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高出力パルススパッタリンググロー放電プラズマの電気的特性
Electrical Characteristics of a Glow Discharge Plasma for High-Power Pulsed Sputtering

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Introduction

Surface modification of a material by a metal film or a ceramic film is an important process for various applications of the material. High-power impulse magnetron sputtering (HiPIMS) is one of the promising methods of droplet-free surface deposition because of its high power density and high ionization rate of sputtered metals [1]. However, its low target utilization efficiency and large size, limits installation in a practical use. A high-power pulsed sputtering (HPPS) discharge generated by parallel electric and magnetic fields at the ionization region was developed to overcome some disadvantage of HiPIMS [2]. In this paper, the influence of magnetic field on the electrical characteristics of the HPPS discharge (with magnets) is investigated and are compared with those of the hollow cathode discharge (without magnets).

Experimental Setup

A cylindrical vacuum chamber was evacuated to 5×10^{-3} Pa and the argon gas was fed into the chamber with the gas pressure of 9.5 Pa. A rectangular pulsed voltage with a pulse width of 600 μs and amplitude of -1000 V was applied to the target cathode. The repetition rate was fixed at 50 Hz. A 20 Ω resistor was connected in series to the cathode.

Figure 1 shows a schematic diagram of the HPPS discharge ion source. The HPPS discharge unit is compact in size (60 × 67 × 86 mm^3). A pair of rectangular Ti plates with a length of 60 mm, a height of 20 mm and a thickness of 5 mm was used as the sputtering target cathode. Two Ti target plates were placed on the opposite side with a gap length of 10 mm and set the permanent samarium-cobalt magnets (540 mT) in the magnet holders behind the targets. A magnetic field was produced perpendicular to the targets. The strength of the magnetic field in the gap was approximately 0.2 T.

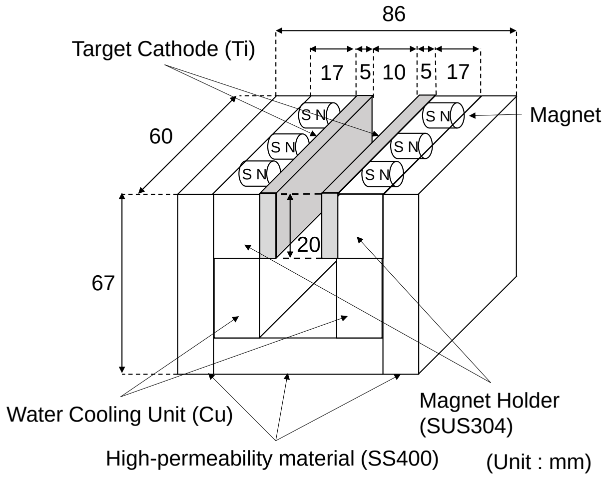

Fig. 1. HPPS discharge ion source.

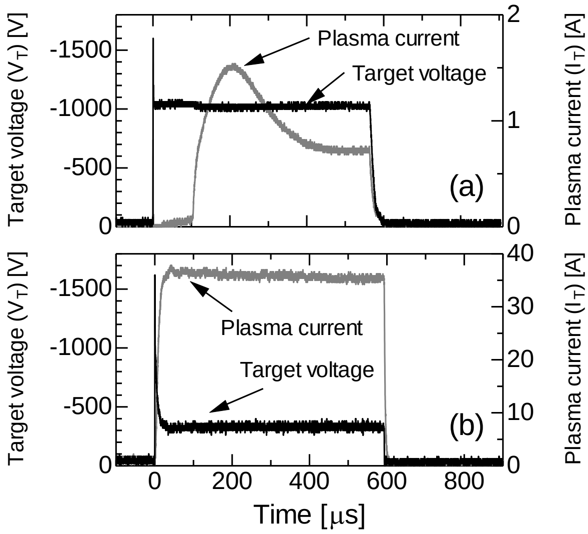

Fig. 2. Waveforms of voltage applied to the target and plasma current with and without magnets.

Results

Figure 2 shows the waveforms of voltage applied to the target and plasma current with and without magnets. The current density on the target with the magnets (HPPS discharge) was approximately 15 kA/m^2 and was one order of magnitude higher than that without the magnets (hollow-cathode discharge; HCD). The rise time of the plasma current has a delay of 100 μs in the HCD, whereas there is almost no delay time in the HPPS discharge. The consumed power of the HPPS discharge is 12 kW (=1.0 kW/cm^2), while those of the HCD is 0.6 kW. The glow discharge plasma is confined between the rectangular target plates by setting the magnets behind the target plates.

References

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