§ 21. Production of Over Dense Plasma with 2.45 GHz Microwaves

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Simulation experiments of energy and particle transport in high temperature and density plasmas are attempted in CHS using low temperature and density plasmas produced at low magnetic field (Bt < 0.1 T).

For this purpose, 2.45 GHz microwaves up to 20 kW are employed in the range of B_t=0.03 – 0.11 T. Microwaves are launched perpendicularly to the toroidal field through a horizontally elongated port section. When fundamental ECH is applied, the electron density easily reaches close to the O-mode cut-off (n_{ec}=7.3x10^{16} m^{-3}) or even higher density. Dependences of line averaged electron density $\langle n_e \rangle$and electron temperature Te at r=0.7 on B_t are plotted for hydrogen plasma in Fig.1, where the magnetic axis position R_{ax}=0.921 m, and launched microwave power is about 12 kW. $\langle n_e \rangle$ is measured by 2 mm interferometer with high precision phase counter and Te is measured by a triple probe. $\langle n_e \rangle$ increases with the decrease of B_t toward about 600 G, and reaches the value that is by a factor of 1.7 larger than n_{ec}. This tendency of $\langle n_e \rangle$ on Bt is similar to helium and neon plasmas, but much more significant for them For He and Ne plasmas, $\langle n_e \rangle$ reaches ~4x10^{17} m^{-3} and ~1x10^{18} m^{-3}, respectively (Fig.2). For hydrogen plasma, Te is also increased up to 18 eV. For B_t=612 G at the magnetic axis where highest density is obtained, the fundamental electron cyclotron layer locates very close to the plasma edge as shown in Fig.3. As a result, the upper hybrid resonance layer is placed at the steep gradient zone of electron density. The mode conversion from X-mode to electron Bernstein waves is thought to effectively take place there. On the condition of f_{ce}~f_{pe} (f_{ce}, f_{pe}: electron cyclotron frequency, electron plasma frequency), the effective tunneling parameter η is about 0.26 for Ln=0.01 m where Ln is the density scale length. The maximum power conversion efficiency $C_{max} = 4e^{-\pi\eta}(1-e^{-\pi\eta})$ is estimated about unity [1]. However, both cases of X-mode or O-mode launching show same data. This is thought the wave polarization is randomized by multiple reflection on the vacuum chamber wall.

Reference
[1] A.K. Ram et al., 18th IAEA Fusion Conference, Sorrento, Italy, 4 to 10 Oct., 2000, Paper No. IAEA-CN-77/THP2/25.

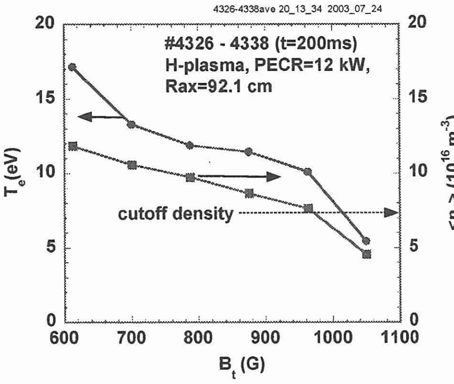

Fig.1 Dependence of $\langle n_e \rangle$ and Te on B_t for hydrogen plasma.

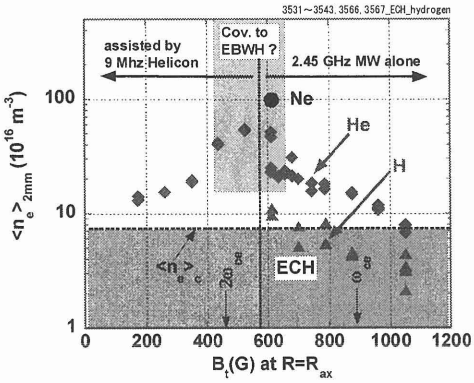

Fig.2 Achieved electron density by 2.45 GHz Microwaves alone and assisted by 9 MHz helicon waves for H, He and Ne plasmas.

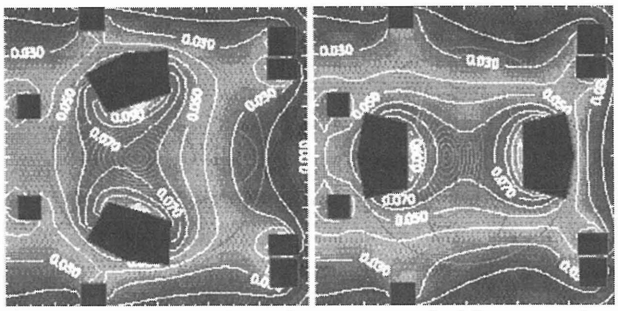

Fig.3 Contour plot of magnetic field strength in the case of B_t=612 G at the magnetic axis at vertically and horizontally elongated sections. Numbers in Figures stand for B_t-value.