Etching Effect of an Atmospheric DC Arc Plasmatron

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1. Introduction

Thermal plasmas (especially arc plasma) were extensively industrialized, principally by aeronautic sector. Cold plasma technologies have been developed in the microelectronics but their vacuum equipment limits their implantation [1].

Plasmas used in dry etching, thin film deposition and surface treatment for display or semiconductor industries are operating at low pressures in very costly due to the use of vacuum equipment and vacuum components.

Use of DC arc plasmatrons in welding, soldering, and cutting of metals is well known. A DC-arc plasmatron with high durability was reported to be a suitable device for etching silicon and photo-resist surfaces [2].

2. Methods and Results

2.1 Experimental device and parameters

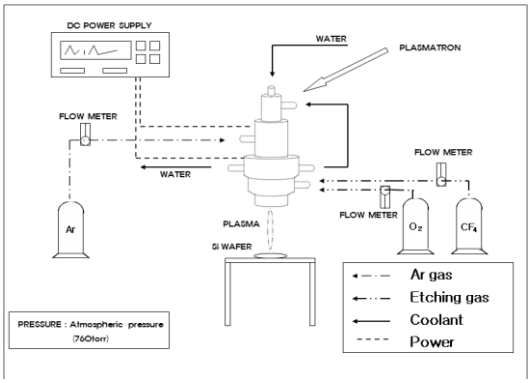

Fig. 1. A Etching system with a DC arc plasmatron

Figure 1 is shown a brief configuration by Dc arc etching plasmatron. This Plasmatron was developed by our research group, and power supply is 90 V, 350 A of the maximum output inverter DC TIG Welder is used.

This power supply voltage and high-frequency oscillator should have burning plasmas. This was a stable power supply.

Table I. Experimental condition of the plasmatron current
(argon: 5000 sccm, processing time: 60 sec.)

current (A)	CF_4 gas (sccm)	O_2 gas (sccm)
110	100	100
120	200	200
130	300	300
140	400	400
150	500	500

Table II. Experimental condition of the distance between exit cap to the substrate.
(argon: 5000 sccm, processing time: 60 sec.)

Distance (mm)	Current (A)	CF_4 gas (sccm)	O_2 gas (sccm)
5	150	200	500
10			
15			
20			
25			

2.2 Measurement and analysis of the etching rates.

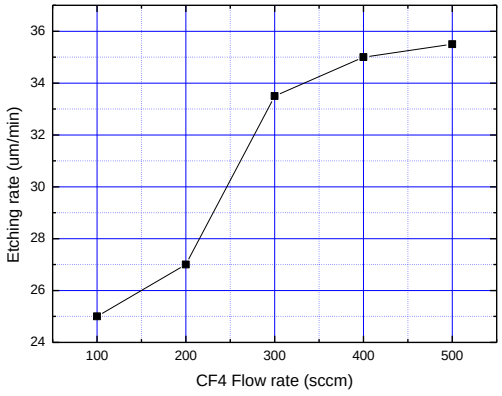

Fig 2. CF_4 flow rate on the etching
(O_2:300sccm, Ar: 5000sccm, Current: 150A, Distance: 5mm)

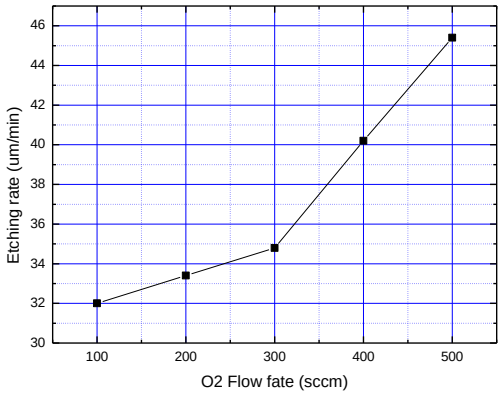

Fig.3. O_2 flow rate on the etching
(CF_4:300sccm, Ar: 5000sccm, Current: 150A, Distance: 5mm).

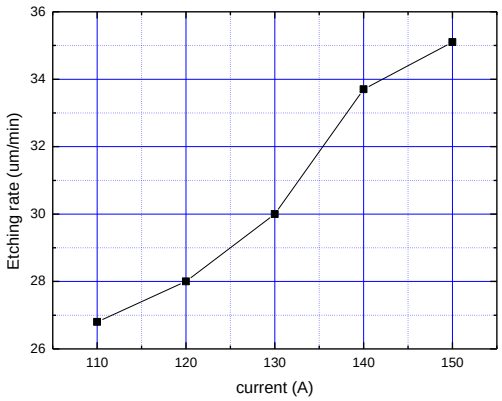

Fig.4. Current variation on the etching
(CF_4:300sccm, Ar: 5000sccm, O_2: 300sccm, Distance: 5mm).

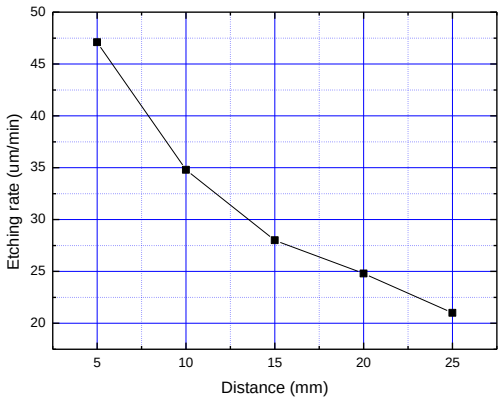

Fig.5. Distance variation on the etching
(CF_4: 300sccm, Ar: 5000sccm, O_2: 30 sccm, Current: 150 A)

2.3 Results and Discussion

At atmospheric pressure experiment, the substrate was lay at a distance of about 5–15 mm from the plasmatron exit to substrate. The etching of the mono-crystalline silicon was carried out in CF_4 plasma and etch of the surface was measured. To observe the etched silicon surface, a field emission scanning electron microscope (FE-SEM) is used.

The etching process was performed at the atmospheric pressure condition. Fig. 2, 3, 4 and 5 show etching rates on the CF_4 and O_2 flow rates, plasmatron current and distance. When flow rate of CF_4 and O_2 are 500 sccm, the results of etching rate are 35.5 and 45.5 μm/min respectively. The etching rates on the plasmatron current and distance are shown in a Fig. 4, 5 respectively. If the distance will be increased, substrate is not etched.

3. Conclusions

In this experiment, we found the optimizing conditions. When flow rates are CF_4 of 500 sccm, O_2 of 500 sccm, etching rates are very high. When plasmatron current and distance are 150A and 5mm, the etching rates show 35, 47.5 μm/min respectively. It is possible to fine optimal conditions on the quantity of working gas and distance. Main point to this data is that distance was very important with flow rate and current. Exactly, we need to short distance between exit cap to substrate for etching rate increasing. Atmospheric pressure plasmas have many advantages compared with vacuum plasmas on the economics of the processing equipment.

In this experiment, atmospheric pressure plasma etching process showed a possibility of the next generation processing. Also, this is expected to process like a cleaning and ashing processing.

In the future we have to research on increasing a processing area.

4. REFERENCES

[1] Claire Tendero, Christelle Tixier, Pascal Tristant, Jean Desmaison and Philippe Leprince, Spectroshimica Acta Part B, Vol. 61, p. 2 (2006)

[**2]** V. A. Riaby, V. Yu. Plaksin, J. H. Kim, Y. S. Mok, H. J. Lee, C. K. Choi, Journal of the Korean Physical Society, Vol. 48 (2006)