Resistivity Control of Cutting Water with CO_2 Injector and Hub Blade Wear

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Abstract

In the blade dicing process, static electricity is generated during workpiece processing/cleaning, which leads to electrostatic discharge (ESD) in the workpiece. As one ESD countermeasure, DISCO has adopted technology that mixes CO_2 into the cutting water supplied during processing using a CO_2 injector, controlling the resistivity of the cutting water. While the workpiece's electric charge does decrease as the amount of CO_2 supplied increases, wear to the hub blade tends to increase. However, with DISCO's standard resistivity of 0.5 M to 1.0 MΩ/cm, blade wear is comparable to that with DI water.

1. Introduction

As semiconductor miniaturization progresses, the requirements have increased for electrostatic discharge anti-countermeasures in blade dicing saw equipment (hereinafter referred to as dicers).

DISCO has clarified the root cause of static electricity and has taken the following measures to control electrostatic discharge.

1. Installed CO_2 injector[1] (decreases resistivity of DI water)
2. Installed ionizer (removes electric charge on workpiece)
3. Controlled ascension rate of transfer arm (makes change in capacitance more gradual)

Details are provided in past technical reviews[2].

This report examines "1. Installed CO_2 injector" and presents investigation results regarding ESD countermeasure effectiveness and hub blade wear.

2. Test method

2-1 Measurement of Si wafer electric charge generated by contact with water

After a ⌀12-inch, 775 µm thick Si wafer was mounted to a frame with SPV224 tape (Nitto), the frame was mounted on the dicer spinner table. The nozzle supplied cutting water at each resistivity to the wafer surface at 6 MPa, spin-dry was performed, and electric charge was measured after removal from the spinner table.

Electric charge at the time of removal was measured using the ZJ-SD100 (OMRON) static electricity sensor, which was placed in the transfer area directly above the wafer.

For water resistivity, three values were tested: 18 MΩ・cm (DI water, no CO_2), 0.9 MΩ・cm, and 0.5 MΩ・cm.

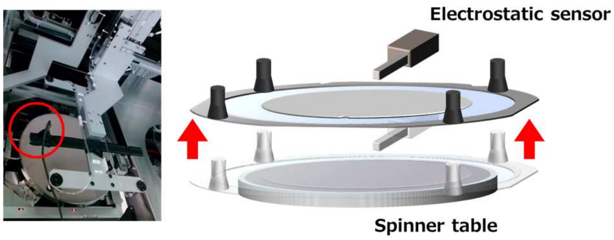

Figure 1. Measurement of wafer electric charge

2-2 Blade wear measurement

After a hub blade was installed and precut was performed, thirteen ⌀12-inch, 400 µm thick Si wafers were processed. After the wafers were processed, blade wear was measured with the non-contact setup function[3] using a transmission-type sensor installed to the equipment. After the 13 wafers were processed, the blade was inspected by SEM. For water resistivity, three values were tested: 18 MΩ･cm (DI water, no CO_2 supply), 0.5 MΩ･cm, and 0.1 MΩ･cm.

The equipment and blade used for processing are shown in tables 1 and 2.

Table 1. Blade used and precut condition

Blade Used, Dress Condition		
Equipment used		DFD6362
Blade used		ZH05-SD2000-N1-70 DD
Dresser board		N/A
Precut Condition		
Precut wafer		Si ⌀12 inch x 0.40 mm thick
Spindle RPM [/min]		30,000
Cutting depth [mm]		0.02 into the tape
Step 1	Feed speed [mm/s]	1,3,5,7,9
	# of lines [lines]	3 each
Step 2	Feed speed [mm/s]	10,15,20,25
	# of lines [lines]	10 each

Table 2. Processing condition

Process Condition		
Wafer processed		Si ⌀12 inch x 0.40 mm thick
Index (CH1 x CH2) [mm]		3 x 3
Spindle RPM [/min]		30,000
Feed speed [mm/s]		30
Cut mode		A
Cutting depth [mm]		0.02 into the tape
Water amount [L/min]	Blade cooler	1.5
	Shower	1.0
	Spray	0
Flange size [mm]		Hub mount
Dicing tape		SPV-224
Process time		7 hours 11 minutes

3. Measurement results and remarks

3-1 Measurement of Si wafer electric charge generated by cutting water

The electric charge of the wafers upon removal from the spinner table is shown in figure 2. It was confirmed that the electric charge decreases monotonically as the amount of CO_2 supplied is increased and water resistivity is decreased. It is suspected that reduced resistivity decreases triboelectric charging on the wafer surface when the water makes contact.

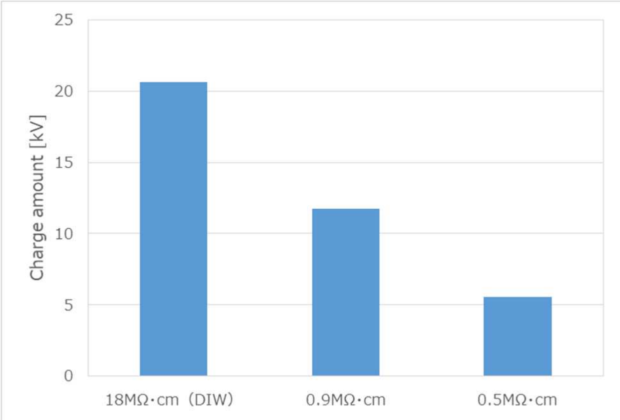

Figure 2. Water resistivity and electric charge upon removal from spinner table

3-2 Blade wear

Figure 3 shows trends in blade wear when wafers were processed under each condition. No drastic difference in blade wear was observed with the resistivity of 0.5 MΩ･cm compared to with DI water. However, a drastic increase in blade wear was observed with the resistivity of 0.1 MΩ･cm. Blade wear after processing 13 wafers was 43 µm with the resistivity of 0.5 MΩ･cm but was 67 µm with the resistivity of 0.1 MΩ･cm, which was 1.5x the wear.

