

§23. Study of Selective Exhaust of Particles on LHD Closed Divertor

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The pumping of helium ash has become important for the control in the edge plasma of the divertor because of the helium ash has limit of concentration. Selective exhaust of particles by Ion cyclotron resonance heating (ICRH) technique can be applied to many applications, such as, separation of deuterium and tritium for the fuels of nuclear fusion, selective removal of helium from nuclear fusion reactor.

The first successful experiment to demonstrate this idea was carried out by Takayama and his coworkers at the Institute of Plasma Physics, Nagoya¹⁾. We have proposed to perform mass or isotope separation by ICRH in a sheet plasma on the linear plasma divertor simulator TPD-Sheet IV²⁻⁴⁾. The sheet plasma is a special type of strongly magnetized highly ionized slab plasma. The sheet plasma has thickness which is as thin as twice the mean ion Larmor radius, in a direction perpendicular to a magnetic field. Guiding centers of all gyrating ions in the plasma lie in the vicinity of the mid-plane of the plasma by the thickness. Because of these characteristics energetic ions in a sheet plasma traverse the dense plasma region only momentarily in each cyclotron gyration. As a result, the adverse effect of collisions to mass separations by ICRH can be negligible small.

The purpose of the present work is to demonstrate high heat flux plasmas for fundamental research on divertor plasmas in magnetically confined fusion devices. In this paper, we report the experimental simulation of ICRH of the helium/hydrogen sheet plasma ($\sim 10^{18} \text{ m}^{-3}$) by the RF electrodes of two parallel plates, sandwiching the sheet plasma. Ion densities in the plasma and the neutral densities of resonant ions were measured by an omegatron mass analyzer and a quadruple mass analyzer (Q-mass).

The TPD-SheetIV device consists of the sheet plasma source, magnetic coils, RF heating part, a measurement part, end chamber, a vacuum exhaust, and a Faraday cup. The plasma in TPD-Sheet IV is divided into two regions; the sheet plasma source region and the experimental region. The hydrogen sheet plasma is produced by modified test plasma generated by direct current (TPD)-type DC discharge. The anode slit is 2 mm thick and 40 mm wide. Ten rectangular magnetic coils form a non-uniform magnetic field of 0.1 T in the experimental region. The magnetic field at the center of the RF electrodes has a large gradient of *ca.* 0.35 T m^{-1} when $B_{\text{max}} = 0.1 \text{ T}$. Efficient heating in the sheet plasma is thus expected due to the low collision frequency of ions. Therefore, the sheet plasma can be easily heated using a simple electrode structure, such as two parallel plate electrodes. The plasma density is

varied between 10^{17} m^{-3} and 10^{19} m^{-3} , while the electron temperature is maintained at 7-10 eV.

The RF application circuit consists of an RF power supply, a matching circuit, and RF electrodes. The RF power supply consists of a function generator, a RF amplifier, and a power meter. The maximum output of the RF power supply is approximately 500 W. The matching circuit consists of an LC circuit and a BAL-UN circuit, and transmits electric power without loss. The RF electrode is two parallel plate electrodes that are 200 mm long and 60 mm wide and face each other 38 mm apart. The plasma is sandwiched between the two parallel plate electrodes. The RF frequency can be swept from 0.8 to 1.5 MHz with a constant RF voltage. The resonant neutral particles were detected by the recovery box with vacuum pumping system and Q-mass analyzer. The selective exhaust of neutral particles ratio was measured by a Q-mass.

Figure 1 shows the dependence of the selective exhaust of helium neutral particles ratio on RF power f_{RF} of ICRH at a discharge current of 50 A in helium/hydrogen plasma. The helium neutral particles increase with increasing RF power f_{RF} of ICRH. It is found that the selective removal of the helium ions in the sheet plasma is successful by ICRH methods.

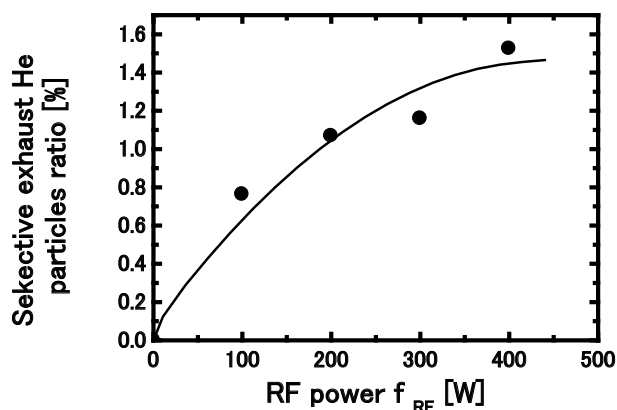


Fig.1. Selective exhaust of He neutral particles ratio is plotted for various RF power f_{RF} .

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