Contribution ID: **516** Type: **Poster**

Global particle balance and its relationship with the plasma wall interaction emerging in long pulse discharges on the Large Helical Device

Friday, 21 October 2016 14:00 (4h 45m)

We report the global particle balance analysis and its relationship with the plasma wall interaction emerging for the first time in long pulse helium discharges reaching 48 min on the Large Helical Device (LHD). Experimental observations show that (i) the wall retention has dynamic characteristics and the differences of the plasma facing material, which are composed of the first wall with stainless steel and the divertor with graphite, is a possible candidate to explain the wall retention, and (ii) the mixed-material deposition layer which plays an important role in the wall retention is quantified by the reflection measurement, suggesting that the deposition-dominant area of the outer torus side and near the divertor in the measured toroidal section is a possible sink of the wall retention on the first wall.

The understanding of the wall retention of the fuel particles is crucial from the viewpoint of the efficient fueling and the inventory of tritium. In LHD, the wall retention has been investigated for steady-state long pulse discharges. Analysis of the global particle balance is conducted in the long-pulse helium discharge heated by ICH + ECH (1.2 MW × 48 min = 3.4×10^3 MJ). The wall inventory is separated into three phases. In the first phase, quite high wall inventory occurs. After the first phase, the wall inventory shows modest declination in the second phase. However, the high wall inventory appears again in the third phase. The physics of the phased retention is discussed based on an assumption that there are two kinds of helium reservoir, “first wall with stainless”and “divertor plate with graphite”.

An innovative measurement technique is employed for obtaining in broad spatial extent and in great detail the color information, equivalent to the reflectivity, by a handy color analyzer. The relation between the color and the thickness of the deposition layer is revealed by the long-term exposed samples. Experimental observations show that the thickness decreases exponentially with the averaged RGB (Red, Green, and Blue) values. The RGB mainly of the stainless steel plates on the helically twisted coil in one of 10 toroidal sections of the vacuum vessel is measured. The results indicate that about 60% of the area on the measured helical coil, which is the outer torus side and near the divertor, suggests a sink of the wall retention.

Paper Number

EX/P8-3

Country or International Organization

Japan

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Session Classification: Poster 8

Track Classification: EXC - Magnetic Confinement Experiments: Confinement