

論文 / 著書情報
Article / Book Information

題目(和文)	トモグラフィック発光分光計測と衝突輻射モデルにもとづくアルゴン誘導結合プラズマの位置分布診断
Title(English)	Positional Distribution Diagnosis of Argon Inductively Coupled Plasma Based on Tomographic Optical Emission Spectroscopic Measurement and Collisional-Radiative Model
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学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

(博士課程)
Doctoral Program

論文要旨

THESIS SUMMARY

系・コース :	電気電子	系	申請学位 (専攻分野) :	博士	(工学)
Department of, Graduate major in	電気電子	コース	Academic Degree Requested	Doctor of	(Engineering)
学生氏名 :	山下 雄也		審査員主査 :	赤塚 洋 准教授	
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

This thesis presents studies in diagnostic methods and findings for plasma diagnostics based on optical emission spectroscopic (OES) measurements. With backgrounds in both plasma science and engineering, the need for positional distribution diagnostics is becoming increasingly important. The objective of this thesis is to establish positional distribution diagnostics based on tomographic OES measurements and collisional-radiative (CR) models. The core content of this thesis consists of two published original papers. The first study focuses on the uncertainty of OES measurement-based plasma diagnostics caused by spectral reflectance of chamber inner wall. The second study finally established the objective of this thesis. In this thesis, 0.5-10 Pa argon (Ar) 13.56 MHz inductively coupled plasma (ICP) was employed as the experimental measurement target.

The first study addresses the issue of multiple reflected light from the chamber inner wall in OES-based plasma diagnostics. The multiple reflected light cases uncertainty in OES measurement of plasmas. However, the multiple reflected light has not been compensated for in previous studies. To resolve this problem, this study developed a simple method for measuring the spectral reflectance of the chamber inner wall. The developed method has a high degree of applicability to existing chambers. Additionally, a measurement method for the spectral emission coefficient was developed with compensation of multiple reflected light. This method reliably provides the radial distribution of the spectral emission coefficient under axial symmetry assumptions. Furthermore, the radial distribution of electron temperature (T_e) and electron density (N_e) was diagnosed based on the Ar CR model. This study employed 10 lines-of-sight on each side of the horizontal plane of the chamber, with separate sets for each side. The results showed that the uncertainty in T_e measurements increased by 0.6%, and the uncertainty in N_e measurements increased by 3.1% without correcting for spectral reflectance. These findings provide the first quantitative insight into the uncertainty of T_e and N_e due to multiple reflected light. The results suggest that accounting for chamber wall reflection improves the accuracy of OES measurement-based diagnostics. T_e and N_e were also measured with a Langmuir probe and compared with the proposed method. Electromagnetic simulations further revealed that T_e and N_e distributions are influenced by the shape of the antenna and the placement of the window.

The second study focused on positional distribution diagnostics without any positional assumptions. Most tomographic OES measurement studies have remained focused on observing positional distributions of spectral emission coefficients or excited-level number densities. Some studies of tomographic OES measurement diagnosed T_e or N_e by analyzing based on simplified excitation-kinetics. However, these oversimplify excitation kinetics, leading to significant discrepancies with real structures and limitations in the plasma pressures and generation principles to which they can be applied. This study established positional distribution diagnostics based on tomographic OES measurements and CR models. A spectroradiometric system was constructed to simultaneously measure spectral radiance dependence on 18 lines-of-sight. Additionally, the computation program was developed for line-of-sight dependency spectral radiance, including a wavelength interpolation algorithm to enable using multi-channel polychromators, even with wide wavelength resolution. The spectral tomography calculation program was developed by the constrained regularization algorithm. The positional dependence of spectral emission coefficients was reconstructed. The positional distributions of T_e and N_e were diagnosed based on the Ar CR model. The dependence of power and pressure on the positional distribution of T_e and N_e was revealed. This study further assessed the repeatable uncertainty of the spectral emission coefficient, T_e , and N_e . This study also discussed the dependence of reduced population density on the position.

In conclusion, this thesis presents innovative approaches to improving plasma diagnostics through OES and spectral tomography. The findings demonstrate that the proposed tomographic OES system is a valuable, non-invasive diagnostic tool for industrial plasma applications. This research contributes to advancing non-invasive diagnostic methods of plasmas and lays the groundwork for further innovation in diagnostics and related fundamental and applied fields.

備考 : 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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