Dicing technologies for SiC

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Abstract

SiC, which is expected to be the new material for power devices, is a difficult material to process with regular blade dicing due to its hardness. Ultrasonic dicing and stealth dicing are being suggested for processing SiC wafers. In this review, we introduce each feature of these dicing technologies and compare the quality and productivity.

1. Introduction

Power devices are used in various fields such as consumer electronics, automobiles, railways, and generators. The market for these devices is expected to expand further. Conventionally, silicon (Si) was used as the material for power devices. However, silicon carbide (SiC) is the subject of attention at present, and some SiC power devices are already commercially available.

Using SiC in power devices provides numerous advantages owing to its capability to withstand higher breakdown voltage, reduce the power loss due to high-speed operation, and minimize the size of cooling system due to its high heat dissipation. However, it is difficult to process SiC at high speed while maintaining high quality because of its hardness.

Fig. 1 shows the results of processing Si and SiC with standard blade dicing. These pictures indicate that blade dicing could process Si without causing any problem whereas blade dicing of SiC caused chipping. Chipping and cracks can be suppressed by lowering the processing speed, however, the market demands high quality processing of this material while maintaining high productivity.

Further, a power device typically has a vertical current flow structure, and there is a metallic film on the wafer backside, which acts as an

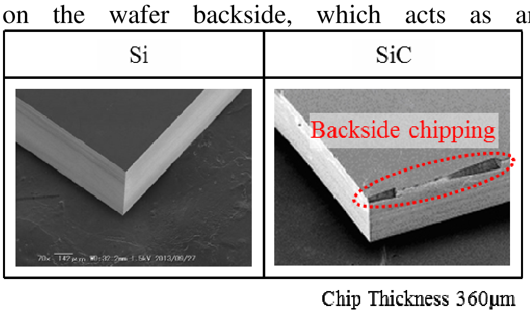


Fig.1 Examples of Si and SiC blade dicing

electrode. During the dicing of metals, burr tends to occur because of their ductility. Thus, a dicing technology capable of suppressing this problem is required.

2. Dicing technologies for SiC

Application of ultrasonic-wave dicing and stealth dicing (SD) is effective in solving the problems associated with the dicing of SiC power devices.

2.1 Ultrasonic-wave dicing

Ultrasonic-wave dicing is a technology capable of reducing the processing load by applying ultrasonic vibrations in the blade radial direction (Fig. 2).

Fig. 3 shows the processing loads with and without the application of ultrasonic vibrations. The graph clearly indicates that the processing load is greatly reduced by applying ultrasonic vibrations. This is because water flow to the processing point is improved, thereby suppressing blade glazing and loading.

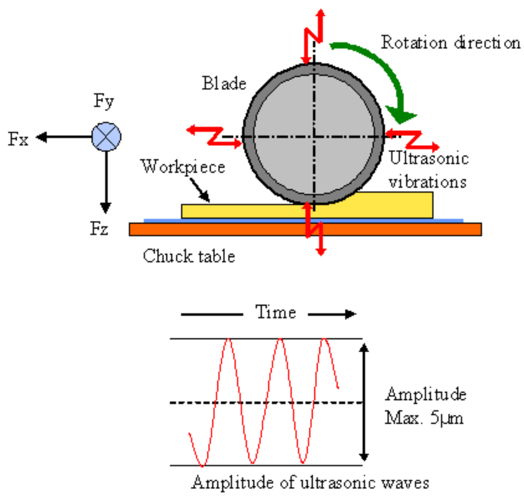


Fig. 2 Ultrasonic-wave dicing

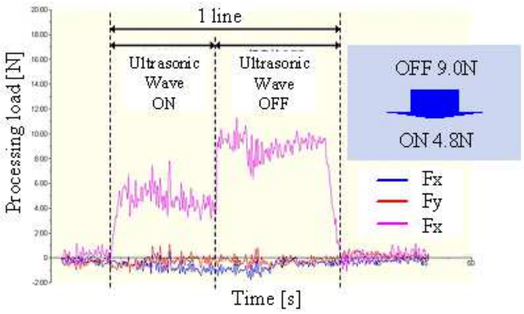


Fig. 3 Processing load during dicing

Lower processing load in ultrasonic-wave dicing enables the selection of a blade with smaller grit size, thereby improving the processing quality. This technology also makes it possible to increase the processing speed.

Fig. 4 shows examples processed by standard blade dicing and ultrasonic-wave dicing. SiC could be processed by blade dicing at a low speed. However, at a higher processing speed, dicing caused chipping and cracks. On the other hand, when ultrasonic-wave dicing was applied, chipping and cracks could be prevented even at a processing speed of 10 mm/s. Thus, this dicing technology enables high quality processing while maintaining high productivity.

