§1. Particle Control by Moving-surface PFCs

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It is widely recognized that particle control is a critical issue affecting the overall plasma confinement performance in steady state fusion devices. However, this technical issue has not experimentally been addressed because of the fact that essentially all major confinement devices are operating in the pulse mode.

Interestingly, reported at the most recent IAEA-TCM on "Steady State Operation" held in India in February 2005 were a number of observations indicative of the effects of particle recycling from the walls, saturated during extended pulse operation, which led to the termination of plasma confinement. These observations are from the major devices including JT-60U, LHD, HT-7, etc. The common problem pointed out with these cases is that wall recycling exceeds 100%, meaning that the core plasma density can not be controlled with external fueling.

As opposed to these, the effect of continuous wall pumping due to codeposition was also reported to help maintain long-pulse discharges conducted in TORE SUPRA and TRIAM-1M. For fusion power reactors, codeposition will result in a build-up of tritium, generating a safety issue.

These arguments clearly point to a need enabling wall concept development. For this purpose, the concept of moving-surface plasma-facing component (MS-PFC) has been evaluated over the past several years as part of NIFS collaborative programs with universities [1].

Used in this work is the MS-PFC test unit integrated in the Vehicle facility [2], shown in Fig. 1. In this test unit, a rotating drum made of copper and held at the floating potential, can be deposited with lithium simultaneously with steady state hydrogen or helium plasma bombardment. This is so that the plasma always sees freshly deposited lithium surface. Deposition rate measurements were conducted using a separate setup not.

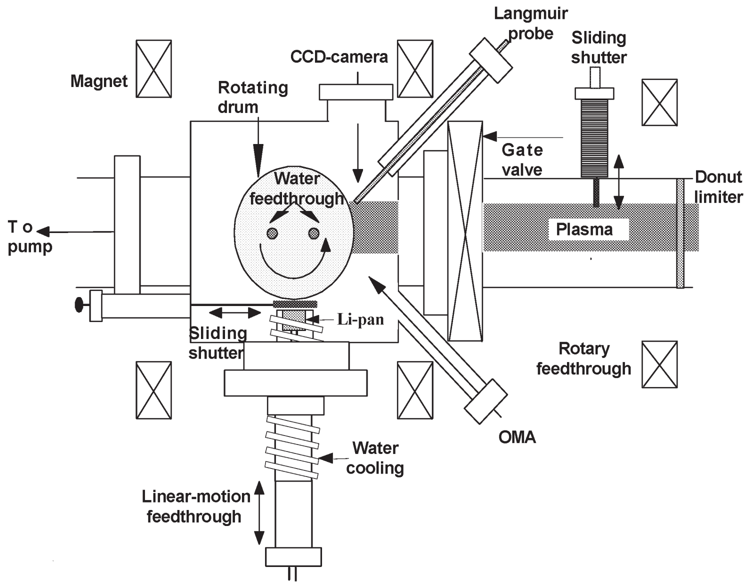

Fig. 1 A schematic diagram of the MS-PFC test unit.

Results of particle recycling measurements are shown in Fig. 2-(a) and (b), respectively, taken from hydrogen and helium plasma bombardment. The deposition of lithium in these data was initiated after steady respective state recycling conditions were established.

Notice that, as soon as lithium deposition starts, steady state hydrogen and helium recycling levels decreases significantly. In the case of hydrogen plasma, the two deposition rates of approximately 7 and 9 Å/s were examined and the degrees of H_α intensity reduction have been found to be nearly proportional to the deposition rate. The detailed particle balance modeling has recently been published [1]. As opposed to hydrogen plasmas, apparently helium plasmas require higher lithium deposition rates to exhibit noticeable reduction in recycling. The data shown in Fig. 2-(b) were taken at the lithium deposition rate of 50 Å/s.

Lithium is known to form a hydride in the form of LiH, whereas there is no such chemical affinity for helium. Using the molecular dynamics simulation method, it has been shown that helium can be trapped due to a three dimensional electrostatic potential "cage" effect, associated with lattice imperfections of lithium. Details on this will be published elsewhere [3].

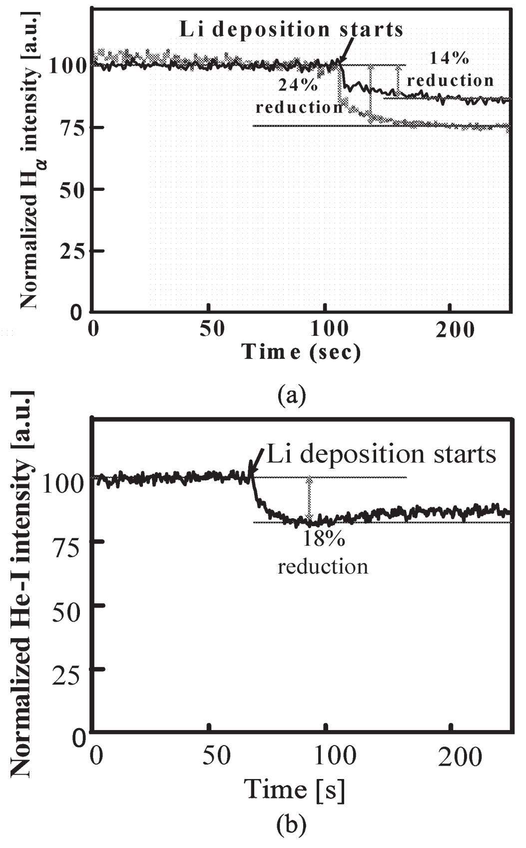

Fig. 2 Reduced steady state hydrogen and helium recycling from a lithium-deposited rotating drum.

Reference
1) Hirooka, Y. et al, Fusion Sci. Technol, **47**(2005)703.
2) Hirooka, Y. et al., Nucl. Mater. **337-339**(2005)585.
3) Hirooka, Y. et al., Submitted to Nucl. Fusion.