Dressing Criteria for Inline Laser Dressing of Metal-bonded Dicing Blades

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Abstract

By using inline dressing, the tool can be in-situ controlled and dressed on demand. This way, constant machining conditions can be obtained during the entire processing time. Especially for dicing of hard and brittle materials, which causes high blade wear, is a very important issue regarding process control and efficiency. The first step to integrate the laser dressing process into a dicing machine is to determine the inline dressing criteria, which is the topic of this work.

1 Introduction

Due to their high hardness, thermal stability, and chemical inertness, advanced ceramics are applicable for parts made for extreme environmental conditions (corrosive media, high temperature (>200°C), rapid thermal cycles) [1]. Precision machining of these materials is accompanied by increased tool wear and reduction of form accuracy and surface quality of work pieces [2]. Conventional inline dressing processes are characterized by increased process times due to the application of additional dressing tools (dressing sticks). Task of former work has been to develop a concept for inline dressing of metal-bonded dicing blades [3]. The proposed inline dressing process will be executed using a solid state laser attached to the dicing machine. Important for the dressing control are the inline dressing criteria. These criteria should determine when (inline) the laser assisted dressing process has to start.

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 are used. The dicing blades feature a grit of 30 µm (8-30 NiF). Dicing is performed on an ultra-precision dicing machine with a spindle diameter of 2 inches. The machining is executed with a feed of 0.6 mm/s, a cutting depth of 0.7 mm and a cutting speed of 58 m/s. For the determination of the dressing criteria, a spindle power consumption analysis system is developed and applied. The system allows an indirect analysis of the change in cutting force by measuring the variation of the power consumption of the rotating spindle (Fig. 1).

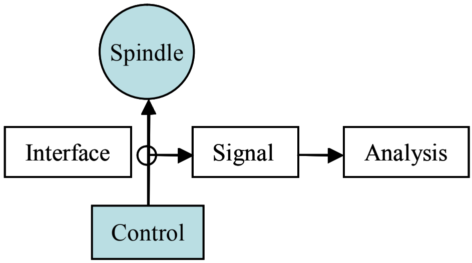

Figure 1: Measuring principle

The DISCO dicing saw is equipped with a DC spindle motor in Y-configuration. For a three-phase electrical motor with balanced load, active power (P) of a three-phase electrical motor is a function of the powering current (I) and the resistance of a motor winding, respectively. In order to measure active power, the current is sensed via a current transducer and filtered by a fourth-order Butterworth low pass filter with a cut-off frequency of 600 Hz. The spindle speed is holding constant at 20.000 rpm. An analogue multiplier AD633 is employed for an I^2 calculation. The signals are sent to a PC and analyzed using a software (voltcraft®). The power consumption system allows to analyze the signal output in volts over the cutting length. As a quality feedback, the blade front edge roughness is measured after cutting the dicing grooves. The roughness of the dicing blade is measured by Confocal Laser Scanning Microscopy (CLSM).

3 Results

The wear during dicing hard and brittle materials like SSiC leads to a significant change of the blade edge roughness. With advancing wear the edge roughness decreases due to the reduction of the diamond grain protrusion. The initial average roughness (R_z) of the dicing blade is 150 µm. The changing of the blade roughness leads to a variation in the resulting cutting kerf quality. Figure 2 shows the measurement results after dicing five dicing grooves with 100 mm cutting length in SSiC. The advancing in wear leads to the increase of the signal after each dicing street. This represents the high diamond wear during cutting ceramics.

