§52. Active Control Over Wall Recycling in a Spherical Tokamak: CPD by a Li-gettered Rotating Limiter

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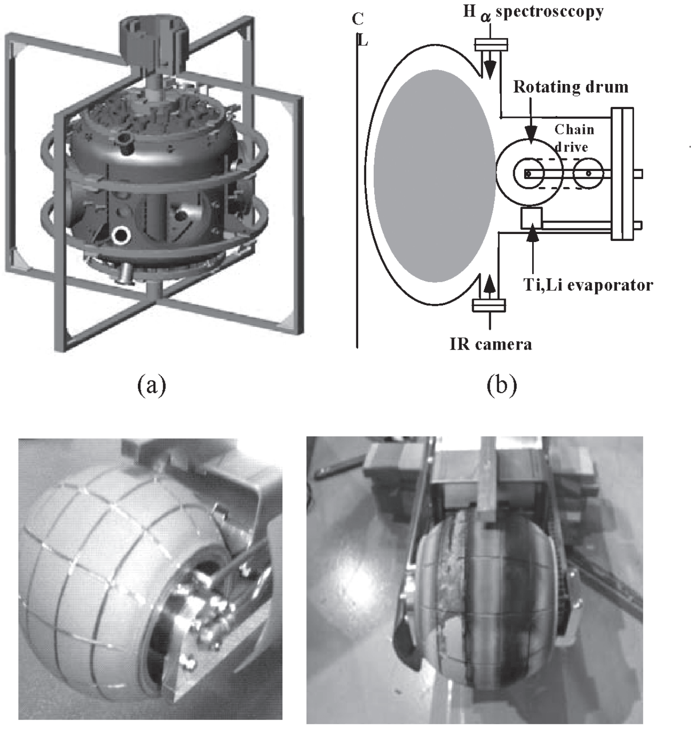
Ever since the discovery of the "Supershot" confinement regime in TFTR experiments in late 1980's, it has widely been recognized in the magnetic fusion community that high performance core plasmas often favor reduced wall recycling. To reduce edge recycling, wall conditioning techniques such as boronization have been applied for many plasma confinement experiments. However, due to the surface saturation with trapped particles, the efficacy of wall conditioning has a finite lifetime, necessitating the shutdown of plasma operation for re-conditioning. Clearly, this is not acceptable from the point of view of operating steady state fusion power reactors. It is clear from these arguments that enabling wall concepts R&D is necessary for the successful operation of steady state fusion devices beyond ITER.

Over the past decade, therefore, a variety of innovative wall concepts have been proposed to provide a resolution for this particle control issue. These concepts employ either a solid or liquid plasma-facing material, but both are continuously circulating for in-line regeneration of their particle trapping capabilities. These may be referred to as moving-surface plasma-facing component (MS-PFC) concepts. One such concept proposed by Hirooka et al. [1)] employs a moving belt of SiC-SiC fiber fabrics with an in-line getter film deposition system.

In our previous work[2)], proof-of-principle experiments on the MS-PFC concept with the moving belt, simplified by a belt of lithium deposited on a water-cooled rotating drum, were conducted at bombarding plasma densities of the order of 10^{10}cm^{-3} and electron temperatures around 5eV. Spectroscopic data on H_α have indicated that steady state hydrogen recycling is reduced by 14% and 24%, respectively, at the lithium deposition rates of 9.5 Å/s and 7.3 Å/s due to the chemical codeposition effect, forming LiH.

In the present work, a compact spherical tokamak: CPD located at the Kyushu Univ. has been installed with a similar rotating drum as the limiter to investigate if the MS-PFC concept can be used for active control over edge recycling in a confinement device, leading the improvement of core plasma performance. A schematic diagram of the experimental setup is shown in Fig. 1.

Preliminary results taken from ICRF-heated plasma discharges with a flat-top duration of 400ms have indicated reduced recycling nearby the rotating limiter surface, as shown in Fig. 2, by about 20%. As shown in Fig. 1-(d), the surface after plasma and lithium exposure exhibits rather strong discoloration. However, these discharges are not quite "confinement discharges" in that magnetic flux surfaces are closed to the edge area. Confinement discharges will be conducted in conjunction with RF current drive heating in JFY2007 whereby the MS-PFC concept will be evaluated, again.



(a) (b)

(c) (d)

Fig. 1 A bird-eye view of the CPD-tokamak (a), a schematic diagram of the rotating drum limiter on CPD (b), a close-up view of the rotating head both coated with plasma-sprayed tungsten, before exposure in CPD (c) and after exposure (d).

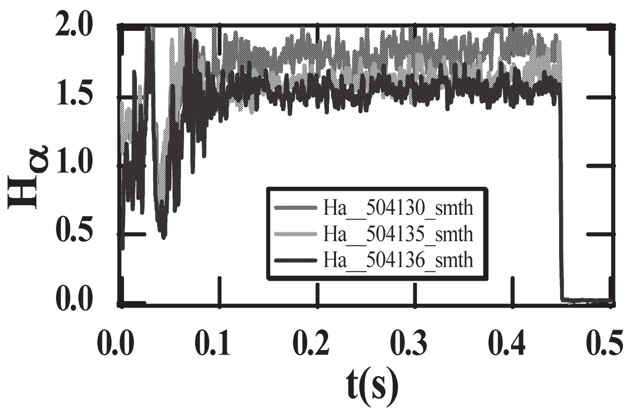


Fig. 2 Hydrogen recycling over the rotating drum limiter, where the curve in red is before Li gettering and those in green and blue are during Li gettering. The lithium deposition rate was of the order of 100 Å/s during these measurements.

References:
1) Hirooka, Y. et al., Proc. 17th IEEE-SOFE, San Diego, Oct. 6th -10th, 1997, pp.906.
2) Hirooka, Y. et al., Fusion Sci. & Technol. **47**(2005)703.