Generation of Three-Phase AC Triangle Plasmas for Fine Wire Stripping

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Abstract

We propose the removal method of brass plating on fine wire using plasma sputtering process. New type of line-shaped plasma source has been developed by applying three-phase alternating current voltage to triangle-type electrodes. The discharge characteristics of this plasma source will be reported.

Introduction

The silicon wafer used as a substrate for the crystal type solar cell is carved out from the silicon ingot by thin metallic wire that is called “saw-wire”. The brass plating (Cu: 65%,Zn: 35%) must be performed to the wire surface in order to the drawing process. Since, the basis of plating (copper) is easily diffused in the wafer as contamination. So the semiconductor bandgap changes, and then there is the possibility of decrease the efficiency of solar power generation. Therefore the Cu-free saw wire is strongly required. In the saw-wire factory, various wet processes by ammonia, oxygenated water and sulfuric acid have been used as a method for removing brass plating. Such wet processes have some disadvantages so that the environmental load is large and generally very expensive.

In the present research, we propose a rapid sputter etching method of brass plating in dry plasma process by using high density line-shaped plasmas generated by the three-phase AC triangle discharges.

Experimental Setup

Figure 1 show the experimental apparatus used in this research. The experiments were performed in argon gas. Plasma can be generated by applying three-phase AC power supply (3 ϕ 3W,

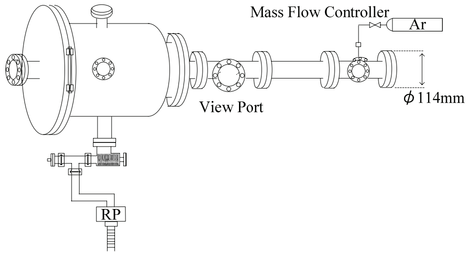

Fig.1 Experimental Setup

200V, 60Hz) to the triangle electrodes. DC power supply (800V, 0.2A) is also used as a power supply for the bias voltage to the wire.

The electrode systems are shown in Fig.2. Three tungsten rods were arranged in the equilateral triangle, and wire substrate was set in the center of triangle electrodes. Also the tension of the wire was kept by pulling from the one side of the wire with spring. In this study, the gap length between tungsten electrode and wire was set to 1mm and use tungsten wire of 0.25mm in diameter.

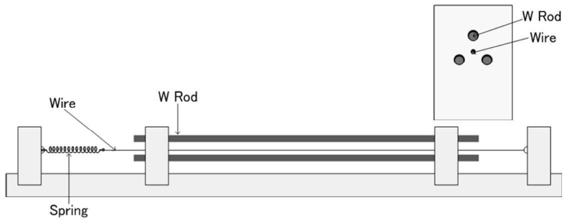

Fig.2 Electrodes system

Results and Discussions

With increasing the negative bias voltage to the wire, it is found in Fig.3 that the ion current density is also increased until about 0.35mA/cm^2 for the discharge voltage 200V and Ar gas flow 10sccm. When the higher operation pressure, 200Pa and 300Pa, it is found that rapid increase of the current density showing the other discharge mode.

Not only the three-phase AC discharge but also the direct current discharge between three electrodes started to superimpose over the critical bias voltage.

As a result, it is expected that high density hybrid plasmas by superimposing of three-phase discharge and direct-current one can be generated over the critical bias voltage.

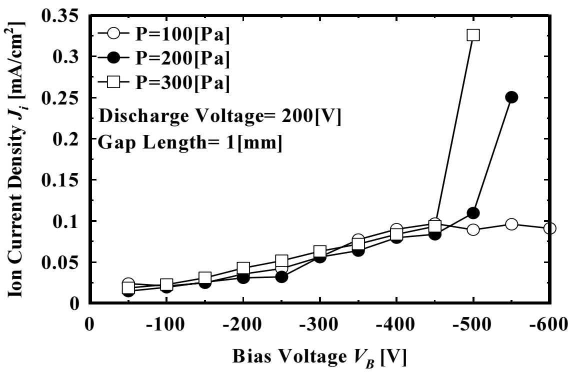

Fig.3 Ion Current Density to the Wire as a function of Negative Bias Voltage

Conclusions

Line-shaped plasma generated by the short gap three-phase AC discharge between triangle electrodes was successfully generated. When DC negative bias voltage applied to the wire over the critical value, expected hybrid plasmas could be generated. As a result, the plasma density around wire was increased rapidly.

The removal of the brass plating on saw wire is scheduled to be conducted in the future.