§14. ECH Plasma Experiments with an Internal Coil Device Mini-RT

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In the internal coil device Mini-RT which has magnetically-levitated HTS coil, overdense plasma was observed. We considered about the possibility of heating by electron Bernstein wave (EBW) which enables us to heat overdense plasma.

Mini-RT has steep magnetic field gradient and it means that many harmonic electron cyclotron resonance (ECR) layers appear in the plasma confinement region. Figure 1 shows the cross section of Mini-RT.

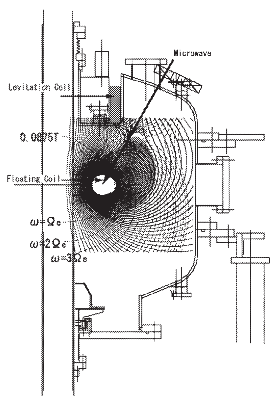
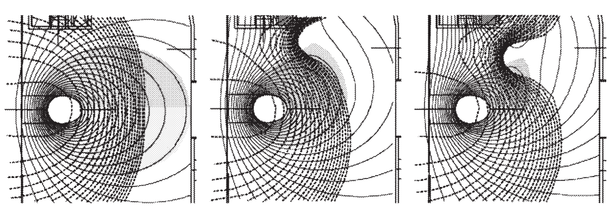


Fig. 1 Cross section of Mini-RT. Solid and dashed lines are contours of $|\boldsymbol{B}|$ and magnetic field line, respectively.

Experiments were carried out with F-coil supported. To control the plasma confinement region, we have applied a levitation coil current I_L. This enables us to change some important parameters for mode conversion, e.g. the characteristic scale length of density gradient. Examples of magnetic flux plot are shown in Fig. 2. Microwave with X-mode was injected from low field side and it was fed at a 30 degree to vertical. In this case, mode conversion efficiency C_B is given by

$$C_B = e^{-\pi\eta}(1 - e^{-\pi\eta}). \qquad (1)$$

where η is called tunneling factor which is determined by the distance between R-cutoff and UHR locations. The frequency and power of microwave were 2.45GHz and 2.8kW c.w., respectively. Filling gas was hydrogen with



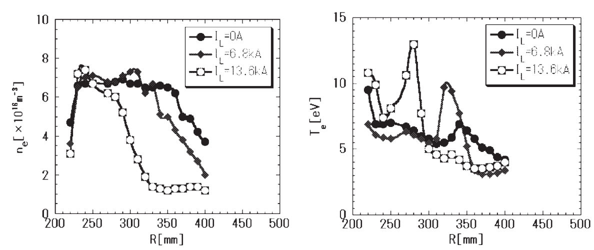
(a) I_L=0A (b) I_L=6.8kA (c) I_L=13.6kA

Fig. 2 Magnetic configuration and plasma confinement region on Mini-RT, where a floating coil current is fixed to be I_F=28kA in all three cases.

pressure of 4×10^{-2} Pa, and base pressure was 1×10^{-5} Pa.

Electron density and electron temperature on the midplane were measured by Langmuir probe. Line-integrated electron density was measured with 75GHz microwave interferometer, as well.

Figure 3 shows the profiles of electron density n_e and electron temperature T_e. Here we have compared three cases (I_L =0 kA, 6.8 kA and 13.6 kA). The edge of electron density was determined by separatrix. Experiments were carried out with 2.8kW of microwave injection. For all three cases, electron density n_e has peak value comparable with 2.45GHz, O-mode cutoff density, i.e. 7.6×10^{16} m^{-3}. For the cases of I_L=6.8, 13.6kA, steep density gradient at UHR location is expected. Therefore transport across evanescent region and mode conversion near the UHR may occur effectively.



(a) (b)

Fig. 3 Radial profile of (a)n_e and (b)T_e.

We estimated the conversion efficiencies by Eq. (1). Tunneling parameter η was written as

$$\eta = \frac{\Omega_e L_n}{c} \frac{\alpha}{\sqrt{\alpha^2 + 2L_n/L_B}} \left[\frac{\sqrt{1+\alpha^2} - 1}{\alpha^2 + (L_n/L_B)\sqrt{1+\alpha^2}} \right]^{1/2} \qquad (2)$$

where $\alpha \equiv \left|\omega_{pe}/\Omega_e\right|_{UHR}$, $L_n \equiv n/|\nabla n|_{UHR}$ and $L_B \equiv B/|\nabla B|_{UHR}$.

Table I shows the estimated mode conversion efficiencies.

TABLE I. Estimated Mode Conversion Efficiency

I_L [kA]	L_n [cm]	L_B [cm]	B_{UHR}[T]	α	C_B [%]
0	$>>L_B$	6.9	0.029	2.9	1.5
6.8	6.5	3.0	0.021	4.0	24.8
13.6	3.9	4.3	0.032	2.6	24.4

We assumed n_e and T_e are the constant on flux surface and estimated L_n on the extended line of incident microwave. When the estimated conversion efficiency is large, electron temperature profile tends to have peak near the top of density slope. Thus heating by EBW due to the steep density gradient was expected. It is possible to achieve mode conversion more effectively due to reflection at L-cutoff. Generation of overdense plasma, e.g. by levitation of F-coil to avoid plasma energy loss, is one of the reasonable methods to attain effective mode conversion.

For the parameters in Mini-RT, absorption of cold waves is quite weak. Optical depths for fundamental O-mode and second harmonic X-mode are in the order of 10^{-5}.