Particle Control in Steady State Magnetic Fusion Devices by Moving-Surface Plasma-Facing Components

-A review of PoP experiments in the VEHICLE-1 facility-

1st International Symposium and 1st Korea-Japan Workshop on
edge plasma and surface component interations in steady state magnetic fusion devices

May 20th-22nd, 2007
NIFS

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NIFS-CRC

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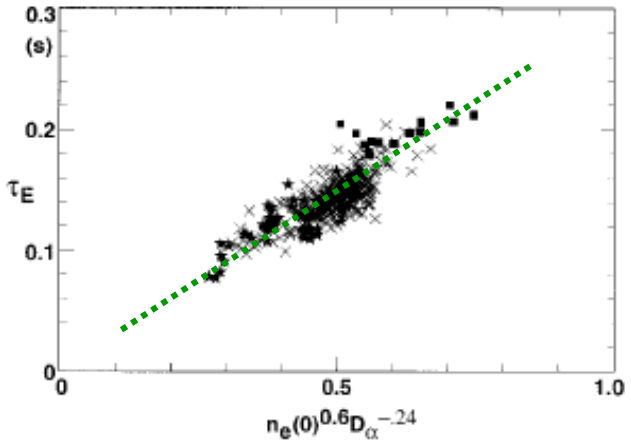
Reduced recycling => Better confinement!

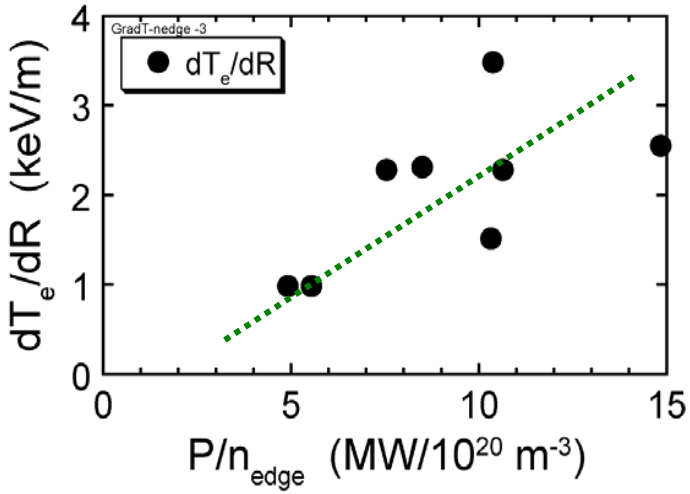
High-performance plasmas tend to favor reduced edge recycling:

Efficacy of wall conditioning has a finite lifetime

=> Need for PFCs with reduced recycling at steady state!

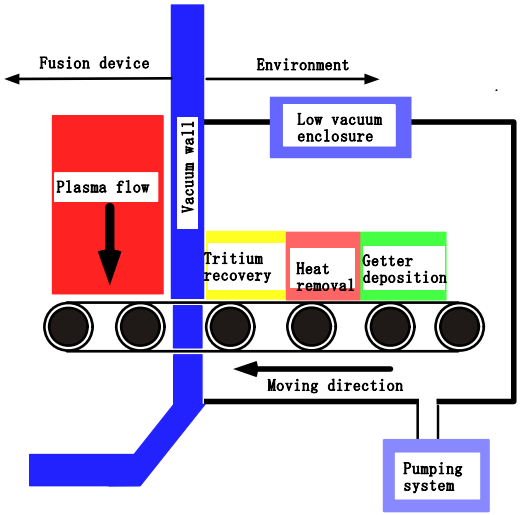


After J.D.Strachan, Nucl. Fusion 39(1999)1093.

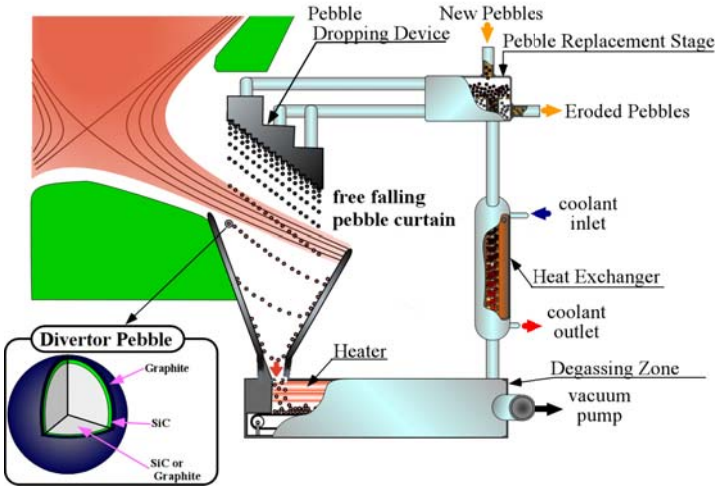


After N. Ohyabu et al., Phys. Rev. Lett.97(2006)055002.

