表面磁場で閉じ込めた大容積パルスプラズマのカーリングプローブ時空間測定

Curling Probe Spatio-temporal Measurement of Large-Volume Pulsed Plasma with Surface Magnetic Confinement

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1) Introduction

As well known, a plasma can be confined within a magnetic field *B* owing to suppression of diffusion loss to a vessel wall. On the other hand, a plasma produced in a region of *B*~0 can be confined by a magnetic field near the wall surface. This concept of *surface magnetic confinement* (SMC) was applied to an inductively coupled plasma source [1]. Dramatic effects of the SMC were observed such as ultra-low pressure discharge (~3×10^{-3} Pa).

Here we report a curling probe (CP) measurement of a meter-scale plasma produced by a 1 kV pulsed discharge at 0.3-5 kHz with the SMC for plasma CVD of DLC (diamond-like carbon). The electron density is obtained from a shift of resonance frequency of spiral antenna in plasma ON and OFF monitored by a network analyzer (NWA). In the case of pulsed glow discharge, synchronization of discharge pulse with a frequency sweep of NWA must be established.

2) Experiment

As shown in Fig.1, a glow discharge plasma is produced typically at 1 kHz in various gases (Ar, N_2, C_2H_2) in (a) small chamber (60 cm diam.) without the SMC, and in (b) large chamber (105 cm diam.) with a surface magnetic field (~0.03 T) provided by permanent magnets around a cylindrical anode.

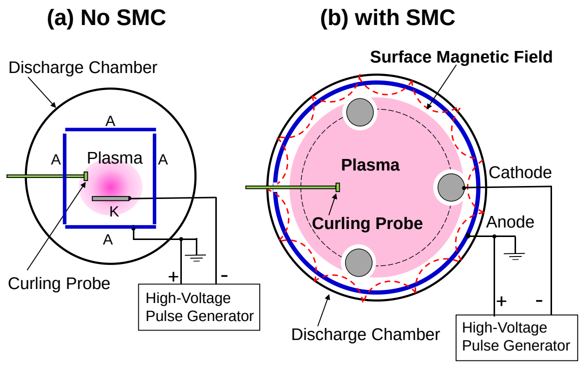

Fig. 1.Discharge apparatuses.

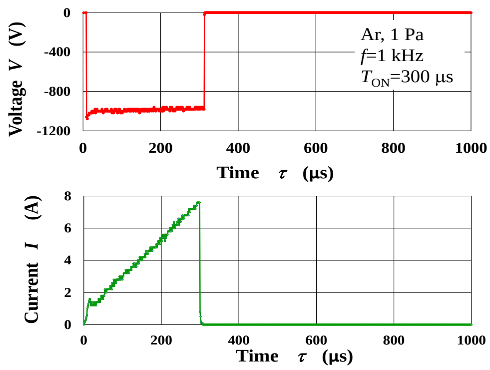

Fig. 2. Discharge V-I characteristics with SMC.

As shown in Fig.2, compared to the small chamber the large chamber with SMC leads to a discharge at 1 Pa(1/10th the pressure) with half the discharge voltage (V = -1kV) and ten times the discharge current (*I*=8A peak).

As illustrated in Fig. 1, the CP is radially inserted in the discharge chamber. A frequency sweep of the NWA is triggered by the discharge pulse, and a reflected signal from the CP is digitally measured, point by point, at a specified delayed time τ, which gives a time variation of electron density as shown in Fig. 3. A marked effect of the SMC is observed: decay of electron density is very slow, thus yielding a significant amount of steady density.

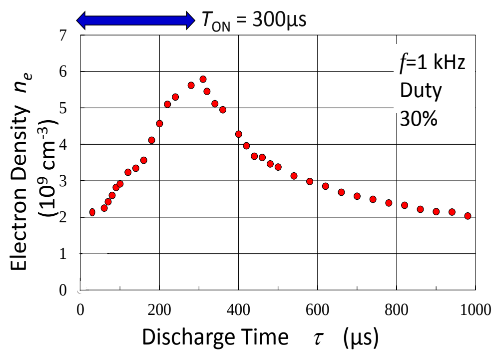

Fig. 3. Time variation of electron density.

[1] T. Shirakawa, H. Toyoda, and H. Sugai: Jpn. J. Appl. Phys. **29**, L1015 (1990).