Wafer ESD in dicing saws and the effect of the countermeasures

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Abstract

There have been some reports of ESD (electrostatic discharge) occurring when transferring the workpiece due to static electricity generated when processing and cleaning the workpiece in the dicing saw. In particular, extremely large amounts of electrostatic charge have been observed in the cleaning and drying spinners. This review explains the effects of the transferring speed control specification, which is recently being used with dicing saws in addition to CO_2 injectors and ionizers as a countermeasure for ESD.

1. Introduction

In recent years, owing to scaling in the manufacturing process, electrostatic discharge (ESD) failure in semiconductor devices is being reported more frequently.

Device manufacturers have also been specifying more strict control standards for static electricity every year. In some cases, the amount of electrostatic charge is required to be below several hundreds of volts at a constant level. Therefore, taking proper electrostatic countermeasures in a dicing saw (hereafter, "dicer") is essential.

2. Static electricity in the dicer

In the dicer, static electricity is mainly generated by frictional charging, spray charging, or separation charging.

A workpiece is processed and cleaned in the dicer while it is vacuumed on a chuck table (hereafter, "C/T") or a spinner table (hereinafter, "S/T"). This causes frictional electrification.

Spray electrification also occurs as deionized water is sprayed during processing and cleaning.

The workpiece has been charged by processing and cleaning, and when it is lifted up from each table, static electricity appears on the surface, which causes separation charging.

Electric charge is generated mostly at the spinner section in the dicer. This is a result of frictional charging owing to cleaning with deionized water and drying with dry air, and separation charging when the workpiece is lifted up from the S/T. Hereafter, the electrostatic countermeasures and their effectiveness will be presented.

2.1 Electrostatic countermeasures

The following three measures are mainly taken in the dicer:

(1) Installing the CO_2 injector
(To reduce the resistivity of deionized water)

(2) Installing the ionizer
(To remove static electricity charged on workpieces)

(3) Suppressing the raising speed of the transfer arm*
(To reduce changes in capacitance)

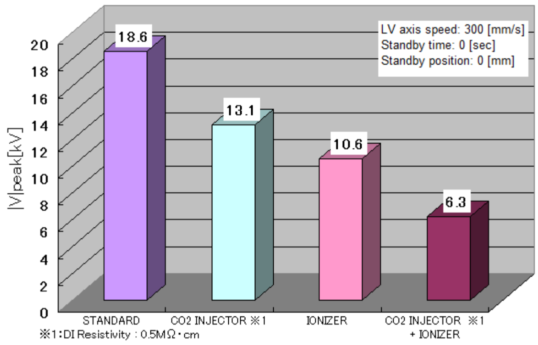

Fig. 1 Effect of the CO_2 injector and ionizer (under each condition)

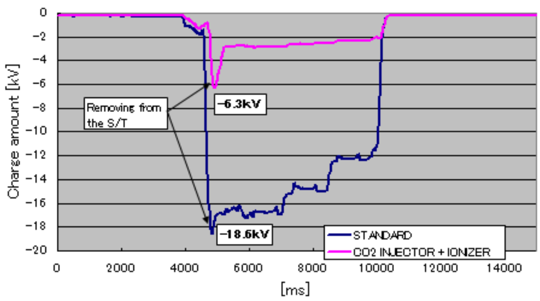

Fig. 2 Effect of the CO_2 injector and ionizer (time series)

Countermeasures (1) and (2) can be installed as optional accessories. As shown in Fig. 1 and Fig. 2, the peak voltage can be suppressed to approximately 6 kV by using both the CO_2 injector and ionizer when approximately 18 kV is charged in the standard specification. Since the effects of suppressing the charging of both optional accessories are well known, the verification results of Countermeasure (3) will be explained in this review.

2.2 Parallel-plate capacitor model

The relationship between a lower speed to raise the transfer arm and suppression of the charge amount will be explained using a parallel-plate capacitor model.

First, the charge amount (V) is expressed with the following equation:

$$V = \frac{Q}{C} \quad \text{(Equation 1)}$$

where V is the electrical potential [V], Q is the charge amount [C], and C is the capacitance [F].

