A New Facility for POP exps. on Innovative PFC Concepts and the First Experiments on Liquid Li and Ga

US-Japan Workshop on HHF and PWI
Seattle, WA
Jul. 28th-30th , 2003

Yoshi Hirooka - NIFS, Japan

Y. Ohgaki, Y. Ohtsuka, and M.Nishikawa - Osaka U.

Workshop Agenda

Table of Contents

- **Motivation**
  - **Issues on particles control in steady state fusion devices**
  - **Moving surfaces (solid or liquid) for PFCs-→MS-PFCs**
- **Where I was at the last US-Japan workshop:**
  - **POP exps. on the MS-PFC concept went successfully, demonstrating reduced recycling over a rotating drum.**
- **Where I am now:**
  - **A new facility has been put together for POP exps. on innovative PFC concepts such as those using liquid metals.**

Motivation

PMI-issues in steady state reactors :

Erosion lifetime if low-Z materials are used
Tritium build-up if low-Z materials are used
Heat flux removal, depending on the mode of divertor operation
Particles control (DT, He, impurities) if wall conditioning is used
(Is the debate over High-Z vs. Low-Z materials truly over ??)

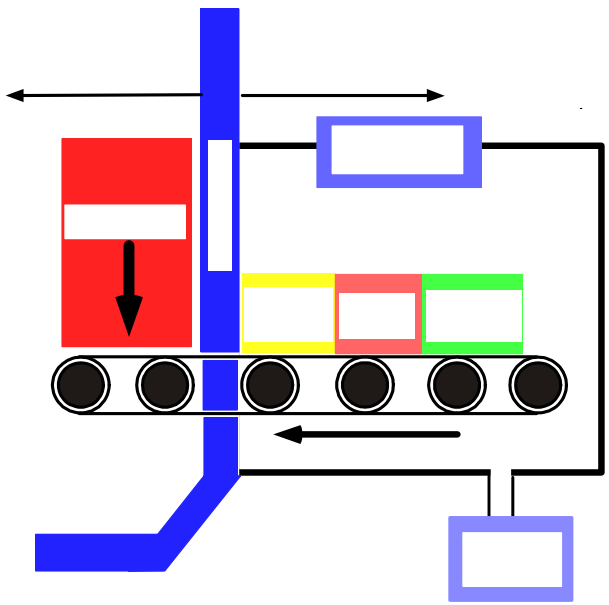
Possible solutions by "Innovative" PFC concepts (MS-PFCs):

Moving solids	**(1) continuous surface; Moving belt PFC**
	(2) discontinuous surface; Pebble drop curtain
Moving liquids	**(1) continuous flow; Liquid metal waterfall**
	(2) discontinuous flow; Mist/droplet curtain

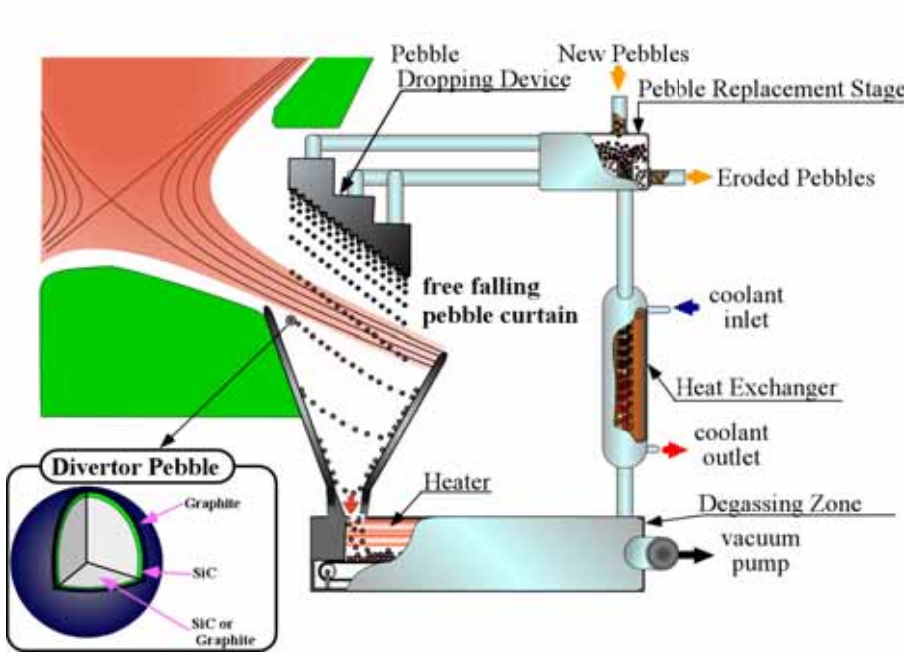
Proof-of-principle experiments on MS-PFC concepts

Need for laboratory facilities with steady state plasma generators.