Moving solid surface PFC concepts

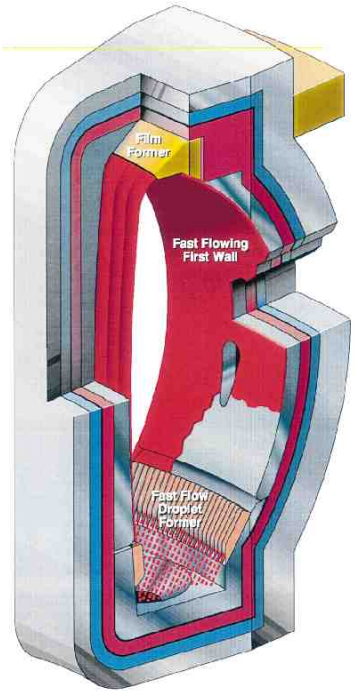


After Y. Hirooka et al. , 17th SOFE, in San Diego 1997

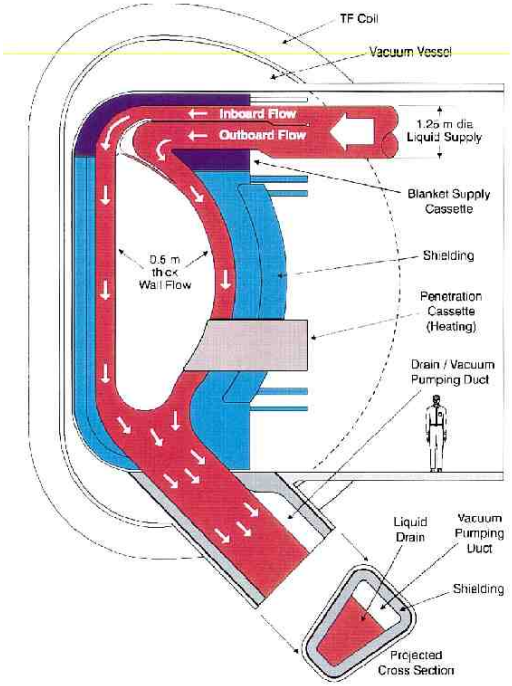


After M. Nishikawa, J. Plasma and Fusion Res. 78(2002)129

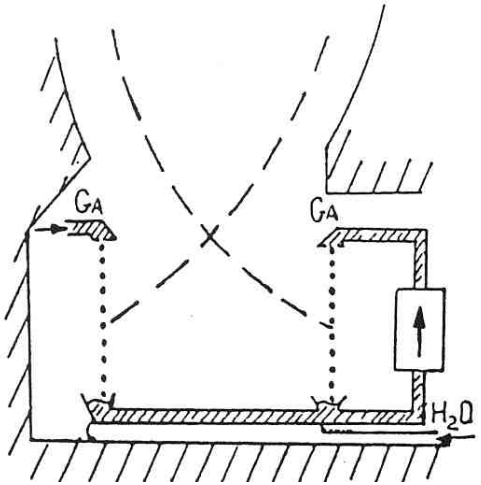
Moving liquid surface PFC concepts



Thin Liquid Wall



Thick Liquid Wall



Droplet

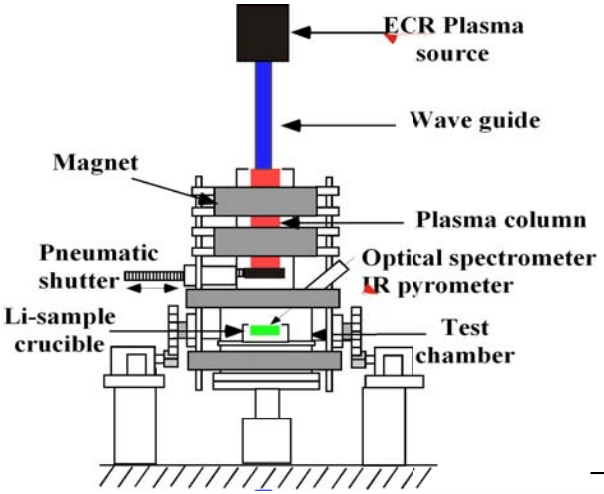
After S.V. Mirnov et al.,
J. Nucl. Mater. 196-198(1992)45.

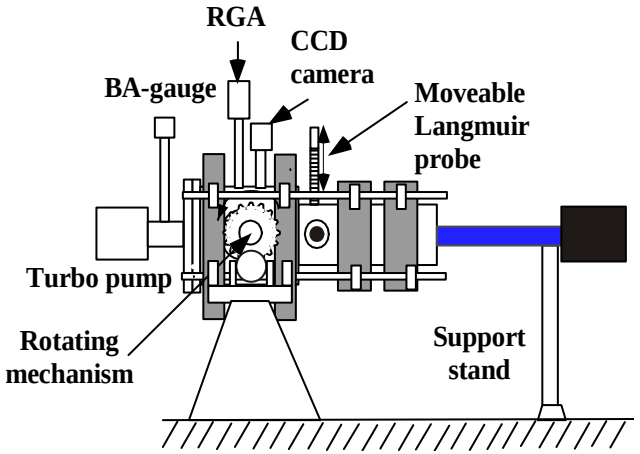
After M. Abdou et al., Fusion Eng. Des. 54(2001)181.

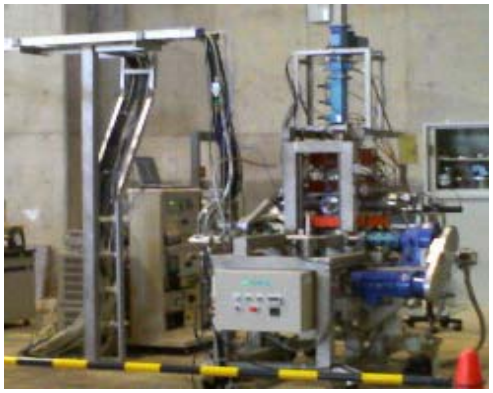
Vehicle-1 facility

Vertical and Horizontal positions Interchangeable test stand for Components and Liquids for fusion Experiment

(Presented at PSI-conf., 2004)



