§12. Effects of Particle Control in the End Region on the Central Plasma Characteristics in GAMMA-10

Hirooka, Y.,
Zhou, H. (Dept. Fusion Sci., Grad. Univ. Advanced Studies), Nakashima, Y., Sakamoto, M. (Univ. Tsukuba)

It has widely been recognized that particle recycling from plasma-facing components in magnetic fusion devices can affect core confinement performance. This effect was first observed by the "Supershot" confinement experiments in TFTR[1)], whereby particle recycling from the graphite bumper limiter was reduced by thermal degassing and helium discharge conditioning prior to confinement discharges. In the Supershot confinement regime, the energy confinement time in has been found to increase with decreasing edge particle recycling from the limiter. Similar reduced recycling effects have been observed in a number of toroidal fusion devices, including even stellarators and spherical tokamaks, over the past several decades although the physics behind these effects is not thoroughly understood.

The present work is intended to investigate whether or not such wall recycling effects on core confinement can be observed in mirror machines such as GAMMA-10. It is expected that particles recycling effects, if any, may be observed, using reflective end plates which separate the end cell from the central cell.

Generally, the total heat flow along the magnetic field line is considered to be the sum of convection and conduction effects such that:

$$q_{//} = q_{//\,conv.} + q_{//\,cond.} \qquad (1)$$

Here, it is extremely important to point out here that the SOL collisionality, ν_{SOL}, plays a key role in determining the heat loss mechanism to the plasma-facing component. Also, for the same plasma temperature and density, ν_{SOL} is linearly proportional to connection length.

If ν_{SOL} <10, as a general guideline, the heat loss will be "sheath-limited" to be given by[2)]:

$$q_{//} \approx q_{//\,conv.} = \left\{ \frac{1}{2} m_i v^2 + \frac{5}{2} k(T_e + T_i) \right\} n_{edge} v \qquad (2)$$

This condition can easily be met in small-to-medium size devices such as NSTX where lithium is used as the plasma-facing materials to reduce n_{edge}. This is believed to be very true with mirror machines.

As opposed to that, if ν_{SOL} >20 is established, the heat loss will become "conduction-dominated" to be expressed as[2)]:

$$q_{//} \approx q_{//\,cond.} \approx -\kappa_{0e} T_e^{\frac{5}{2}} \frac{dT_e}{dx} \qquad (3)$$

This may be met by relatively large machines such as JET.

A schematic diagram of the end plate prepared for this purpose is shown in Fig. 1. Employed as the end plate materials are titanium and tungsten, completely different in hydrogen recycling characteristics, as shown in Fig. 2. Recognize that titanium (a) is an absorbing surface whereas tungsten (b) is essentially a reflecting surface.

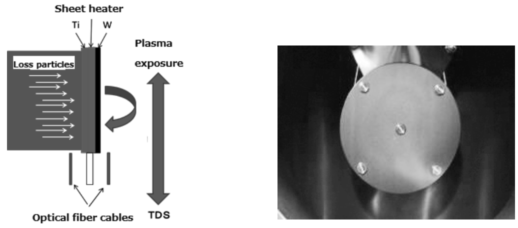

Fig. 1 A schematic diagram and a photo of the end plate.

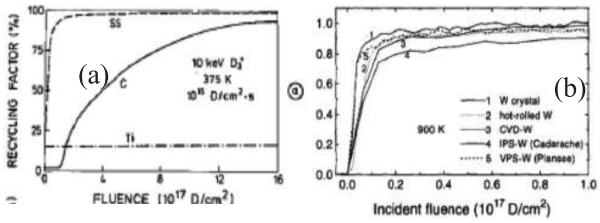

Fig. 2 Hydrogen recycling properties of (a)Ti and (b)W.[3)]

These two materials can readily be exchanged in-situ by flipping the end plate, as shown in Fig. 1. Also, a resistive heater is inserted in between these plates, so that post-exposure TDS can be done.

Shown in Fig. 3 are the spectroscopic data for H_α as H_β taken as the measure of hydrogen recycling, for the Ti and W end plates. As shown in Fig. 4, however, no clear change in stored energy has been observed. The next step to be taken will be to change the Ti plate with a C-plate for even further reduced recycling.[3)]

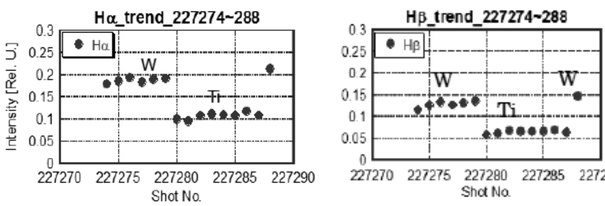

Fig. 3 Hydrogen recycling over the Ti and W end plates.

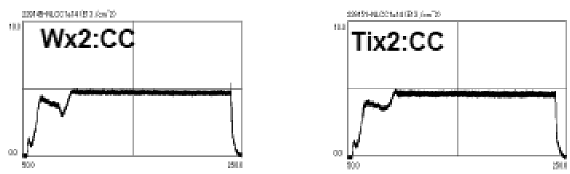

Fig. 4 Stored energies(A.U.) with the Ti and W end plates.

1) Strachan, J. D., Nucl. Fusion **39**(1999)1093.
2) Stangeby, P. C, "The plasma boundary of magnetic fusion devices", IoP (2000).
3) Post, D. E. and Behrisch, R. "Physics of plasma-wall interactions in controlled fusion" Plenum Press (1986).