30aA03

QUEST高温壁における一時間を超える長時間放電の粒子バランス解析
Analysis of particle balance in long duration discharge beyond 1 h with hot wall on QUEST

花田和明[1]、中村一男[1]、出射　浩[1]、長谷川　真[1]、図子秀樹[1]、吉田直亮[1]、 Kuzmin Arseniy[1]、恩地拓己[1]、渡辺　理[1]、川崎昌二[1]、中島寿年[1]、東島亜紀[1]、永田貴大[1]、大和田裕晃[1]、龍昊[1]、藤澤彰英[1]、永島芳彦[1]、渡辺英雄[1]、川口　晃[1]、荒木邦明[1]、高瀬雄一[2]、福山　淳[3]、御手洗　修[4]、高木郁二[3]、大矢恭久[5]、宮本光貴[6]、QUEST グループ
Kazuaki Hanada, Kazuo Nakamura, Makoto Hasegawa, Hideki Zushi, Naoaki Yoshida, et al.

[1]九大, [2]東大、[3]京大、[4]東海大、[5]静岡大、[6]島根大
[1]Kyushu Univ., [2]Univ. of Tokyo, [3]Kyoto Univ., [4]Tokai Univ., [5]Shizuoka Univ., [6]Shimane Univ.[4]

Introduction

To realize nuclear fusion power plants based on magnetic confined plasma devices, steady state operation (SSO) of the devices is one of the crucial issues. QUEST, which is a middle sized spherical tokamak of 0.64m/0.4m in major/minor radii, and 0.25 T in toroidal magnetic field, is mainly operating to focus on particle balance control with a hot wall being a fraction of approximately 40% of plasma facing wall (PFW). In this presentation, we report typical progression of particle balance in long duration discharges beyond 1 h, and plausible explanation is proposed based on hydrogen barrier between plasma-induced deposition layer and substrate made of atmospheric plasma played tungsten (APS-W).

Experimental Apparatus

The hot wall (Fig. 1) was installed on QUEST since 2014 autumn/winter (A/W) campaign. The hot wall is composed of 24 x 2 heater-cooling panels on top and bottom conical areas as shown in Fig. 1 and is sharing 7.6 m^2. The surface temperture can be controlled in the range of room temperature (RT) - 673K. The surface on plasma facing side is covered with APS-W of 0.1mm in thickness.

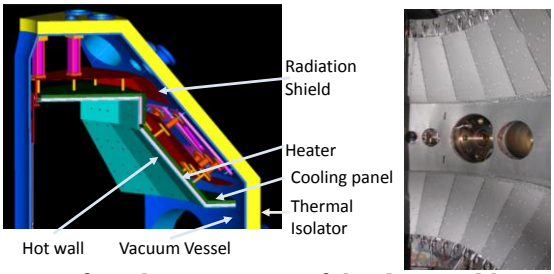

Fig. 1 Left: Schematic view of the designed hot wall, Right: A photo of the hot wall viewing from plasma side in the vacuum vessel of QUEST.

Experimental results

The longest duration discharge of 1h55min was obtained with the hot wall controlling its temperature at 393K by 40kW, 8.2GHz microwave power. It should be noted that after 4000s, no H_2 fueling was done

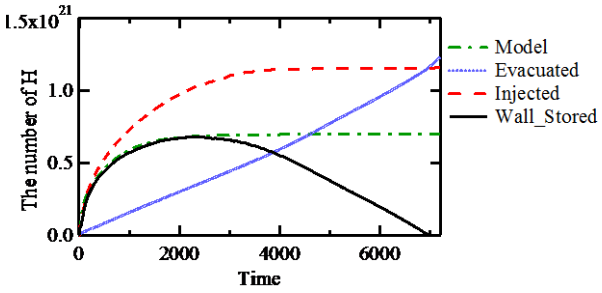

Fig. 2 Waveforms of injected, evacuated, wall stored H in the longest duration discharge. The dot and dash line indicates the calculation result based on the hydrogen barrier model.

Although the plasma density (~1x10^{17}m^3) and current (~5kA) was extremely low, the limiter configuration with aspect ratio of 1.8 was formed. Intensity of H_α, $I_{H\alpha}$ was kept constant in a feedback manner as possible, because $I_{H\alpha}$ is a good indicator to control the amount of depositing H flux to PFWs [1]. It found that we lost the control of $I_{H\alpha}$ after approximately 4000s and the less-controllability of plasma density induced a drastic plasma modification around 6900 s. In the discharge, the closed-flux surface could not be maintained and the plasma shifts to an electron cyclotron resonance (ECR) heating plasma. The wall stored hydrogen atom (H) was estimating from the time-integration of the difference between in-coming and out-going H flux into the plasma forming vessel. The dotted and dashed line in Fig. 2 is a model calculation of wall stored H based on hydrogen barrier model proposed previously [2]. The model calculation is well-fitted to the experimental data except the period from 3000s to the end of the discharge during which very few fuel H_2 gas was injected. This is mainly caused by gradual increase of PFWs temperature due to radiation, charge exchange neutral, and non-absorbed RF. The details will be discussed in the presentation.

[1] K.Hanada et al., IAEA-FEC (2016) EX/P4-49
[2] K.Hanada et al., JNM (2015)