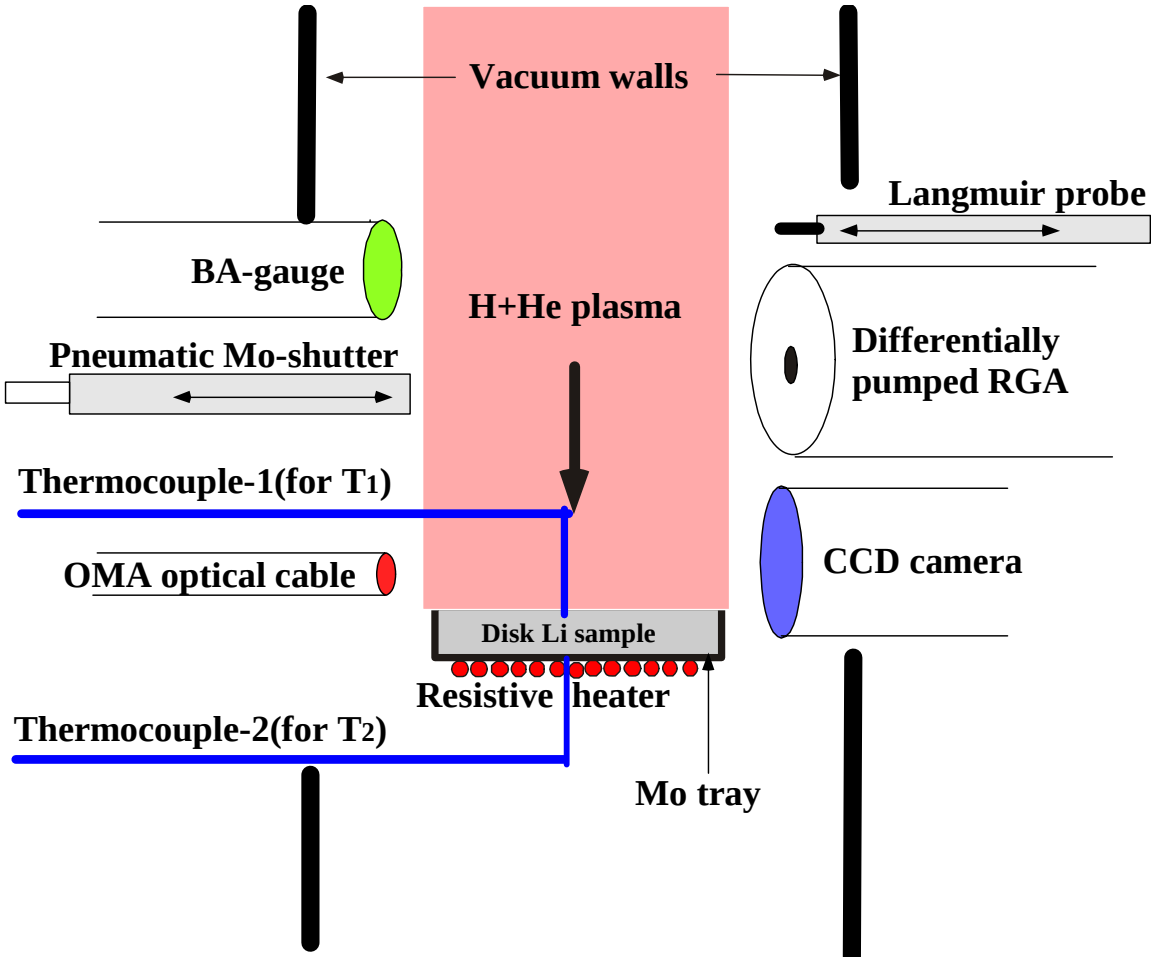




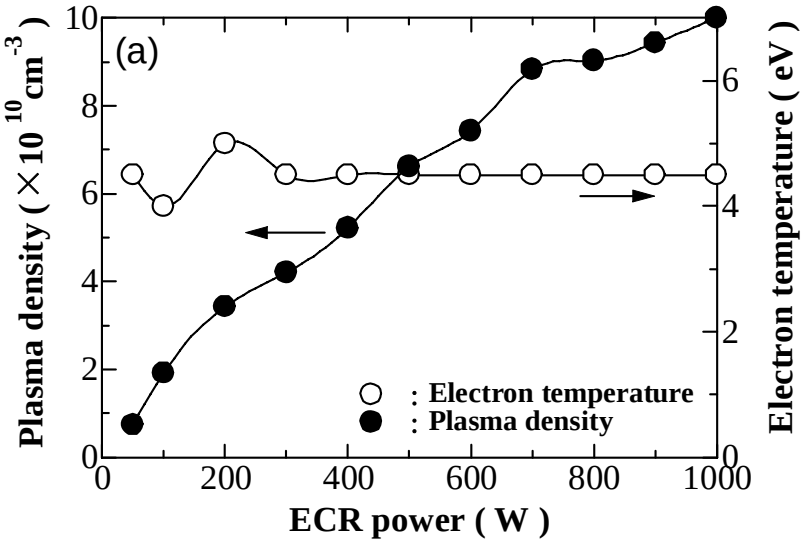
(a) vertical position

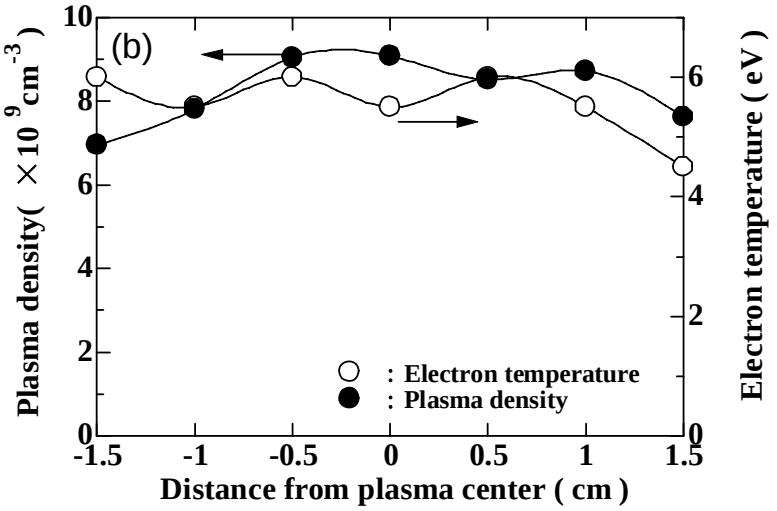
(b) horizontal position.

