StayClean Anti-Particle and Anti-Corrosion Effects on Electrode Pads

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Abstract

The dicing process is a process in which workpieces, etc. are singulated into die using a blade and cutting water. Challenges within the dicing process are particle contamination caused by exposure to a large number of cutting particles and corrosion of electrode pads on the die caused by the cutting water.

To prevent these issues, DISCO has created StayClean, which is used by adding small amounts to the cutting water. In this paper, StayClean effectiveness is examined.

1. Introduction

In the dicing process, Si semiconductor workpieces and package substrates are singulated into die by a blade. As dicing is a mechanical process, particles such as processing particles or blade wear fragments are produced during processing.

Generally, particles are flushed out by continuously running water at the processing point. However, even if a high level of workpiece cleanliness is maintained in the processes leading up to the dicing process, the workpiece is exposed to these particles during the dicing process. Preventing contamination by these particles is one challenge faced with image sensors in particular, which require particle adhesion prevention after dicing as well.

As an example, figure 1 shows particles that had become adhered to a wafer during dicing. In addition to the materials comprising the wafer, other particle sources that have been observed are fractured blades and dicing tape.

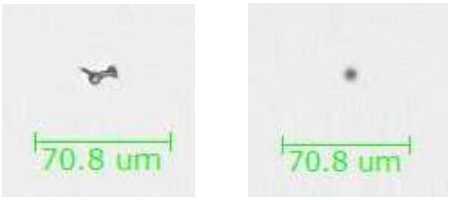

Figure 1. Example of particles produced during dicing

Anti-corrosion countermeasures during dicing are also important. When the materials to be processed are semiconductor die or electronic devices, the electrode pads on the surface of the die, which are used to stack these die and to test electrical properties, will be exposed to the cutting water. This causes the issue of dissolved oxygen and/or electrolytes in the cutting water corroding the electrode pad (figure 2).

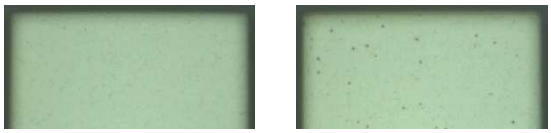

Figure 2. Electrode pad (left) and an example of the corrosion that occurs during dicing (right)

Furthermore, the blades used in dicing are often hub-style blades, which are comprised of an aluminum hub base and a metal bond, such as nickel. Similar to the electrode pads mentioned earlier, the edge and hub in hub-style blades are known to become corroded or dissolve, leading to blade meandering and blade wear.

To prevent particle contamination and corrosion during dicing, DISCO provides StayClean, which is added in small amounts to the cutting water. This paper will examine the functionality and effectiveness of StayClean301, which is the latest DISCO technology in particle and corrosion prevention.

2. StayClean Anti-Particle Effect

To evaluate the level of particle contamination caused by dicing, a silicon wafer with polyimide film was prepared.

Polyimide materials are generally used on the outermost surface of the die as surface protection for semiconductor elements (including image sensors) or bump-side surface protection film for packaging materials. Polyimide materials are therefore exposed to particles on the outermost surface of the workpiece during dicing.

Polyimide materials are comparatively low in hydrophilicity and, during dicing, attract polyimide cutting particles originating from the polyimide film and hydrophobic silicon cutting particles originating from the wafers. Therefore, polyimide materials tend to experience more cutting particle adhesion than materials with hydrophilic surfaces, such as oxide wafers.

Figure 3 shows the surface inspection results for a Si wafer with polyimide film and a Si wafer with oxide film that were processed using cutting water (DI water) and standard dicing conditions (table 1). Particles were detected across the entire surface of the polyimide film Si wafer, and as shown by a comparison with the oxide film Si wafer, the polyimide film Si wafer clearly requires further countermeasures against particle adhesion.