Next, the capacitance is expressed with the following equation from Fig. 3:

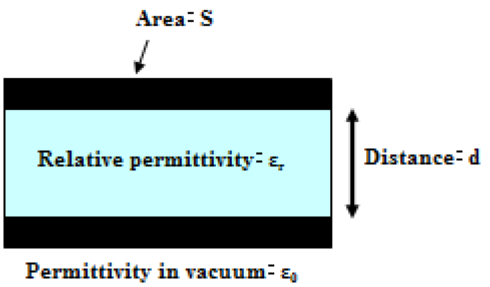

Fig. 3 Parallel plate capacitor model

$$C = \frac{S}{d}\varepsilon_0\varepsilon_r \quad \text{(Equation 2)}$$

where S is the area [m^2], d is the distance [m], ε_0 is the permittivity in a vacuum [F/m], and ε_r is the relative permittivity.

From Equation 2, Equation 1 is expressed as shown below:

$$V = \frac{d}{S}\varepsilon_0\varepsilon_r \cdot Q \quad \text{(Equation 3)}$$

In the dicer, since variations of the workpiece area S and relative permittivity ε are small, the charge amount V depends on the distance d between the workpiece and table.

Because of this, if a charge Q can be removed with the ionizer while the value of this distance d is small, the peak of the charge voltage V can be suppressed at a low level, thereby being able to prevent an ESD failure.

3. Verification results

3.1 Measurement method

When a workpiece is in contact with the table, an electrically neutralized state is generated on the contact surface so the voltage on the workpiece surface is 0 V; therefore, static electricity cannot be measured. The static electricity can be measured only after the workpiece is removed from the table.

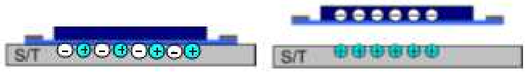

Fig.4 Schematic view of separation charging.

Because of this, an electrical sensor is installed in the transfer arm so that the charge amount can be measured at the moment when the workpiece is removed from the table (Figs. 4 and 5).

Fig. 5 When the sensor is installed

The following measurement devices are used:

ZJ-SD100 (OMRON)
ZJ-SDA11 (OMRON)

3.2 Measurement results

When installing the ionizer and lowering the transfer arm's vertical axis speed:

Fig. 6 shows the peak voltage measurement results of the separation charging at the speed of the transfer arm which picks up the workpiece from the S/T (hereafter, "LV axis speed").

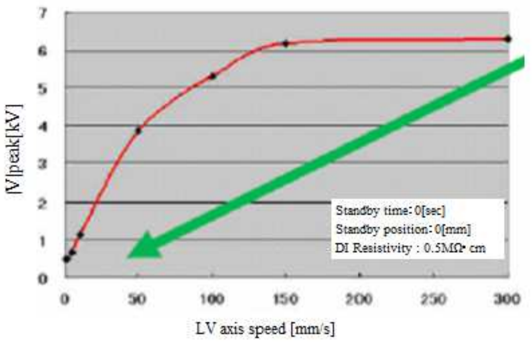

Fig. 6 Spinner section separation charging (depending on the LV axis speed)

When a workpiece is picked up from the S/T at an LV axis speed of 300 mm/s in the standard specification, approximately 6 kV or more of peak voltage of separation charging is measured (Fig. 6).

When the LV axis speed is decreased, the peak voltage of the separation charging drops. When the speed is 5 mm/s or less, the peak voltage can be suppressed to 1 kV or less.

The standby time and position settings for static elimination were not added to the ionizer operation in this verification. If this function is used at the same time, the peak voltage of the separation charging can be further suppressed.

4. Conclusion

A high level of charge, which may cause an ESD failure at the time of the workpiece transfer, was measured inside the dicer, especially at the spinner section for cleaning and drying.

The measurement results verified that the charge amount can be suppressed with the use of the CO_2 injector and ionizer. In addition, lowering the LV axis speed is effective as an ESD countermeasure.

*This countermeasure can be introduced into the DFD6341/6362/6560.

References

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