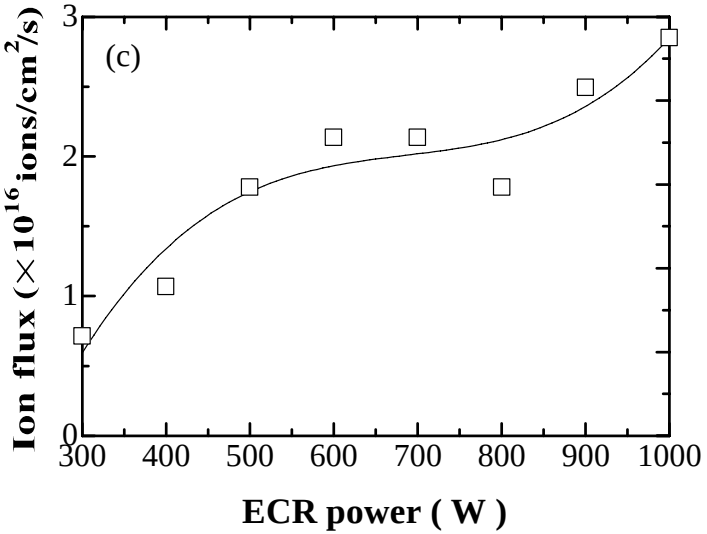
PSI-diagnostics in VEHICLE-1

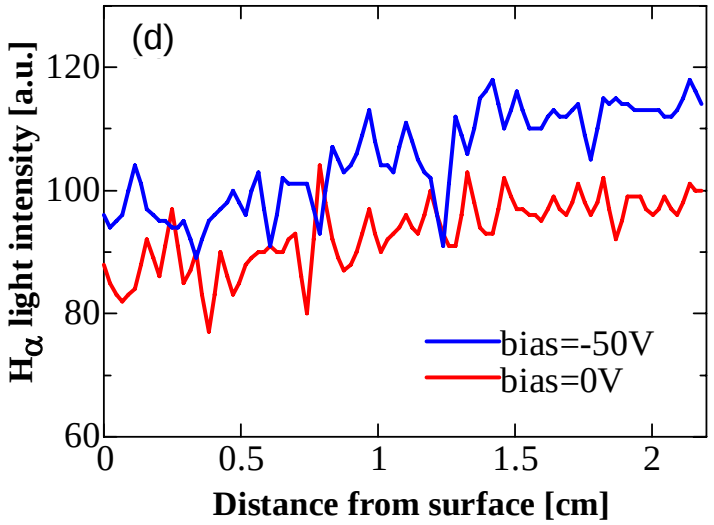


Vehicle-1 plasma characteristics



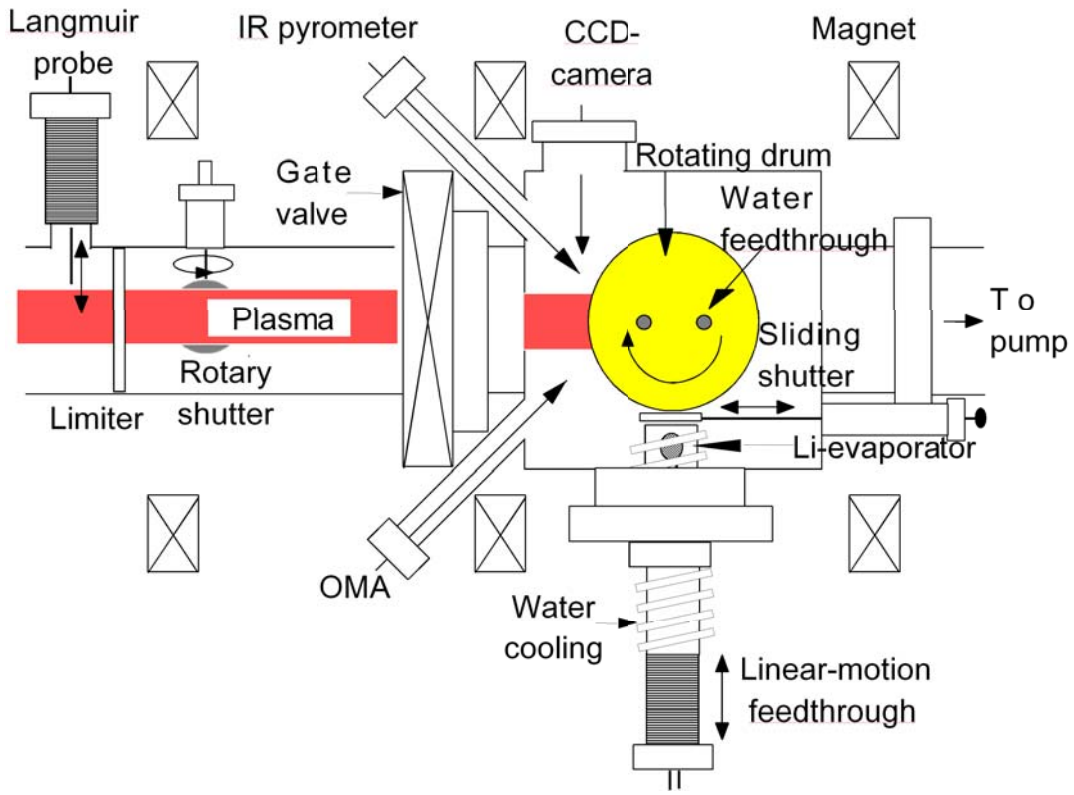






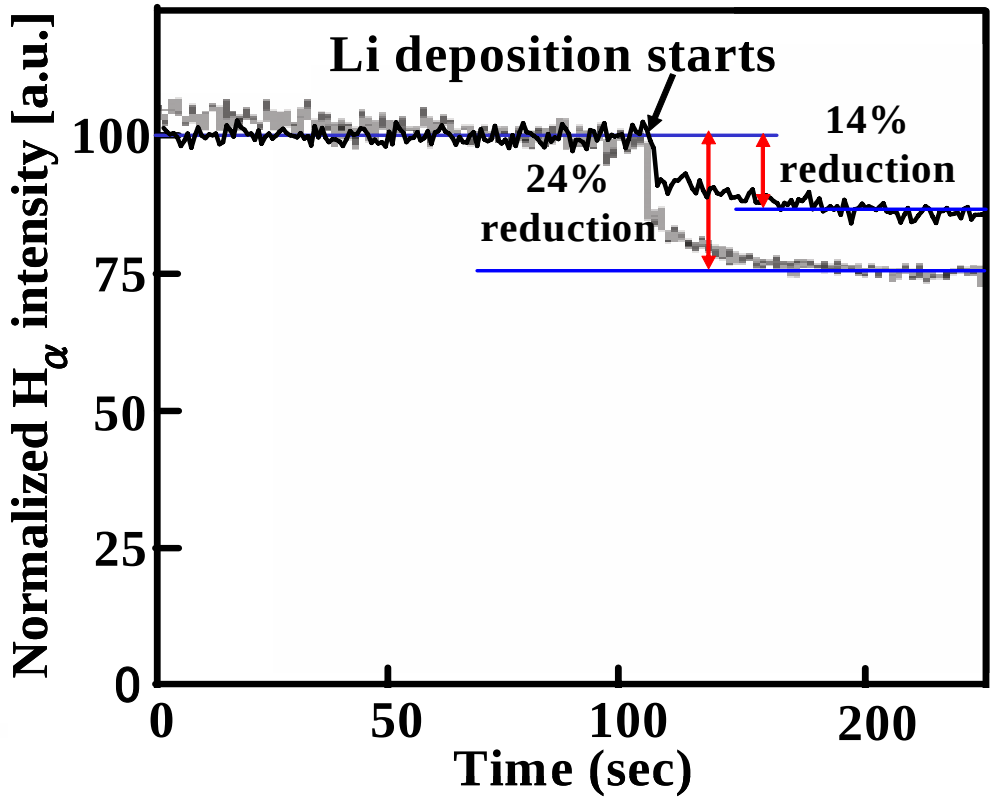
POP exps. on particle control by MS-PFCs

