

Effects of Drill Geometry on Quality of Hole Drilled into Quartz Glass by Micro PCD Drill

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Abstract

The present paper deals with the micro drilling into quartz glass with micro polycrystalline diamond drills, hereafter called micro PCD drills. Micro PCD drills with a nominal diameter of 300 μm are fabricated by wire electro-discharge machining, hereafter called wire-EDM. The fabricated drills have various shapes. The fabricated drills are used in the drilling into quartz glass with or without ultrasonic vibration and influences of drill geometry are investigated. As the result, it is found that a certain geometry of drill improves quality of hole entrance and hole wall.

1 Introduction

Recently miniaturization of many products is progressing. Therefore, it is required to accurately and efficiently produce micro holes for these products and components. At present various methods are available for machining micro holes such as micro drilling with drills, laser machining, electro-discharge machining, etc. Among them micro drilling with drills plays important roles in manufacturing. On the other hand, it is required to machine brittle materials with cutting tools because cutting process is very efficient. However brittle materials are easy to be damaged in cutting process. In the previous studies of machining brittle materials with cutting tools, tools used in their experiments are mainly monocrystalline diamond tools.

The main purpose of our research is to realize accurate and efficient micro hole drilling into quartz glass with micro PCD drills. Our previous studies described about characteristics of processing PCD with wire-EDM and pilot drilling tests [1-2]. In the present paper, micro PCD drills with various drill shapes have been fabricated, and

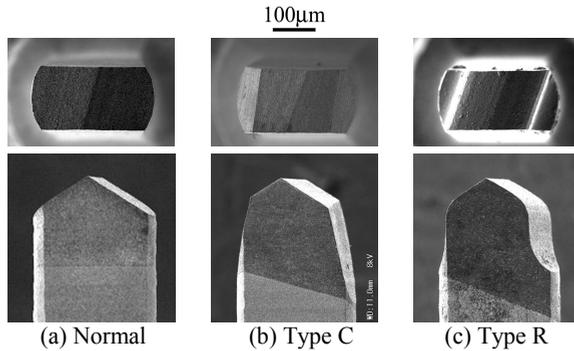


Figure 1: Fabricated micro PCD drills

drilling into quartz glass has been carried out. And the influences of drill geometry are investigated.

2 Experimental Equipment and Method

In the experiments, micro PCD drills were fabricated first and then drilling test was carried out.

In the fabrication of micro PCD drills, cylindrical tool blanks are cut out from PCD indexable insert by wire-EDM. Those tool blanks are made into micro PCD drills by wire-EDM. Nominal geometry of drills is as follows, diameter: 300 μm , point angle: 118°, chisel edge angle: 115°, web thickness: 150 μm . Figure 1 shows fabricated micro PCD drills. Hereafter a drill as shown in Fig.1(a) is called “normal type drill”, a drill whose corners of cutting edges are cut straightly as shown in Fig.1(b) is called “type C” and the other drill whose corners of cutting edges are cut roundly as shown in Fig.1(c) is called “type R”. Drills of type C and R are expected to cut quartz glass in ductile mode near corners of cutting edges because of their small depth of cut around a corner of cutting edge.

In the drilling test, fabricated micro PCD drill is clamped on the main spindle and workpiece whose material is quartz glass is clamped on a jig or an ultrasonic vibration table which is mounted on the XY table of machining center. Drilling conditions are shown in Table 1. All drilling conditions should be tested for each type of drills essentially, but drilling under the condition of changed feeds without ultrasonic vibration and the condition of with or without ultrasonic vibration at the feed of 0.1 $\mu\text{m}/\text{rev}$ were carried out in order to simplify drilling tests.

