

# Micro mechanical machining of cemented carbide using PCD tools

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*This study presents mechanical machining of cemented carbide (WC-Co) using EDMed polycrystalline diamond (PCD) tools. Since the hardness of PCD is higher than that of cemented carbide, micro holes and micro 3D structures can be fabricated on cemented carbide by micro PCD tools. Micro tools of dia. 50 μm were fabricated by wire electrical discharge grinding (WEDG) and then were used in micro drilling and milling. In micro drilling, we investigated the effect of feedrate on the cutting force. Since the PCD surface machined by EDM is rough, it can be used as a pencil grinding tool in micro grinding. Using the PCD micro tools, micro holes and walls were machined without burr or crack.*

## 1. Introduction

As the demand for high precision components or parts increases, many researches on the machining method of difficult-to-cut materials are conducted. Cemented carbide (WC-Co) is one of the difficult-to-cut materials with high hardness and wear resistance. These properties are suitable for micro components such as micro mold and micro nozzle that are used at high-pressure and high-temperature. However, cemented carbide is very difficult to be machined due to brittleness and hardness. Micro mechanical machining using polycrystalline diamond (PCD) tool is an effective method to meet surface quality and geometric accuracy. In this study, micro holes were drilled to investigate the effect of tool feedrate on the cutting force and some 3D micro structures were machined.

## 2. Experimental setup

Figure 1(a) shows the experimental setup for micro mechanical machining using PCD tools. It consists of X-Y-Z precision linear stages, a module of wire electrical discharge grinding (WEDG), dynamometer and high speed spindle. WEDG is one of wire EDM variants, which is very useful method for micro pin machining.[1-3] A PCD rod was installed to the spindle and machined to micro tool by WEDG. After that, the micro tool was moved near to a workpiece and machined micro features on the workpiece. The cutting force generated during the machining was measured through the dynamometer (9256, Kistler). Figure 1(b) shows the schematic of the process.

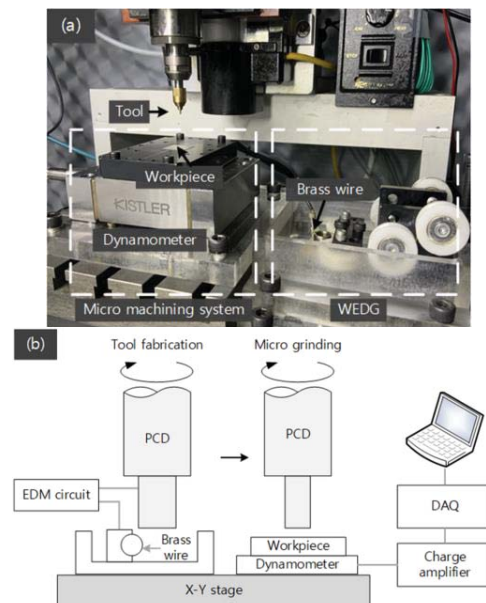


Fig. 1 (a) photo of machining system (b) schematic of the machining process

## 3. Results

Figure 2 shows micro tool machined by WEDG. The tool diameter is about 50 μm. Using this tool, as shown in figure 3, micro holes were machined on cemented carbide plate with thickness of 100 μm. The rotational speed of the tool was 60,000 rpm and the feedrate was 0.25 μm/sec. To investigate the effect of feedrate on the force (thrust force), micro holes were machined with different feedrate. As shown in figure 4, the force increased from 0.12 N to 0.5 N when the

feedrate increased from 0.25 to 0.75  $\mu\text{m}/\text{sec}$ .

Since the PCD surface generated by EDM is very rough, it can be used as a grinding tool in micro grinding.[1] Figure 5 shows micro walls machined on cemented carbide. Severe burrs were not observed and sharp edges were obtained. Since cemented carbide has very high brittleness, micro hole and structures can be machined without burrs.

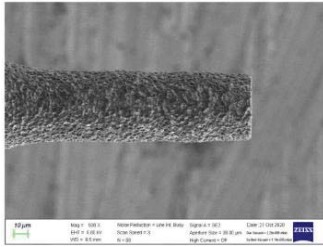


Fig. 2 Micro tool machined by WEDG (PCD, 50  $\mu\text{m}$  in diameter)

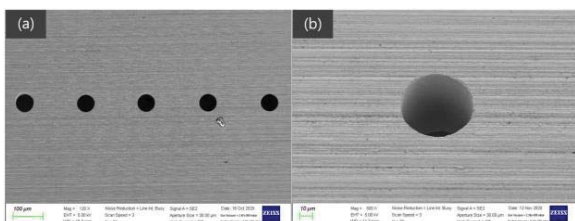


Fig. 3 Micro holes machined on cemented carbide (100  $\mu\text{m}$  thickness, 60,000 rpm, 0.25  $\mu\text{m}/\text{s}$ )

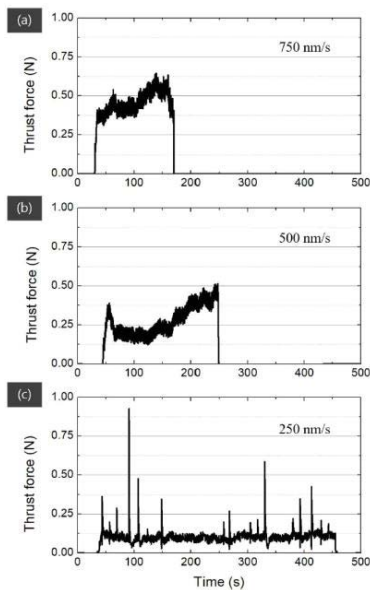


Fig. 4 Thrust force with different feedrates (a) 0.75  $\mu\text{m}/\text{s}$ , (b) 0.5  $\mu\text{m}/\text{s}$  (c) 0.25  $\mu\text{m}/\text{s}$

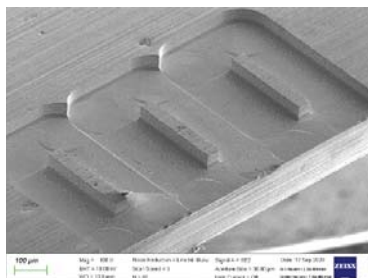


Fig. 5 Micro structures machined on cemented carbide

#### 4. Conclusions

Cemented carbide is one of the difficult-to-cut materials. Since the hardness of PCD is higher than that of cemented carbide, micro tool made of PCD can be used to machine the cemented carbide mechanically. In this paper, micro PCD tools were machined by EDM and used in micro drilling and milling. Due to the tool size, very high rotational speed and low feedrate were applied to machine micro structures. When micro holes of 50  $\mu\text{m}$  in a diameter were drilled, the thrust force was measured 0.1 to 0.5 N, which depended on the feedrate. Due to the high hardness of cemented carbide, sharp edges without burrs were obtained.

#### ACKNOWLEDGEMENT

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