Optical measurement of meter-scale microwave line plasma under atmospheric pressure

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Meter-scale microwave line plasma is produced under atmospheric pressure using a loop-waveguide with a microwave circulator to suppress ununiformity of electromagnetic field inside the waveguide, and is investigated by an optical emission spectroscopy. Gas temperature and electron density of argon plasma are ~600 K and ~10^{20} m^{-3}, respectively, and are spatially-uniform in 80 cm in length.

1. Introduction

Recently, large-area surface treatment using atmospheric-pressure (AP) plasma attracts much attention due to its cost benefit and a variety of possibilities for industrial applications. As a new AP plasma source for large area processing, we have proposed a one-dimensionally long-scale AP microwave plasma source using a loop-waveguide system, where plasma uniformity is realized by suppression of standing wave inside the waveguide. Using this plasma source, spatially-uniform line plasma of 40 cm in length has been realized with helium gas and cw microwave power of 1.0 kW [1]. Furthermore, production of pure molecular gas line plasma inside a slot of 50 cm in length has been realized by improving the waveguide structure to increase power efficiency [2]. To apply this plasma source to industrial processing, understanding of the plasma characteristics such as spatial uniformity, gas temperature, plasma density and plasma-sustainment mechanism are important. In this study, plasma parameters are investigated by optical emission spectroscopy (OES).

2. Experimental Setup

A microwave source (2.45 GHz, power: <5.0 kW) is connected to the circulator through an impedance matcher. A slot antenna of 0.1 mm in gap width is cut along the modified ridge waveguide wall. Discharge gas (Ar: 14 slm) is introduced into the waveguide through small holes and is released through the slot. Plasma is produced inside the slot by applying microwave power. Spatiotemporal distribution of the plasma is investigated by a digital still camera and an optical multi-channel analyzer through an optical fiber. Gas temperature and electron density are measured from N_2 second positive band profile and Stark broadening of H_β spectrum, respectively. Microwave powers at the upstream and downstream of the slotted waveguide are monitored by crystal mounts.

3. Results and discussion

Firstly, the line plasma is produced with an input microwave-power of 500 W to a slot of 1.1 m in length. The emission intensity monitored by the digital camera is quite uniform and its spatial fluctuation is less than 8% in 80 cm around the slot center. Spatial profiles of the gas temperature and electron density are shown in Figure 1 and are uniform at ~600 K and ~10^{20} m^{-3}, respectively. These results suggest that meter-scale almost uniform plasma with low temperature and high plasma density is realized by using the plasma source.

Acknowledgement

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References

[1] H. Suzuki et al.: Appl. Phys. Express **8** (2015) 036001.

[2] H. Suzuki et al.: 69th Gaseous Electronics Conference, 2016, NW3.7

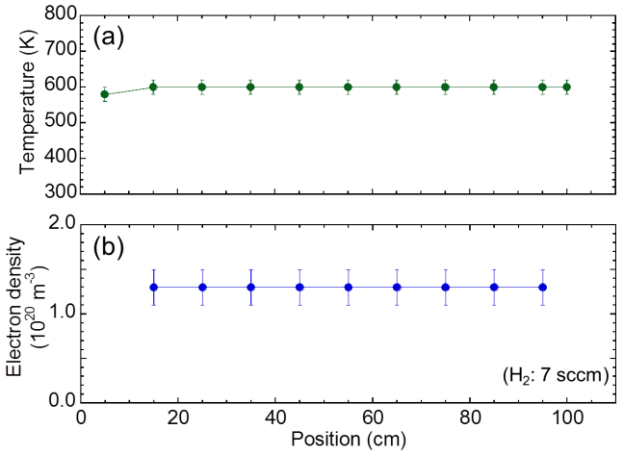

Fig. 1. Spatial distributions of (a) N_2 rotational temperature and (b) electron density along the slot.