Backgrinding Tape Selection Analysis for Adhesion Problem Mitigation

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ABSTRACT

Wafer passivation plays a major role of providing protection and also the isolation of electrical stability of the active circuit on the top area of the wafer. Passivation is normally a masking of an oxide layer on the surface of the silicon wafer. Passivation is normally in the form of polyimide or a glass material. On the wafer structure, it is important to cover the active circuit to ensure no other noises will be induced to the wafer. Inclusion of the passivation layer will help maximize the functionality of the semiconductor device thus eliminating noises coming from the external sources.

As the integrated circuit (IC) package goes thinner, the requirement of having the active circuit or the die thinner is the main concern during the wafer preparation process. Wafer back grinding is the focal process involved to satisfy such requirement. Prior performing the wafer back grinding process, the application of tape should be performed to eliminate contamination and protects the active layer of the wafer during wafer backgrinding process. However, there should be enough adhesion between the wafer and the back grinding tape itself. High adhesion strength may lead to adhesive remains or worst, passivation will be peeled off from the active layer of the wafer.

Adhesion to the passivation layer should be properly evaluated and monitored in such way that will eliminate adhesive remains during detaping process after wafer back grinding. The effect of adhesion strength could be predicted by properly selecting back grinding tape to be used. Higher adhesion strength could be achieved but due to criticality of passivation to tape adhesion, ultra-violet (UV) process should be included to substantially decreased the adhesion. The importance of UV exposure is also discussed on this paper.

Keywords: Backgrinding tape; wafer preparation; ultraviolet; passivation; adhesion.

1. INTRODUCTION

Wafer back grinding is one of the critical pre assembly process in which wafers are grinded to a required thickness to cater the package requirements. However, it is important to protect the active layer of the wafer, thus applying an adhesive tape is a must. There should be no water penetration during the grinding process and no contamination on the back grinding tape so that the active layer is totally intact after grinding process. In line with that, backgrinding (or simply BG) tape should have three critical characteristics: Suitable adhesion, Easy de taping and good uniformity after grinding.

Different Silicon technologies have been developed according to its application. Wafer could have different surface finish and the common is the application of a passivation layer. The peeling off of the wafer passivation together with the BG tape during detaping process is one major concern. With this, the assembly manufacturing plant carefully analyzed the criticality of backgrinding tape adhesion. Three (3) different BG tapes are evaluated and prudently select the suitable BG tape to this wafer technology. The evaluation will involve on how proper selection of the BG tape adhesion strength will eliminate wafer passivation removals.

1.1 Wafer Passivation

Wafer passivation is normally the masking of an oxide layer on the surface of the active layer of the wafer. Passivation is important to provide electrical stability and insulation to the environment. There are two common forms of passivation which are polyimides and silicate glass. Though on the specific silicon wafer technology has been developed polyimide resin is used.

Polyimides are a polymer of imide monomers [1], normally on orange or yellow color appearance. Exceptional characteristics of polyimides are thermal stability, good chemical resistance, and excellent mechanical properties. Polyimides have good mechanical elongation and tensile strength. The polyimide layers have good mechanical elongation and tensile strength, which helps provide good adhesion of the deposited metal layer to the polyimide. The minimal interaction of the polyimide and the deposited metal and the thermal stability helps provide good and reliable insulation of the wafer to the environmental stresses [2]. Normally in the wafer fabrication process, passivation is placed on the top surface of the silicon wafer as shown in Fig. 1.

Fig. 1. Wafer structure cross-sectional view

1.2 Wafer Backgrinding Tape

Prior wafer back grinding, taping the active circuit of wafer is necessary. BG tape would help eliminate water penetration, breakage or cushioning adsorbs during grinding process and maintains uniformity after grind, which have been verified by TTV (Total Thickness Variation). After back grinding, BG tape would be de taped and there should be no wafer breakage and no contamination due to adhesive material. In with all these requirements and as final wafer thickness goes thinner; two types of BG tape in Fig. 2 are derived: conventional Non-UV type and UV curable type.