Figure 4 shows the SEM images of the blade edge before and after processing. Comparing to that with DI water and the resistivity of 0.5 MΩ･cm, grit on the blade edge was more exposed after 13 wafers were processed with the resistivity of 0.1 MΩ･cm, confirming that the Ni bond that secures the diamond grit is being eluted.

It is assumed that increasing the supply of CO_2 caused the pH of the cutting water to decrease and eluted the Ni bond of the blade, leading to blade wear as a result.

$$CO_2(aq) + H_2O \rightleftarrows H^+(aq) + HCO_3^-(aq) \rightleftarrows 2H^+(aq) + CO_3^{2-}(aq)$$

$$Ni + 2H^+(aq) \rightleftarrows Ni^{2+}(aq) + H_2$$

As reference, the relationship between water resistivity when CO_2 is dissolved in the water and pH is shown in the figure 5. This diagram was calculated from internal testing and measurement errors are included.

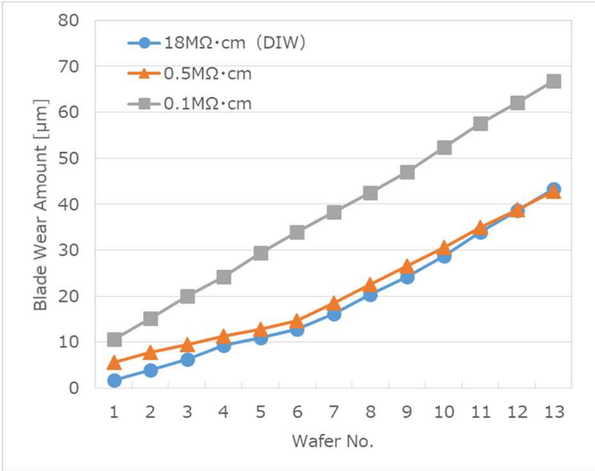

Figure 3. Blade wear trends

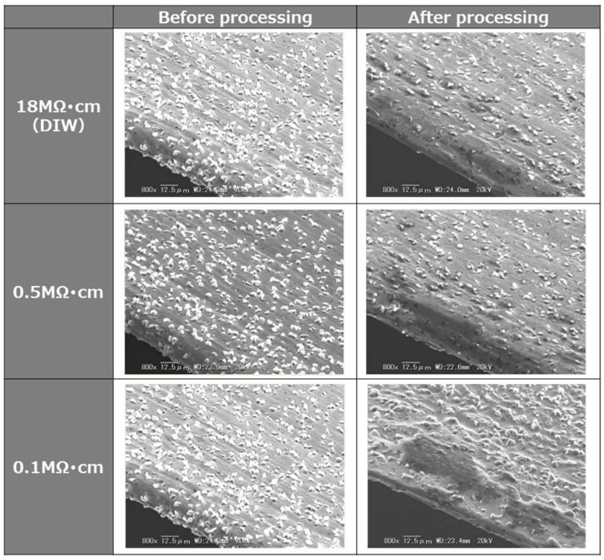

Figure 4. SEM images before and after processing

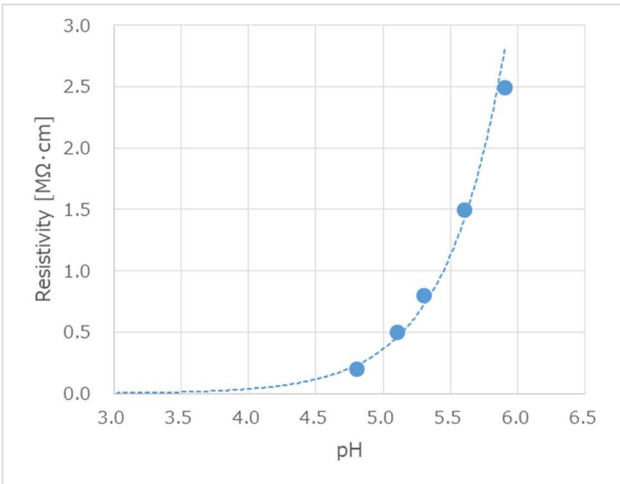

Figure 5. Water resistivity when CO_2 is dissolved and pH

4. Conclusion

Based on the test results, a workpiece's electric charge decreases when CO_2 supply is increased and water resistivity is decreased. On the other hand, Ni eluting reaction accelerates, leading to an increase in blade wear.

At the resistivity of 0.5 MΩ･cm, a decrease in electric charge was observed. In addition, blade wear comparable to that with DI water was achieved.

For that reason, the CO_2 injector at DISCO sets 0.5 M–1.0 MΩ･cm as the standard for resistivity.

*Blade wear changes depending on the bond type and environment, and thus, these are reference values and are not guaranteed.

References

(1) DISCO website: Product Information / Accessory Equipment / CO_2 Injector

https://www.disco.co.jp/eg/products/accessory/co2.html

(2) DISCO Technical Review "Wafer ESD in dicing saws and the effect of the countermeasures (TR16-02)"

https://www.disco.co.jp/eg/solution/technical_review/doc/TR16-02_Wafer%20ESD%20in%20dicing%20saws%20and%20the%20effect%20of%20the%20countermeasure_20160610.pdf

(3) DISCO website: Solutions / Blade Dicing / The Advantages of Non-Contact Setup (NCS)

https://www.disco.co.jp/eg/solution/library/dicing/setup.html