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Blade Wear and Sidewall Quality by Dicing of Sintered Silicon Carbide (SSiC)

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Abstract

Dicing of Sintered Silicon Carbide (SSiC) is a challenge for implementing this material into MEMS applications. Due to the self-dressing effect, the wear of the resin-bonded dicing blades is significant. The application of dicing blades with metal bond can better resist the harsh environment during dicing hard and brittle material like SSiC. This paper present the results of the blade wear and its effect on the sidewall quality during dicing of SSiC with metal bonded diamond dicing blades.

1. Introduction

The ability of SSiC devices to work under high-temperature conditions and under high mechanical load allows for a significant enhancement of the system's and application's performance [1]. SiC is a hard and brittle material, preventing the ductile mode of machining under normal machining conditions, which makes it difficult to cut and profile [2]. On the one hand, an optimal dicing blade form is desired to meet the high demands of form accuracy, surface quality, and low subsurface damage of machined sidewalls. On the other hand, due to its hardness, dicing of SSiC substrate material is related to a high wear of the dicing blades. A higher blade wear causes profile inaccuracies and increases the process costs (frequent dicing blade change and its dressing time). The recommended grain size for dicing of Si is 5 µm [3] and for dicing hard and brittle materials it is 30 µm or even more [4].

2. Experimentals

For the dicing experiments, ring shaped metal-bonded dicing blades with an outer diameter of 55 mm and a thickness of 200 µm were used. The dicing blades feature a grit of 5 µm (8-5NiF) and 30 µm (8-30NiF), respectively. Two materials were cut: monocrystalline Si and SiC ceramic (SSiC). Dicing was performed on an ultra-precision dicing machine with a spindle diameter of 2 inches. To investigate the influence of the dicing blade wear and its effects on the cutting quality, some basic dicing parameters were varied (the feed rate, the spindle speed, and coolant supply). The cutting length was constant for all experiments.The blade wear was investigated by measuring the radial blade profile and blade roughness (diamond wear) using confocal laser scanning microscopy (CLSM). For analyzing the effect of the dicing blade wear on the dicing result, the surface profile of the kerf sidewall was measured (sidewall roughness and kerf edge chipping).

3. Results

3.1. Blade Wear

Due to the wear, the roughness of the dicing blade is changed in the frontal area. Figure 1 shows the change of two different roughness types (R_a and R_z) dependant on the cutting length. The value of R_z decreases (Figure 1b). This is the result of the diamond wear during the process. For dicing of Si, the wear of the metal bonded dicing blade is very low (Figure 1a and b). The change of R_a was undetermined for both materials (Figure 1a). Typically R_a is used, but R_z is for more significant for machined surfaces.

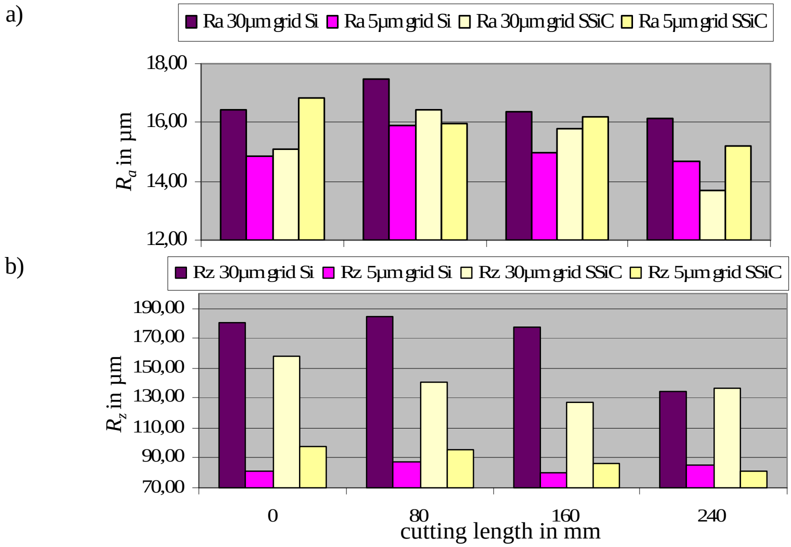
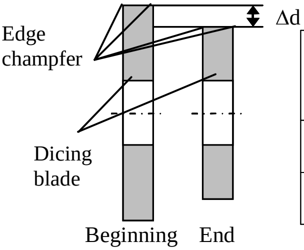