(Presented at ANS-TOFE, 2002)



Reduced H-recycling over a MS-PFC

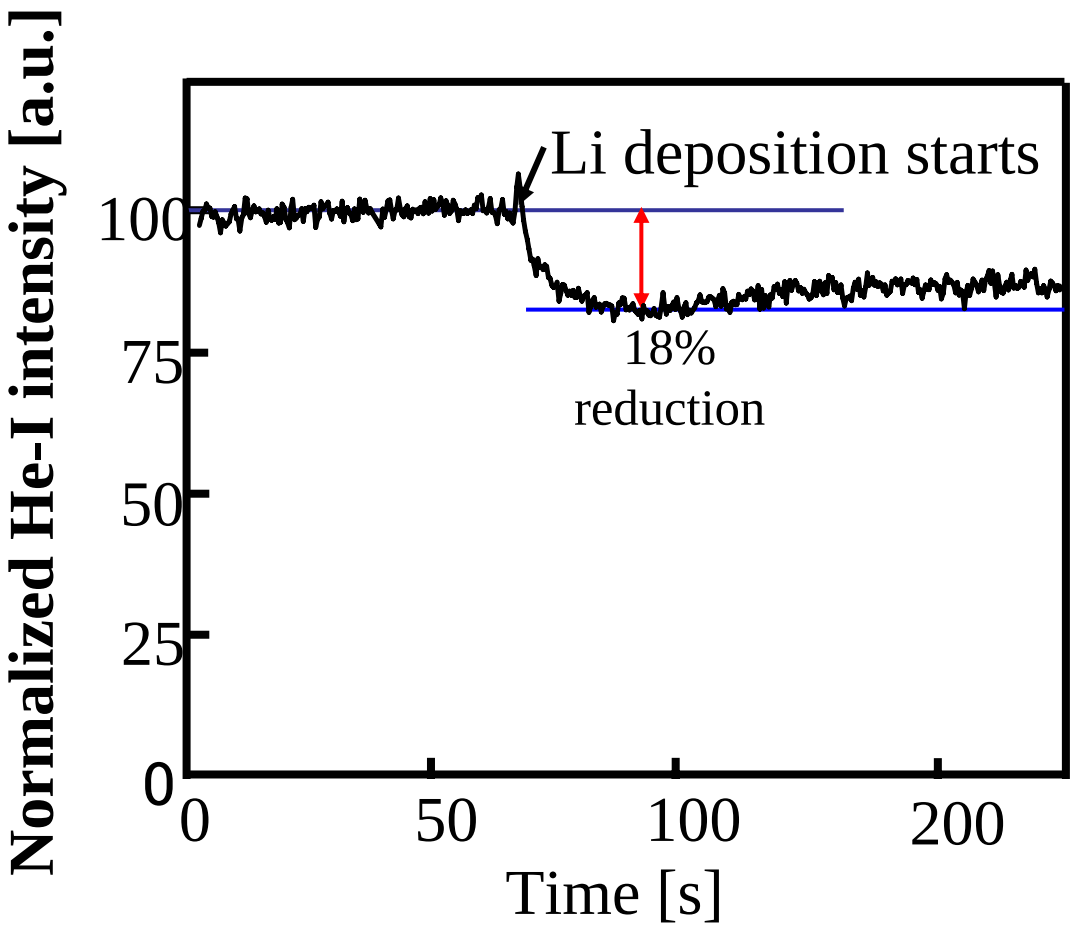
(Presented at ANS-TOFE, 2004)



Li deposition rate ~ 7 Å/s and 10 Å/s

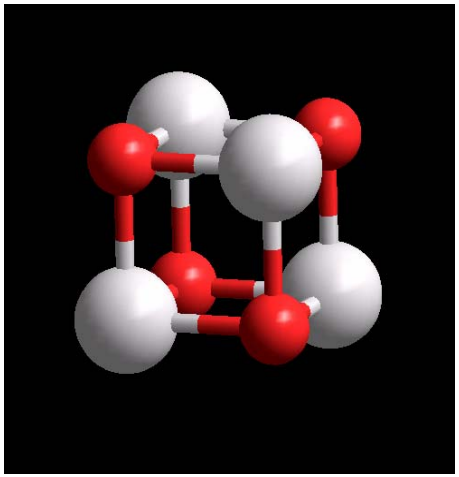
Reduced He-recycling over a MS-PFC

(Presented at IAEA-TCM-SSO, 2005)