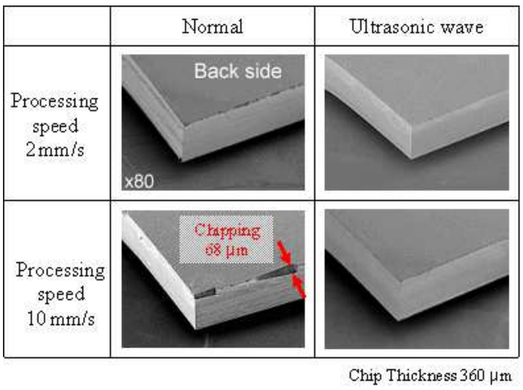


Fig. 4 Examples processed by standard blade and ultrasonic-wave dicing

2.2 Stealth dicing

SD is a technology that forms a modified layer by focusing a laser beam below the surface of a workpiece[1] and then separates the workpiece into chips by breaking (Fig. 5).

SD is capable of processing SiC at a speed higher than that of ultrasonic-wave dicing. The number

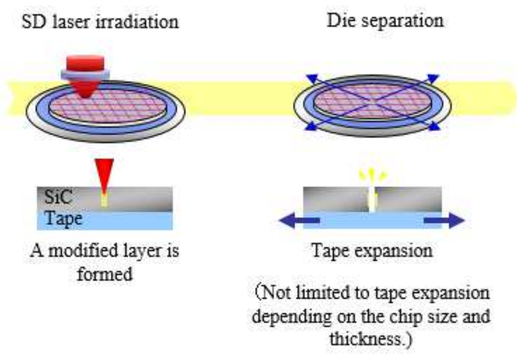
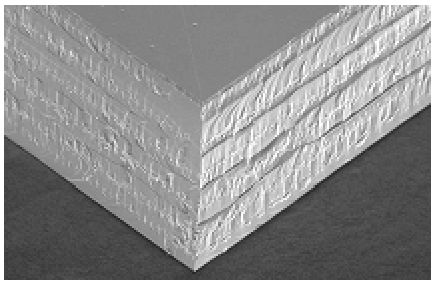


Fig. 5 Stealth dicing process

of laser passes required for dicing differs depending on the chip thickness. Since this dicing technology achieves a processing speed as high as 350 mm/s or more per pass, it is particularly effective for high volume production.

In the example shown in Fig. 6, a 350 µm thick chip was processed by SD. Since the workpiece is divided into chips from the modified layer as a starting point, this layer remains at the side of the chip. However, in terms of productivity, SD achieves a processing speed equal to or greater than five times the processing speed of ultrasonic-wave dicing even when a large number of laser passes is required (six passes when the thickness is 350 µm).



Chip Thickness 350µm
SD 350mm/s 4pass + 500mm/s 2pass

Fig. 6 SD processing example

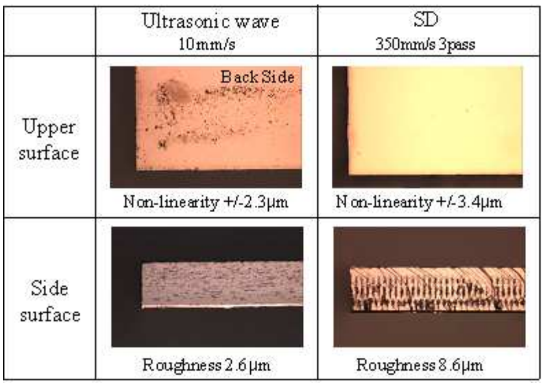
3. Comparison of the dicing technologies

The qualities and productivities achieved by ultrasonic-wave dicing and SD are compared. In the vertical structure of power devices, the chip thickness determines their withholding voltage and power loss. Chips with thicknesses of 110 µm and 350 µm were selected for comparison. In order to verify the influence of dicing on the metallic layer, a 5 µm thick nickel-titanium

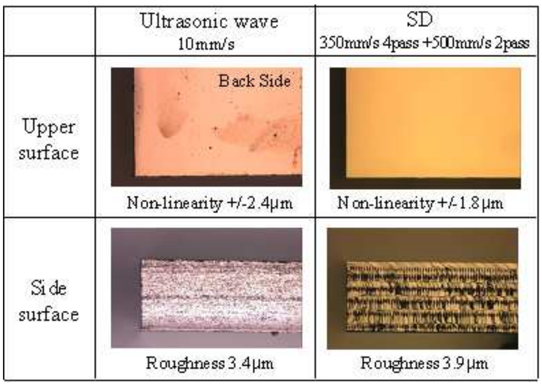
(Ni-Ti) alloy layer was formed on the wafer backside. Since the number of laser pulses needed to divide a wafer into chips differs depending on the chip thickness, the 110 and 350 µm chips were irradiated by three and six passes, respectively.

