# PCD Grinding 과 전해방전가공을 이용한 알루미나의 복합미세가공

# Hybid Micro Machining of Alumina ($Al_2O_3$) using Electrochemical Discharge Machining and Polycrystalline Diamond Grinding

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## 1. Introduction

Recently, the demand of micro systems which work in harsh environments has increased. Micro sensors and micro actuators working in high temperatures, intense vibrations or corrosive media such as measurement instrument in micropropulsion, automative, turbomachinary are made of ceramic materials. However, there are not many machining processes which are able to machining the ceramics. Laser beam machining (LBM) is a well-known method in machining the ceramics. But the residual stress on the surface, the low surface quality and expensive equipment are main limitations of applying in mass production [1]. Lithography is also used in machining the ceramics. Nevertheless, an etching process is dependent on material properties and only low aspect ratio structures were able to be machined. Micro grinding using diamond wheels was studied to machine various kinds of ceramics however only 2D structures were machined due to wheel sizes [2].

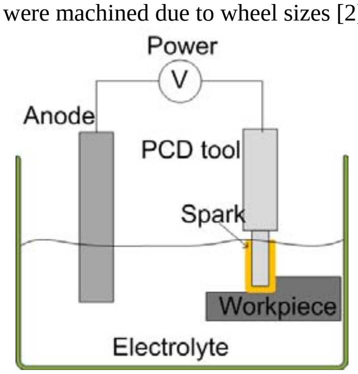


Fig 1. Mechanism of the hybrid process

In this paper, a novel process using ECDM and PCD grinding was introduced. ECDM is a well-known method which is usually applied in machining glass. Workpiece material is removed by evaporation thanks to sparks. In this hybrid process, the sparks generated in ECDM heat up local regions and assist the mechanical grinding of a PCD tool. Therefore, machining speed can be improved while maintaining a ground surface quality.

## 2. The hybrid process using ECDM and PCD grinding

The hybrid process was shown in figure 1. A micro PCD tool was used to machine an alumina plate, which was immersed in a KOH 20 %wt solution. If a voltage is applied between the tool and a counter electrode, the sparks appear around the PCD tool. The sparks heat up the local region in the alumina surface. Because the hardness of alumina reduces as the temperature increases, the PCD tool can easily cut the alumina workpiece [3].

## 3. Results and discussion

3.1 Machining time according to the voltage

In this part, an effect of the voltage on the machining time was studied. Machining conditions are a length of cut of 200 μm, a frequency of 10 kHz with duty pulse of 50 %, a depth of cut of 15 μm, a solution KOH 30 % and a rotational speed of 5000 rpm. The effect of the voltage on the machining time was shown in figure 2. As the voltage increases, the machining time reduces. In ECDM, the sparks are strong at high voltage [4]. Therefore, the temperature is high at high voltage and the machined zone is softer, which permits the cutting process to be faster.

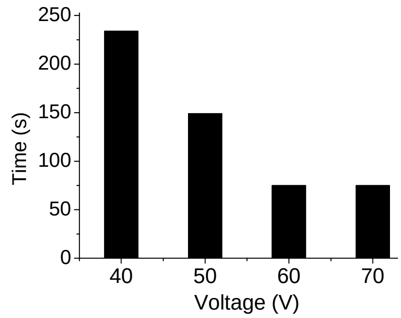


Fig. 2 Machining time according to the voltage

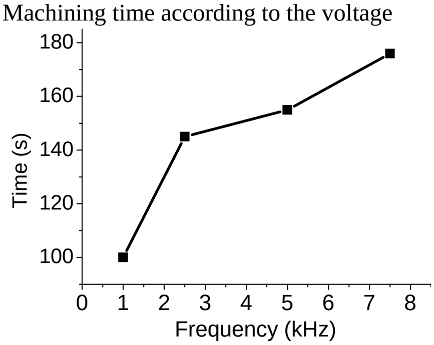


Fig. 3 Machining time according to the frequency

3.2 Machining time according to the frequency

In ECDM, frequency of a power supply also affects the machining process [4]. The voltage of 50 V was used in experiments. In the hybrid process, the machining time increases when the frequency increases as shown in figure 3.

3.3 Sample structures

The hybrid process can be used to machine alumina workpieces. Micro structures are shown in figures 4 and 5. The machining conditions were a voltage of 50 V at 10 kHz, a feedrate of 3 μm/s, a rotational speed of 5000 rpm and a solution of KOH 20 %. It took 380 s to machine a groove and 1 hour 15 minutes to machine a pyramid.

## 4. Conclusions

It has been demonstrated that the hybrid process using ECDM and PCD grinding can successfully used as a micro machining method of ceramic materials. It is also shown that the machining time is dependent on the voltage and the frequency of the power supply. Sample structures shows a feasibility of the process in micro machining of ceramics.

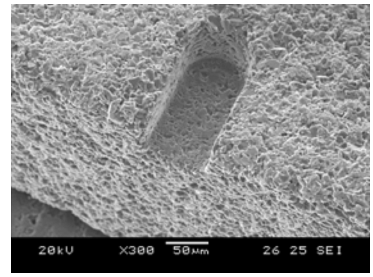


Fig. 4 Micro groove in alumina machined by the hybrid process

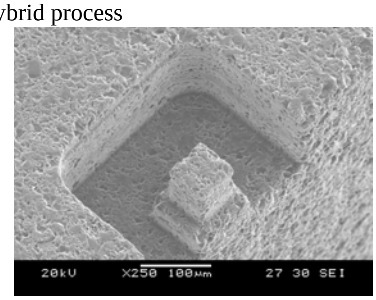


Fig. 5 Micro pyramid in alumina machined by the hybrid process

## Acknowledgment

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