Moving solid surface PFC concepts

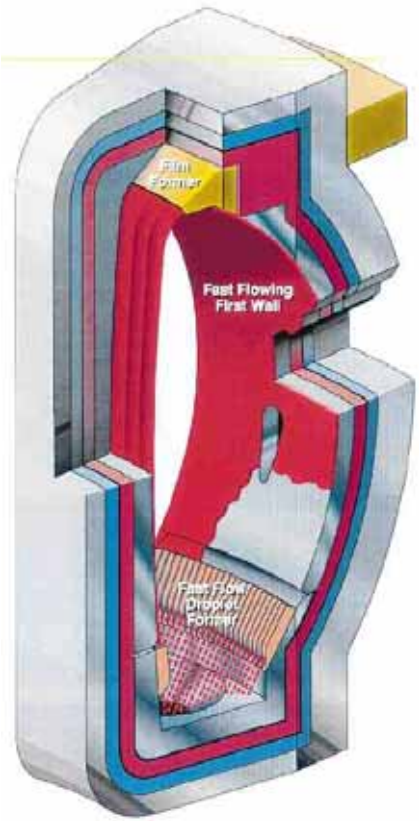


After Y. Hirooka et al., 17th SOFE, in San Diego 1997

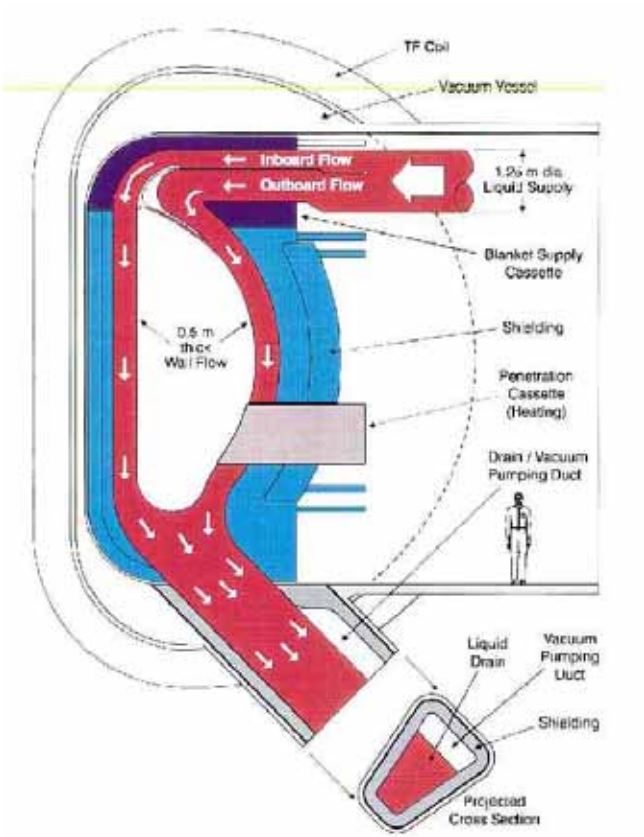


After M. Nishikawa, J. Plasma and Fusion Res. 78(2002)129

Moving liquid surface PFC concepts

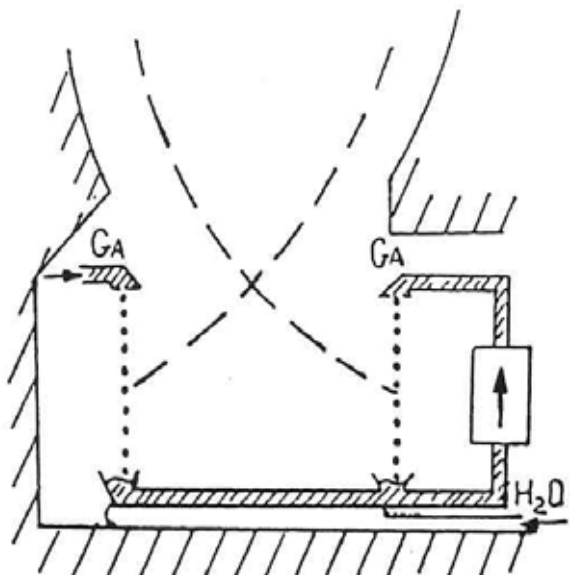


Thin Liquid Wall



Thick Liquid Wall

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



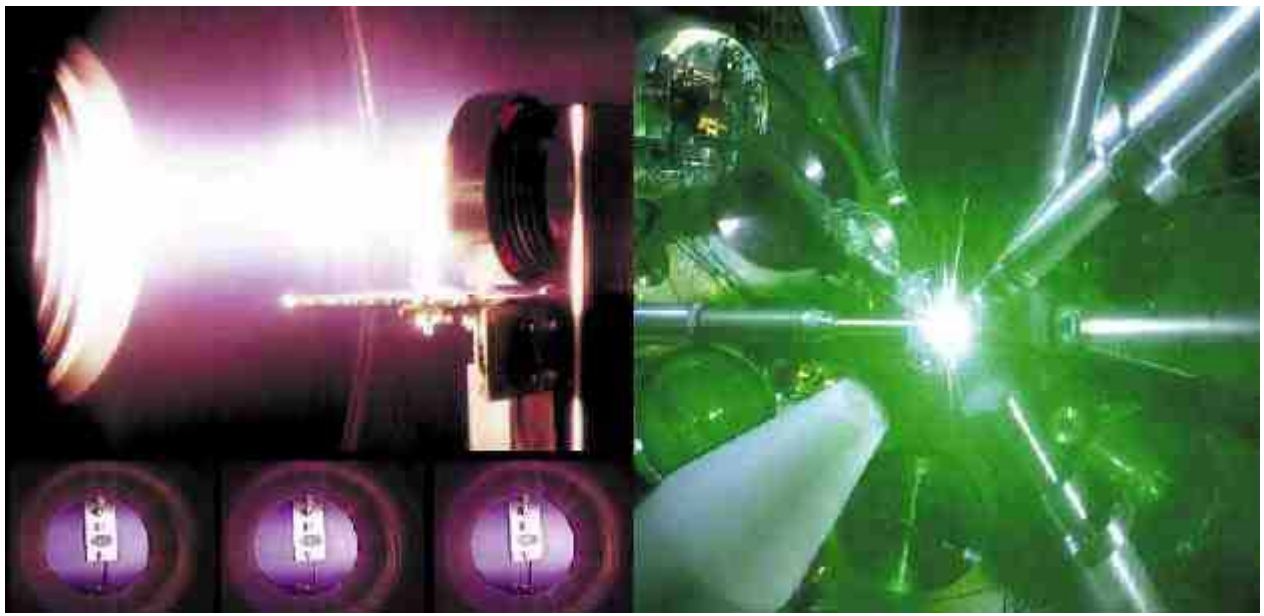
Droplet

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

1st International Workshop on

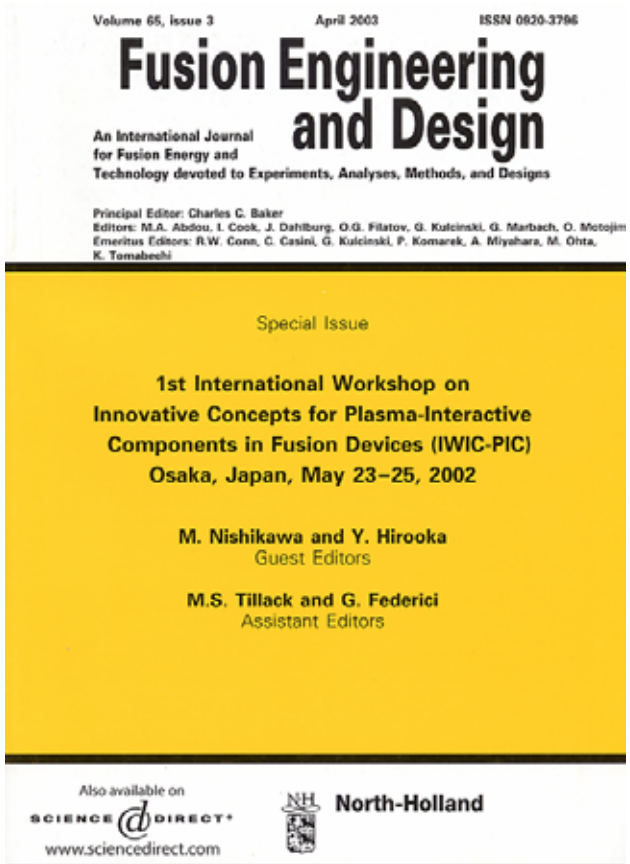
Innovative Concepts for Plasma-Interactive Components in Fusion Devices

(1st IWIC-PIC)



May 23 rd -25 th, 2002
Osaka, Japan

Proceedings of 1st IWIC-PIC published!



Volume 66, Issue 3 April 2003 ISSN 0920-3796

Fusion Engineering and Design

An International Journal for Fusion Energy and Technology devoted to Experiments, Analyses, Methods, and Designs

Principal Editor: Charles C. Baker
Editors: M.A. Abdou, I. Cook, J. Dahlburg, O.G. Filatov, G. Kulcinski, G. Marbach, O. Motojim
Emeritus Editors: R.W. Conn, C. Casini, G. Kulcinski, P. Komarek, A. Miyahara, M. Ohta, K. Tomabechi

Special Issue

1st International Workshop on Innovative Concepts for Plasma-Interactive Components in Fusion Devices (IWIC-PIC)
Osaka, Japan, May 23–25, 2002

