§4. Formation of Minimum-B Torus by ECH

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In this term we have looked for conditions for better coupling of microwave power to the plasma by changing polarization of incident microwave and attempted to suppress hot spots generated by the bombardment of fast electrons fell in lost orbits. Both experiments have been carried out by using 2.45 GHz microwave power up to 60 kW from three 20 kW magnetrons in the low aspect ratio torus experiment (LATE) device. [1]

The plasma current can be ramped up to Ip ~ 10 kA with ~10 times the plasma cutoff density when the electron cyclotron resonance (ECR) layer is located at R = 20 cm, slightly inside the vessel center of R = 25cm as reported in the previous annual report.[2] In this configuration, the upper hybrid resonance (UHR) layer is located just inside the second harmonic resonance layer and the ECR layer locates just inside the current center. Therefore, electron Bernstein (EB) waves mode-converted from the electromagnetic (EM) waves at the UHR layer are already in the first propagation band between the ECR and 2nd ECR layers. They can propagate towards the ECR layer without any barrier. Therefore effective heating of bulk electrons by EB waves is expected at the plasma core before the ECR layer if good mode-conversion efficiency at UHR layer is obtained.

In order to examine the polarization effect on mode-conversion efficiency, we have injected microwave power at 2.45 GHz with an optimized polarization predicted by a linear theory for a plasma slab[3] as shown in Fig.1. Actually, additional power is also injected by using other three ECH systems with usual liner polarization in the horizontal direction since only one ECH system has polarization converter[4] and its power alone is not high enough to generate extremely over-dense plasma mentioned above. For comparison we have also injected the same total microwave power with worst polarization for the polarization converter system.

For both discharges we have measured four line integrated densities; one horizontal chord on the mid-plane with a tangential radius of 12cm and three vertical chords. In the case of optimized injection the density increases until the end of microwave pulse while the discharge terminates before the density reaches final highest value. Note that magnetic analyses indicates that vertical width of the last closed flux surface decreases while horizontal width does not change as the discharge evolves from t=0.1 s to 0.15 s. Therefore the horizontal chord density is proportional to line-averaged density on mid plane, indicating that the worst polarization injection can not maintain extremely over-dense discharge. Thus the results shown in Fig.1 suggest that polarization adjustment for the EM waves is effective to ensure good coupling to EB waves from the EM waves.

We have newly fabricated a molybdenum guard system at bottom to protect the vessel wall from the bombardment of energetic electrons as shown in Fig.2. Furthermore, we have water-cooled the radial molybdenum limiter. Then reproducibility of discharges has been improved and microwave power can be saved by 20 % to generate and maintain the plasmas that have Ip~10kA.

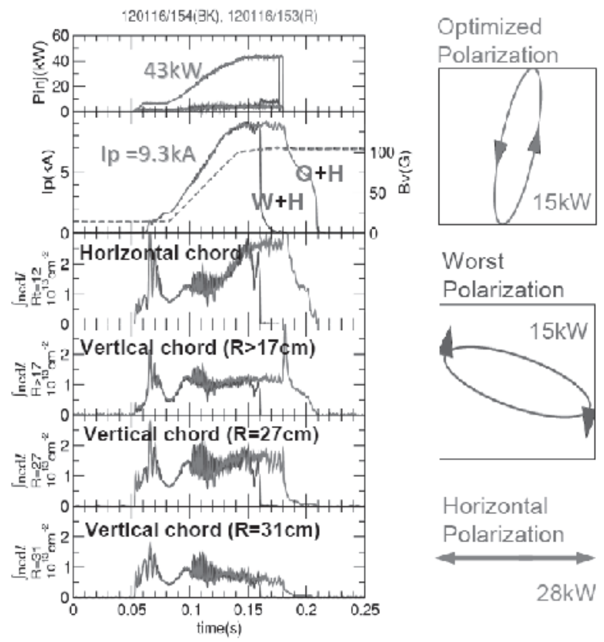
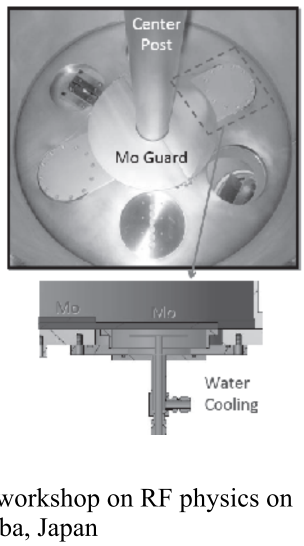


Fig. 1. Total of 43 kW microwave injection with an optimized polarization (15kW) and horizontal polarization (28kW) can maintain an extremely over-dense discharge while the same total power injection with a worst polarization (15kW) and horizontal polarization (28kW) can not maintain the discharge.

Fig. 2 Walter cooled molybdenum guard



1) T. Maekawa et al., US-J workshop on RF physics on plasmas, Feb. 8-9, 2011, Toba, Japan
2) T. Maekawa et al. NIFS Annual Report Apr.2010-Mar.2011
3) H. Igami, H. Tanaka and T. Maekawa, Plasma Phys. Controlled Fusion Vol.48, (2006) 573-598.
4) T. Maekawa et al. NIFS Annual Report Apr.2008-2009