

# Micro Tools Fabrication Using Developed Micro Grinding and Lapping Setup for Micro Machining

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## Abstract

Developed micro grinding and lapping process was used for fabrication of tungsten micro tools. The machines successfully produced a cylindrically shaped micro tools having diameter ranging from 12  $\mu\text{m}$  to 476 $\mu\text{m}$  and aspect ratio ranging from 10.07 to 150. Preliminary examples of micro machining have also been reported with the 285  $\mu\text{m}$  diameter tool on micro EDM. A micro hole 318  $\mu\text{m}$  diameter is successfully generated. This micro tool fabrication method is very simple, low cost and required less time.

## Keywords

Micro Machining, Micro Tool fabrication, Micro EDM, Micro Grinding, Lapping

## I. Introduction

Micro machining is the process to manufacturing of miniaturization components such as MEMS (micro electro mechanical systems), aerospace equipments, and medical devices etc. One of the biggest problems for micro machining is the fabrication of high aspect ratio micro tools as explained by Jain and Rajurkar (1991). A cylindrical micro tool can be made by micro turning, grinding, electrical discharge machining (EDM), electrochemical etching and wire discharge grinding (WEDG) as elaborated by Lim and Kim (2001); and Ohmori et al. (2003). Each process has its own limitations. In EDM, tool shape is limited to straight or stepped as discussed by Masuzawa and Toutholf (1997). In electrochemical etching, the bottle neck is in controlling the shape and size of micro tool. Wire electrical discharge grinding has the limitation of low productivity as stated by Lim and Kim (2001). Turning has the problem of bending of the work piece due to the turning force of tool.

These processes are expensive, time consuming and not suitable for small scale industries. In this article, we shall report a very simple process for the fabrication of micro tools i.e. micro grinding and lapping. The micro grinding setup is developed for this purpose. The tool is typically a tungsten rod 2 mm initial diameter with 5cm long is first prepared at the developed micro grinding setup, and then translated to the lapping setup for final finishing. Therefore high aspect ratio 150, diameter 12  $\mu\text{m}$ , height 1.8mm micro tool is generated on developed micro grinding and lapping setup.

## II. Experimental Setup for Generation of Micro Tool

As stated above, the developed micro grinding and lapping setup is used to fabrication of micro tools. An AC motor 8000 rpm is used for this purpose. The voltage controller is used to control the revolution of the motor by varying voltage. The one end of tool is hold in the motor shaft and another end is free in between adjustable supporting three grinder plates. The tool is rotates with the help of motor, free end of tool is rotates between grinder plates.

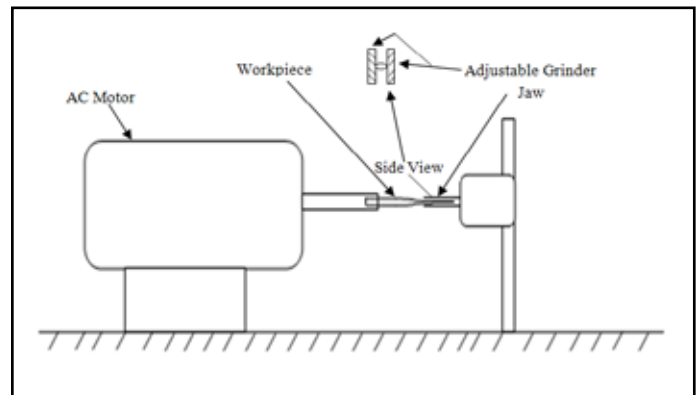


Fig. 1: Schematic View of Developed Micro Grinding Setup

The initial diameter of the tool is 2mm, which is reduces upto  $300 \pm 10 \mu\text{m}$  by this method. Table 1 reported the steps to perform successive micro tools with control of speed, time and gap between adjustable grinding plates.

Table 1: Steps of micro grinding

Steps	RPM	Machining Time (min)	Accumulated Time (min)	Gap ( $\mu\text{m}$ )	Tool Diameters ( $\mu\text{m}$ ) ( $\pm 10 \mu\text{m}$ )	
					Initial	Final
1	6000	8.15	8.15	2100	2000	1200
2	6000	7.10	15.25	1400	1200	800
3	4000	5.15	20.40	1000	800	500
4	3000	5.20	25.60	600	500	300

At the end of step 1, the front part of the tool is unremoved while only end part under grinding plate is removed. Then steps 2-4 are performed with a decreasing of speed and decreasing of gap of adjustable grinding plate. At the end stage, once the end part of tool has reached the  $300 \pm 10 \mu\text{m}$  diameter, the tool is translated to lapping process.