M. Nishikawa and Y. Hirooka
Guest Editors

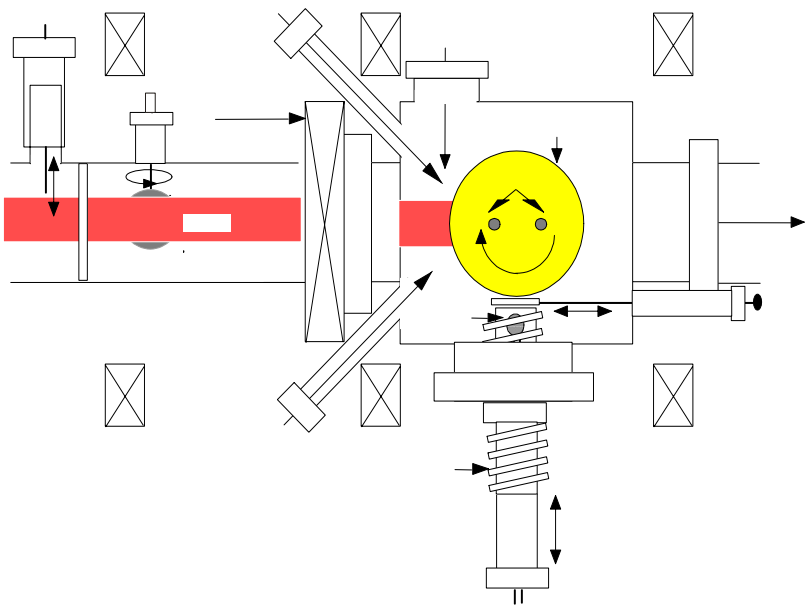
M.S. Tillack and G. Federici
Assistant Editors

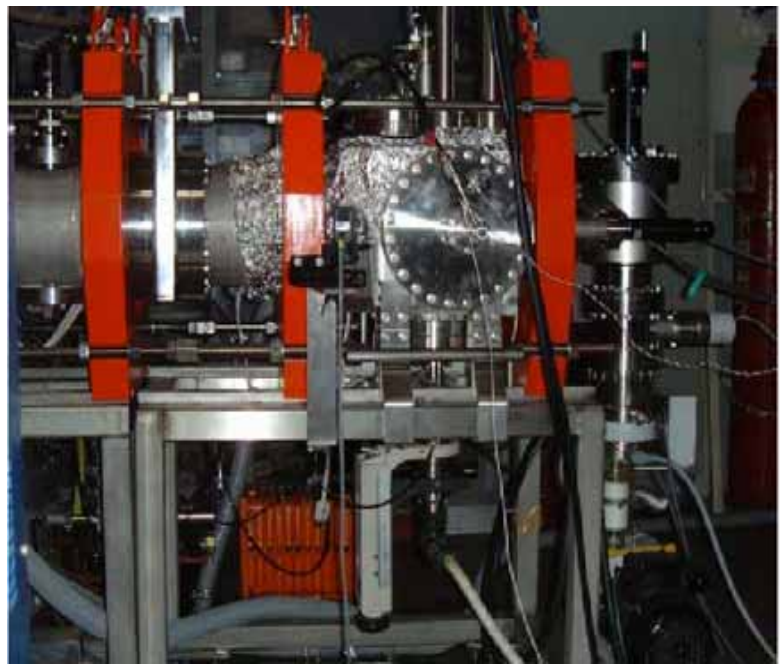
Also available on SCIENCE DIRECT®
www.sciencedirect.com

North-Holland

First POP experiments on MS-PFC

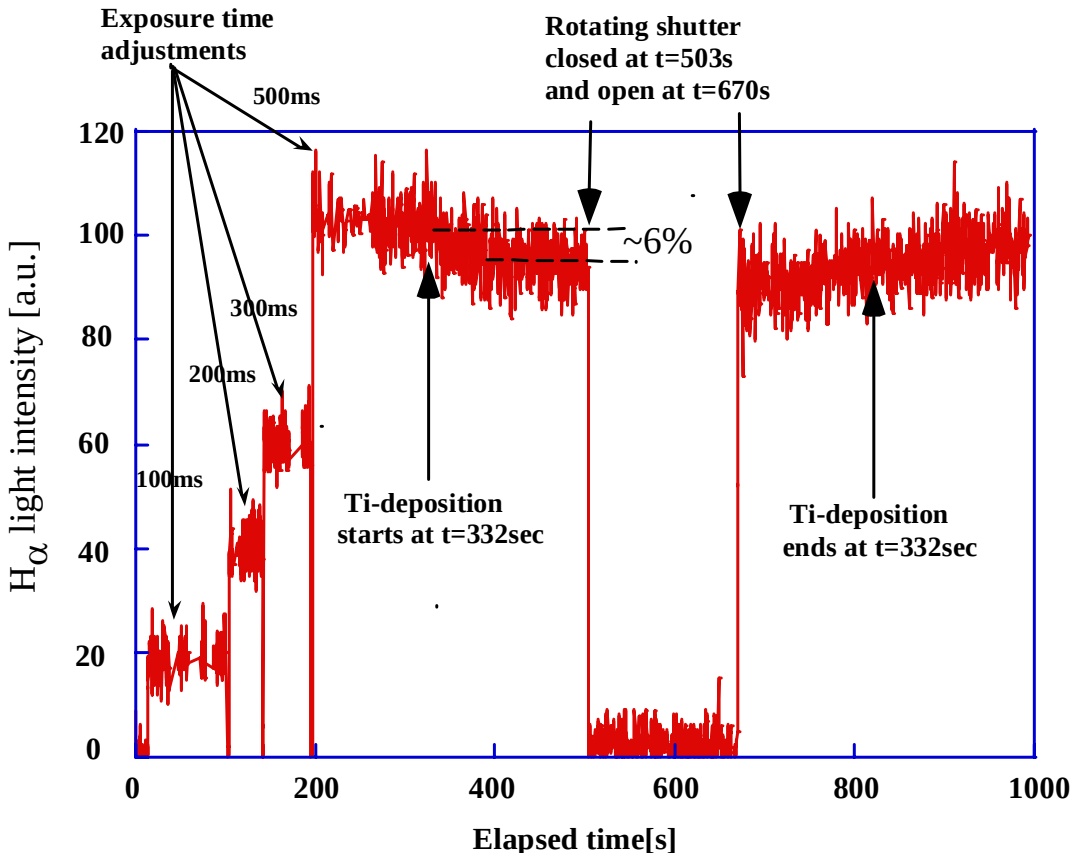
(Photos taken in Summer, 2001 in Nagoya)





