第62回応用物理学会春季学術講演会 講演予稿集 (2015 東海大学 湘南キャンパス)

Study of Temporal Behavior of Microwave sheath-Voltage combination Plasma

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Microwave sheath-Voltage combination Plasma (MVP) source [1-5] produces high density plasma. So an MVP source can be used as a suitable plasma processing device. In MVP sources, microwave plasmas are produced along a dielectric-free metal antenna and the surface waves propagate along the plasma-sheath interfaces. Here, we present the temporal behavior of MVP sustaining along a Ti rod (18 mm in diameter and 250 mm length) using Ar. At the early time of the MVP (at the beginning of microwave plasma), we can term it "oxidized state" (OS), where a thin oxidized layer of metal rod may prevent higher sputter yield, and at later times, we can term it "ionized sputter state" (ISS). Mode changing from OS to ISS, resulting plasma color changes (Fig. 1) and plasma density, which is estimated by Langmuir probe, increases significantly. In OS, plasma is dominated by Ar ions and the density is around $\geq 1\times10^{11}$ cm^{-3}. In ISS, metal ions would be dominated the ion composition and over-dense plasmas ($> 1\times10^{12}$ cm^{-3}) are generated (Fig. 2), which is much greater than the cutoff plasma density (i.e., 7.6×10^{10} cm^{-3} for 2.45 GHz). Normally, in conventional sputtering cases, plasma source is non-uniform (high density plasma near to the source). But in MVP sources, nearly uniform high density plasmas are produced by very low input microwave powers (around 30 W, which is much less than the conventional sputtering microwave power, greater than 200 W). Optical emission spectroscopy measurements are taken in ISS to observe the sputtered Ti ions and neutrals (Fig. 3). So MVP source can be used as a better sputtered deposition device.

Acknowledgement

This work was supported partly by DAIKO Foundation RESEARCH FELLOWSHIP PROGRAM in FY2014 and a “Grant for Advanced Industrial Technology Development (No. 11B06004d)” in 2011 from the New Energy and Industrial Technology Development Organization (NEDO) of Japan.

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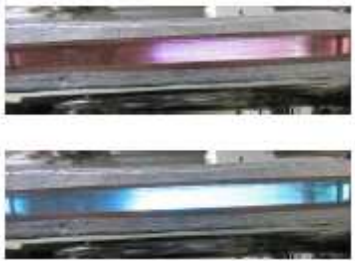

Fig. 1. Color changing from OS to ISS. The antenna starts from right side.

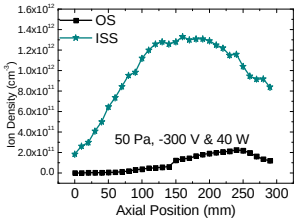

Fig. 2. Ion density distribution for OS to ISS. Measurements are taken from left side.

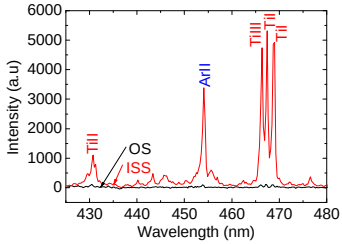

Fig. 3. Emission intensity for OS to ISS.