3.1 Appearance inspection

Fig. 7 shows the appearance of the diced chips. For ultrasonic-wave dicing, the roughness at the side of the chip is low. On the other hand, SD forms a modified layer to divide the chips, and therefore, the roughness on the side of chips tends to be higher. Both dicing technologies did not cause burr, which indicates that the metallic layer on the backside did not influence the processing.



110 µm thickness



350 µm thickness

Fig. 7 Comparison of appearance inspection results

3.2 Die strength

The results of the comparison of the die (chip) strength are shown in Fig. 8. Ultrasonic-wave dicing produces stronger dies, but the difference in strength between this technology and SD is only approximately 10 % on average. In SD, the significant reduction in die strength is a concern because the modified layer remains on the side of the chip. However, this comparison revealed that the modified layer did not cause any significant deterioration of die strength.

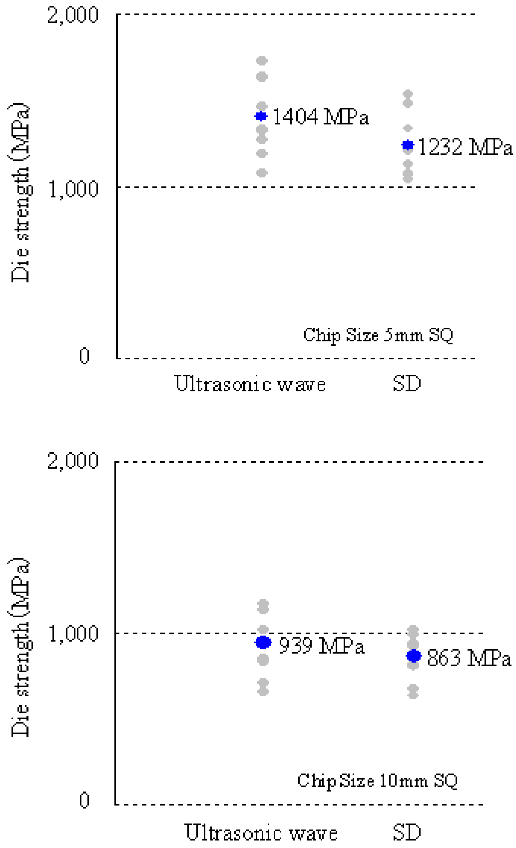


Fig. 8 Die strength comparison

3.3 Productivity

Fig. 9 shows the comparison of the units per hour (UPH) required by both the dicing processes. UPH was compared not only for the chip thickness but also for the chip size. Disregarding the chip thickness and size, SD achieved higher productivity. SD especially excels in the region where the chip is thin, which requires less laser passes per line, and in small chips with larger number of lines per wafer.

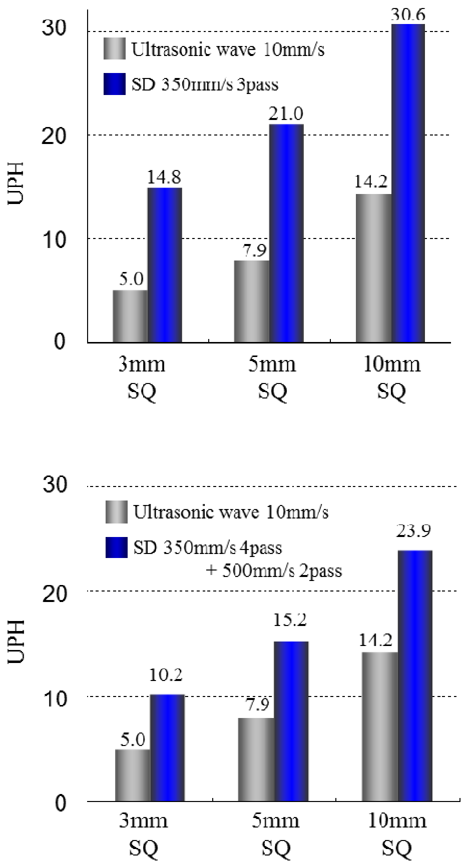


Fig. 9 UPH comparison

4. Conclusion

In this review, two dicing technologies for SiC, namely the ultrasonic-wave dicing and SD, were compared and their characteristics were presented. Disregarding chip thickness, ultrasonic-wave dicing is effective when quality is emphasized, whereas SD is preferable when high productivity is required.

References

[1]DISCO Technical Review TR16-04

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