Hydrogen Isotope Retention and Release from Liquid Gallium

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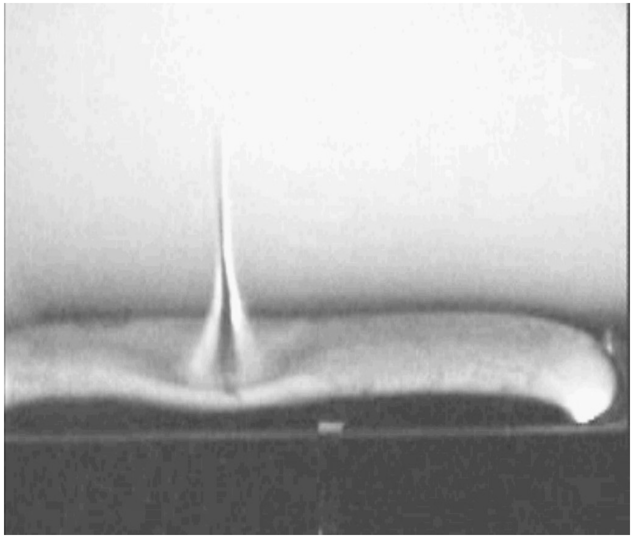
Overview

- Gallium-Hydrogen interactions and delayed TDS (previous studies)
- In situ TDS experiments in PISCES E for deuterium retention in gallium
- Enhanced D_2 retention/ loading (500 ppm) and bubble formation in PISCES E
- Temperature and time effects on retention of deuterium
- Gallane as a carrier for hydrogen trapping and recovery

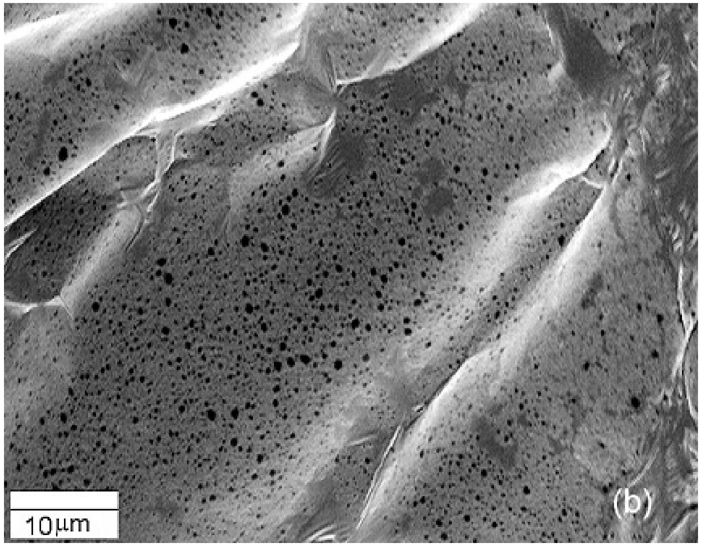
Hydrogen –Gallium (l) Interactions (previous studies)

- 2-7 ppm up to 250^{o}C in Low flux (10^{15} ions/cm^2), glow discharge plasma (*Mazayev et al., J. Nuclear Materials 212-215(1994) 1497*) and molecular flow.
- Gas Bubbles formation in D_2 plasma with 67% Ga alloy (*Begrambekov et al., Atomniya Energiya 64 (1988) 212*) in the early stages after oxide removal
- Ejection of droplets and micro-pitting of exposed samples in PISCES A & B with high Deuterium ion flux (10^{17} ions/cm^2) with very low deuterium retention (~ 5 atomic ppm)
- Previous PISCES experiments used external TDS, time delay (3-5 hrs).