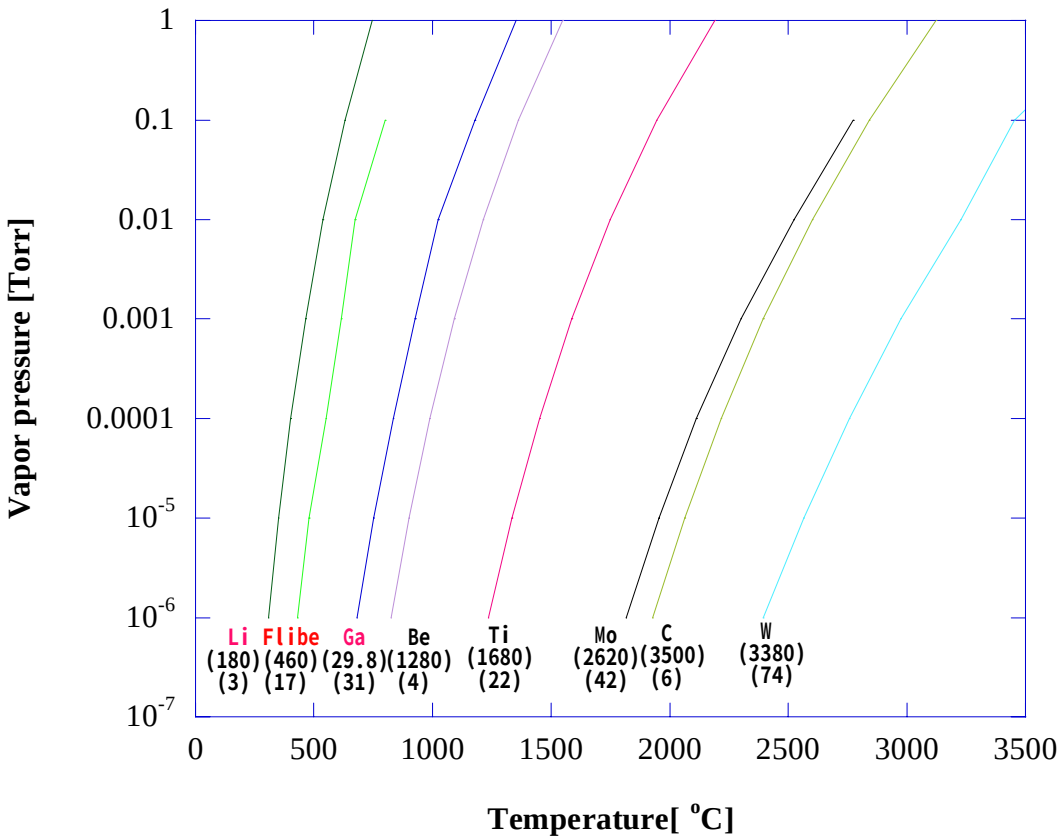
Reduced recycling at steady state!

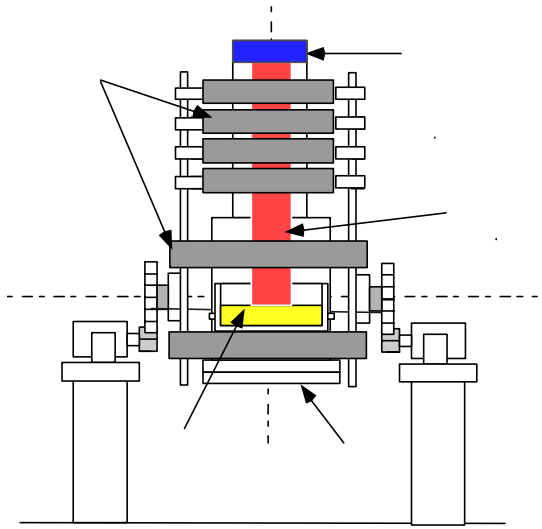
(Hirooka et al. IWIC-PIC in Osaka, 2002)

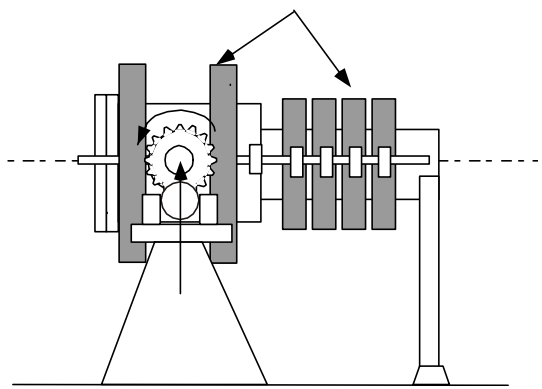


What's next after solid surface MS-PFC?

As the next step, liquid surface MS-PFCs will be evaluated but the vapor pressure (i.e. liquid temperature) control is the key.







What is VeHICLE-1 facility?

