05pE08P

真空紫外吸収分光計測用小型マイクロ波プラズマ光源の開発

Development of Coaxial Type Compact Microwave Plasma Light Source for Vacuum Ultraviolet Absorption Spectroscopy

鄭 霊東[1], Xijiang Chang[2], 佐々木 浩一[3], 永津 雅章[1,2]

Reitou Tei[1], Xijiang Chang [2], Koichi Sasaki[3], Masaaki Nagatsu[1,2]

[1]静岡大学工学研究科、[2]創造科学技術大学院、[3]北海道大学

[1]Graduate School of Engineering, Shizuoka University, [2]Graduate School of Science and Technology, Shizuoka University, [3]Graduate School of Engineering, Hokkaido University

1. Introduction

In the industrial applications of dry processing plasmas, excited atoms or molecules play an important role in surface chemical modification and chemical vapor deposition(CVD). In the most plasma processing, the excited atom or molecules is one of important parameter to control the plasma chemical reaction. In our previous work, O_2 and N_2 gas mixture surface-wave plasma (SWP) was used for the low-temperature plasma sterilization of medical instrument[1]. To study the role of the plasma on the sterilization, the information of excited neutral atoms or molecules generated by plasma discharge is inevitably important. The vacuum ultraviolent absorption spectroscopy (VUVAS) technique was used to measure the absolute oxygen atom density in processing plasma. Its advantage is that the measurement will cause less interference to plasma.

In this work, we developed the coaxial type compact microwave plasma light source to measure for the VUVAS, which is able to measure excited oxygen and nitrogen atoms in nitrogen plasma.

2. Experiments

For the VUVAS method, we developed a compact plasma light source. The new type microwave induced plasma (MIP) light source is based on the coaxial type SWP discharge, driven by 2.45[GHz] microwave up to 100[W]. Figure 1 shows the light source structure and photo of discharge. With different working gas filled in, many certain emitting lines can be produced for different purpose.

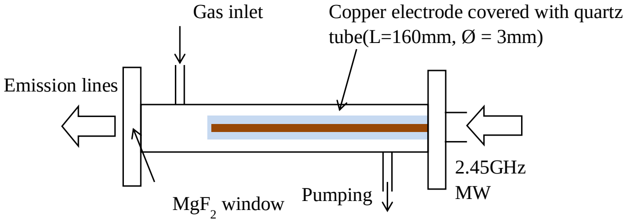

Fig.1 Structure of the MIP light source

3. Results

In this study, we intend to use the VUVAS method to measure the absolute oxygen and nitrogen atom densities in the O_2 and N_2 gas mixture plasmas. As references, the emitting lines for oxygen atom density measurement should select near resonance line which is near 130 [nm]. There are three lines, 130.22 [nm] ($3s^3S_0$–$2p^{43}P_2$), 130.49[nm] ($3s^3S_0$–$2p^{43}P_1$), 130.60 [nm] ($3s^3S_0$–$2p^{43}P_0$) near resonance line. The absorption of these lines can be used to calculate the oxygen atom density in the SWP.

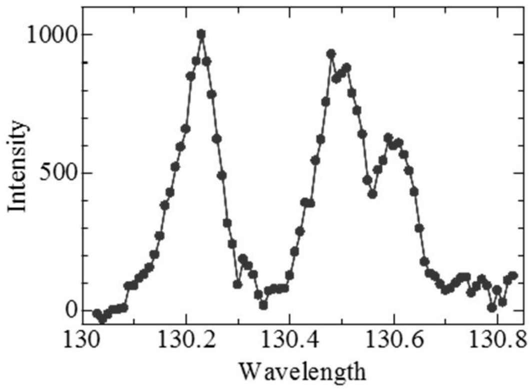

Fig.2 Light source spectra with O_2/Ar discharge

Figure 2 shows the O line emission spectra of light source, where light source was operated at pressure of 1[Pa] and gas ratio O_2/Ar =1:100 with an incident microwave power of 75 W.

To check the self-absorption effect on 130.5[nm] line, we measured the absorption of incident light through SWPs under the fixed condition (O_2 , 0.1[Torr], 600[W]) using different light source conditions. We found that with lower power and lower pressure conditions, the absorption at 130.5 nm kept almost constant. It seems that the self-absorption can be ignored by controlling the light source operating conditions. We obtained the oxygen atom density in the pure O_2 plasma from 0.6×10^{12} to 1.1×10^{12} cm^{-3} when the incident power changed from 300 to 900 W at pressure of 13.3 Pa. Present results revealed that the oxygen atom densities in N_2/O_2 SWPs are clearly correlated with the etching phenomena of the spores observed in the previous sterilization experiments.[1]

Reference

[1]Y. Zhao, A. Ogino, M. Nagatsu, Jpn. J. Appl. Phys.: 42 (2011) 08JF05.