Macro and micro gas evolution causing droplets and pitting in PISCES A & B



Droplet in PISCES A

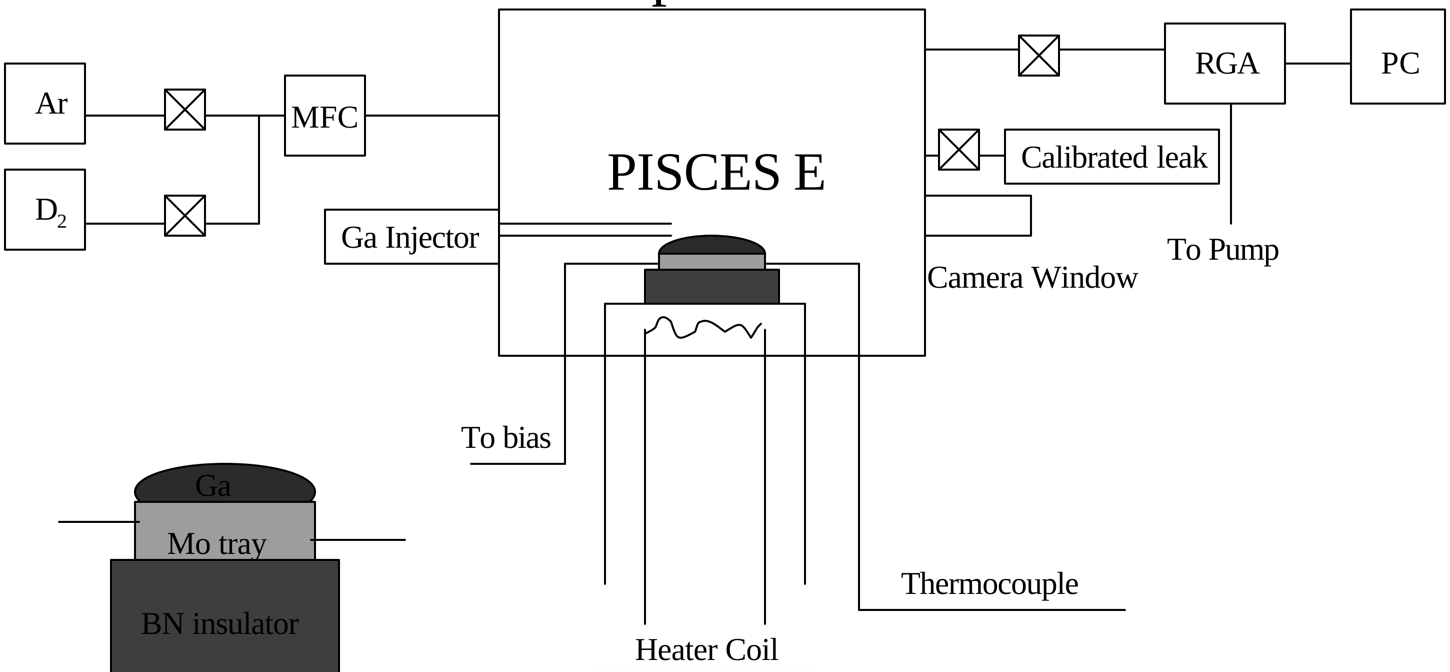


Micro-pitting in PISCES B

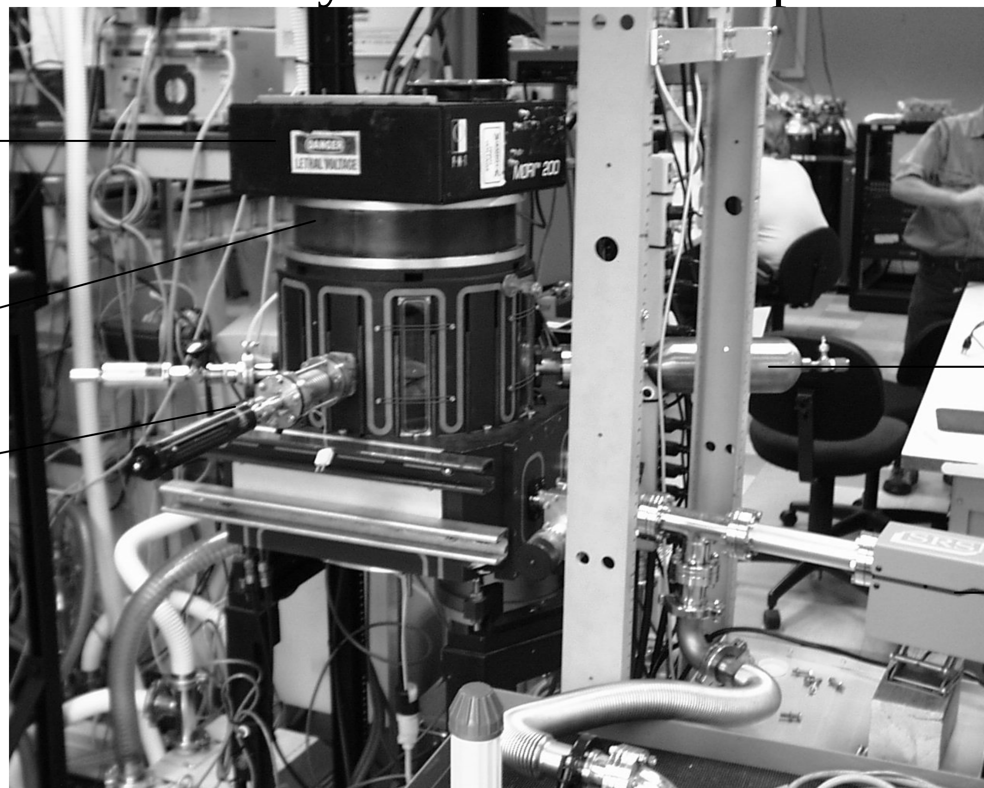
Improvements in Measurements from Past Year