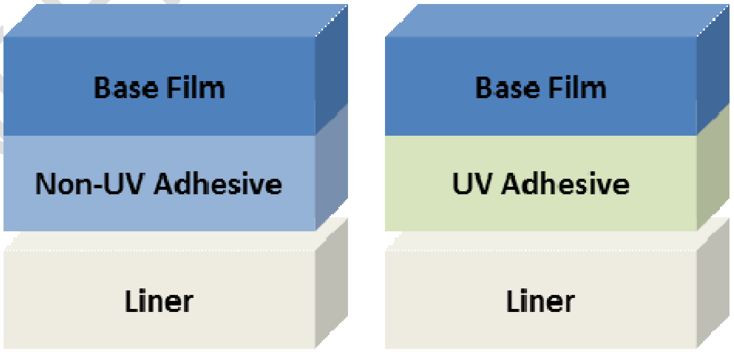

Fig. 2. Graphical representation of types of BG tape

Conventional BG tapes have normally a much lower adhesion strength compared to UV type tapes. Hence, a little contamination could be transferred to the wafer surface. On the other hand, UV type tapes show no water penetration and wafer breakage during grinding due to its higher adhesion strength compared to conventional types. Also, UV type tape requires additional exposure to ultra violet radiation that will help reduce its adhesion strength, will therefore aid the ease of detaping process. Due to peeling off of passivation from the active circuit of the wafer, three different BG tapes have been selected to check different responses during detaping process.

2. LITERATURE REVIEW

2.1 Wafer Backgrinding Process

Wafer back grinding is the thinning of semiconductor wafers by removing material from the unpolished wafer back side. Wafers are often fabricated thicker than necessary, normally at 600 to 750µm thick, and this has been determined by the stresses during processing and the requirement of handling robustness. During the back end process, there is a need for thinning the wafers in order to meet the package requirements and at the same time, the functionality of the IC package. In connection, most of IC assembly wafer thickness is reduced to around 50% thinner, partly for mechanical reasons and improve thermal transfer.

There are several methods that are presently being used for thinning wafers; the most popular is the well-established mechanical back grinding and polishing technique. As illustrated in Fig. 4, a standard back grinder has a rotating work chuck table wherein the wafer or the work piece is being positioned; diagonally a spindle will help the rotating diamond cup wheel turn towards the chuck table [3]. The downward movement of the spindle carrying the cup wheel removes silicon material from the surface of the wafer, thus creating a flat surface. The wheel alignment and chuck table planarity plays a major role on attaining uniformity of wafer thickness. However, it is difficult to measure this setting so post-grinding measurements are made using a non-contact capacitive probe. The parameter normally assessed is total thickness variation (TTV), where a typical target value is <10µm [3].

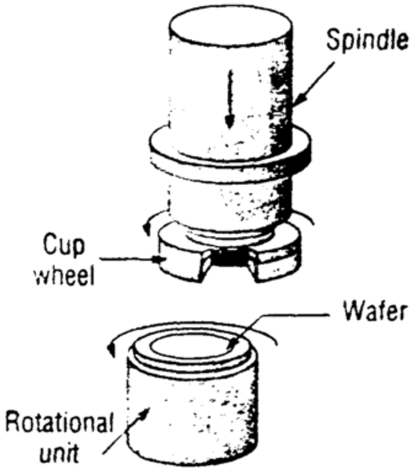

Fig. 3. Schematic of a rotational grinder [3]

As of today, back grinding machines are using a multi-step grinding operation. The typical two-step backgrinding shown in Fig. 4 is using the two separate spindles and chuck tables. The operation will involve a back grinding using a large grit diamond wheel (Z1) that will coarsely grind the wafer while the second process using a finer grit (Z2) will grind the wafer to its final thickness precisely. The large grit diamond wheel removes approximately 90 percent of the excess material. While the fine grit is responsible for attaining the final thickness with a smoother silicon back side finish.

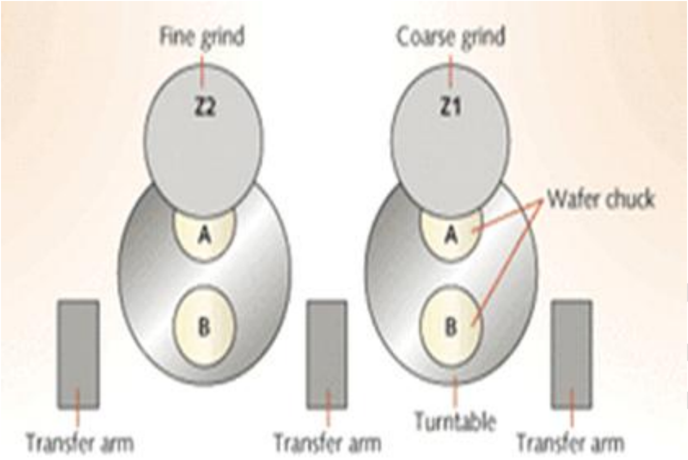

Fig. 4. Two-step backgrinding process

After back grinding process, the BG tape should be removed in preparation for the wafer sawing. There should be no adhesive residuals that may lead to wafer surface contamination. Therefore, an extensive evaluation should be performed to suitably select the BG tape that will surpass all backgrinding requirements, specifically adhesion strength that will eliminate surface contamination, ease of detaping and will not incur wafer breakage.