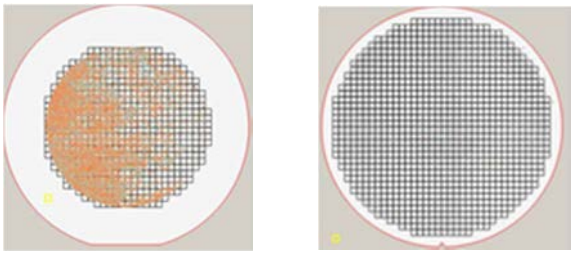

Figure 3. Particle residue mapping after dicing
(left: ⌀6-inch Si wafer with polyimide film; right: ⌀8-inch Si wafer with oxide film)

Next, dicing was performed on the same Si wafer with polyimide film, but this time StayClean301 was added to the cutting water. The amount added to the cutting water was only 0.03%. Surface inspection results are shown in figure 4.

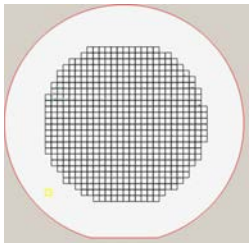

Figure 4. Particle residue mapping after dicing with StayClean301 (0.03%) (⌀6-inch Si wafer with polyimide film)

As you can see, a minute amount of StayClean is effective in preventing particles.

The fact that it is effective at a low concentration is advantageous from the point of view of operations management, including cost of consumables and supply bottle replacement frequency. At the same time, however, precision control of fluid supply is required. In practical use, the DISCO-manufactured StayClean injector (figure 5) is able to control concentration and supply StayClean with high accuracy through the use of several types of sensors, contributing to improved yield.

Figure 5. StayClean injector

3. StayClean Anti-Corrosion Effect

When there is metal on the surface of the dicing side of the wafer to be processed, corrosion may occur in the metal section from the cutting water coming into contact with this section during dicing. Metal sections can include electrode pads (e.g., probe pads located on the surface of the wafer), lead frames, bumps, and bump pads. Root causes of corrosion vary and can include cutting water quality, wafer structure, or electrochemical characteristics of the wafer. For example, in order to prevent ESD damage (electrostatic discharge), CO2 gas is dissolved in the cutting water. This can cause several issues to occur. In

some cases, the metal section may weaken and dissolve. In others, if the workpiece is a semiconductor device, discoloration defects may be observed in only the electrode pads, which are connected to the transistors on the circuit, or elution may occur, possibly due to differences in the metals.

In response to these challenges, some StayClean products have an anti-corrosion effect. As an example, the results of a performance evaluation that used StayClean301 (newest StayClean product) will be examined below.

An anti-corrosion evaluation was performed using Al film (containing 1–3% Cu) and Cu plating film to examine the effect on electrode pads and lead frames, which are commonly seen dicing materials. However, actual dicing was not performed. Instead, the workpieces were soaked in running cutting water for a certain length of time while vacuumed on the chuck table and then subjected to the standard processes of DI water cleaning and drying on the spinner table. Following that, the wafer surface was inspected for corrosion.

Next, the same operation was conducted using cutting water containing StayClean, after which wafer appearance was inspected using an optical microscope.

As before, the amount of StayClean added was 0.03%. Figures 6 and 7 show the results after soaking for both the Al film and Cu film.

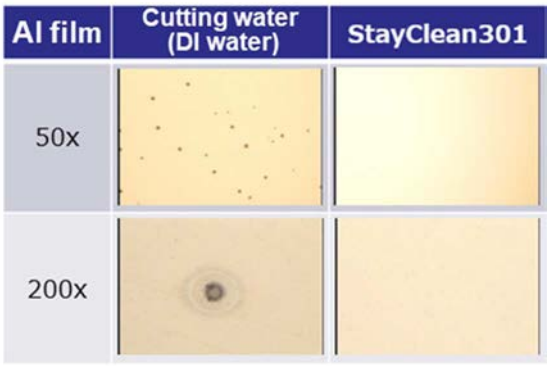

Figure 6. Anti-corrosion evaluation results for Al film when StayClean was added to cutting water (optical microscope images)