- Introduced a horizontal tray for gallium and a helicon plasma source (PISCES E).
- Reduced time gap between the plasma exposure and deuterium retention measurements (in situ).
- Increased the temperature range of experiments to 500^{o}C.

PICSES E: In-situ TDS, Ga Injector/ Phase Separator, Horizontal Sample Tray, and Externally Controlled Sample Heater

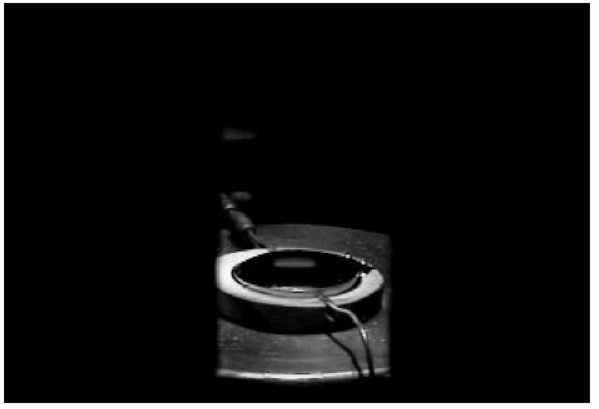


PISCES E Facilitates Deuterium Retention Studies (In situ) Immediately After Plasma Exposure



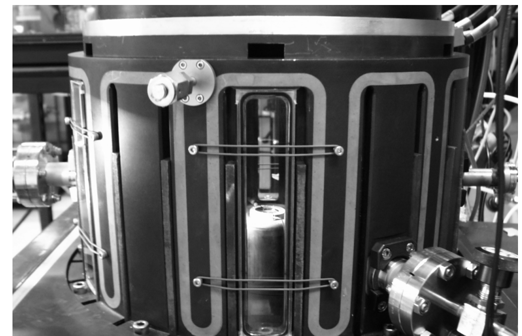
Clean, oxide free Gallium is loaded in to Molybdenum Tray using a Phase Separator Injector at 60^{o}C