Vertical and

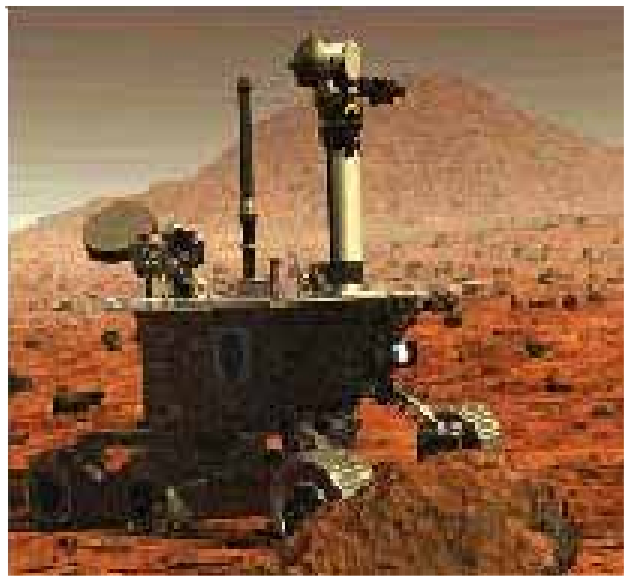
Horizontal configurations

Interchangeable test stand for

Components and

Liquids for fusion

Experiments

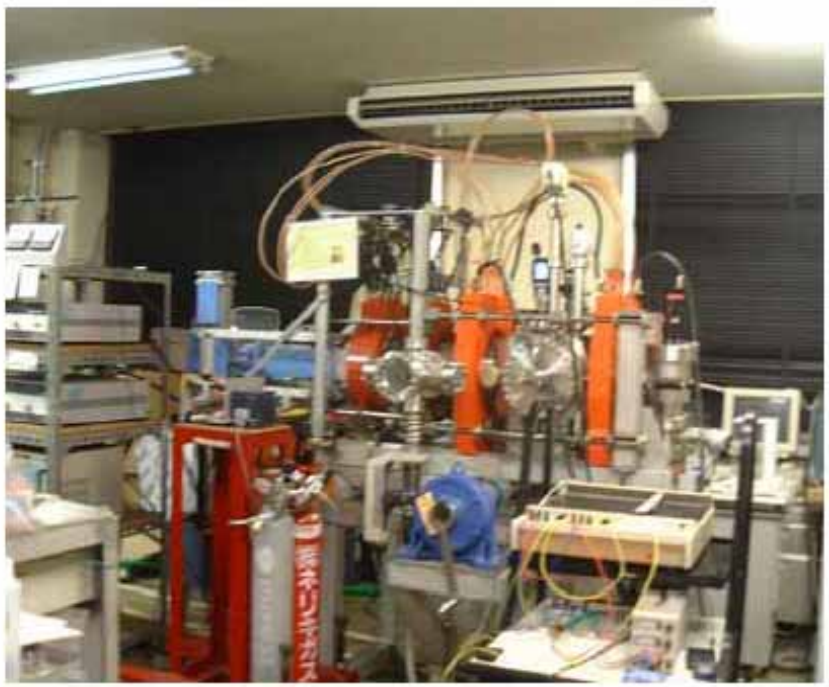


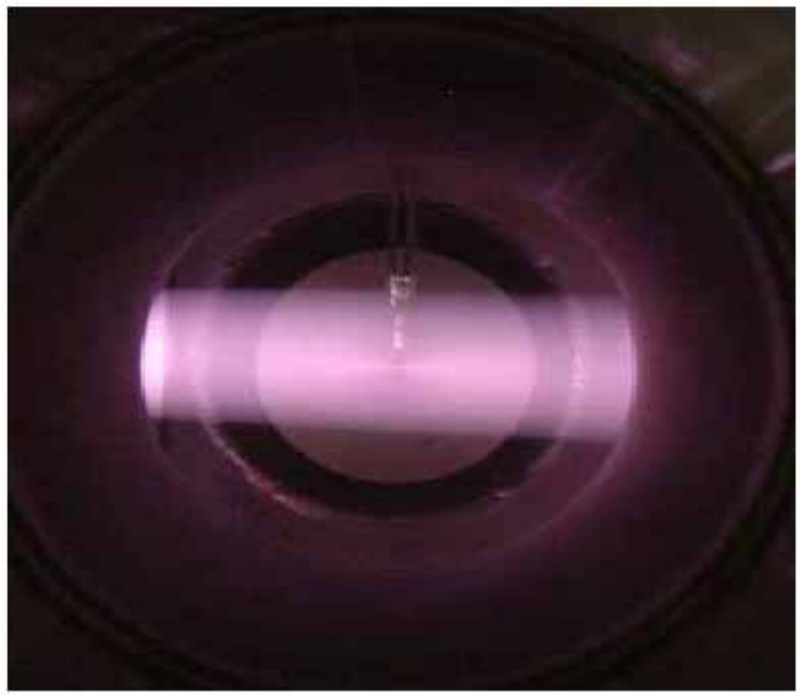
Vehicle-1 under construction #1
(Photos taken on Jan. 20th, 2003 in Gifu)

Vehicle-1 with the turbo-pump switched on!
(Photos taken on Mar. 10th, 2003 in Osaka)

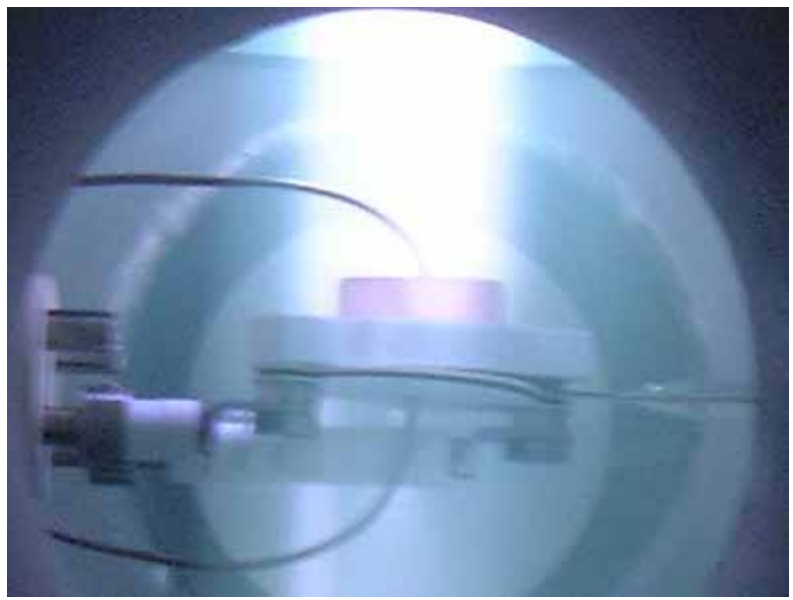
Vehicle-1 with the first hydrogen plasma on!

(Photos taken on May. 9th, 2003 in Osaka)





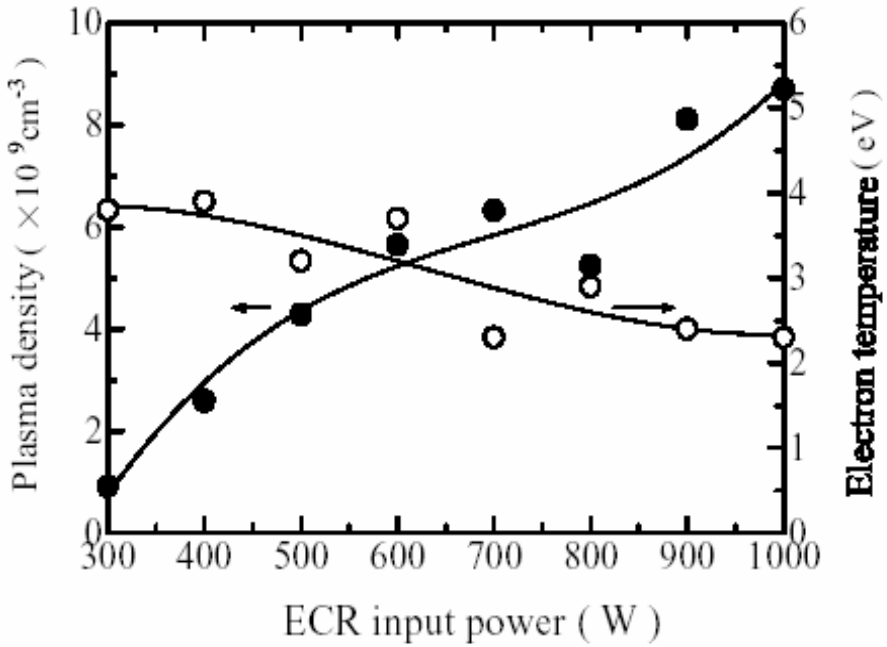
Vehicle-1 with the first vertical plasma on (Photos taken July 3rd, 2003 in Osaka)

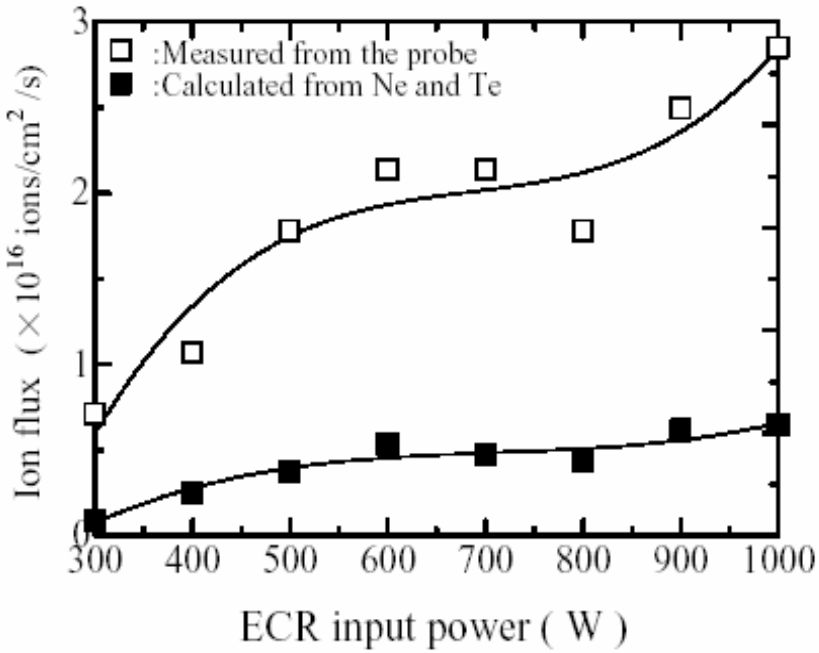


Vehicle-1 has a comprehensive set of diagnostics

1. Total and partial pressure gauges (RGA)
2. Scanning Langmuir probe
3. Optical multi-channel analyzer (OMA)
4. IR pyrometer
5. 2 thermocouples; one dipped in the liquid, and the other attached to the crucible.
6. CCD video camera