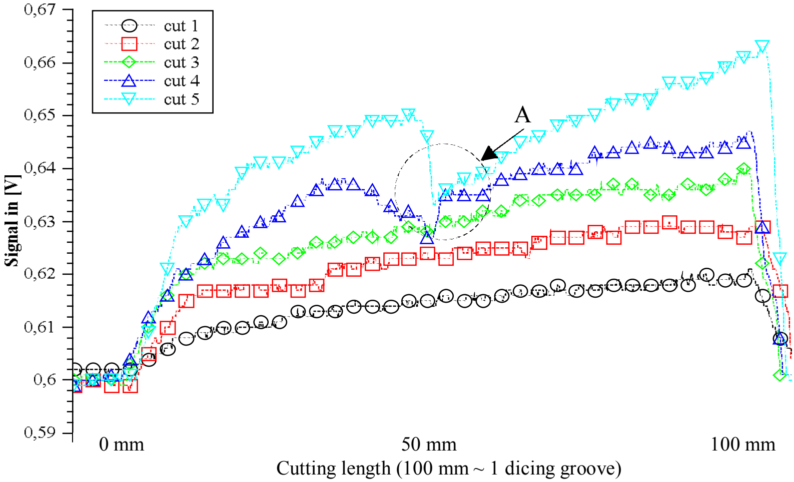

Figure 2: Signal analysis of five cuts before laser dressing

After a cutting length of 350 mm the signal shows a specific characteristic (maximum line, A, drop of the signal). This effect occurs, when the dicing blade wear reaches a specific level. The forces to fix the blade in the flange are lower then the cutting and process forces. For a short time the dicing blade slips in the flange. When the dicing blade sticks again, the signal increases again. This is the last point of cutting with a constant quality; following there is no guaranty of getting good cutting results. While cutting, the blade front edge roughness decreases about 30% (R_z= 100-110 µm).

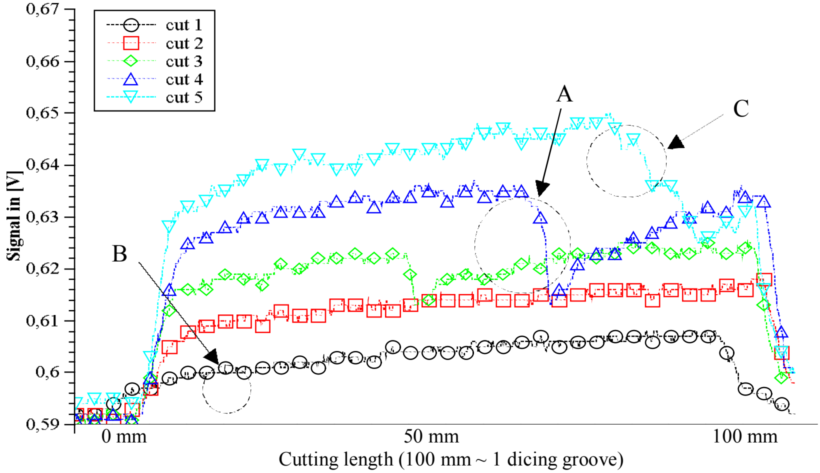

Figure 3: Signal analysis of five cuts after laser dressing

After the dressing, the power consumption returns to the minimal value of 600 mV (Fig. 3 B). If the minimal spindle power (zero load signal of 600 mV) increases over 8-10%, the dressing process has to be started (due to degradation and increasing blade load, C). For a short time the dicing blade slips in the flange (cut 3 and 4, same as in fig. 2, A) causing a drop of the signal. To verify this conclusion, an offline laser dressing on worn blade is executed. Due to the experimental results collected by using a measurement system presented, specific dressing criteria for starting the inline laser dressing process for SSiC can be determined.

4 Conclusion and Outlook

The process control proposed (spindle power consumption) is optimally applicable for advanced ceramics. Due to the higher blade wear, the signal variation can be better pinpointed. The developed system offers an inline detection of cutting effects and presents a base for determining dressing criteria. To prevent dicing blade damage, the dressing process has to start already after a signal rise of 8-10%. This allows an increase in productivity due to less blade damage, constant cutting quality und process stability. Further work will concentrate on integration of the laser in the dicing saw, as well as on optimizing and developing the inline laser dressing process to reach high quality cutting results and high endurance.

Acknowledgment

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References:

[1] M. Willander, M. Friesel, Q.-U. Wahab, B. Straumal: Silicon Carbide and Diamond for High Temperature Device Applications, J. of M. S.: Mat. in Elec., Vol. 17, pp. 1-25, 2006

[2] M. Stompe, S. Cvetković, and L. Rissing: Blade Wear and Sidewall Quality by Dicing of Sintered Silicon Carbide (SSiC), proc. of the 11. euspen Int. Conf., Italy, pp. 333-336, 2011

[3] M. Stompe, P. v. Witzendorff, S. Cvetkovic, A. Moalem, R. Kling and L. Rissing: Concept for Performance-Enhancement of Ultra-Precision Dicing for Bulk Hard and Brittle Materials in Micro Applications by Laser Dressing, 37th MNE, 2011