Video of liquid gallium plasma exposure in PISCES-E



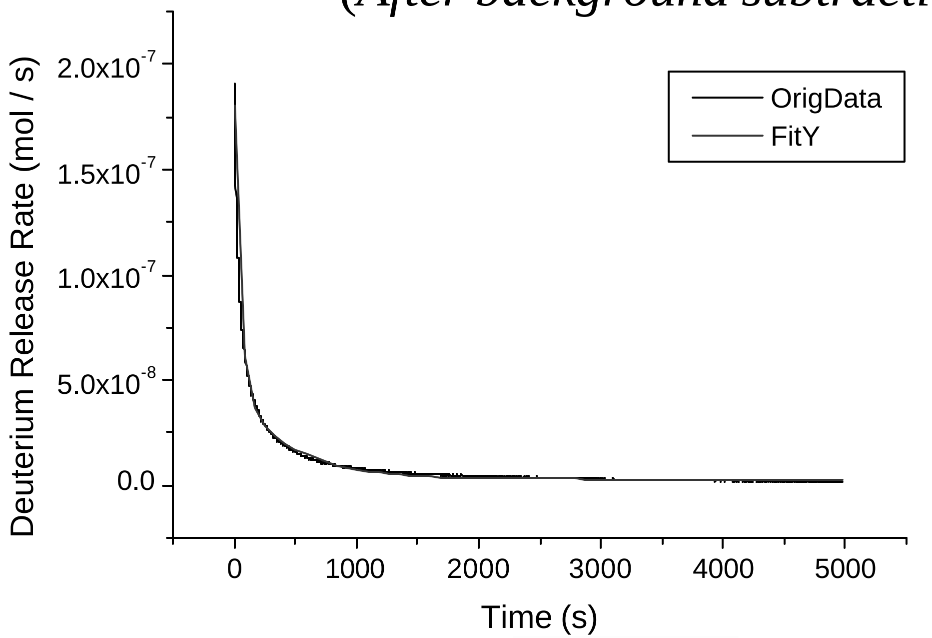
Molybdenum Sample Tray Used Instead of Highly Reactive SS 304 for Liquid Gallium

- Mass loaded in the tray ~ 5.3g
- Moles of Ga = 0.081
- Bias Voltage = -50V
- Deuterium Plasma Flux = 5×10^{16} ions/cm^2 (22 mA)
- Plasma Density ~ 10^{11}cm^{-3}
- T_e = 2-3 eV



Deuterium Plasma Exposure of Gallium at 400°C Releases 500 ppm of Deuterium with a Release Time Constant of ~ 60sec.

(*After background subtraction*)



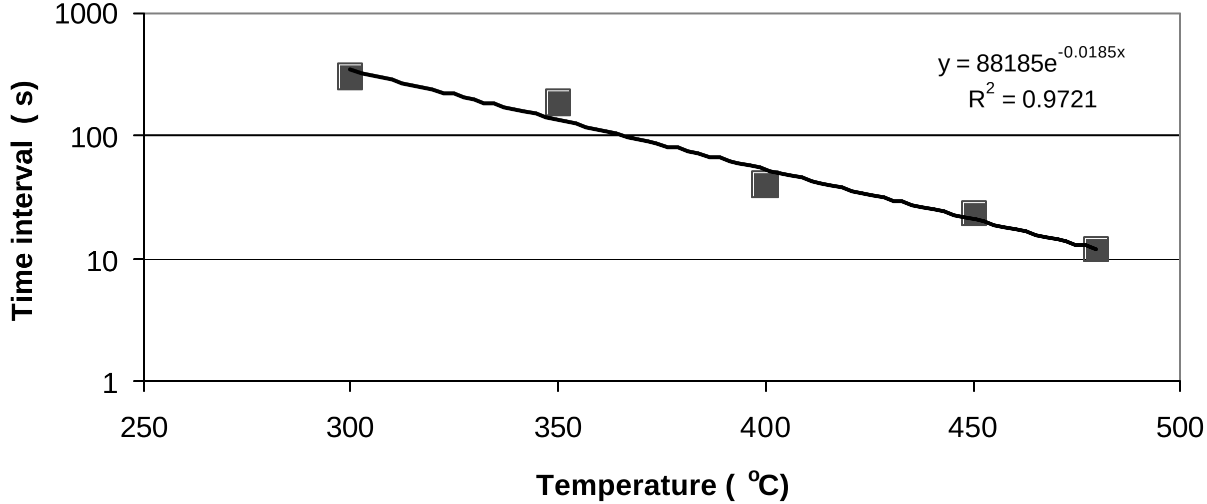
- Fluence ~ 10^{21}
- Temp. = 400°C
- Duration 7200 s
- Retained D