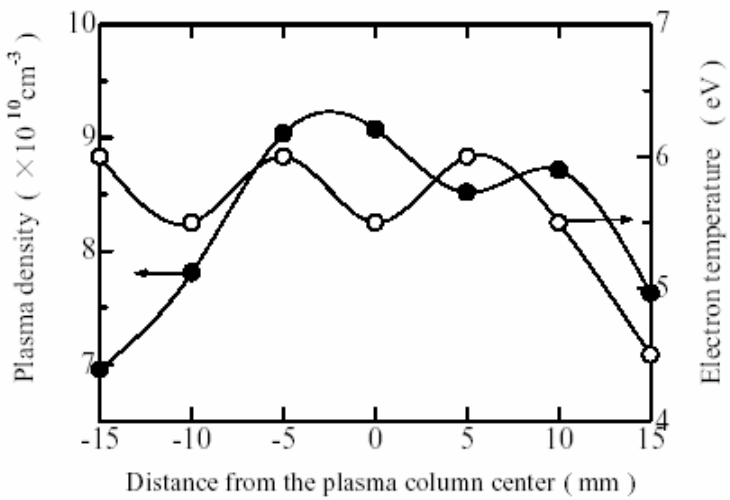
Plasma parameters in Vehicle-1



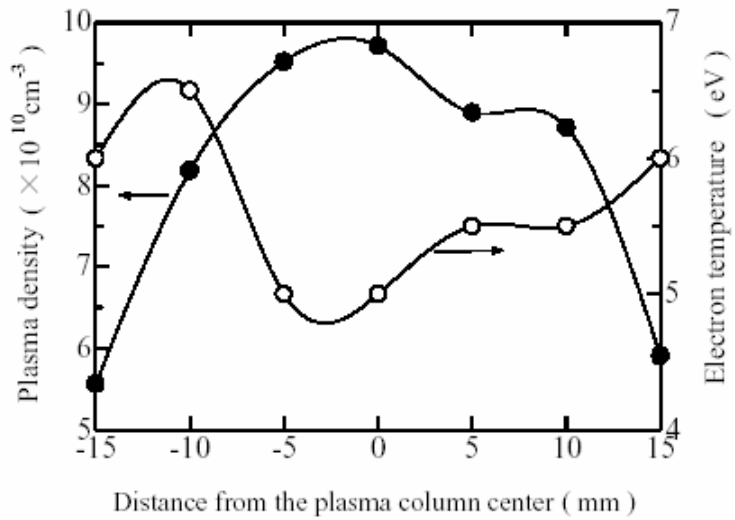


Plasma parameter radial profiles in Vehicle-1

H-plasma

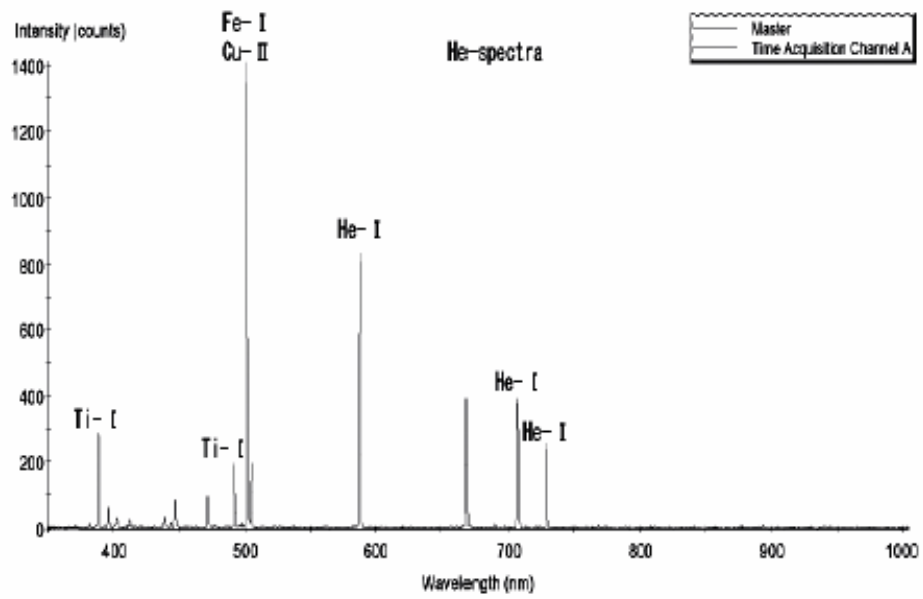


He-plasma

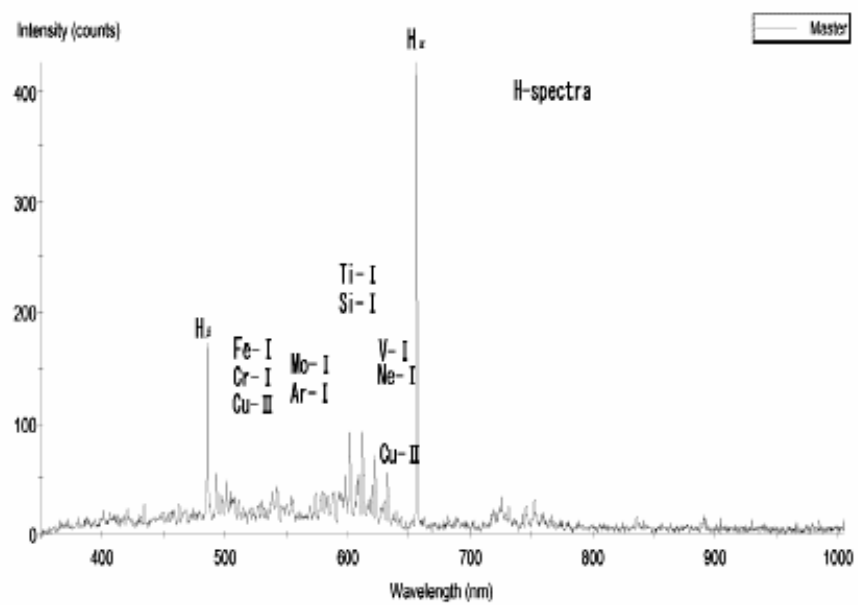


Plasma spectroscopy with a Cu crucible on

