§8. Neutral Particles at the Boundary of a Microwave Discharge Plasma

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The pressure modulation of neutral gas particles in the frequency range of 10 kHz was measured near the cylindrical inner wall surrounding a microwave discharge plasma in ordor to study the relation of neutral particles with a plasma.[1]

The experiment was performed in the HYPER-I device as illustrated in Fig. 1 (a) with a profile of magnetic field intensity on the axis, which is indicated in Fig. 1 (b). A piezoelectric transducer (FUS-300A) with the outer diameter of 13 mm on the top of a cylindrical support was set in the port at $z = 1175$ mm and the surface of the transducer was retracted by 10 mm from the inner surface of the vacuum vessel in the radial direction. The sensitivity of the output of the transducer is considered to be independent of a frequency in the range of $\sim$ 10 kHz, since its resonant frequency is 300 kHz. To measure ion saturation currents, two Langmuir probes with the bias of -90 V were used. One (Probe A) was set at $z = 1555$ mm from the same side with the transducer, which can be moved in the radial direction, and the other (Probe B) at $z = 1175$ mm, which was the same axial location with the transducer, and at $r = 140$ mm from the opposite side to the transducer.

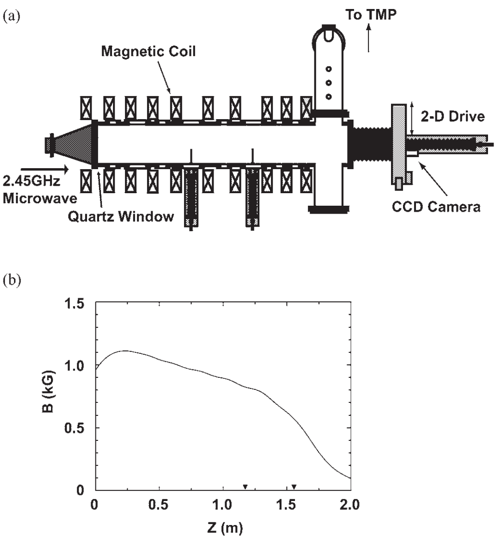

Fig. 1: (a) Sketch of HYPER-I device and (b) profile of magnetic field intensity on the axis.

In the case of a microwave power of $P_\mu = 12.5$ kW and a helium gas pressure of $p = 3.0 \times 10^{-3}$ Torr, time traces of the output of the transducer and the ion saturation current at $r = 140$ mm of Probe A ($z = 1555$ mm) were obtained at $t \simeq 2.0$ s after the breakdown, as shown in Figs. 2 (a) and (b), respectively. The sampling frequency is 20 MHz. The most significant frequency component of the two time traces is $\sim$ 7 kHz, although higher frequency components of the time traces of the transducer ($\sim$ 12 kHz and $\sim$ 20 kHz) do not agree with frequency components of the ion saturation current of Probe A. However, the frequency component of $\sim$ 12 kHz is seen in frequency components of the ion saturation current of Probe B.

Under the experimental condition, the mean-free-path of the neutral particles, $\lambda_{\rm mfp}$, is comparable with the expected wavelength of the sound wave, $\lambda_{\rm s}$, or $\lambda_{\rm mfp} \sim \lambda_s$. This indicates the observed pressure modulation is not derived by sound waves. However, it is noted that the pressure modulation can propagate even in the condition of $\lambda_{\rm mfp} > \lambda_{\rm s}$.[2] Then, it is considered that the observed pressure modulation is caused by the density and/or velocity modulation of neutral gas particles.

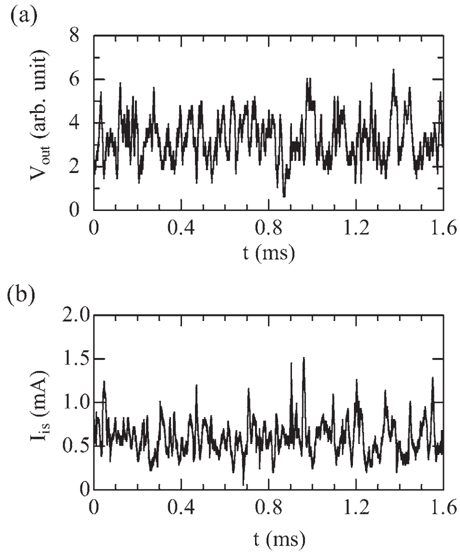

Fig. 2: (a) Time trace of output of transducer ($z = 1175$ mm) and (b) that of ion saturation current of Probe A ($z = 1555$ mm) at $r = 140$ mm in the case of $P_\mu = 12.5$ kW and $p = 3.0 \times 10^{-3}$ Torr.

1) A. Tsushima, S. Yoshimura, Y. Saitou, 19th Toki Conf. (Toki, 2009) P2-58.

2) A. Tsushima, T. K. Tanaka, J. Phys. Soc. Jpn. **70** pp. 1805-1808 (2002).