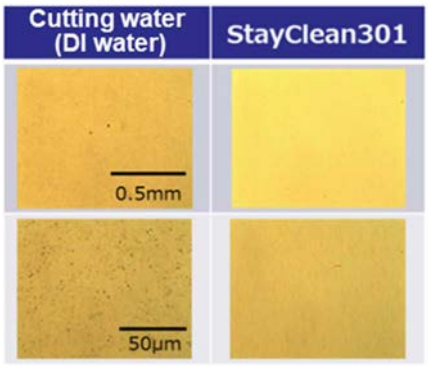

Figure 7. Anti-corrosion evaluation results for Cu film when StayClean was added to cutting water (optical microscope images)

As seen in figure 6, it was confirmed that pitting corrosion occurred in the Al film when dicing was performed using DI water. On the other hand, with cutting water containing 0.03% StayClean301, this pitting corrosion was not observed, and the original state of the Al film was maintained, which confirms that StayClean301 has an anti-corrosion effect on Al film.

Moreover, as seen in figure 7, it was confirmed that the surface became rough (micro-pits at high density) in the Cu film when dicing was performed using DI water. On the other hand, with cutting water containing 0.03% StayClean301, this roughness was not observed, which confirms that StayClean301 has an anti-corrosion effect on Cu film as well.

4. Blade Corrosion by Lubricant

In some cases, even when dicing is not being performed (warmup), the equipment is operated with cutting water continuously running and a constant spindle rpm to maintain processing accuracy.

In this case, when the blade is in contact with cutting water or CO2 water (see below) for a long period of time, the effects of the cutting water or lubricant on that type of blade need to be considered. For example, in dicing using an electroformed or metal blade, it is important to select lubricant that does not chemically attack the blade bond materials. If the lubricant and blade are not compatible, the

blade edge, which is in contact with the lubricant at all times (figure 8), will become tapered, which can cause issues such as the required processing accuracy not being obtained or meandering. If this effect is strong, it will lead to blade breakage.

StayClean301 is designed with importance placed on compatibility with DISCO blades over long periods of contact.

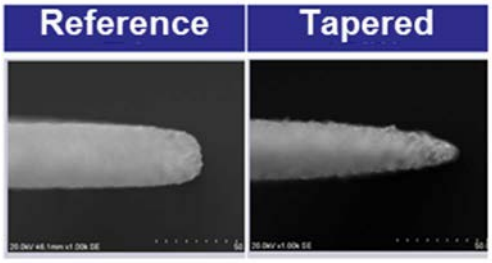

Figure 8. An example of blade tapering caused by lubricant

(SEM image of DISCO-manufactured hub-style blade edge)

Next, the results from an evaluation of lubricant effects on DISCO's main hub-style blades (ZH05, ZHZZ, ZH14) will be examined below.

Testing methods and procedures are shown in table 1. In this evaluation, CO2 water was injected into cutting water to which StayClean had been added. CO2 water is generally used to supply electrolytes in order to prevent ESD damage to semiconductor devices during dicing or spinner table cleaning. CO2 water exhibits a certain acidity depending on the amount of CO2 dissolved, leading to elution and corrosion of hub-style blade bond materials.

In this evaluation, DISCO StayClean products that have an anti-corrosion effect (StayClean-F and StayClean301) were added to CO2 water, which tends to cause corrosion, and anti-corrosion performance was evaluated.

Table 1. Conditions for evaluating effects on hub-style blades

Test Conditions	
Blades	ZH05-SD3500-N1-70 ZHZZ-SD3500-H1-70 ZH14-SD3500-V1-70
Dicer	DFD6361
CO2 water resistivity	ZH05: 0.1MΩ·cm ZHZZ/ZH14: 0.2MΩ·cm
StayClean concentration	0.03% (x3,300 dilution)
Spindle rpm	30k min^{-1} when idling
Idling hours	12 hours

Test Procedure

Measured blade thickness and weight

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Idling (12 hours)

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Inspected blade using SEM / Measured blade thickness and weight

Figure 9 shows results from the evaluation of StayClean effects on DISCO's main hub-style blades (ZH05 series).

