Topic number

RF plasma simulation using semi-analytical sheath model

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We have developed a simulation technique to calculate sputtering etch rate distribution by accelerated energetic ions in radio frequency(RF) sheath within short computation time, in order to develop a high density and low metal contamination plasma source. The estimated sputtering etch rate distribution on the RF antenna cover qualitatively reproduced the experimental result.

1. Introduction

We have developed a plasma model according to the equipment in order to design the new device [1]. This paper focuses on the RF plasma source. A RF plasma source is expected as one of the plasma source with low metal contamination and high density. The plasma is sustained by providing RF power of 13.56MHz through U-shaped antenna in chamber. The RF antenna is isolated by dielectric cover from plasma. In design, the sputtering etch rate distribution on the RF antenna cover is important. However, expensive calculation cost is needed for RF simulation. We introduce a new model which does not resolve sheath thickness by interface problem.

2. Method

2.1. Interface Problem

The electronic fluid equation in plasma connects to usual Poisson equation in antenna cover and chamber with semi-analytical RF sheath model. This is so called interface problem. The calculation cost can be reduced for the mesh of the sheath area can be ignored. We have developed a hybridized discontinuous Galerkin method to deal with this interface problems [2].

2.2. Semi-analytical RF sheath model

A unified RF sheath model for wide frequency region is proposed in this report [3]. First of all, we investigated the mathematical property of this RF model by method of dynamical system. The phase space diagram reveals stability of the trajectory. Thus far, the calculation diverged because the surface of the dielectric is positively charging if large voltage condition is applied to the antenna on numerical simulation. We found this phenomenon is not a numerical divergence but a problem in the physical model.

2.3. Ion Energy Distribution Function (IEDF) and sputtering etch rate.

The ion energy distribution on the RF antenna cover can be estimated from the potential waveform. An approximation of ion energy distribution is described with convolution integral by Green function and sheath voltage wave form under the some simple assumption [4]. The IEDF can be gotten by inverse Fourier transformation. Finally, the sputtering etch rate distribution is calculated by using the estimated IEDF and sputtering yield. The calculated sputtering etch rate distribution on the RF antenna cover is compared with result of measurement.

3. Results and Discussions

Fig.1 shows the sputtering etch rate distribution on the RF antenna cover. The calculated result qualitatively reproduced the experimental result. The rate in the proposed method is relatively larger than the rate in the conventional single frequency model on the power supply side (0, 0.8m). In the near future, we will perform experiment by improved design using simulation technique.

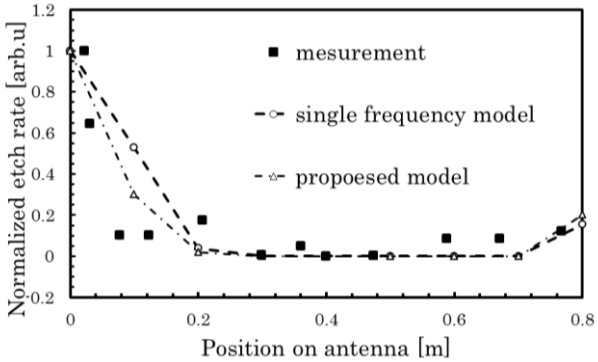

Fig.1 sputtering etch rate distribution on the RF antenna cover.

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