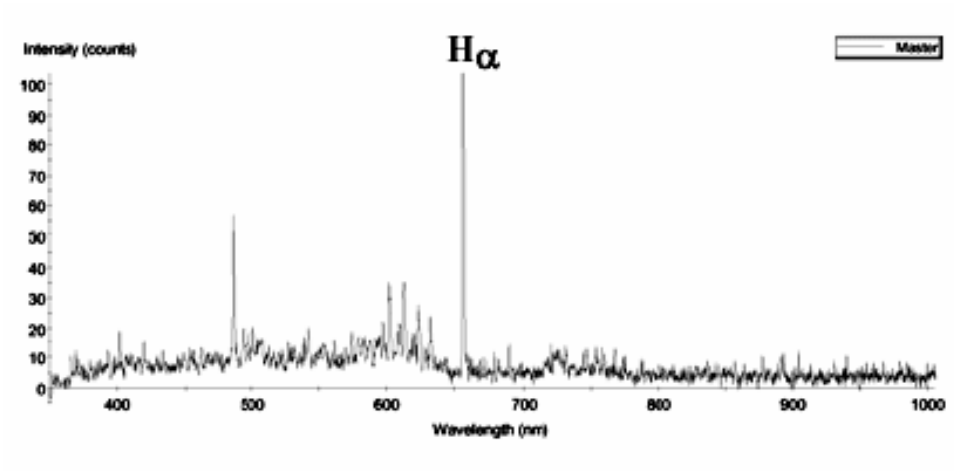
He-plasma



H-plasma

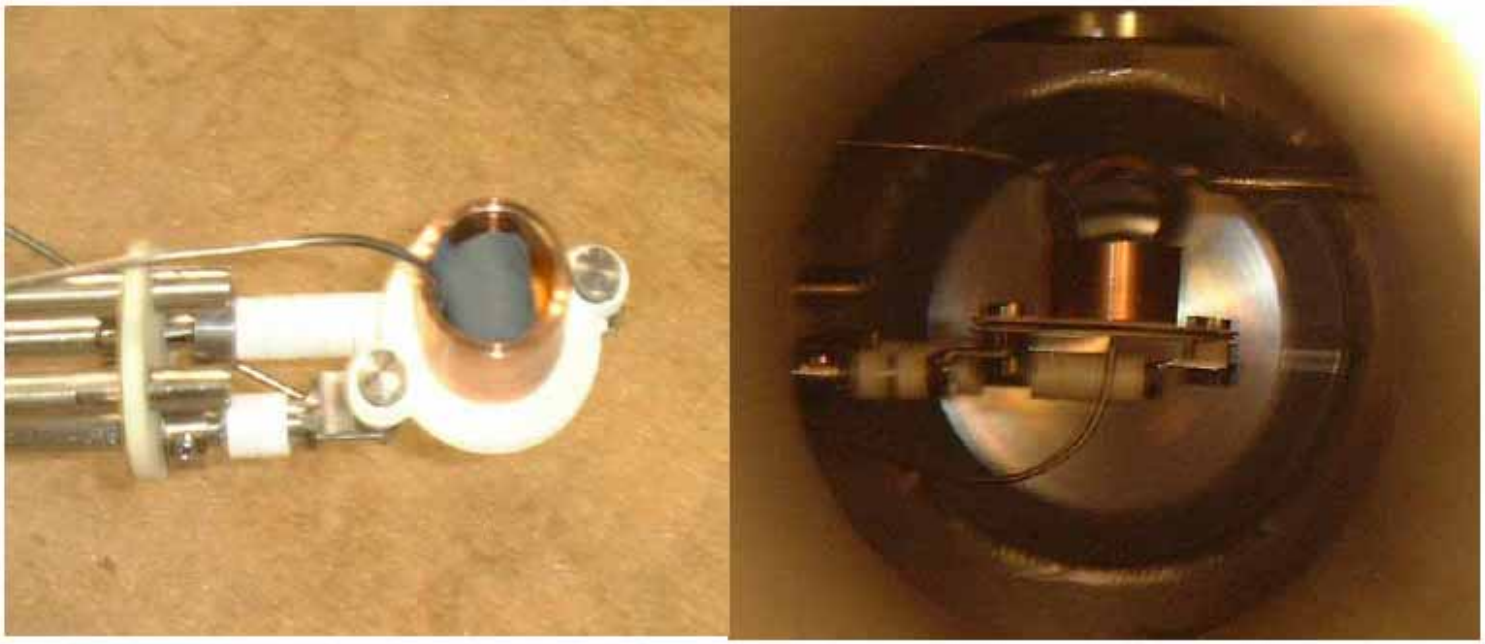


Hydrogen plasma interactions with liquid Ga in an Al crucible

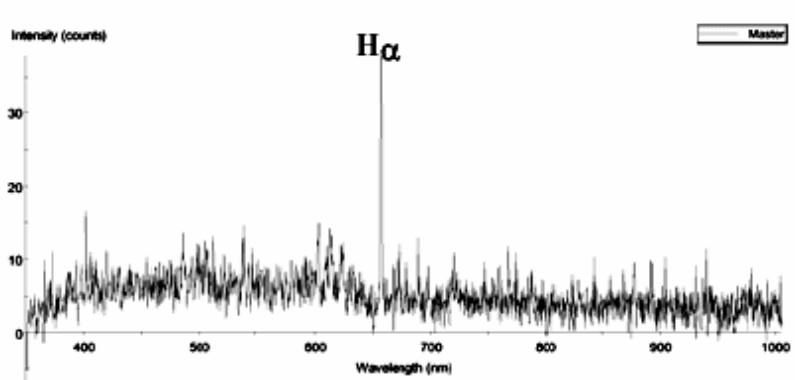


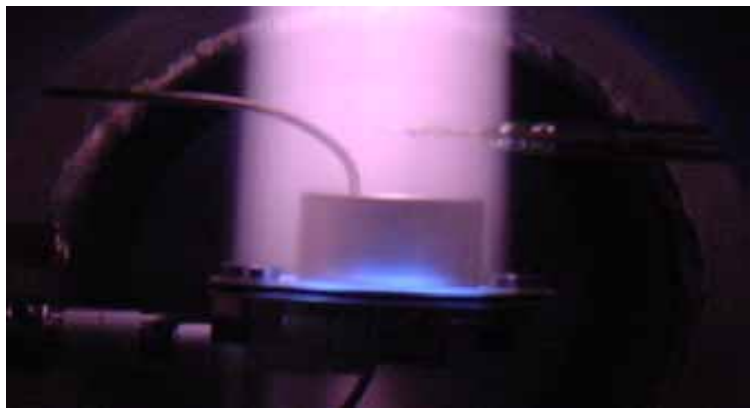
Protection against “unwanted” chemical compounds of Li and Ga

