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TiN成膜用ハイパワーインパルスマグネトロンスパッタリングプラズマの気相診断

Gas phase diagnostics on high power impulse magnetron sputtering plasma for TiN deposition

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1. Introduction

TiN(Titanium nitride) having fcc(Face Centered Cubic) crystal structure has been used for hard coating materials in many industrial applications. In order to improve hardness, an ionization of sputtered species and a production of high energy ions are essential to realize a densification of TiN film. High power impulse magnetron sputtering (HiPIMS) is a pulse sputtering with peak power density of higher than 0.5 kW/cm^2 and pulse width of around 100 μs, realizing high ionization degree of sputtered species and a production of high energy ions. Plasma diagnostics is essential to clarify the ionization process on gas phase of TiN-HiPIMS and control the quality of TiN thin film. In this study, ion energy distribution function(IEDF) of ionic species in TiN-HiPIMS was measured with mass spectrometry.

2. Experimental

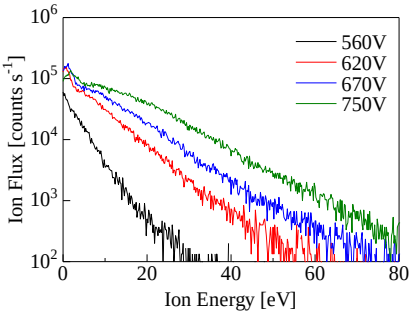
A negative pulse voltage with repetition frequency of 200Hz, pulse duration of 128μs was applied to the Ti target. The applied voltage was varied from 560V to 750V. The total gas flow rate was 5.6sccm, nitrogen gas flow rate ratio $N_2/(N_2 + Ar)$ was 50% and the working pressure was kept at 0.5Pa. IEDF were measured with an energy-resolved mass spectrometer. The orifice (diameter of 0.1 mm) of the mass spectrometer was set at opposite of the Ti target, and the distance between the target and the orifice was 84mm.

3. Results

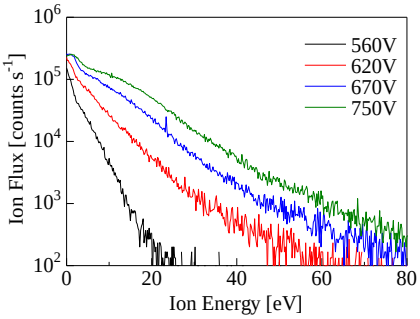
Figure 1 shows the IEDF of (a)Ti^+, (b)N^+ with various applied voltage. The measured IEDF included the information of ions produced from both pulse-ON and pulse-OFF time since the time-averaged measurement was carried out. The IEDFs of Ti^+ composed of low energy component around 3eV and high energy component. The total ion flux increased from 0.2 x 10^7 to 1.1 x 10^7 counts/s and high energy tail from 25 to 90 eV with increasing applied voltage. The low energy component would be mainly produced from an electron impact ionization of sputtered Ti atom during long pulse-OFF time. High energy Ti^+ would be produced from sputtered Ti atom by electron impact ionization, Penning ionization, and charge exchange with Ar^+ during pulse-ON time. As shown in Fig. 1(b), the shape and behavior of IEDF for N^+ was similar to those of Ti^+. These results indicated that N^+ would be dominantly produced from the absorbed nitrogen atom to target.

Reference

[1] A. P. Ehiasarian *et al*., J. Appl. Phys., **109**, 104314 (2011).



(a) Ti^+



(b) N^+

Fig. 1. Ion energy distribution function.