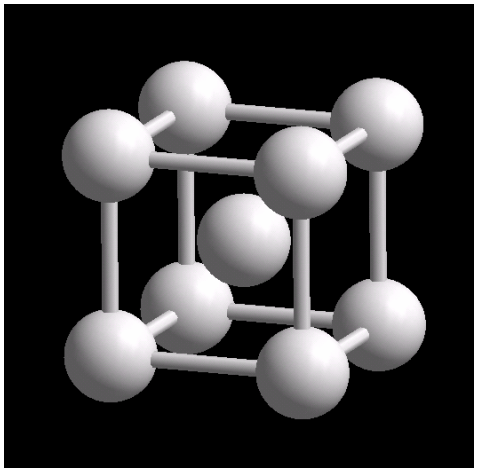
Li deposition rate ~ 40 Å/s

Li , LiH and Li+He lattice structures



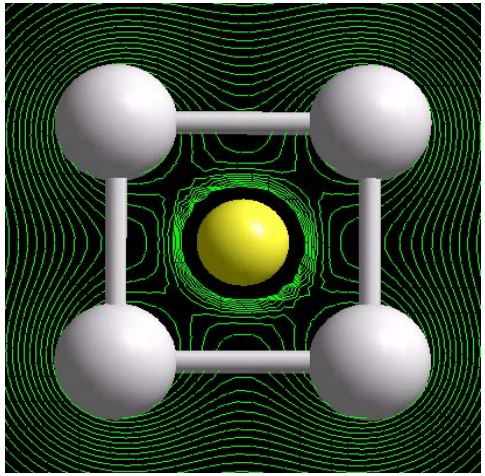
LiH
NaCl-type
ionic crystal

←



Li
bcc crystal

→

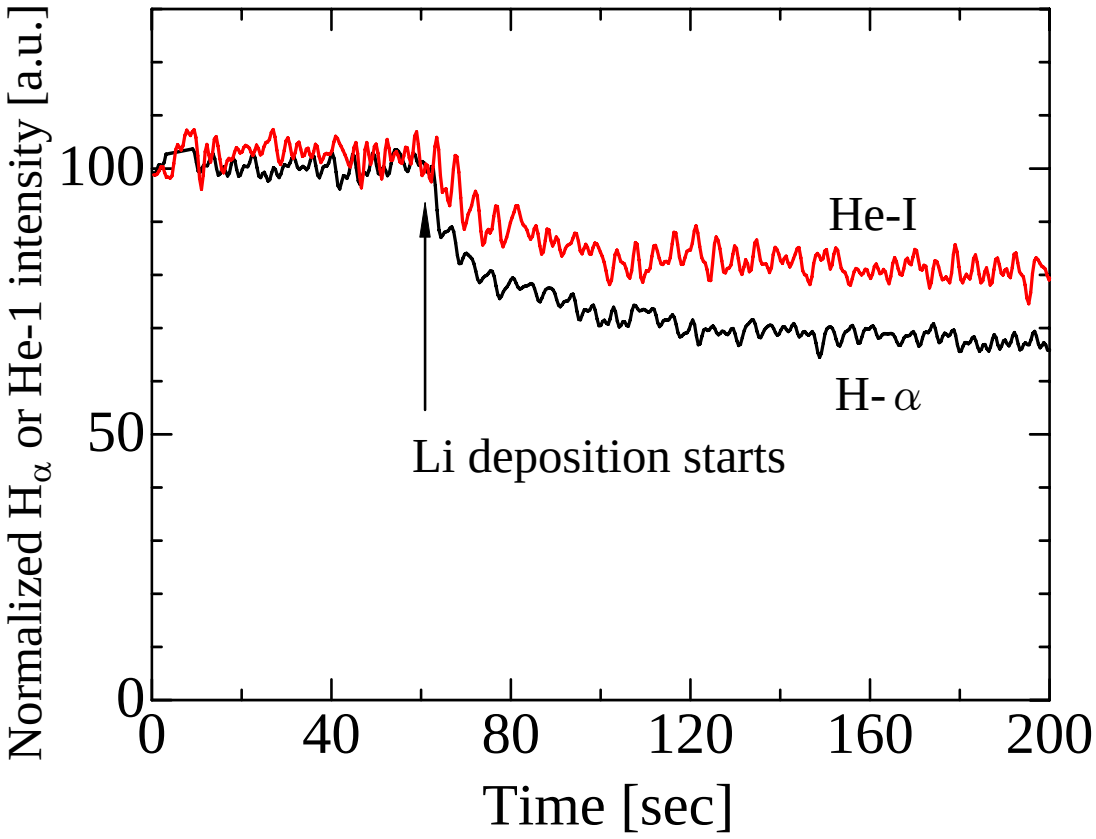


Li+He
with He trapped
in defect

A 2-dimensional cut of electrostatic potential contours around helium (in yellow) trapped in a vacancy created at the body-centered site of a cubic lattice of lithium (in white). These contours are drawn with the increment of 0.01 e/aB, where e is the single electron charge and aB is the Bohr radius.

Reduced H+He-recycling over a MS-PFC

(Presented at PSI-conf., 2006)

