Dicing Technologies for SiC Vol. 2

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Abstract

With the rapid expansion of the SiC market, expectations for dicing technologies are also increasing. This review focuses on ultrasonic dicing, Stealth Dicing™, and laser full cut, and compares the processing quality and productivity.

1. Introduction

In recent years, the importance of carbon neutrality has been rapidly increasing, and new technologies are being developed one after another. The market for silicon carbide (SiC), which is used in electric vehicles and other representative applications, is expanding rapidly, partly due to the emergence of 8-inch wafers. With the expansion of the market, expectations are also growing for higher quality and more efficient SiC dicing technologies.

2. Dicing technologies

Blade dicing is one of the dicing technologies used for SiC. Although the processing speed is slower than that of Si, it is widely used as a simple process. On the other hand, the emergence of diverse thicknesses and device structures has led to diversification in processing methods. In this volume, we will focus on three technologies that enable increased processing speed without compromising quality [1].

2-1. Ultrasonic dicing

Ultrasonic dicing is a dicing technology that applies ultrasonic vibration in the radial direction of the blade (Fig. 1). Compared with conventional blade dicing, it promotes self sharpening (constant exposure of fresh abrasive grains), thereby suppressing blade wear and clogging. In addition, the ultrasonic vibration creates a microscopic clearance between the workpiece and the blade, which improves the cutting water discharge performances, enhances cooling at the processing point, and reduces processing load. As a result, processing speed can be increased while maintaining quality, compared to conventional blade dicing [1].

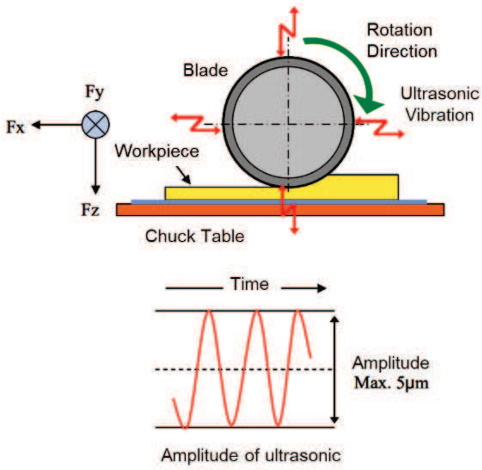

Fig. 1 Ultrasonic Dicing.

2-2. Stealth Dicing™

Stealth Dicing™ is a technology in which a laser beam is irradiated inside the workpiece to form a modified layer, followed by die separation through tape expansion. When the wavelength, capable of penetrating the workpiece, is focused inside the material, a modified layer is formed. The stress difference between this modified region and the surrounding material induces the initiation of cracks. Subsequently, external stress is applied via tape expansion to propagate these cracks in the thickness direction, thereby separating the workpiece into die. In the case of SiC, due to its high hardness, it is recommended to incorporate a breaking process. This method has a superior processing speed and, as processing is performed within the workpiece, it causes minimal damage to the front and back surfaces, thus achieving high die strength. Furthermore, because the kerf width is virtually zero, it is well-suited for processing narrow streets.

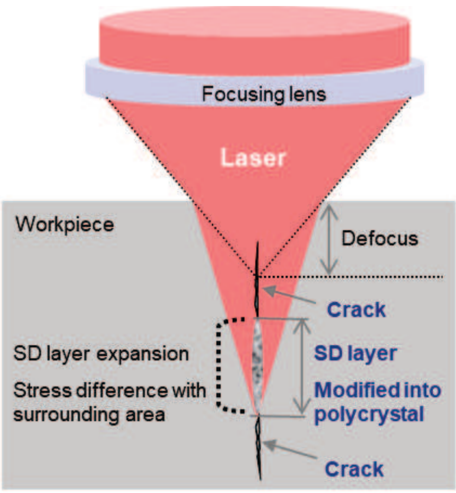

Fig. 2 Stealth Dicing™

2-3. Laser full-cut

Next, the laser full-cut process is described. When a laser beam is focused onto the surface of the workpiece, vaporization occurs once the energy exceeds a certain threshold. This phenomenon, known as laser ablation, is utilized in the laser full-cut process to divide the workpiece into individual die. A schematic illustration is presented in Fig. 3. Laser ablation exhibits excellent processing performance for metallic regions, enabling dicing of workpieces containing up to approximately 200 µm of metal. It is also effective for small die and narrow streets because the processing width can be narrowed. In addition, the method does not require tape expansion or breaking, which constitutes another advantage in that processing can be accomplished through a simplified process flow.

