§47. Current Drive and Heating Experiments using RF/mm-Waves on the TRIAM-1M Tokamak

Idei, H. (Kyushu Univ.) for the TRIAM Experimental Group

The power dependence on density and current drive efficiency in the Lower Hybrid Current Drive (LHCD) plasma was investigated in wide ranges of line-averaged electron density of $\bar{n}_e = 0.1 \sim 4.7 \times 10^{19} m^{-3}$, and plasma current of $I_p = 15 \sim 100$kA. The high power RF-wave of the frequency of 8.2GHz was generated at the klystron system, and the net power up to 0.24MW was injected to the plasma. The generated power was almost maximum of the system. The highest current achieved ever, of 100kA , that corresponded to a safety factor $q \lesssim 4$, was achieved in series of the high power experiments. The highest density achieved ever, of $4.7 \times 10^{19} m^{-3}$, was also achieved in the series of the experiments. The power dependence was studied in the wide ranges of the plasma parameters. Figure1 shows the typical waveforms at the high density operation. The density increased with the net injected power $P_{\rm LH}$, and the maximum density was attained by the high power and the strong gas-puffing. The current drive efficiency $\eta_{\rm CD}$ gradually decreased with the increase of the density. The plasma discharge was terminated at the maximum density, but the achieved density was far from the density limit predicted by Sverdrup and Wegrowe models based on the wave propagation characteristics. The $\eta_{\rm CD}$ scaling has a dependence on both the density and the electron temperature. The observed decrease of $\eta_{\rm CD}$ was due to the decrease of the electron temperature by the density increase. The driven current decreased, and the plasma confinement became worse. The ion temperature $T_{\rm i}$ gradually decreased with the decrease of the current, as shown in Fig.1. The electron temperature also decreased by the degradation of the plasma confinement. The power dependence on density and current drive efficiency has been studied in the link with the plasma confinement. The observed improved-$\eta_{\rm CD}$ (Enhanced CD: ECD) mode has been also modeled in association with the electron temperature.

In order to investigate the spectrum gap problem and controllability for the current profile by means of counter current drive (ctr-CD) in the LHCD plasma, combination experiments with the backward (BW) propagating LH wave and/or Electron Cyclotron (EC) wave were performed in LHCD plasmas sustained by the forward (FW) propagating wave. Figure 2 shows time evolutions of the plasma current change $\Delta I_{\rm p}$ and the Shafranov shift Λ when the ratio $P_{\rm BW}/P_{\rm FW}$ of the BW and FW injected power was scanned. The current decreased due to the peaking of the current profile $j(r)$ for the BW injection at $P_{\rm BW}/P_{\rm FW} < 0.8$, and the current rapidly increased due to the broadening of $j(r)$ at $P_{\rm BW}/P_{\rm FW} > 0.8$. A large Shafranov shift was observed in the hard X-ray radial profile, which suggests that a high poloidal beta plasma was achieved via the contribution of tail electrons. The ctr-ECCD decreased the current at a larger raio of $P_{\rm BW}/P_{\rm FW} \sim 1.3$, when the EC resonance position was inboard side for the magnetic-axis of the plasma. The effects of the ctr-CD with the BW propagating LH- and EC-waves have been studied.

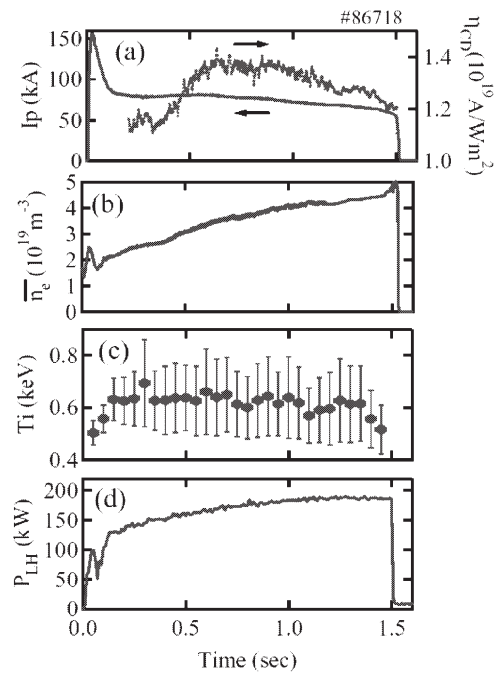

Fig. 1: Typical waveforms at the high density operation.

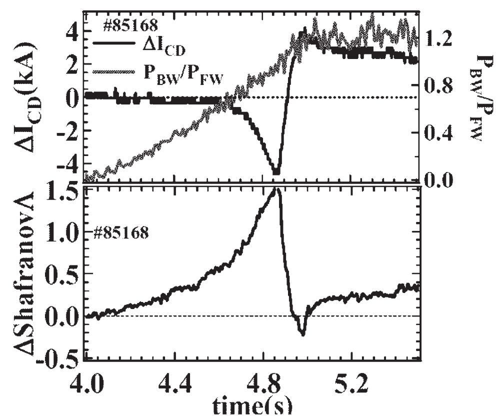

Fig. 2: Plasma current change $\Delta I_{\rm p}$ and Shafranov shift Λ when the ratio $P_{\rm BW}/P_{\rm FW}$ of the BW and FW injected power was scanned.

This work was realized in the bi-directional collaboration (NIFS06KUTR016) organized by NIFS.