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Fine Wire Stripping by Hybrid Plasmas at Medium Pressures
N. Goto¹, K. Tatsuishi¹, S. Nishiyama², N. Iwamoto³, Y. Tokunaga², M. Shinohara¹ and
H. Fujiyama¹
¹Graduate School of Science and Technology, Nagasaki Univ.,
²Japan Fine Steel CO., Ltd.
Nagasaki University, 1-14 Bunkyo-machi, Nagasaki 852-8521, Japan
*Tel: +81-95-819-2538, Fax: +81-95-819-2538, E-mail: plasma@nagasaki-u.ac.jp

Abstract
The study has aimed to remove the brass layer on fine wire by using plasma dry etchings. The discharge characteristics of newly developed line-shaped plasma and the effect of brass wire sputtering for various gas pressures are presented.

1. Introduction
Recently, increase of carbon dioxide emissions that causes global warming has become serious problem. So solar cell production with low carbon dioxide emissions is showing rapid increase. Silicon wafer used crystal silicon solar cell is carved out from the silicon ingot by saw wire. Saw wire (Fig.1) is covered with brass (Cu:65%, Zn:35%) plated to need in wire drawing process. As a result basis of plating (copper) are diffused in the wafer as contamination. So the electric conductivity changes, and there is a possibility of cause to decrease solar cell efficiency. Therefore the saw wire with Cu free is strongly required.

Now, in the factory, various wet processes by ammonia, hydrochloric acid, sulfuric acid and oxygenated water have been used as a method for removing brass plating. The processes have some disadvantages that the environmental load is large and generally very expensive. In the present research, we propose to use plasma dry process for wire stripping. Dry process have some advantages that the waste liquid treatment is unnecessary, pollution policy of flue-gas treatment etc. is easy and high reaction rate is obtained at low temperature.

We aim to remove brass plating by the present hybrid discharge with coaxial direct current discharge and low frequency glow discharge at medium pressures [1].

2. Experimental
The experiments were performed in argon gas for the moment. The hybrid plasma could be generated by applying of both low frequency power (1~10kVpp, 13kHz) to the glass coated triangle electrodes and negative direct current power (0~-1kV) to the substrate wire located in the triangle center, as shown in Fig.2. In the present experiments, we investigated the effect of sputter etching of brass wire under the 5kVpp of low frequency power supply and the negative DC bias voltage from -300 and -350V by varying the operating pressure from 100 to 300Pa.

The surface of wire after plasma treatment was determined mass percent of residual copper by using EDS (Energy Dispersive x-ray Spectroscopy).
3. Experimental Results and Discussions

Figure 3 shows the mass percent of residual copper after plasma stripping. In the figure, it is also shown those of untreated brass wire (39.3% of Cu) and brass stripped wire by the wet etching (0.12% of Cu) using of medicine that adds a small amount of oxygenated water to ammonia. In this figure, it is found that the mass percent of residual copper clearly decreased from 39.3% to 11.0% with gas pressure reduce from 300 to 100Pa at 100Pa interval under negative DC bias voltage set to -300 or -350V. So it is considered the sputtering process is useful to remove brass plating on the fine wire.

Figure 4 shows mass percent of iron of plasma stripped wire. In the same figure, it is also shown those of untreated brass covered wire (38.5%) and the removed wire by wet process (99.8%). From these experimental results, it is found that mass percent of iron increase from 38.5% to 82.9% with decreasing of the gas pressure. The surface of brass wire shows the decrease of mass percent of copper and increase of mass percent of iron with decrease of the operating gas pressure. It is considered that ion has sufficient energy to sputter the brass plated wire for low pressure conditions.

4. Conclusions

From the present research, it is confirmed that sputter etching at the Ar pressure of 100Pa can decrease Cu mass percent of wire surface by using sputter etching process. It is considered higher etching rate can be obtained for lower pressure condition.

For the moment, we can apply until the maximum 5kVpp of low frequency voltage to the electrodes. In near future, we will plan to enhance the low frequency power, and try hybrid process which combined sputter etching and chemical etching by using reactive gases.

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References