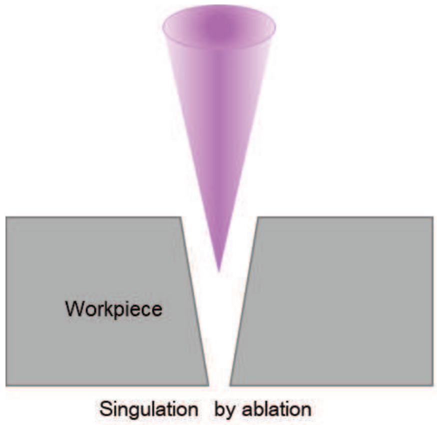

Fig. 3 Laser full-cut.

3. Comparison of quality and productivity for each method

In this section, the three dicing techniques described in the preceding sections are compared in terms of quality and processing speed for the processing of 100 µm-thick SiC wafers. Figure 4 presents the die strength measured on the backside (C-side) of the wafer using a fully automated die inspection system (DIS100) [2]. The results indicate that Stealth Dicing™ achieved higher die strength than both ultrasonic dicing and laser full-cut. This is attributed to the smaller degree of backside damage compared with ultrasonic dicing, which imposes significant processing load during processing, and laser full-cut, which imposes high thermal load. While no statistically significant differences were observed between ultrasonic dicing and laser full-cut, it is known that reducing the processing speed in ultrasonic dicing improves the die strength [1].

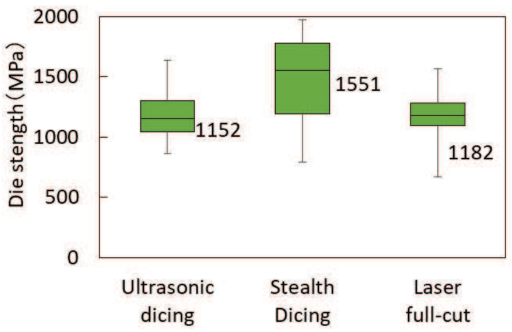

Fig. 4 Die strength by technology

Subsequently, a comparison of processing times was conducted. Figure 5 presents the relative processing times for dicing an 8-inch wafer into 3 mm squares, normalized to that of conventional blade dicing. Under the present experimental conditions, the reductions in processing time were approximately 74% for ultrasonic dicing, 91% for Stealth Dicing™, and 57% for laser full-cut.

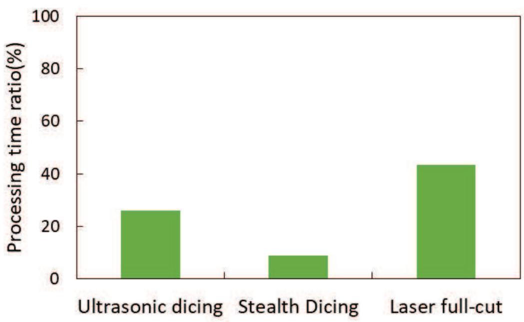

Fig. 5 Processing time ratio.

Based on the above, each dicing technology can be considered as follows. Stealth Dicing™ achieved the highest fracture strength with the shortest processing time. Since this technology enables efficient production while maintaining quality, it is suitable for mass production. On the other hand, when metal is present in the streets, the laser cannot penetrate the metal, making it impossible to focus inside the wafer, which makes Stealth Dicing™ difficult. In such cases, designing the workpiece so that there is no metal in the streets, or alternatively applying ultrasonic dicing or laser full-cut, is effective. Ultrasonic dicing has the advantage of maintaining both productivity and quality even when processing thick workpieces. In contrast, laser full-cut requires multiple passes, but as the workpiece becomes thinner, the number of passes decreases, thereby improving productivity. Therefore, in the SiC market, where wafer thinning is progressing, demand for laser full-cut is expected to increase. In this way, the most suitable dicing technology varies depending on the workpiece.

4. Conclusion

In this review, ultrasonic dicing, Stealth Dicing™, and laser full-cut were examined and compared as dicing techniques for SiC. By selecting the appropriate technique according to the thickness and structure of the workpiece, high-quality and high-efficiency processing can be expected. Furthermore, as these technologies continue to evolve, further advancements are anticipated in the future.

5. References

[1] DISCO Technical Review TR16-05

[2] DISCO Technical Review TR23-03