Development of Anti-static UV-tapes for Semiconductor Processing

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ABSTRACT In accordance with the increase in semiconductor products that are sensitive to Electrostatic Discharge (ESD) problems, operating problems and additional product defects due to ESD are becoming serious problems in semiconductor processing. As well as higher quality and higher performance, anti-static properties are required of UV-tapes used in dicing and back-grinding processes.

In general, UV-tapes are easy to charge at voltages up to around 10 kV in the peeling process from liner film. Because the surface voltage on UV-tape usually decays very slowly, the probability of additional product defects due to ESD are very high in the following manufacturing process. The anti-static UV-tapes we have developed show the high performance of conventional UV-tape, and also have highly efficient anti-static properties such as a lower static charge voltage of below 0.01 kV and faster surface voltage decay of less than a second, which were measured by a static-honest meter.

1. INTRODUCTION

Since 1987, the Industrial Products Division of Furukawa Electric has been manufacturing and selling UV light curable adhesive tapes (UV-tapes), which are used in semiconductor manufacturing processes such as dicing and the back-grinding processes (See Photo 1, Figure 1 and 2). UV-tape is used in a variety of semiconductor manufacturing process lines because of its superior adhesive properties and fewer impurities than conventional non-UV tapes. In accordance with development of high-performance and high-quality semiconductor products, the requirements of adhesive tapes used in semiconductor processes are becoming more complex. Today, to develop fast clock rate and low electricity-consuming devices, attempts have been made to reduce protective circuit and drive voltage of devices. As a result of these developments, newly developed high-performance semiconductor devices are usually very sensitive to ESD problems compared to conventional devices. Therefore, guidelines for ESD problems are needed at many factories manufacturing high-performance devices 1), 2) (See Table 1).

ESD events also cause electromagnetic interference (EMI), resulting in equipment malfunctions in computer-automated factories. In general, to eliminate static electricity in factories an ionizer is usually used as efficient anti-static equipment. But, simply installing an ionizer is not

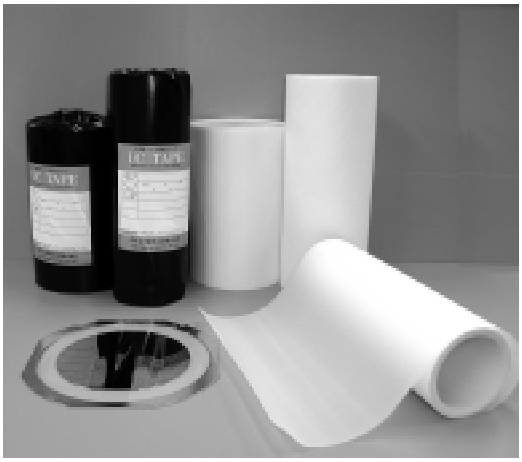

Photo 1 UV-tapes for semiconductor processing.

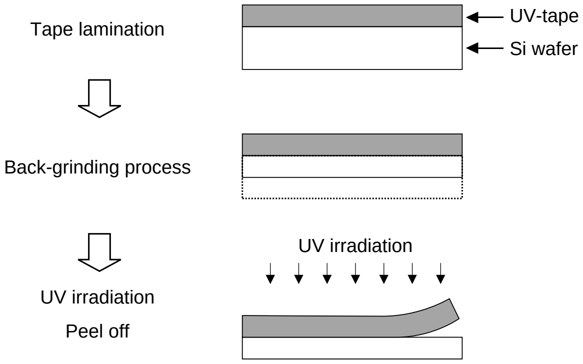

Figure 1 An application example of UV-tape for back-grinding process.

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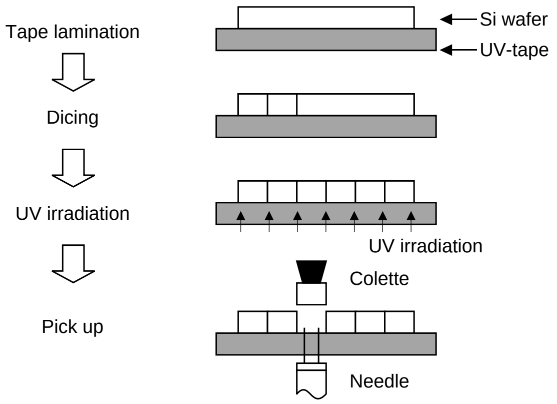

Figure 2 An application example of UV-tape for dicing process.

Table 1 Recommended level of voltage and charge during processing[1].