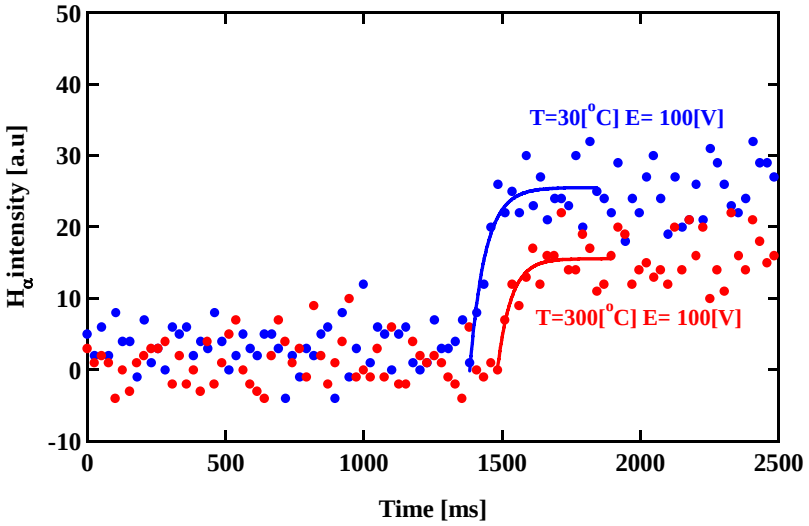


Li deposition rate ~40 Å/s

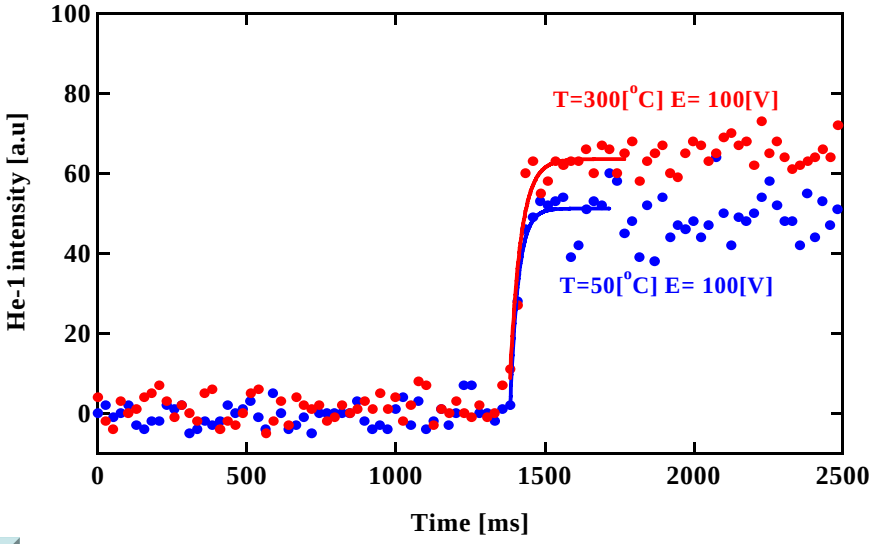
H and He-recycling from solid and liquid Li

(Presented at IAEA-FEC, 2004)

Rapid H-transport in liquid Li



He trapping in solid Li



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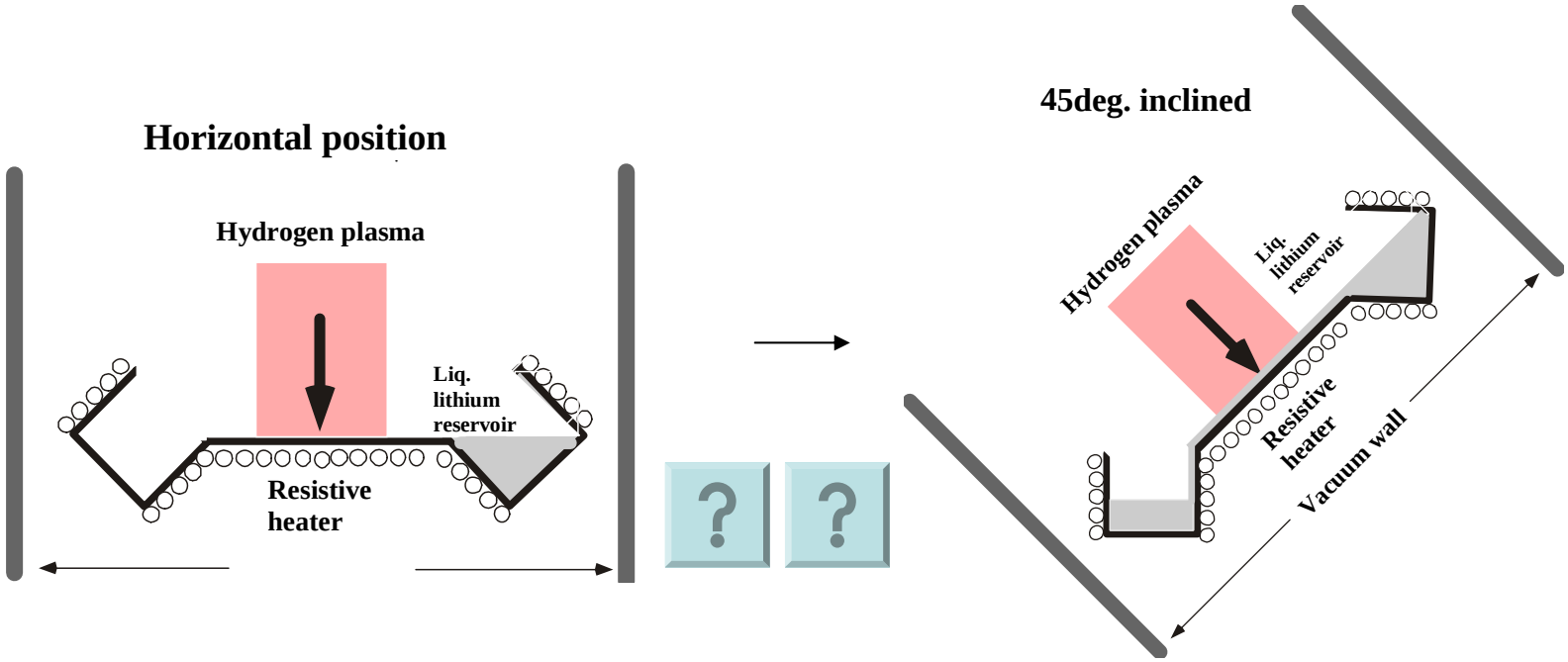
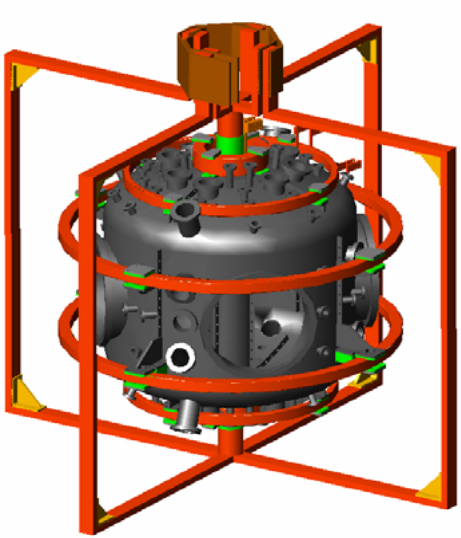
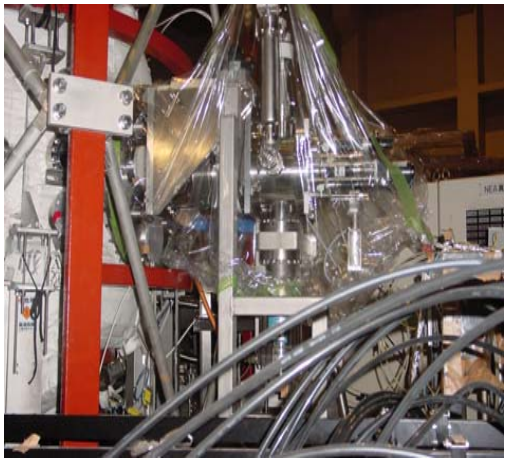
Flowing liq. Li experiments