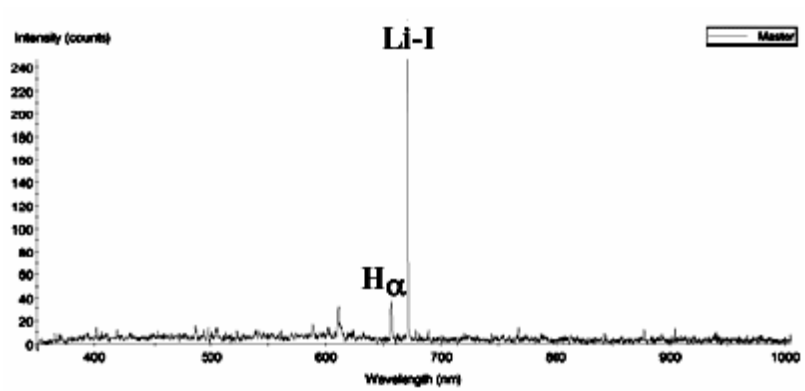
Solid Li set in a Cu crucible

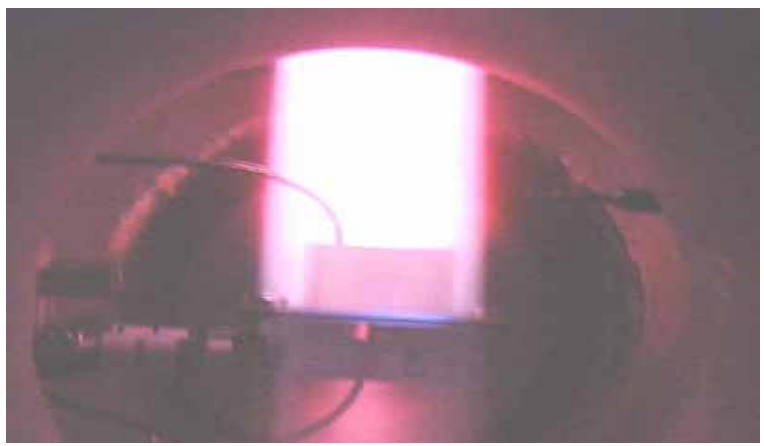


H-plasma and liq. Li interactions-I

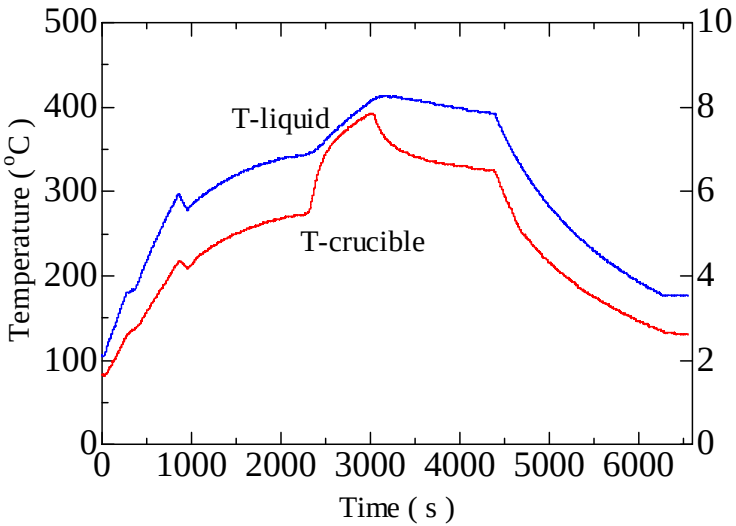


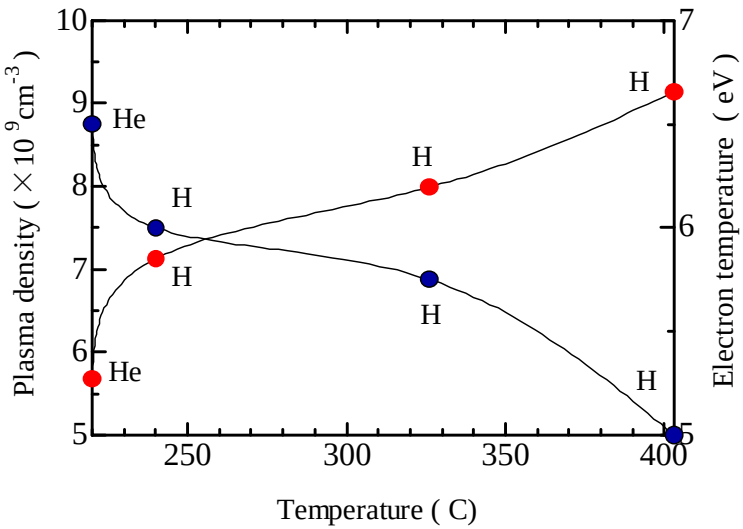






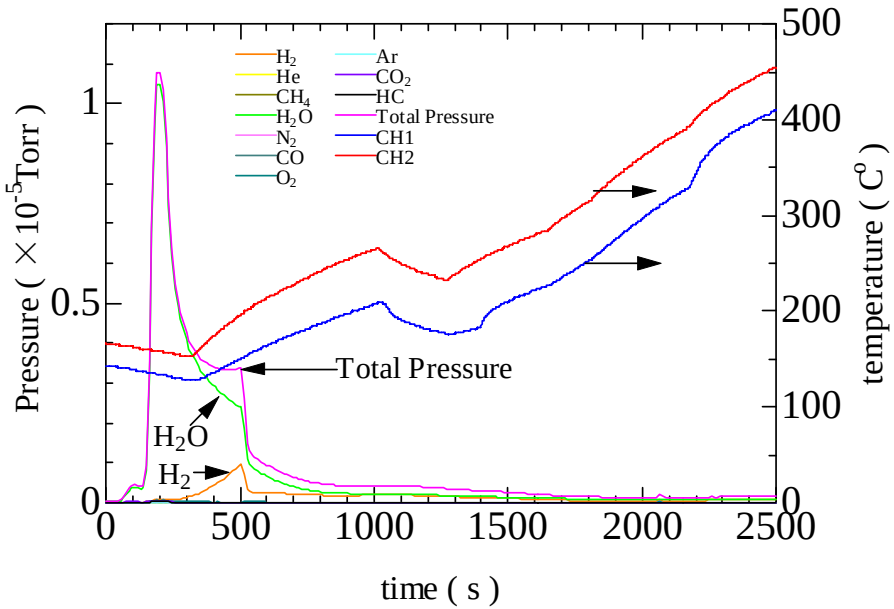
H-plasma interactions with liquid Li-II



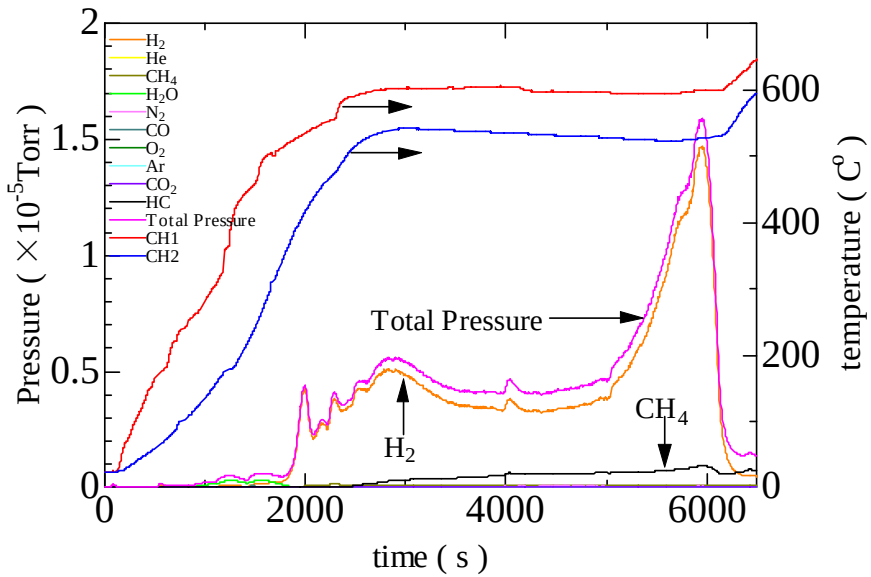


Degassing from liquid Li

Before H-plasma bomb.



After H-plasma bomb.



Degassed-H2=5.1torr liter=3.3e20-H
Bombarded-H(?)=8.5e19-H(?)

Summary and future plans

- **The VeHICLE-1 facility has come in line.**
- **The first exps. on liquid Ga and Li done.**

- **Spectroscopy has indicated no measurable Ga but significant Li during hydrogen plasma exposure.**
- **Liquid Li interactions appear to decrease Te and increase Ne: due to Li vapor(?) or recycled H(?)**
- **A high trapping efficiency indicated, which however, needs more quantitative analysis.**

- **More work on H recycling over liquid Li and Ga.**
- **VeHICLE-1 open for international collaborations.**