§2. Intermittent Excitation of Hot Spot in an ECR Plasma

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Intermittent behavior of plasma can be seen in thermally non-equilibrium open systems, for example the solar flare in the sun and the plasma blobs in the magnetically confined fusion devices and the laboratory. Recently, an intermittent behavior of floating potential signal has been observed in a linear electron cyclotron resonance (ECR) plasma.[1, 2] This phenomena occurs randomly, and the probably density function of waiting time follows an exponential distribution. In order to clarify the mechanism of the intermittent floating potential behavior, we have studied the spatiotemporal behavior of the phenomenon.

The experiment was performed in the HYPER-I device[3] at NIFS. The device has a cylindrical vacuum chamber with 2.0 in axial length and 0.3 m in inner diameter. The eight magnetic coils produced a weakly-diverging magnetic field (< 0.12 T). Plasma was produced by ECR heating with a 2.45 GHz microwave (the microwave power of 20 kW and a helium gas pressure of 1.5 mTorr in this experiment).

To obtain the 2D structure of the intermittent phenomenon, we developed the high-impedance wire grid (HIWG) detector.[4] The HIWG detector consists of the electrically isolated 16 wire electrodes (8 horizontal and 8 vertical) as shown in Fig. 1(a). Each wire measures the floating potential as shown in Fig. 1(b), and the 2D distribution of the floating potential spikes is reconstructed by making a structure matrix defined by geometrical mean of floating potentials, $F(j = 1, 2, \cdots, 8, k = 1, 2, \cdots, 8)$. Figure 1(c) shows the time slices of a single event, and the growth and decay process of the floating potential spike with typical diameter of 40 mm is clearly visualized.

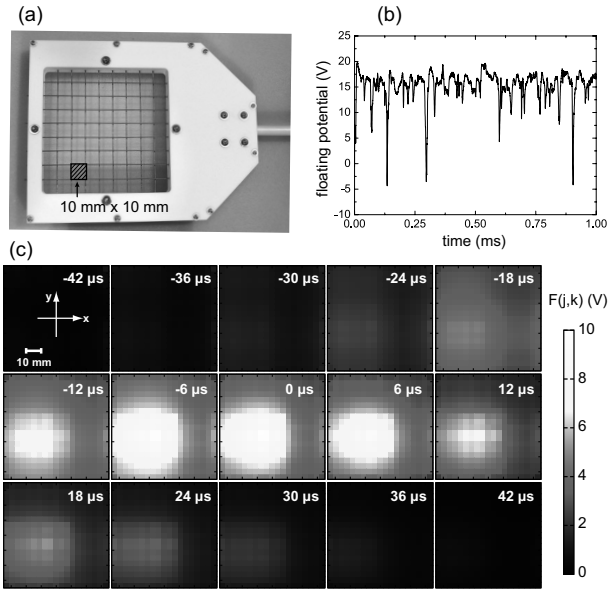

Fig. 1: (a): A picture of the HIWG detector, and (b): time series of floating potential. (c): Time slices of the reconstruction result.[4]

We also evaluated the electron density, electron temperature, and also neutral gas density with an ICCD camera. The camera measures the line-integrated emission along the axis of chamber. A Langmuir probe was also introduced to extract the trigger signal for conditional operation of ICCD camera. Figure 2(a) shows the conditionally averaged 2D distribution of emission intensity ratio of 728 nm spectral line (He-I) to 706 nm one (He-I). Since this ratio has a positive dependence to the electron temperature, it is found that the high electron temperature region (hot spot) with a diameter of 40 mm is produced in the plasma. Figure 2(b) shows the temporal behavior of the electron temperature inside and outside the hot spot. The temperature is evaluated from the conditionally averaged current-voltage characteristic of Langmuir probe. The electron temperature locally increases and reaches about 25 eV, and then, decays within 30 μs.

These results indicate that a growth-decay process of high electron temperature region (hot spot) occurs in the ECR plasma. The spatiotemporal behavior of the hot spot seems to be similar to the bubbles in boiling water.

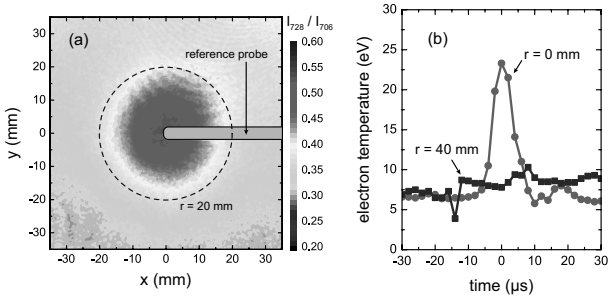

Fig. 2: (a) 2D distribution of emission intensity ratio between two He-I spectral lines. (b): Temporal behavior of the electron temperature in the center of hot spot (circles) and outside the hot spot (boxes).

1) S. Yoshimura *et al.*: JPS conf. Proc. **1** (2014) 051030.

2) S. Yoshimura *et al.*: Plasma Fusion Res. **10** (2015) 3401028.

3) S. Yoshimra *et al.*: J. Plasma Phys. **81** (2015) 345810204.

4) K. Terasaka *et al.*: Rev. Sci. Instrum. **85** (2014) 113503.