Figure 1: Roughness of the dicing blade, a) R_a and b) R_z after dicing Si and SSiC

The radial wear of the dicing blade can be analyzed by measuring the reduction of the outer diameter of the dicing blade *Δd* (Figure 2). Considering the higher tolerance of the

30 µm grit size blade compared to the tolerance of the 5 µm grit sizes, the wear during dicing Si is negligible. It is noticeable that the edge chamfer of the dicing blade for both, Si and SSiC is very low and hard to detect, although SSiC is much harder than Si.



Grit in µm	Δd in µm	
	SSiC	Si
5 µm	50	10
30 µm	150	20

Figure 2: Reduction of the outer diameter after dicing SSiC and Si in µm

3.2. Dicing Quality

Blade wear affects the diced surfaces, particularly the kerf sidewall roughness and the edge chipping. When the dicing process generates an insufficient kerf sidewall quality, the dicing blade has to be dressed again. As a result of the diamond wear the reduction of diamond protrusion occurs. Therefore, the sidewall roughness is modified. Figure 3 shows the change of the sidewall quality from the beginning to the end of the dicing line for both roughness values (R_a and R_z). The increase of sidewall roughness by dicing Si is significantly higher comparing to SSiC. Although the dicing of SSiC causes significant higher blade wear compared to Si (Fig. 1), the increase of the sidewall roughness is lower.

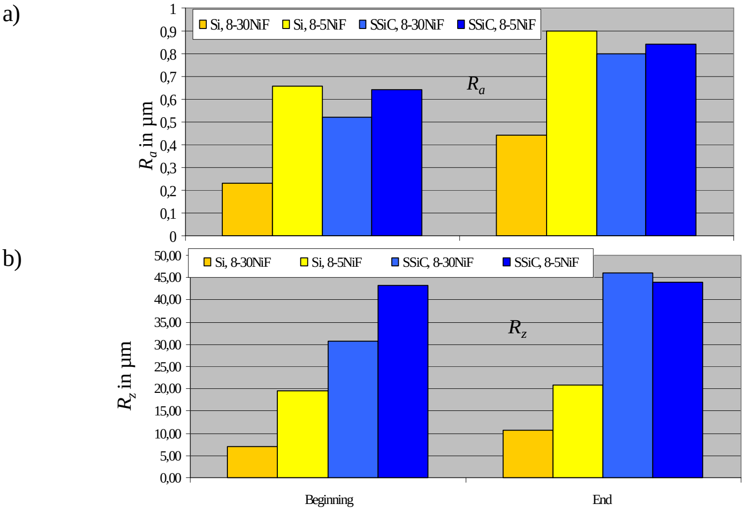


Figure 3: Analysis of roughness a) R_a and b) R_z during dicing for two types of blades

Furthermore, the total kerf edge chipping (SSiC) is also reduced. The increase of edge chipping during dicing of Si was very small, as expected. The edge chipping for dicing SSiC increases with a diamond blade 8-5-NiF only two times and with an 8-30-NiF blade about 5-9 times higher. Despite the higher hardness of SiC (3 GPa) compared to other hard and brittle ceramics such as Al_2O_3-TiC (2 GPa) or alumina (1.5 GPa) [5], the dicing quality of SSiC concerning the dicing blade wear is distinctly better.

4. Conclusion

The described results are an interaction of the tool wear and the material properties. The influence of the blade wear by dicing of SSiC does not affect the sidewall quality in such a magnitude like by dicing of Si. Metal-bonded dicing blades maintain their form during dicing for both materials. Despite the high hardness of SSiC, metal-bonded dicing blades can generate a productive dicing process (better durability without dressing). For better understanding the progression of the wear during dicing, long running investigations are required to analyze and detect advancing wear.

Acknowledgment

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