Table 1: Drilling condition

Workpiece	Quartz glass
Drilling condition	
Rotational speed	1000 min ⁻¹
Feed	0.01, 0.1, 1.0 μm/rev
Drilling depth	600 μm (Blind hole)
Fluid	Water-based coolant
Ultrasonic vibration	None / Application (Frequency: 60 kHz, Amplitude: 0.4 μm)

3 Experimental Results and Discussions

Figure 2 shows the holes drilled with three types of drills without applying ultrasonic vibration. In any types, chipping around hole entrance seems to be larger as feed becomes larger. Size of chipping with a drill of type R was larger than those with the other drills. Figure 3 shows the holes drilled with three types of drills under the condition of applying ultrasonic vibration. With ultrasonic vibration, sizes of

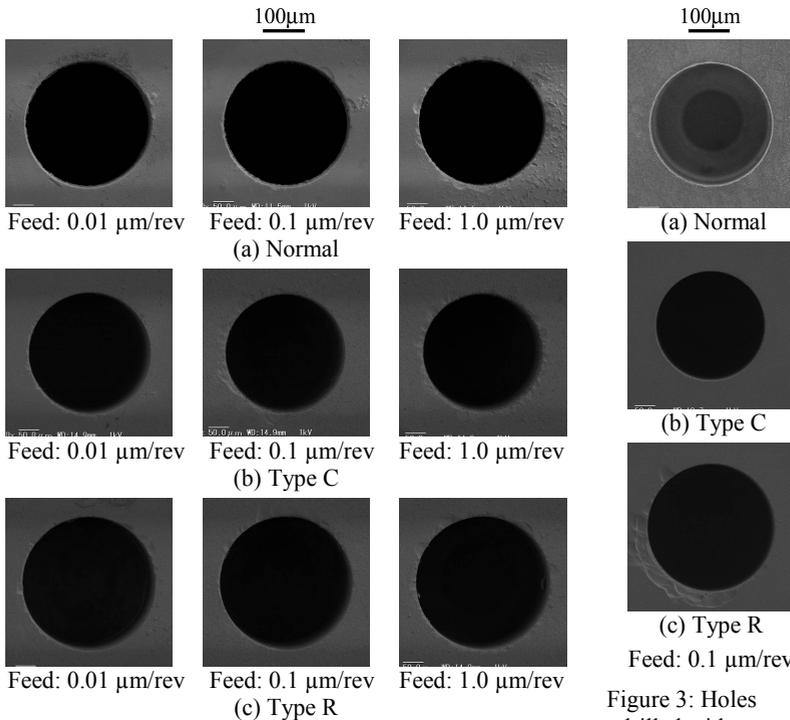


Figure 2: Holes drilled without ultrasonic vibration

Figure 3: Holes drilled with ultrasonic vibration

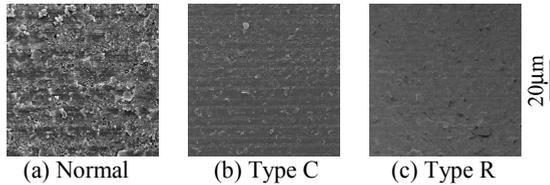


Figure 4: Hole walls drilled without ultrasonic vibration (Feed: $0.1 \mu\text{m}/\text{rev}$)

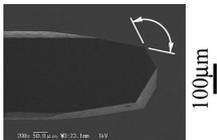


Figure 5: Drill of type C2

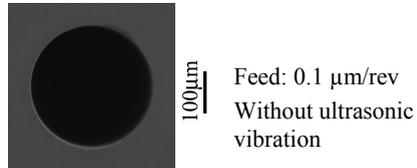


Figure 6: Hole drilled with a drill of type C2

chipping seems to be a little smaller than that without ultrasonic vibration but effects of ultrasonic vibration on chipping are not clear. Figure 4 shows the hole walls drilled without ultrasonic vibration. From this figure, surface appearance machined with a drill of type C seems smoother than those with the other types of drills.

More drilling tests are requested to reveal details, but the drill of type C seems to be the most effective in improving hole quality among three types of drills as the results. Therefore new drill similar to type C, hereafter called type C2, was fabricated in order to investigate effects of inclination angle of secondary cutting edge (refer to Fig. 5). This drill has smaller inclination angle of secondary cutting edge than that of a drill in Fig. 1(b). Figure 6 shows the hole drilled with a drill of type C2. Size of chipping in this figure was smaller than that at the same feed in Fig. 2(b).

4 Conclusion

The micro PCD drills with a nominal diameters of $300 \mu\text{m}$ were fabricated and drilling test was carried out. As a result, it is found that a certain geometry of drill improves quality of hole entrance and hole wall.

References:

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