

# A Study on Improving the Surface Roughness by Ion Beam Sputtering

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## 1. Introduction

Ion beam machining is used for ultra-precision machining of high-melting-point and hard, brittle materials, where machining depth needs to be precisely controlled<sup>1,2</sup>. The ion beam sputtering system has been investigated for decreasing surface roughness of mold & die material BLU(STAVAX) in our laboratory. We manufactured a 30keV, 20mA DuoPIGatron ion source for sputtering. The distance between Target cathode and Accel-electrode is 7.5mm and the distance between Accel-electrode and Decel-electrode is 3mm.

For ultra-precision machining of a large region in ion beam sputtering processes, a high current density ion beam and a large area ion source with a uniform beam extraction unit are necessary. To achieve a high current density and a large area ion beam with a uniform profile, we tried to develop extraction grid systems. The beam profile can be influenced by the multi hole extraction system and we got a uniform ion beam profile with a 4 hole system and solenoidal magnetic lens.

As a result, the surface roughness of mold & die material BLU(STAVAX) decreased from about 900nm to 500nm by a uniform Ar ion beam sputtering.

## 2. Methods and Results

### 2.1 Ion Beam Sputtering System

Ion beam sputtering system is designed to make an experiment on improving the surface roughness of mold & die at low cost, as shown in Fig. 1. The essential beam subsystems of this equipment are the ion source, solenoidal magnetic lens, sputtering chamber, vacuum system, automatic target system and beam diagnostic system.

### 2.2 Ion source

We manufactured a 30keV, 20mA DuoPIGatron ion source for sputtering(Fig. 2.). W filament of helix type is used as a thermal cathode. The intermediate electrode is made of mild steel and cone angle is 60 degree. The insulators are alumina rings and the extraction is a multi-aperture accel-decel system. Target cathode, Accel-electrode and Decel-electrode are also made of OFHC. The distance between Target cathode and Accel electrode is 7.5mm and the distance between Accel-electrode and Decel-electrode is 3mm.



Figure 1. Ion beam sputtering system for making an experiment on improving the surface roughness of mold & die BLU(STAVAX).

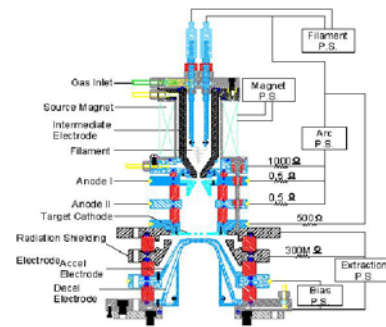


Figure 2. 30keV, 20mA DuoPIGatron ion source for ion beam sputtering.

### 2.3 Development of extraction grid system

To achieve a high current density and a large area ion beam with a uniform profile, we tried to develop multi hole extraction grid systems. We can get a high current density ion beam profile with a large area in case of 4 hole(PCD 23,  $\phi$ 8mm,12mm,12mm) extraction grid system(Fig. 3.).

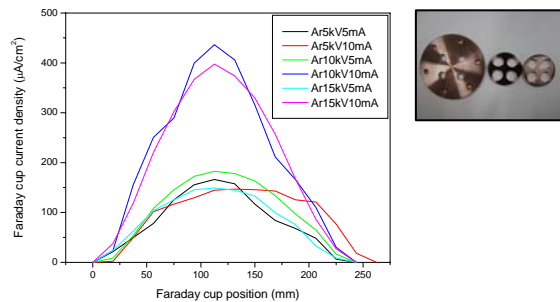


Figure 3. Profile of Ion beam in case of 4 hole system.

and we got uniform ion beam profiles with a solenoidal magnetic lens(Fig. 4)

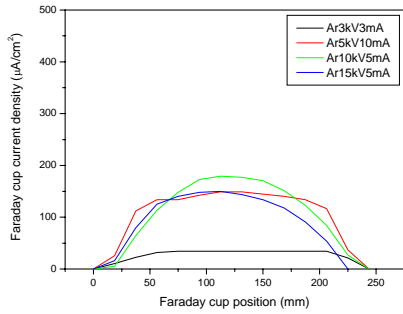


Figure 4. Profile of Ion beam in case of 4 hole system with a solenoidal magnetic lens

### 2.4 Experimental material

The 50 mm × 50 mm workpiece used in this study was high-chromium steel(STAVAX) known as alloy mold & die for BLU(Back Light Unit). Table 1 shows the chemical composition of the workpiece.

Table 1. Chemical composition of STAVAX (%).

Cr	C	Si	Mn	V
13.6	0.38	0.8	0.5	0.3

### 2.5 Experimental procedure

The ion beam sputtering was performed under the pressure of  $5.0 \times 10^{-5}$  Torr. The energy and the current density of argon ion were 3keV and  $35 \mu\text{A cm}^{-2}$ . A wide area over 140 mm in diameter can be uniformly sputtered. Fig. 5 shows the improving of surface roughness after ion beam sputtering.

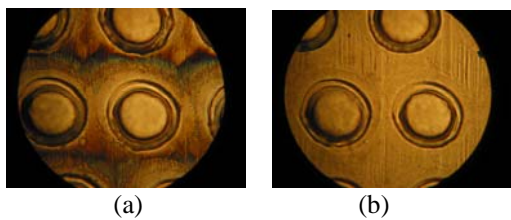


Figure 5. The picture of microscope. (a) Pristine (b) 3keV, Ar ion beam sputtered workpiece for 20hrs.

As a result of surface roughness measurement(NT-2000), the Ra(average surface roughness) decreased from 925.75 nm to 511.45 nm after 3keV, Ar ion beam sputtering for 20hrs.

### 3. Conclusion

The ion beam sputtering of high-chromium steel BLU(STAVAX) by argon ion was performed to investigate the improvement of the surface roughness. It was found that

- To achieve a high current density ion beam with a uniform profile, we tried to develop multi hole extraction grid systems
- In case of 4 hole system with a solenoidal magnetic lens, we got the lowest average error of current density at the broad beam region of 140mm
- We reduced the Ra(average surface roughness) of high-chromium steel BLU(STAVAX) from 925.75 nm to 511.45 nm through 3keV, Ar ion beam sputtering for 20hrs.

### REFERENCES

[1] I. Miyamoto and N. Taniguchi, Study of the Ion Sputter-Machining(2nd report) Fine Machining of Diamond, J Jpn Soc Prec Eng, Vol.46(8), p.1021,1980.  
 [2] N. Taniguchi. Ion Beam Machining on Ceramic, J Ind Mater Jpn, Vol.28(12), p.48,1980.