3. EXPERIMENTATION

3.1 BG Tape Selection

Wafer with polyimide passivation, on a 200mm diameter CMOS Silicon technology outline, have been used to evaluate and select appropriate BG tape to eliminate detachment of the wafer passivation after de taping process. All 3 wafers are all received with 725µm wafer thickness will be back grinded on the same final thickness of 105µm. Also, same backgrinding machine is used, with installed UV curing and de taping process up to wafer mounting, for all the three evaluation wafers. The BG machine have also same machine setting of same mounting and detaping chuck table temperature of 33.5 ± 5°C and 40-50°C respectively, across the evaluation.

Three different back grinding tapes presented in Table 1 have been selected to appropriately evaluate the best eliminator of peeling issue of the passivation from the active layer of the wafer. The first BG tape is on a conventional type and been used on the released process for complementary metal-oxide semiconductor (CMOS) wafers. Adhesion strength of the conventional type is compared lower than the two other BG tape. The other 2 types are both on UV type BG tape, which differs on adhesion strength ratio (before and after UV) but almost on the same total and adhesive thickness. UV Tape 1 is designed to have higher adhesion strength before UV but a lower adhesion after UV.

Table 1. BG tape configuration

Specification		Unit	Conventional	UV Tape 1	UV Tape 2
Total thickness		µm	180	135	120
Adhesive thickness		µm	65	35	40
Adhesion strength	Before UV	N/20mm	1.47	25.33	7.84
	After UV			0.04	0.16

3.2 Process Flow

The evaluation of the three wafers were processed on a single back grinding machine with equipped UV curing and de taping process. The evaluation has been sub divided into two processes. The first process in Fig. 5 involves the procedure of normal back grinding – detaping process flow with conventional tape type as BG tape. Another process show in Fig. 6 involves the activation of UV curing after back grinding. This will lessen the adhesion strength of the two UV curable type of BG tape prior detaping process. The result will be determined by process elimination and be based according to the visual inspection criteria.