  4.01×10^{-05} moles

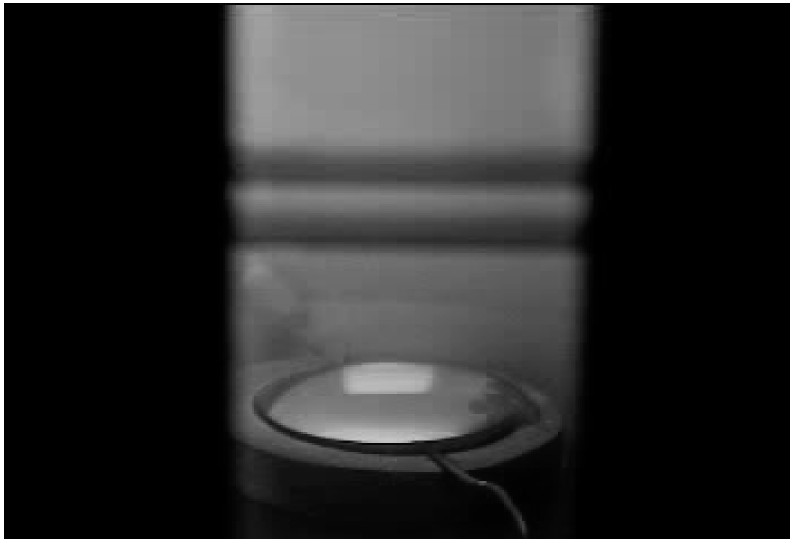
  2.4×10^{19} atoms
- Retention ~ 500 ppm

After an Initial ~20 Minutes of Plasma Exposure, Macroscopic Bubbles were Observed at Periodic Intervals During Plasma Exposure at T > 300 °C.

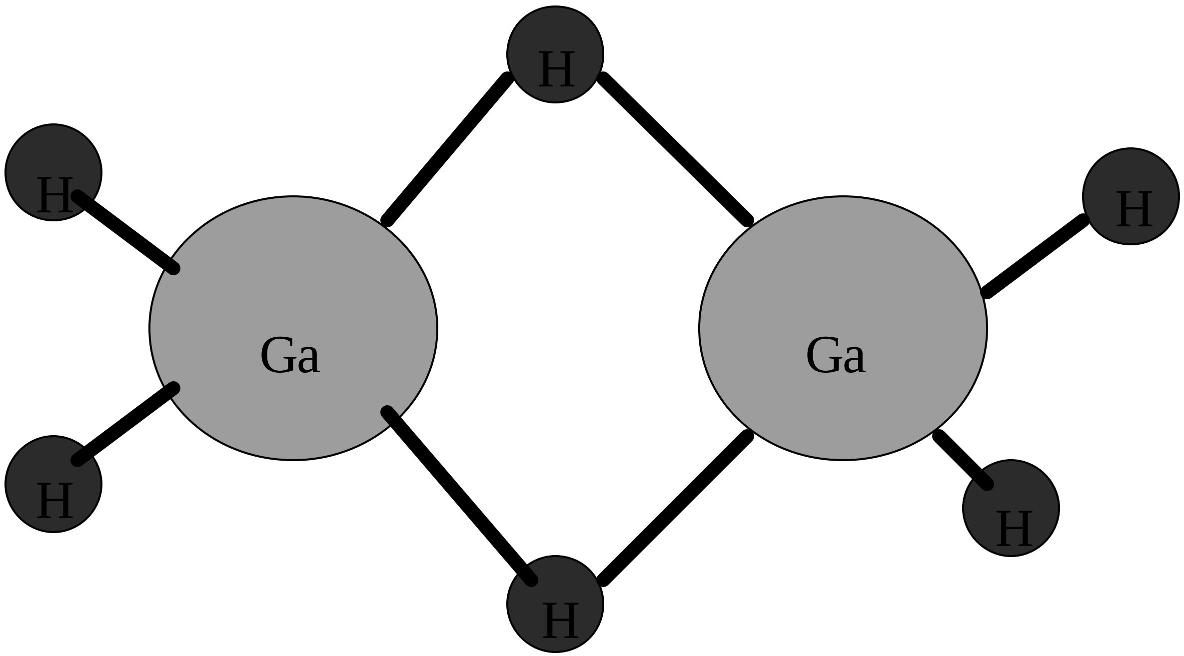
(*the frequency increased with increasing temperature*)



After initial loading period, we observe periodic bubble generation



Structure of Gallane (Ga_2H_6)



