Particle-loss Control for Making RF-induced Breakdown in QUEST

Ryota YONEDA[1], Kazuaki HANADA[2], Hideki ZUSHI[2], Kazuo NAKAMURA[2],
Akihide FUJISAWA[2], Hiroshi IDEI[2], Naoaki YOSHIDA[2], Yoshihiko NAGASHIMA[2],
Makoto HASEGAWA[2], Hisatoshi NAKASHIMA[2], Shoji KAWASAKI[2], Aki HIGASHIJIMA[2],
Takahiro NAGATA[2], Osamu MITARAI[3], Atsushi FUKUYAMA[4], Yuichi TAKASE[5]

[1]*IGSES Kyushu University, Kasuga 816-8580, Japan*
[2]*RIAM Kyushu University, Kasuga 816-8580, Japan*
[3]*Liberal Arts Education Center, Tokai University, Kumamoto 862-8652, Japan*
[4]*Department of Nuclear Engineering, Kyoto University, Nishikyo-ku, Kyoto 625-8540, Japan*
[5]*Graduate School of Frontier Science, University of Tokyo, Kashiwa 277-8561, Japan*

e-mail: yoneda@triam.kyushu-u.ac.jp

RF-induced breakdown will be applied in ITER [1] and plays an essential role in plasma initiation in spherical tokamaks (STs). The process of breakdown in tokamaks is simply described as competition between plasma production and particle-loss [2], however, quantitative investigation still remains insufficient. In this study, the combinative investigation of RF-induced breakdown experiments with altering magnetic configuration and a point model of hydrogen ionization [3] was performed to determine typical duration for particle-loss (τ). Experiments have been performed on QUEST, which is a middle-sized ST equipped with electron cyclotron wave at frequency of 2.45 and 8.2 GHz. Magnetic configurations of positive and negative n-index at electron cyclotron resonance (ECR) layer can be controlled in combination with poloidal field coils. Experiments were carried out at both frequency of 2.45 GHz, 10kW and 8.2 GHz, 12kW in positive and negative n-index configurations.

To give quantitative evaluation to the breakdown procedure, it is necessary to specify τ experimentally and verify whether it is consistent with the model. The point model that developed takes into account possible reactions of hydrogen such as excitation, ionization and recombination. The initial values of electron temperature and electron density for this model were estimated by diverter probe measurement. The conventional particle-loss mechanism during breakdown phase was investigated by the point model with experiments of negative n-index configurations where electron loss parallel to magnetic line is dominantly contributing to τ. In QUEST, the estimated connection length ($\mathrm{L} = C_S \cdot \tau \sim 150\mathrm{m}$) as breakdown threshold for negative n-index experiment was consistent with L calculated from the model. With positive n-index configurations, breakdowns were easily obtained compared with negative n-index. Furthermore, the experimental results indicate that τ contains the terms of not only connection length but also electrons confined in magnetic structure. The current point model does not describe this behavior of confined electrons and it requires quantitative valuation of how much these electrons contribute to τ. Diagnostics by means of velocity space and trajectory calculation are beneficial for that purpose. Further information will be discussed in presentation.

References
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