- Semiconductor Process
  (Process rule: 0.25μm~0.35μm CMOS IC)
  : 50 V (1 nC)
- CCD Assembly Process (1,500,000 pixel)
  : 200 V (4 nC)
- Pickup Optical Device
  : 30~50 V (1 nC)
- CD-ROM Drive Assembly Process
  : 30~150 V (1 nC)
- HDD Assembly Process:
  MR HEAD: 10 V (0.2 nC)
  GMR HEAD: 5 V (≤ 0.2 nC)
- LCD Assembly Process
  : 50~100 V

sufficient to obtain higher reliability. Simultaneous use of antistatic materials that enable earth connections among machine tools is important to achieve higher reliability.

Because even a small electrostatic charge can destroy high-performance devices in an ESD event, anti-static properties are required of UV-tapes used in dicing and back-grinding processes. We have developed antistatic UV-tapes for dicing processes. The anti-static UV-tapes we have developed show the high performance of conventional UV-tape, and also have highly efficient anti-static properties. In this paper, we show the properties of anti-static UV-tapes in comparison with conventional UV-tapes.

2. GENERAL PROPERTIES OF UV-TAPES

2.1 Adhesive Strength Control Mechanism of UV-tapes

In general, UV light curable adhesive is a blend of acrylic pressure sensitive adhesive, UV light curable oligomer, and initiator of UV photochemical reactions (See Figure 3). The major constituents of acrylic pressure sensitive adhesive are polyacrylic esters such as polybutyl acrylate and poly2-ethylhexyl acrylate. Usually, comonomers such as acrylic acid and vinyl acetate are copolymerized with polyacrylic esters. The adhesive properties of acrylic adhesive are controlled by the properties of comomers, blending ratio, molecular weight, molecular weight distribution, and structure of crosslinking. Absorbing UV light with a wavelength of approx. 300-400 nm, the initiator generates radicals through photochemical reactions to initiate chain reaction polymerization of origomers. Irradiating UV light gives the adhesive polymer a crosslinking structure. It had been thought that adhesive properties would be lost due to the increased elastic modulus caused by forming crosslinking structures in adhesive polymer[3].

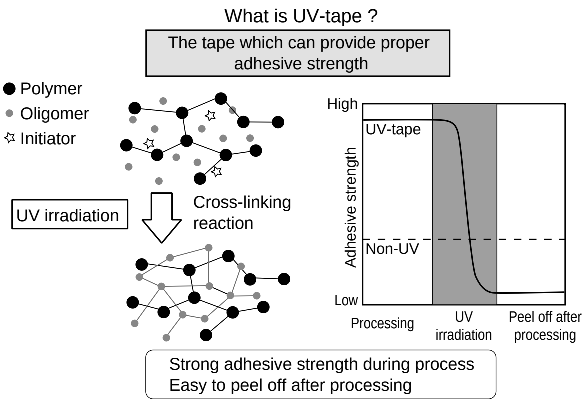

Figure 3 Mechanism of adhesive strength decrease of UV-tapes.

2.2 Surface Contamination

Contamination on the surface of a wafer often creates serious problems in packaging processes. One example is the so-called popcorn phenomenon in a reflow soldering process. When adhesive residue from tapes for dicing or back-grind processes remains on the surface of a wafer, it sometimes results in an adhesion failure between mold resin and wafer surface, because the residue increases concentration of moisture between the boundary. In the worst case, the concentration of moisture on the boundary surface between wafer and mold resin under highly humid conditions cause rapid vaporization and expansion of moisture under reflow soldering conditions, which results in an adhesion failure at the boundary or breakdown of the mold package. Furthermore, with the practical application of a LOC package, a further reduction of surface contamination is required for UV-tapes used, because the back of the wafer directly contacts the mold resin in the LOC package. Analyzing surface contamination on a wafer is very important to reduce the origins of such contamination and successive production of defective devices. Table 2 shows methods of analyzing impurities on semiconductor wafers.

As an example of a method of analyzing impurities on wafers, particle counting on wafers using a laser scanning device is shown in Photo 2 and Figure 4. Although many particles of not less than 0.1μm in diameter are observed on a 5-inch wafer surface protected with non-UV tapes, the number of particles on a wafer protected by UV-tape is much smaller than that on non-UV tape.

Table 2　Analysis methods of impurities on semiconductor wafers.

Classification	Surface composition	Morphology observation	Qualitative/Quantitative	Surface property
Principle	Composition analysis of wafer surface	Direct observation of morphological feature	Analysis of residue on a wafer	Surface energy of a contaminated wafer
Method	XPS, EPMA	Microscope	Thermal desorption/GC-MS	Static contact angle
	TOF-SIMS	SEM, TEM	Solvent extraction/FT-IR	Dynamic contact angle
	ATR-FTIR	Particle counter		
	RAS-FTIR	AFM		

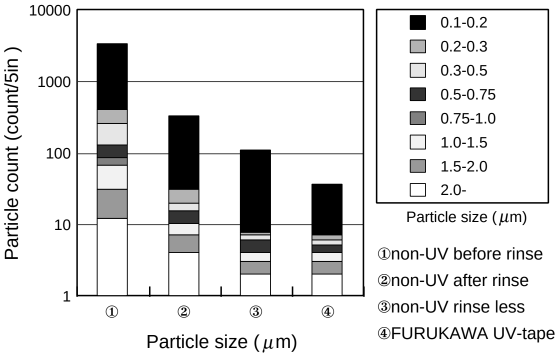

Figure 4　Particle count on wafers by a laser scanning device.