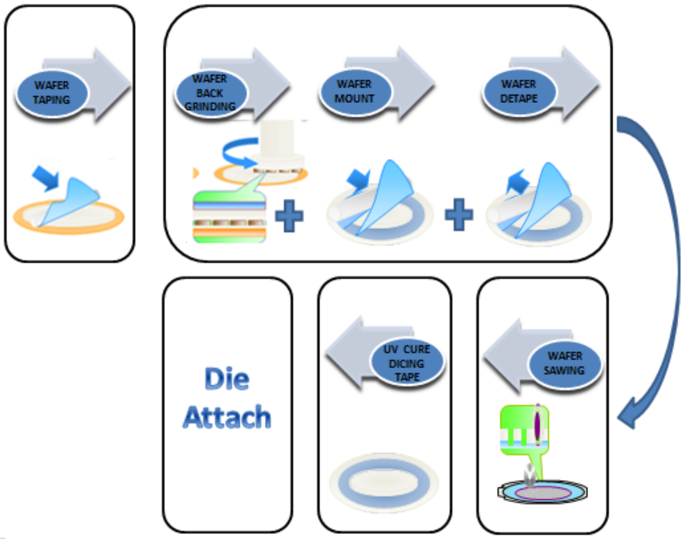

Fig. 5. Pre-assembly process flow for conventional BG tape

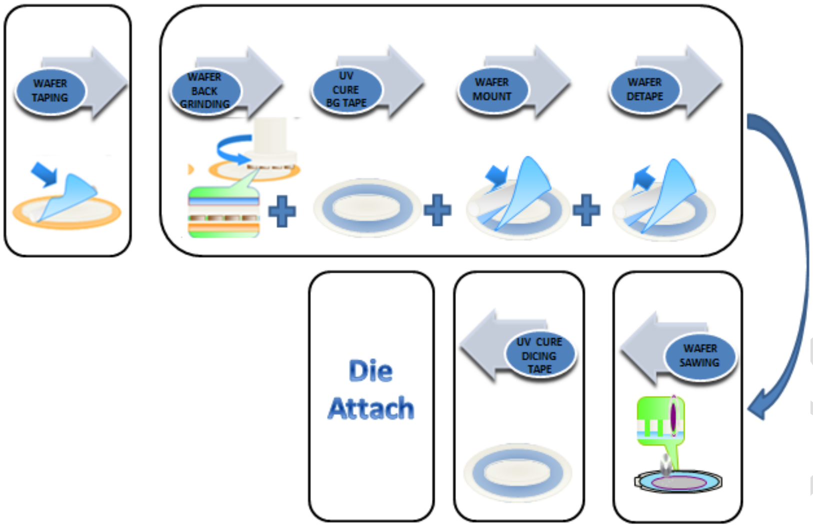

Fig. 6. Pre-assembly process flow for UV-curable BG tape

4. RESULTS AND DISCUSSION

4.1 Conventional Type BG Tape

Conventional type BG tape encountered broken wafer or detachment of the passivation layer after detaping as depicted in Fig. 7. Therefore, the amount of adhesion strength at 1.47 N/20mm is too sticky for the polyimide and back grinding tape.

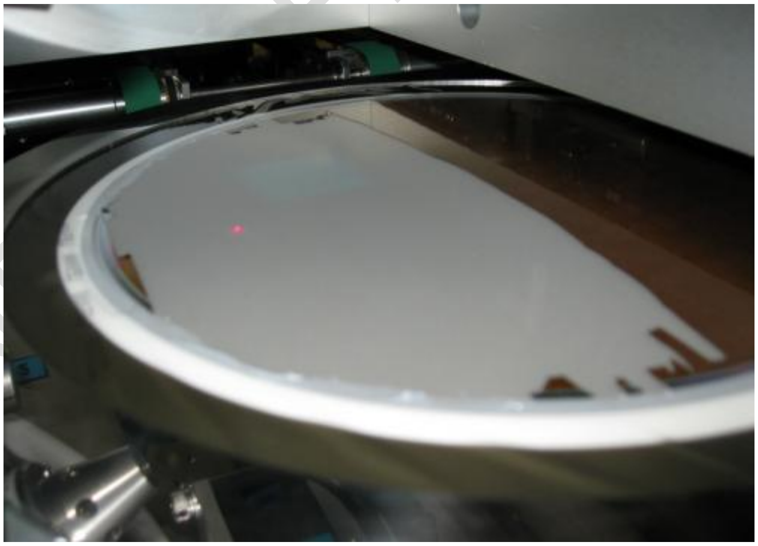

Fig. 7. Detachment of the passivation layer after BG detaping

4.2 UV-Curable Type BG Tape

The two UV curable types are processed on same process flow with the activation of UV curing after back grinding. UV type 1 having higher adhesion strength during back grinding and a much lower adhesion after UV curing have not encountered peeling of the passivation in Fig. 8.

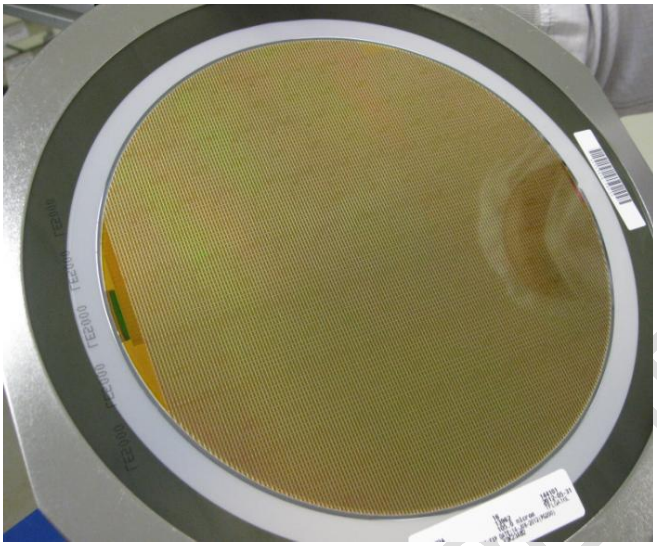

Fig. 8. Actual wafer after detaping process

Meanwhile, adhesive remains/contamination on the passivation surface as well as on the bond pad was observed during the inspection using a high magnification microscope in Fig. 9.