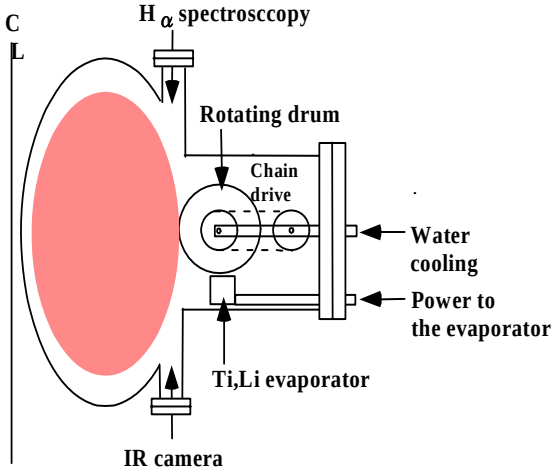
MS-PFC exps. in a compact ST at Kyushu Univ.



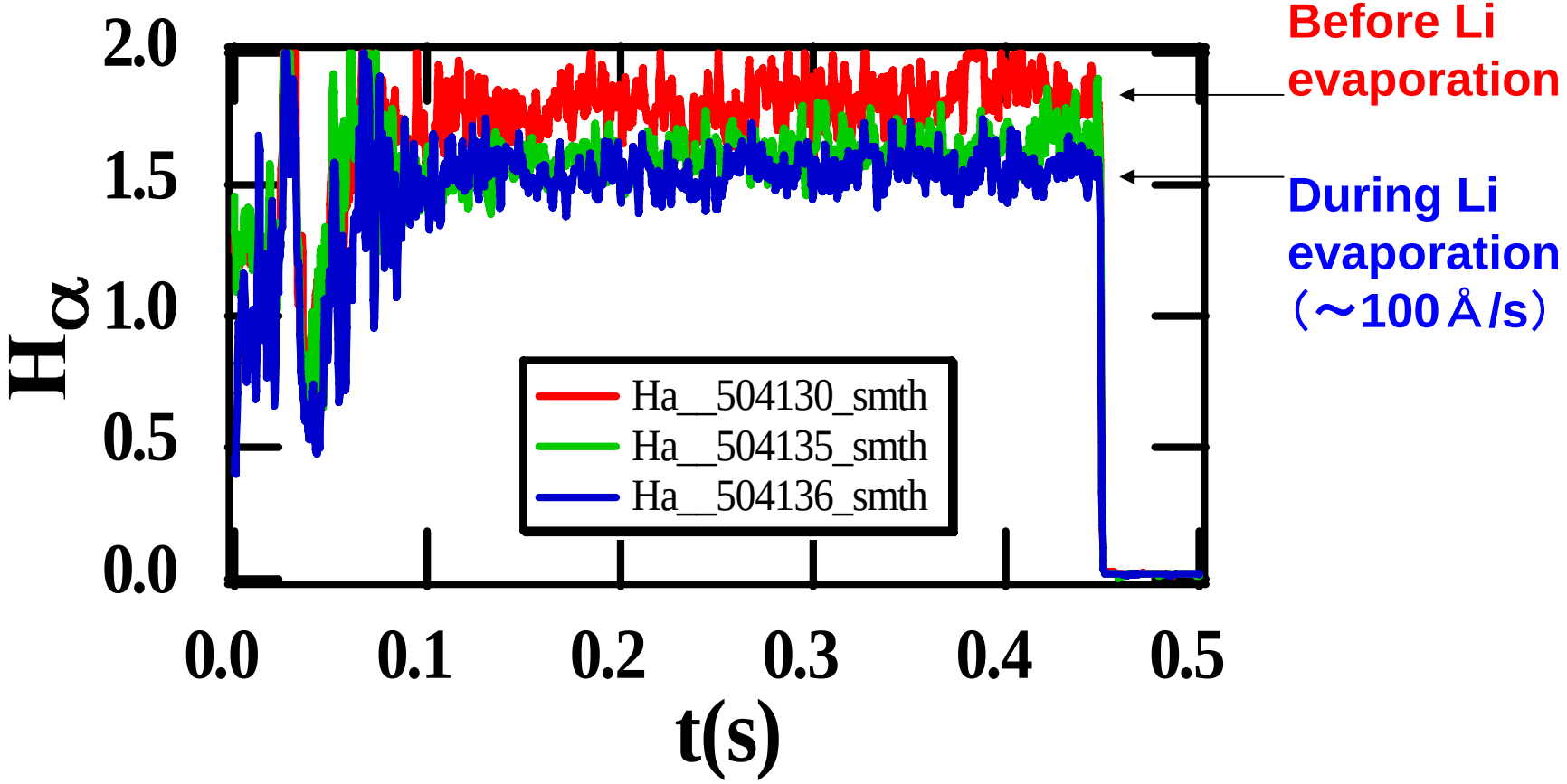
R=0.3m, a=0.2m, B=0.25T



Plasma-sprayed W on the Cu rotating limiter with an active cooling system.



Hydrogen recycling over the rotating limiter in the CPD tokamak



Summary and future plans

- Moving solid Li coatings can reduce steady state H and He recycling, simultaneously with the ratios of (H/Li)~1 and (He/Li)~0.01.
- Standing liquid Li can reduce H recycling.
- Moving liquid Li experiments are under way.
- Rotating limiter exps. in CPD in progress.