Die Strength After Ultrashort Pulse Laser Processing

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Abstract

Adoption of interlayer dielectrics (Low-K film) has been increasing recently due to miniaturization of semiconductor devices. Generally speaking, as the mechanical strength of the Low-K film is low, full cut using the blade dicing process after removing the film using the laser grooving process is common. When compared to the blade dicing process alone, one of the challenges of this process is decline in die strength due to heat damage from the laser. Here, die strength improvement results were verified by controlling the heat damage using an ultrashort pulse laser.

This report shows that the die strength after using an ultrashort pulse laser followed by blade dicing is higher than that after blade dicing alone.

1. Introduction

With the purposes of high-speed and energy-saving, semiconductors are becoming miniaturized and highly integrated. As the distance between wirings becomes narrower due to miniaturization, the wiring capacitance increases, leading to signal delay. In order to prevent this, interlayer dielectrics (Low-K film) started to be adopted. Low-K film has low mechanical strength, and film peeling (delamination) occurs when processing with the blade dicing process. For this reason, the mainstream process for this is to remove the film using the laser grooving process and then singulate into die using the blade dicing process (Fig. 1).

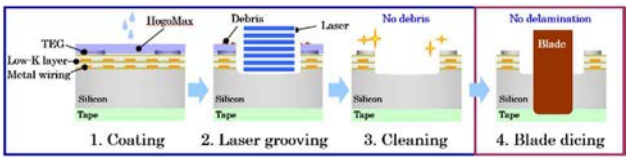


Fig. 1: Laser Grooving + Blade Dicing Process

In this process, water-soluble resin is coated on the wafer surface prior to laser grooving, the Low-K film is removed using the laser grooving process, and then the wafer is cleaned on the spinner table, preventing debris adhesion. As the blade dicing process is performed after the Low-K film is removed, high-quality singulation is possible.

Demands for die thinning have been increasing for the purpose of high integration. Die strength declines as the wafer becomes thinner, and thus reliability of the product also declines. For this reason, die strength improvement is an important theme. When the laser process is used, decline in die strength due to the heat effect is a challenge. In order to resolve this, laser processing using an ultrashort pulse (USP) laser, which controls the heat damage to the die by irradiating the laser instantaneously, is being proposed.

In this report, the die strength after laser grooving using a conventional laser will be compared to the die strength after using an ultrashort pulse laser followed by the blade dicing process.

2. Test Method

Wafers were singulated into die using each of the following processes: a conventional laser + blade dicing, and a USP laser + blade dicing, and then die strength was measured using the 3-point bending die strength measurement method. In addition, in order to measure the laser processing effect more accurately, bare Si wafers without Low-K film were used in this investigation.

The 3-point bending die strength measurement method is a type of material test. As shown in Fig. 2, both edges of the die have simple supports and are not fixed. In this state, load is applied in the perpendicular direction, and the maximum load up until the die breaks is measured. Compressive stress is generated on the front side of the die, and tensile stress on the backside. In this test, breakage strength due to the tensile stress on the backside of the die is observed. The maximum load up until the die breaks can be calculated as the bending stress value per unit area using equation (1).

$$\sigma_{fb} = \frac{3WL}{2bh^2} \qquad (1)$$

Regarding die strength measurement, the cantilever bending test is also standardized in the SEMI standard. In this investigation, the more common 3-point bending method is used.

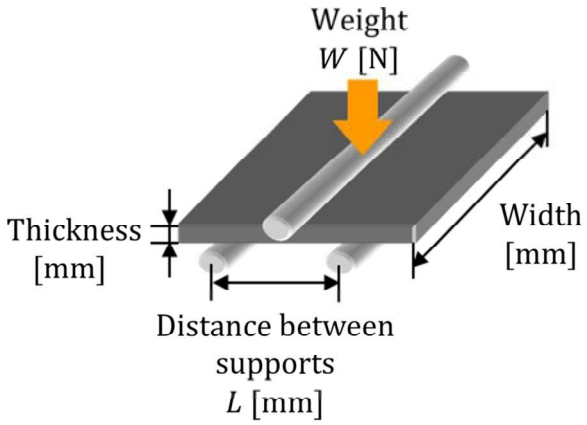


Fig. 2: 3-Point Bending Die Strength Measurement

3. Measurement Results and Remarks

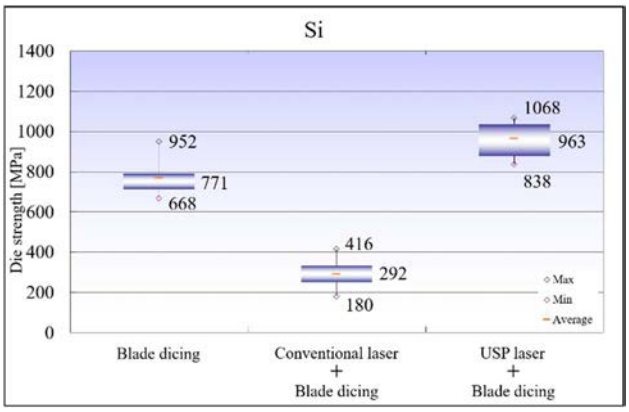
The processing results of the conventional laser + blade dicing and the USP laser + blade dicing are shown in Table 1. Comparing the results of the two processes, melting at the bottom of the groove is less with the USP laser, indicating that the heat effect is lower.

Table 1: Processing Results

	Conventional laser + Blade dicing	USP laser + Blade dicing
Speed [mm/s]	350	800
Upper surface		

Next, die strength comparison is shown in Table 2. Although the die strength after the conventional laser + blade dicing is lower than that after blade dicing alone, the die strength after the USP laser + blade dicing is higher than that after blade dicing alone. The reason for these results could be due to the fact that the heat damage from the USP laser is lower than the head damage from the conventional laser and the physical damage from blade dicing alone.

Table 2: Comparison of Die Strength



4. Summary

By using the USP laser + blade dicing process, die strength can be improved compared to the conventional laser + blade dicing process or blade dicing alone. USP laser processing can be expected to be applied not just in Low-K film removal, but also to process a wide range of materials other than Si such as SiC and GaN.

Please contact DISCO to request test cuts using our USP laser.

Reference Materials

[1]Highly purified water-soluble protective film for semiconductor processes (TR21-02)

[2]Silicon wafer thinning, the singulation process, and die strength (TR16-03)

Inquiries regarding DISCO Technical Review

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