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Influence of gas species on characteristics of High-Power Pulsed Sputtering plasma

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Nitride films, such as titanium nitride and chromium nitride, have been used in various components because of their good wear, fatigue, and corrosion resistance. High-power impulse magnetron sputtering (HiPIMS) is one of the promising methods of droplet-free surface deposition owing to its high power density and high ionization rate of sputtered metals. However, target utilization efficiency is low, and the size of system is large. A high-power pulsed sputtering (HPPS) Penning discharge generated by parallel electric and magnetic fields at the ionization region was developed to overcome disadvantages of HiPIMS[1]. In the case of depositing nitride film, argon and nitrogen mixed gases are used. Although electrical characteristics of HPPS Penning discharge in argon gas have been reported[2], there is few reports in nitrogen gas. In this paper, the influence of gas species on electrical characteristics of HPPS Penning discharge.

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 put on the magnet holders in which permanent magnets set were placed on the opposite side with a gap length of 10 mm. A magnetic field was produced perpendicular to the targets. The strength of the magnetic field in the gap was approximately 0.2 T.

Figure 2 show typical waveforms of (a) target voltage and (b) target current at Ar gas and N_2 gas atmospheres. The target voltage was divided by the resistance and the plasma impedance. The target current that at Ar gas atmosphere was higher than N_2 gas atmosphere.

Figure 3 (a) shows the ion density as a function of vertical distance from the electrode surface measured by the floating double probe measurements. The probe was placed at the center between electrodes. The ion density decreased with increasing the vertical distance. Figure 3 (b) shows the ion density as a function of horizontal distance from the electrode. The probe is placed at 30 mm in vertical distance. The ion density was not affected the horizontal distance when the horizontal distance is less than 30 mm. However, when the horizontal distance is in the range of 40 to 80 mm, the ion density decreased with increasing the distance. The ion density at Ar gas atmosphere was higher than N_2 gas atmosphere.

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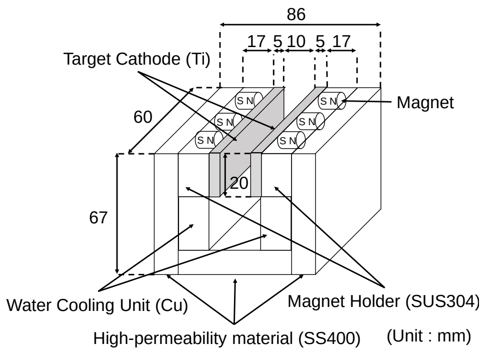

Fig. 1. HPPS Penning unit

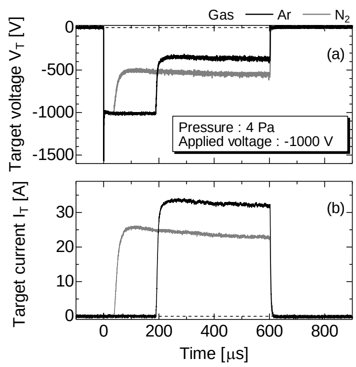

Fig. 2. Typical waveforms of (a) target voltage and (b) target current at Ar gas and N_2 gas atmospheres

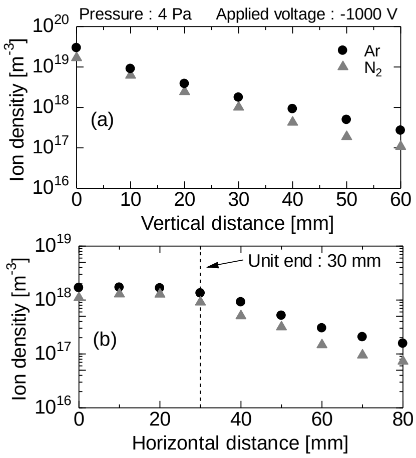

Fig. 3. The ion density as a function of (a) vertical distance and (b) horizontal distance from the electrode measured by the floating double probe

Reference

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