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ヘリウムマイクロプラズマにおけるシース部の禁制線計測と電場評価
Measurement of He I forbidden transition and electric field in sheath region of microhollow cathode plasmas

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Micro-hollow cathode discharges (MHCDs) can readily generate non-equilibrium plasmas that are an alternative means for surface treatments, optical sources and detoxification of gaseous pollutants. We have determined the plasma parameters (electron density and gas temperature) by emission spectroscopy for atmospheric pressure He discharge, so far [1] . However, since the strong electric field is formed in the cathode periphery, the analysis of the spectral profile yielding the parameters becomes complicated. In order to evaluate the field strength, we measure the forbidden transitions attributed to He atom (He I: 2P-4F singlet 492.1 nm) which appears due to the level mixing with 4D level in the strong electric field.

The MHCD with a diameter of 1.0 mm is operated under a discharge current of 8 mA, voltage ~300 V and He gas pressure up to 30 kPa (flow rate: 0.5 L/min.). A visible spectrometer with a focal length of 1 m and 2400 grooves/mm is used to observe the high-resolution spectra. The instrumental width is around 9 pm at 632 nm. The spatial distribution of the emission spectra of He I singlet 2p-4D (allowed) and 2p-4F (forbidden) transitions are measured.

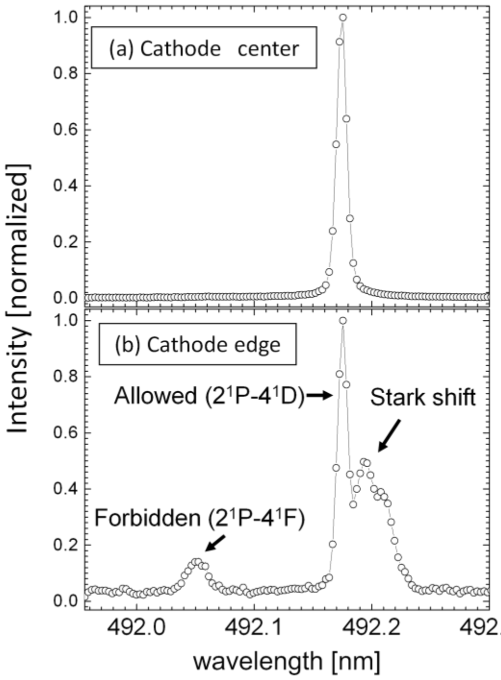

Fig. 1, He I allowed and forbidden spectra at the cathode center (a) and periphery (b).

Figure 1 shows the spectra observed at the center (a) and edge (b) of the cathode electrode. At the cathode periphery, the forbidden line is clearly seen on the left side of the allowed transition. As the intensity ratio of forbidden to the allowed lines is a function of the field strength [2], we evaluate the electric field strength by using the ratio. The field strength of 15 kV/cm is obtained near the cathode surface. On the other hand, the spectra composed of some lines are also observed in the red wing of the allowed transition (see Fig. 1 (b)). The reason for these composents could be explained by the Stark shifts of the allowed transition, since the 4D state splits into 3 levels depending on the magnetic sublevels. The quantitative comparision with the shift values calculated by the perturbation theory will be described in details.

[1] S. Namba et al., J. Appl Phys., , 110. 073307 (2011)
[2] K. Kawasaki et al., J. Phys. Soc. Jpn .51, pp. 3666 (1982).