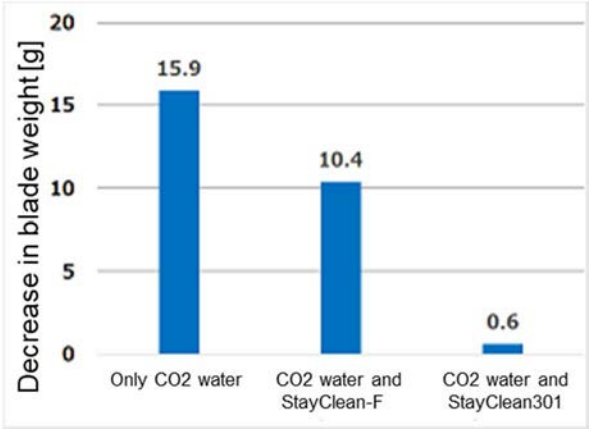

Figure 9. Decrease in blade weight for ZH05 blades by type of cutting water

When only CO2 water was injected into the cutting water, blade weight decreased by more than 15 g after the idling test. The suspected root cause of this weight decrease is blade bond elution caused by the CO2 water.

On the other hand, it was confirmed that this weight decrease was suppressed to two-thirds the amount when StayClean-F was added. Then, when StayClean301

(newest StayClean product) instead was added, it was confirmed that blade weight decrease was almost completely suppressed.

Using the same testing method, the decrease in blade width was evaluated for the three major types of DISCO hub-style blades.

Results for StayClean301 (newest StayClean product) and conventional DISCO products are shown in figure 10.

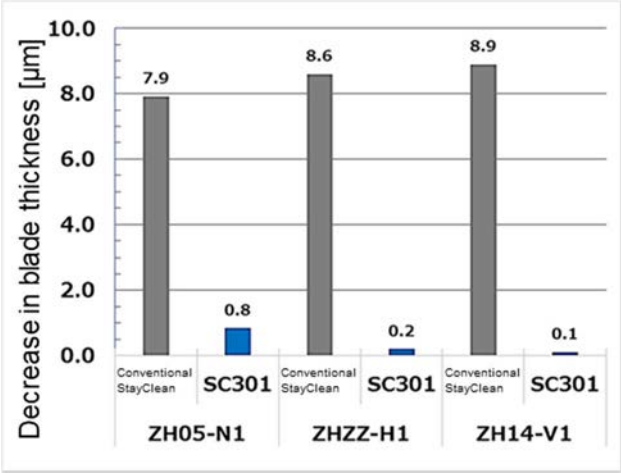

Figure 10. Decrease in blade thickness for each hub-style blade by type of lubricant

It was confirmed that StayClean301 also suppressed blade thickness decrease for these hub-style blades. In addition, the reason that blade thickness decrease in the ZH05 blades was greater than in the other blades was that more CO2 gas was dissolved in the CO2 cutting water (load test on ZH05; refer to table 1).

Next, a similar evaluation was performed using another supplier's lubricant and the ZH05 hub-style blade. In this evaluation, blade edge shape after the idling test was examined using an electron microscope. Results are shown in figure 11.

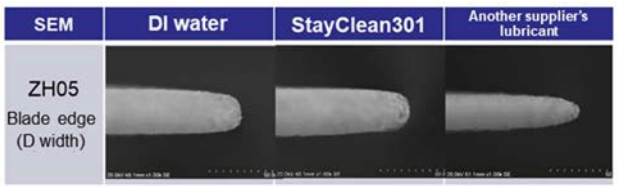

Figure 11. SEM image of hub-style blade edge after idling test

As seen in figure 11, even after the long idling test, blade edge shape was maintained with StayClean301. However, the blade edge became tapered, and the blade itself became thinner with the other supplier's lubricant, which has not been designed with effects on or compatibility with the blade in mind. To prevent issues such as meandering or blade breakage, it is very important to select a lubricant that is designed with blade compatibility in mind.

5. Summary

DISCO's StayClean has anti-particle and anti-corrosion functions, and has been designed with DISCO hub-style blade compatibility in mind.

This paper has clearly demonstrated the effectiveness of StayClean in performing these functions. In addition, the use of StayClean during the dicing process can be considered an effective way to prevent unexpected issues.