23P003-O

Spectral Analysis of Sputtered Atoms by Optical Emission Spectroscopy
発光分光法によるスパッタ粒子のスペクトル解析

K. Miyazaki[1], Y. Kobayashi[2], N. Matsuo[2], S. Nishiyama[3], M. Shinohara[1] and H. Fujiyama[1]
宮崎 清志[1]，小林 祐介[2]，松尾 直志[2]，西山 新一郎[3]，篠原 正典[1]，藤山 寛[1]

Graduate School of Engineering., Nagasaki Univ.[1], Graduate School of Sci. and Technol., Nagasaki Univ.[2]
Japan Fine Steel, Co. Ltd.[3]
1-14, Bunkyo-machi, Nagasaki 852-8521, Japan[1,2]
1-19-1,Ishiide,Sanyo-Onoda 756-0063,Japan[3]
長大院工[1]，長大院生産[2]　〒852-8521　長崎市文教町1-14
ジャパンファインスチール[3]　〒756-0063　山陽小野田市石井手1-19-1

In order to detect the end-point of metal etching process, it has been observed the temporal variation of copper emission intensity in coaxial magnetron plasmas by OES (Optical Emission Spectroscopy). The dependencies of Cu emission intensity on applied magnetic flux density, discharge current density and discharge voltage have been investigated.

1. Introduction

In the wafer slicing process of solar cell development, silicon wafers are carved out from a silicon ingot by saw wires. Saw wire is ultrafine metallic line with about φ0.12～0.16 mm in diameter, that is covered with brass (Cu: 65 %, Zn: 35 %) plating. This plating on wire is necessary in wire drawing process. However, copper which is basis of brass plating is diffused in the silicon wafer as contamination. As a result of the change of electric conductivity in wafers, it is caused decreasing of power generation efficiency of solar cell. Therefore before using saw wires in slicing process, it is necessary to remove the brass plating.

In the previous study [1], we could remove successfully the brass plating from wire surface by coaxial magnetron plasmas. According to the results of EDS analysis of wire surface after plasma treatment (Discharge voltage: -730 V, Discharge current density: 3.0 mA/cm^2) during 30 sec, Zn was removed after 10 sec and Cu after 30 sec. (Fe: 38.5 % → 97.7 %, Cu: 39.3 % → 2.43 %, Zn: 22.2 % → 0.03 %) However the end-point of etching process could not be detected on a real-time basis. So in this study, we aimed to detect the end-point of etching process from temporal variation of Cu emission intensity by OES.

2. End-Point Detection

Since Zn with low vapor pressure is vaporized by heat, we focused attention on Cu emission (especially 324.7 nm). If brass plating on wire surface is removed, Cu emission should not be detected. Thus we think of this point as the end-point of etching process.

3. Experimental

Cross sectional electrode structure is shown in Fig. 1. It is called triangle electrode structure. To generate coaxial magnetron plasmas, a brass rod applied negative voltage was placed at the center position of triangle. The gap length between electrodes and a brass rod was set 29 mm.

Spectroscope (AvaSpec-2048 produced by Avantes) was used for spectral analysis, it bring in fiber-optic cable with collimating lens (Confocal length: 8.7 mm) as shown in Fig. 2. The length between target and lens was fixed to 10 mm.

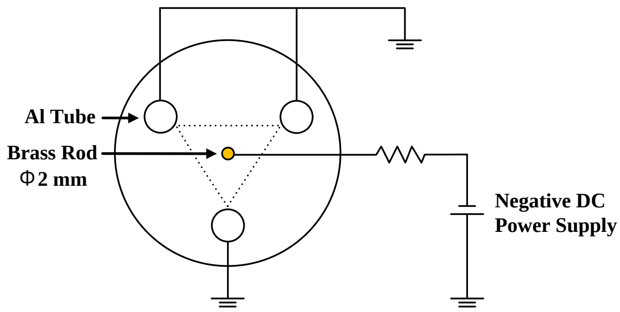

Fig. 1. Cross sectional view of electrode structure

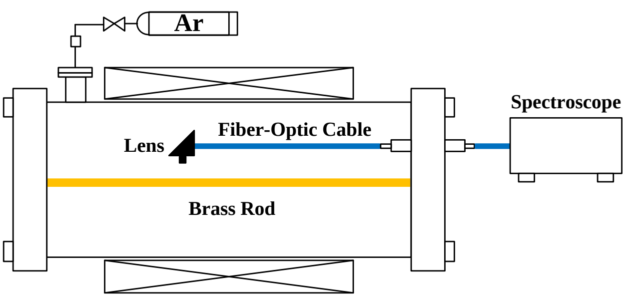

Fig. 2. Experimental setup

4. Results and Discussion

Figure 3 shows the optical emission spectra for both DC discharge and magnetron discharge. The experimental conditions for DC discharge are followings: Discharge voltage: -670 V, Discharge current density: 0.65 mA/cm^2 and Ar gas pressure: 20 Pa. On the other hand, the experimental conditions for magnetron discharge are followings: Discharge voltage: -550 V, Discharge current density: 5.0 mA/cm^2 and Ar gas pressure: 1 Pa. In Fig. 3, it is clearly shown the stronger emission of Cu (324.7 nm) in magnetron discharge than that in DC discharge. From the results of OES, it was found that the coaxial magnetron plasmas can effectively sputter Cu atoms even for the low discharge voltage condition.