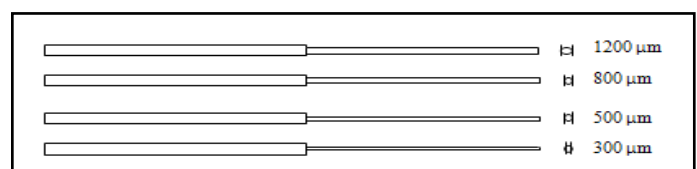


Fig. 2: Schematic View of Micro Tool During Grinding Steps

## III. Experimental Results

### A. Micro Tool Fabrication by Grinding and Lapping Process

After the first grinding step, the diameter of tool is reduced and the result is shown in Table 1. The result is shown in fig. 3, the conical effect is observed on tool surface by grinding process. This conical effect has been significantly reduced by lapping process. Fig. 4 shows an optical view of tool.

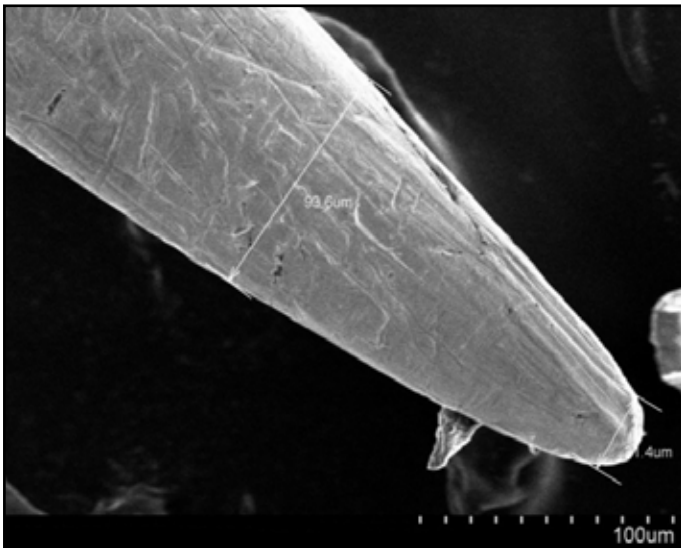


Fig. 3: SEM View of Micro Tool During Grinding Steps

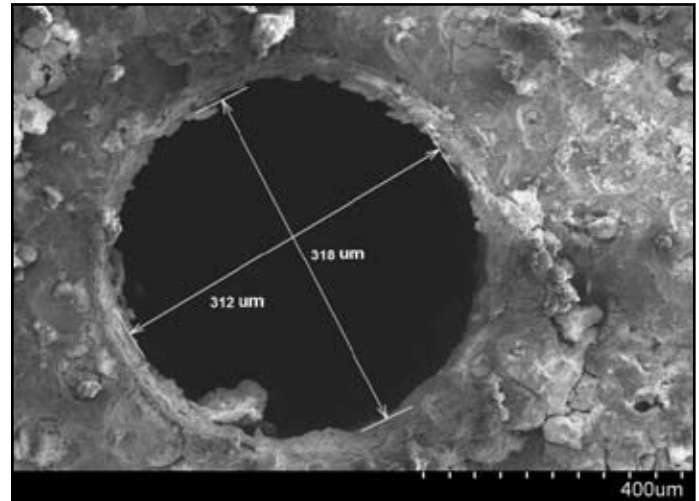


Fig. 5: SEM Photograph of Generated Micro Hole



Fig. 4: SEM View of Micro Tool After Lapping Process

Table 2: Generated Micro Tool Specification

S.No.	Tool Length (mm)	Tool diameter (μm)	Aspect Ratio
1	1.8	12	150
2	4	245	16.32
3	4	397	10.07
4	8.53	476	17.92

### B. Micro Holes Generation on Micro EDM by Fabricated Micro Tool

Micro holes were generated on micro EDM with fabricated micro tools by grinding and lapping process. Micro EDM can removal any material irrespective of its hardness provided they are electrically conductive. Fig. 5 show the micro hole was generated with parametric setting at 3 A supply current, 30 V spark gap voltage, 6 μs pulse on time and 2 μs pulse off time. From the SEM, it is clear that the shape of the generated micro holes is better circular.

### IV. Conclusion

Fabrication of tungsten micro tools have been reported with diameter ranging from 12 μm to 476 μm and aspect ratio ranging from 10.07 to 150 on developed micro grinding and lapping process. Preliminary examples of micro machining have been also reported with the 285 μm diameter tool on micro EDM. A micro hole 318 μm diameter is successfully generated by fabricated micro tool. Further optimization will be necessary to fabrication of more aspect ratio micro tools for micro machining. This micro tool fabrication method is very simple, low cost and required less time. Future research will concern the fabrication of micro tools with micro diameters as well as the increase of aspect ratio by modification in developed setup.

### References

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