Table 3　Comparison of development methods for anti-static adhesive.

	Contamination	Adhesive property	Film elongation	Cost
Surfactant	×	×～△	○	Low
Ammonium salt	×	△	○	Low
Conductive filler	△	×	×	High
Conductive polymer	△～○	×	×	High
Hybrid method	△	△～○	○	Medium

○: good, △: fair, ×: no good

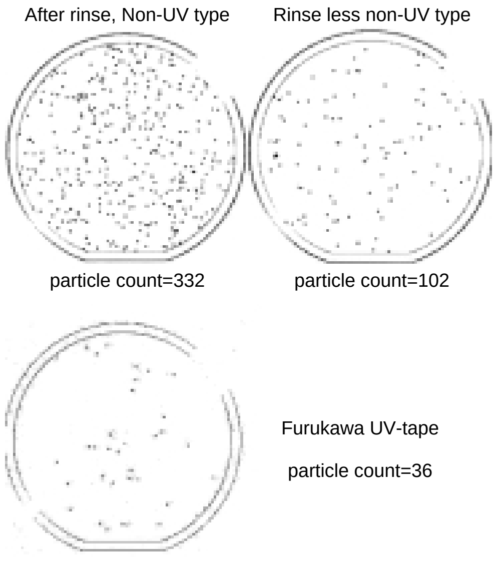

Photo 2　Particle distribution on wafers by a laser scanning device.

3. DEVELOPMENT OF ANTI-STATIC UV-TAPES FOR DICING PROCESS

3.1 Development of Anti-Static UV Curable Adhesive

There are many methods of developing anti-static pressure-sensitive adhesive tape. Several laid-open disclosure public patent bulletins concerning anti-static tapes have been opened to the public by major manufacturing companies of adhesive tapes[4), 6)]. However, as well as anti-static properties of tapes, low surface contamination on wafers and properly controlled stable adhesive strength are very important properties, especially for tapes used in semiconductor processing. Therefore, using surfactants as adhesive additives is not an appropriate method. Although conventional surfactants in adhesive readily ooze out and lower its surface resistivity, they cause adhesive strength fluctuate and sometimes contaminate the surface of a wafer. Using a conductive filler makes it too difficult to balance its anti-static property and adhesive strength (See Table 3). After a careful examination of these methods, we have focused on a hybrid method that adds an anti-static property to the adhesive molecule itself. The anti-static UV-tapes we have developed show the high performance of conventional UV-tape, and also have the highly efficient anti-static properties[7), 8)] shown in the following section.

3.2 Performance of Anti-static UV-tapes

Temperature dependence of storage modulus G', loss modulus G", and tanδ of anti-static adhesive we have developed are shown in Figure 5. Figure 5 shows that the glass transition temperature T_g of anti-static adhesive is around -25°C and G' is approximately 10^4 Pa at room temperature, which indicates that this anti-static adhesive has the same performance as conventional UV-tapes.

Adhesive properties, particle number on adhered wafer, and anti-static properties of UV-tape we have developed are shown in Table 4 and compared to conventional UV-tape. As a reference index of electrostatic properties, surface resistance, electrostatically charged equilibrium voltage and half-life of charged voltage are listed in Table 4. The electrostatically charged equilibrium voltage and half-life are measured by a static honest meter (See Figure 6).

The electrostatically charged equilibrium voltage is measured under an alternative corona discharge condition on a tape sample on a turntable at a rotational speed of 1550 rpm as shown in Figure 6. The half-life is the time taken for the voltage to decrease to half of the equilibrium value after corona discharge is switched off.

The general properties shown in Table 4 indicate that the anti-static UV-tapes we have developed have the high performance of conventional UV-tape and highly efficient anti-static properties. We are continuing to develop higher performance anti-static UV-tapes which are not presented in this paper. Some customers have already evaluated our anti-static UV-tapes as being the most efficient available. In particular, according to the results of their evaluations, the surface voltage on the anti-static UV-tape after dicing and cleaning process with super purified water is lower than that of any other tapes developed by other companies.

4. SUMMARY

With the increase of semiconductor products that are sensitive to ESD problems, operating problems and additional product defects due to ESD are becoming serious problems in semiconductor processing. As well as higher quality and higher performance, anti-static properties are required of UV-tapes used in dicing and back-grinding processes. The anti-static UV-tapes we have developed show the high performance of conventional UV-tape, and also have highly efficient anti-static properties. In this paper, we have shown the properties of antistatic UV-tapes in comparison with conventional UV-tapes.

