Topic number 8

Quantitative Evaluation of High-Energy Oxygen Negative Ion Flux in DC Magnetron Sputtering of Indium-Tin-Oxide

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Particle flux of high-energy (~a few 100 eV) negative ions from indium-tin-oxide target in DC magnetron plasma is evaluated quantitatively, using calorimetric method. Spatial profile of heat flux from the target is measured and localized heat flux originated from high-energy O^- ion is observed. From an O^- kinetic energy of 240 eV measured by an energy-resolved mass spectrometer, O^- particle flux of $2x10^{18}$ ion/m^2s is obtained.

1. Introduction

Indium Tin Oxide (ITO) is popular material as a transparent conductive film because of its low resistivity and high optical transmittance greater than 80%. So far, ITO films are used in many industrial applications, such as solar cell, touch panel, flat panel display, image sensor, and so on.

During the sputter deposition of ITO films, various species are coming to the film depositing surface such as high energy negative ion, positive ion or electrons. To give an insight into the key species for the film quality degradation, we have investigated sputter deposition of ITO films using a magnetron sputter device where 40 MHz VHF power is superposed to conventional DC power [1], reducing kinetic energy of high-energy oxygen negative ions. However, previous studies related to high-energy O^- ions did not mention absolute value of particle flux impinging on the surface, as far as we know. In this study, particle flux of high-energy O^- ions is quantitatively evaluated using calorimetric method.

2. Experimental Set-up

In the experiment, Ar gas is introduced into a cylindrical chamber (30 cm in diameter, 28 cm in height) at a pressure of 0.4 Pa. DC power (<250 V, <0.3 A) is applied to a magnetron sputtering ITO target (12 cm in diameter). A ring-shaped plasma of a 2 cm in radius is produced. A sheathed thermocouple is installed at a target-thermocouple distance of 10 cm. Heat flux is measured from an initial temperature increase rate of the thermocouple after turning on the plasma. To measure radial profile of the heat flux, the thermocouple is movable parallel to the target plate. To discriminate between isotropic heat flux originated from the plasma surrounding the thermocouple and anisotropic heat flux coming from the target, a small shield plate is installed in the vicinity of the thermocouple. Rotating the thermocouple with the shield plate, angle-resolved heat flux is measured and the heat flux originated from the high-energy O^- ions is evaluated.

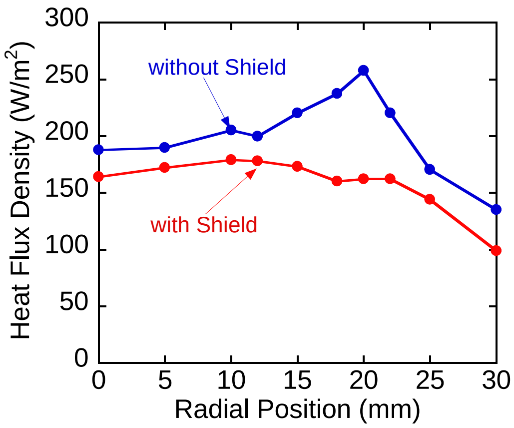

Fig. 1. Radial profile of heat flux with and without heat shield.

3. Results and discussion

Figure shows radial profile of heat flux with and without the shield plate at a discharge current of 0.3 A. With the shield plate, heat flux monotonically decreases with the radial position. Without the shield, however, local increase of the heat flux at a radial position of 2 cm, *i.e.*, just below the magnetron ring, is observed. From space-resolved mass spectrometry, localized high-energy O^- ion at the magnetron-ring radius has been also observed, and considering this fact, the peak of heat flux is considered to be due to the high-energy O^- ions. From the absolute heat flux measurement from O^- ions and O^- ion energy measurement by the energy-resolved mass spectrometer, particle flux of $2x10^{18}$ ions/m^2s is obtained taking account for energy loss by backscatter of surface-neutralized O^- ion and re-sputtering of ITO film by high-energy O^- ions.

Reference

[1] H.Toyoda: J. Vac. Soc. Jpn. **51** (2008) 258.