Figure 4 shows the Cu emission spectrum as a parameter of discharge current density. Cu emission (324.7 nm) increased in proportion to the discharge current density. Figure 5 shows that Cu emission is proportional to the discharge current density and isn't changing with the applied magnetic flux density and the discharge voltage. Coaxial magnetron plasmas are generated under the following experimental formula [2].

$$J_d = A(aP^2 + bB^2)(V_d - V_0)^{3/2}$$

This formula represents to generate the constant discharge current density when three parameters (Gas pressure: P^2, Magnetic flux density: B^2, Discharge voltage: ${V_d}^{3/2}$) are changed. Thus B and V_d are of little relevance to emission intensity, they only have relevance to discharge current density.

5. Conclusion

Coaxial magnetron plasmas are used for etching process, when we analyze spectrum of sputtered atoms, we found that emission intensity changes come out with discharge current density. However emission intensity wasn't changing with magnetic flux density and discharge voltage.

For the future, we will analyze emission of saw wire as etching target, find out the temporal variation of Cu emission intensity.

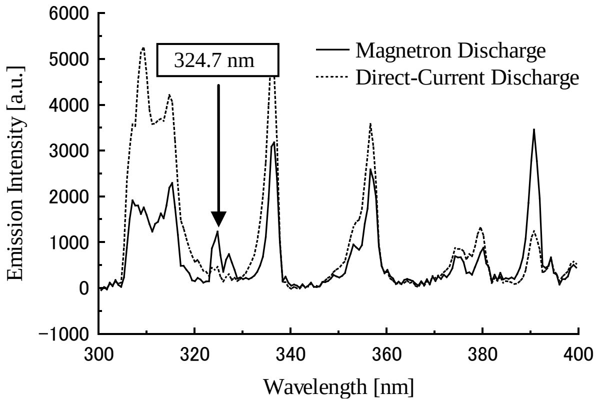

Fig. 3. Cu (324.7 nm) emissions from magnetron discharge and DC discharge

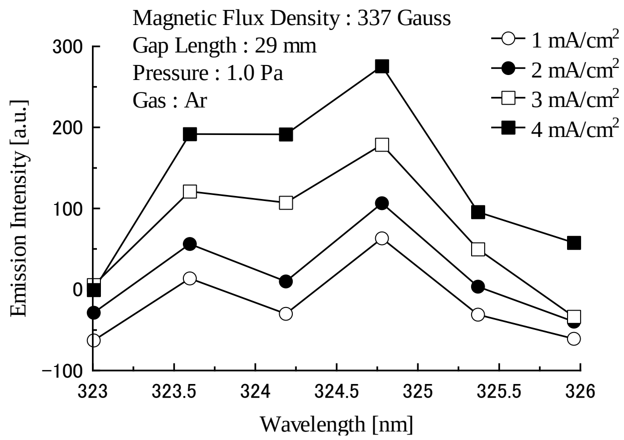

Fig. 4. Emission spectra as a parameter of discharge current density

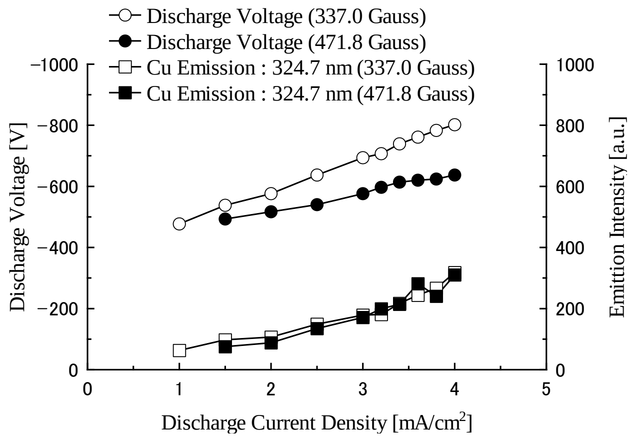

Fig. 5. Cu emission intensity and discharge voltage vs discharge current density

References

[1] H. Fujiyama et al: Proc. of the 8th Asian European International Conference on Plasma Surface Engineering, Dalian (2011)

[2] K. Kuwahara and H. Fujiyama: IEEE TRANSACTIONS ON PLASMA SCIENCE Vol. 22, No. 4 (1994)