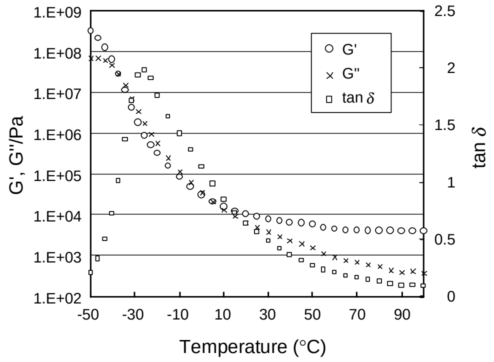

Figure 5 **Temperature dependence of storage modulus G', loss modulus G", and tanδ of anti-static adhesive.**

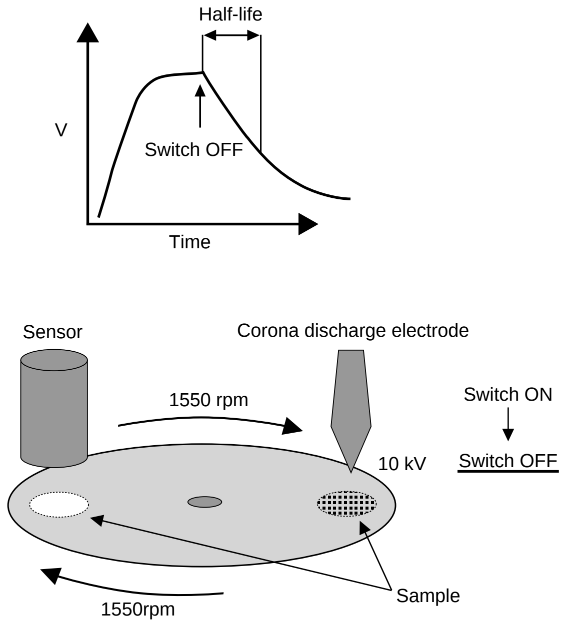

Figure 6 **Measurement method of anti-static properties of UV-tapes by a static honest meter.**

Table 4 Comparison of general properties of anti-static UV-tape.

Description			Anti-static UV-tape	Conventional UV-tape
Anti-static property	Surface resistivity (Ω/□)		1×10^9	1×10^{14}
	Charge voltage (kV)*		0.01	2.0
	Half-life (s)*		<1	1100
Tack Strength	Peak (mN/mm^2)	Before UV	650	164
		After UV	7	7
	Integral (mN/mm^{2}s)	Before UV	280	244
		After UV	1	1
Adhesive strength (N/25 mm)	Package	Before UV	2.6	2.9
		After UV	0.8	0.12
	Si wafer	Before UV	2.1	5.9
		After UV	0.16	0.1
Contamination	Particle count**		3	7

*: Measured by a static honest meter (see Figure 6). Test condition are as follows. Corona discharge:+10 kV, Rotational speed of sample: 1550 rpm

**: Total particle count more than 0.3 mm in diameter are listed. Adherent: 5 inch Si wafer, UV irradiation: 1000 mJ/cm^2

Adhesive Strength Test conditions: Dosage of UV: 1000 mJ/cm^2, Peeling Angle: 90 degree, Peeling Speed: 50 mm/min

5. FUTURE WORK

We have developed anti-static UV-tapes using an anti-static adhesive material. To upgrade the anti-static properties of UV-tapes, additional development of anti-static backing film is also required. A subject of future studies is the development of anti-static UV-tapes used in back-grinding processes and development of low-cost technology which will strengthen our competitiveness. To expand our tape business, it is necessary to develop new products used in processes other than dicing and back-grinding 9).

REFERENCES

1) T. Suzuki, 2001, Guideline Seminar about ESD Problems in Semiconductor Industry organized by Trek Japan INC. and KASUGA DENKI INC. (in Japanese)
2) SEMICON Japan 2000, Workshop of electrostatics, SEMI E78 and Revise E43
3) Y. Kanou, et al. 1992, Polymer Processing, vol41, 146
4) Japanese Patent Laid-open Disclosure 2000-273417, Heisei 11-269436
5) Japanese Patent Laid-open Disclosure 2000-129235
6) Japanese Patent 2955089, 2649731
7) Y.Morishima et al. Proceedings of The 39th Annual Meeting of The Adhesion Society of Japan, 2001, p.45. (in Japanese)
8) Y.Morishima et al. Proceedings of The 11th Annual RCJ Reliability Symposium, November 2001, p.183. (in Japanese)
9) Y.Morishima, et al Proceedings of The 16th JIEP Annual Meeting March, 2002, p.181 (in Japanese)