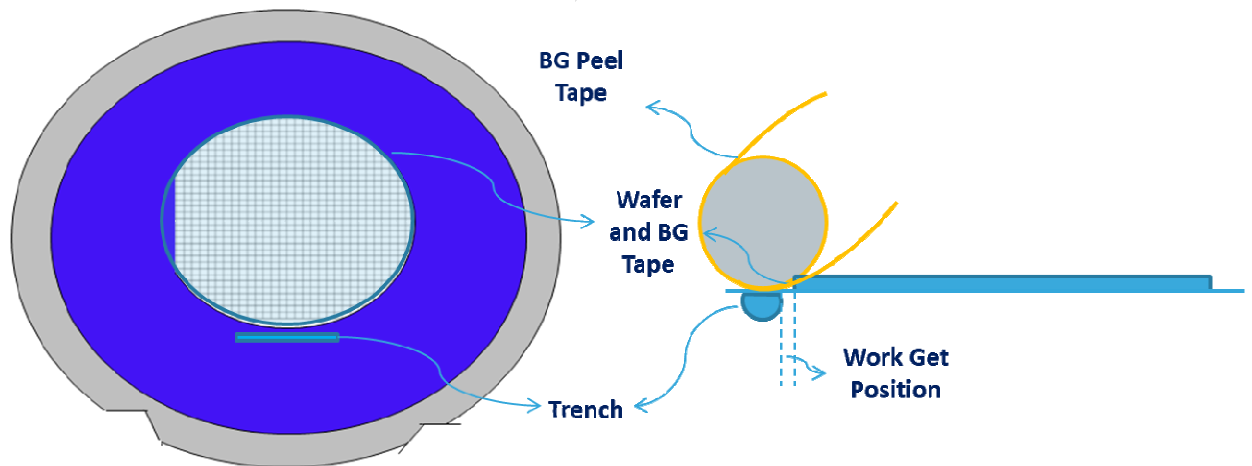

Figure 8. BG Tape peeling station condition

5. CONCLUSION

Wafer thinning process due to its criticality should be carefully defined by establishing process and equipment requirements. Critical items will start from wafer back grind tape lamination, wafer back grind process and its handling system and up to wafer back-grind tape peeling. Foreign Materials, process alignments and clogging are critical items for its handling steps. BG tape lamination and peeling should be defined to eliminate wafer breakage due to potential wafer dislodge at process step. Lastly, UV back-grind tape should be used to ensure high adhesion during wafer back-grinding for cushioning while lower adhesion during peeling process.

COMPETING INTERESTS DISCLAIMER:
Authors have declared that no competing interests exist. 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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