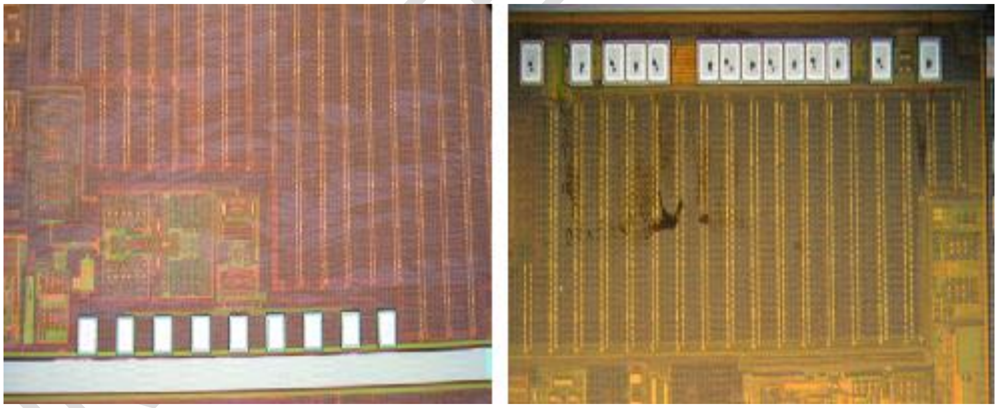

Fig. 9. Contamination after backgrinding

The affected wafer was continuously processed until wafer saw process but still adhesive/contamination is present on the passivation surface after wafer sawing. On the other hand, UV type 2, with higher adhesion strength after the UV exposure and lower adhesion before UV, showed good response after detaping process. As a result, there is none anomaly or adhesive contamination found in Fig. 10 on the passivation and even on the bond pad.

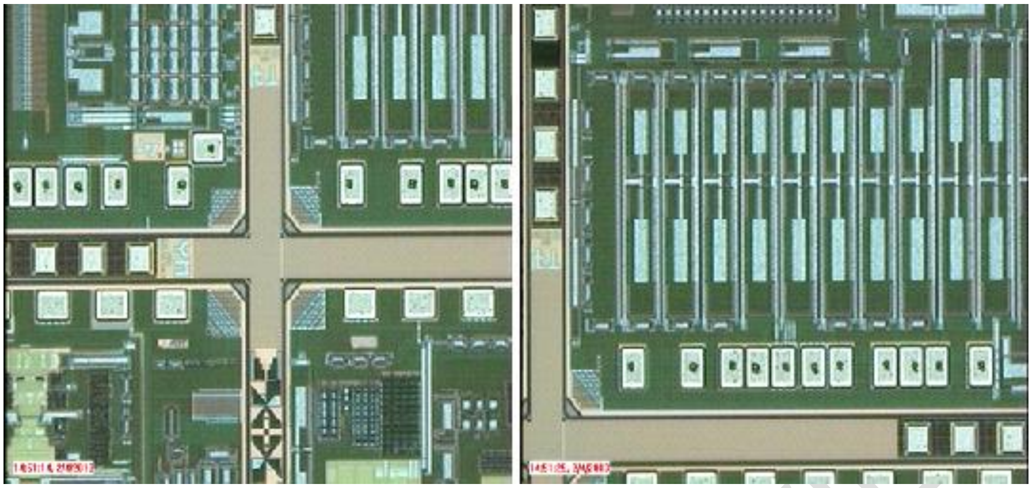

Fig. 10. No adhesive contamination after detaping process

5. CONCLUSION AND RECOMMENDATIONS

Based on the evaluation, Conventional type BG tape will aggravate the peeling off of the passivation from the active layer of the wafer. However, UV type BG tapes will eliminate such peeling problem of the passivation by lower adhesion strength after UV exposure.

Lower adhesion strength before UV exposure and higher adhesion after UV greatly helped to mitigate the peeling off problem of passivation from the active layer after detaping. Hence, maintaining low adhesion strength of the UV curable type BG tapes, both before and after UV exposure, will also eliminate adhesive remains after detaping process.

Based on the results, it is highly recommended to use a UV-curable type BG tape on a polyimide based passivation to eliminate detachment of the passivation after detaping process. It is also important to have the proper selection of the appropriate BG tape to be used and this involves carefully understanding the adhesion strength ratio between before and after UV exposure.

For further improvement, it is highly recommended to use high vacuum efficient chuck table to properly handle incoming wafer warpage and ensure good flattening on the chuck table and eliminating the possibility of inferior grinding. Redesign of special robot arms should also be considered to eliminate the possibility of wafer breakage when handling or unloading thinner wafers after grinding or use an inline BG-mount system. Moreover, a special process should be considered wherein making an outer circumference lip, where no grinding pressure is applied on the edge of the wafer during backgrinding. For ensuing critical processes like that of the wafer saw, discussions in [4] are helpful to prevent or eliminate defects related to wafer preparation. Furthermore, it is highly important that the assembly manufacturing processes ensure appropriate ESD checks and controls. Learnings shared in [5] are very helpful to realize proper and effective ESD-related controls.

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