Properties of Gallane

- Obtained from dichlorogallane, Methylgallium on H_2 in an AC field*
- Melting point* ~ -21.4^{o}C
- Boiling point* ~139^{o}C
- Decomposition Temp ~ 160^{o}C
- Heat of Vaporization* (0-130^{o}C) 9.7kcal/mole

*Handbook of Binary Metallic Systems, Ed. N.V. Ageev, Vol 2 p298 (1967)

Macroscopic View of Gallium Sample After Plasma Exposure Shows Surface Pitting

Conclusions

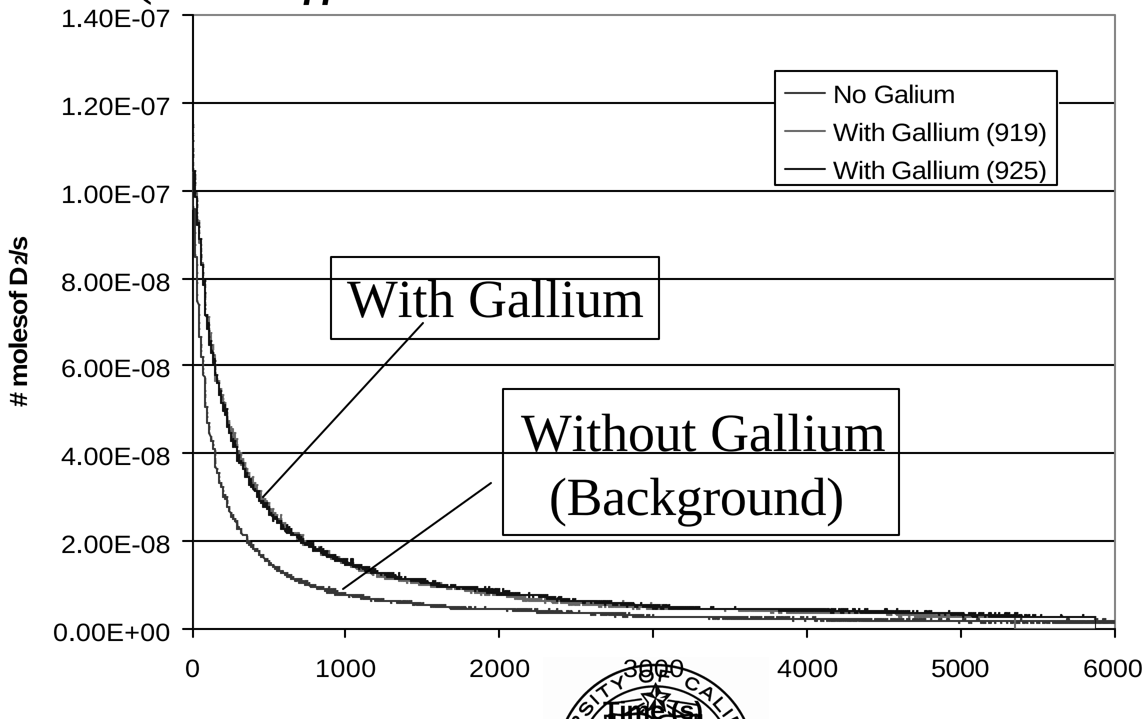
- Approximately 500 ppm of deuterium atoms are slowly released from liquid gallium over several minutes.
- Deuterium release was fitted by a two time constant model, t1 = 60 s; t2 = 2500 s
- Periodic bubbles and droplet formation was observed after an initial loading period of ~20 minutes.
- Bubbling was not observed below 300^{o}C.
- One speculation is that formation of Gallanes within the liquid metal may be occurring.

Future Plans

- Continue experiments to determine temperature scaling of deuterium release.
- Understand the mechanisms responsible for the formation of bubbles, fast video imaging camera.
- Does formation of gallanes control the ability of Ga to retain hydrogen isotopes?
- Experiments with He plasma on Ga at different temperatures to obtain He pumping.
- Mie scattering to detect micro droplets of gallium.

Plasma Exposure of Ga @ 400^{o}C Releases 500 ppm of Deuterium During Cooling

(*the difference between the two curves*)



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