Deuterium retention in liquid lithium plasma-facing components in fusion reactors

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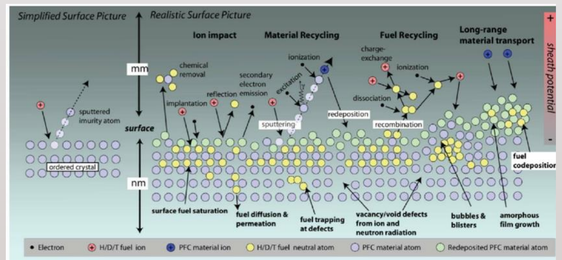
MOTIVATION

- Energetic ions can cause significant modification to wall components in fusion tokamaks
- High recycling reduces plasma temperature, diminishing efficiency of fusion reaction
- Liquid lithium (Li) is a widely accepted candidate for PFCs

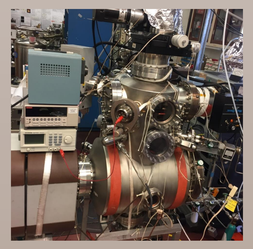


Schematic illustration of synergistic plasma-surface interactions involving hydrogen (H), deuterium (D), tritium (T), and gamma ray (γ) interactions with near-surface lattice atoms [1]

OBJECTIVE

To perform in situ experiments using Temperature Programmed Desorption (TPD) and Auger Electron Spectroscopy (AES) to measure the retention of D^+ in liquid lithium and elucidate the surface chemistry of liquid Li coatings on PFCs.

EXPERIMENTAL SETUP

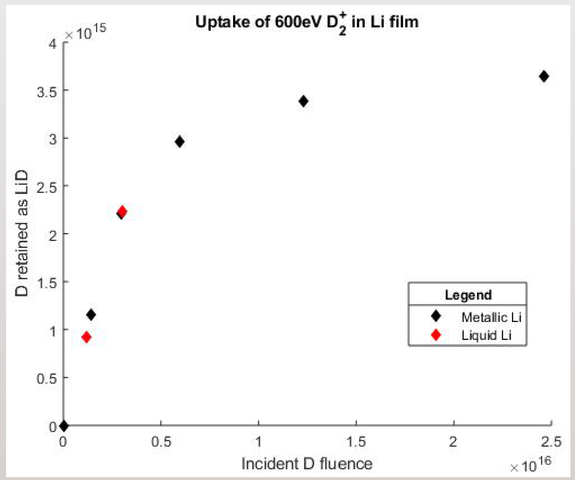


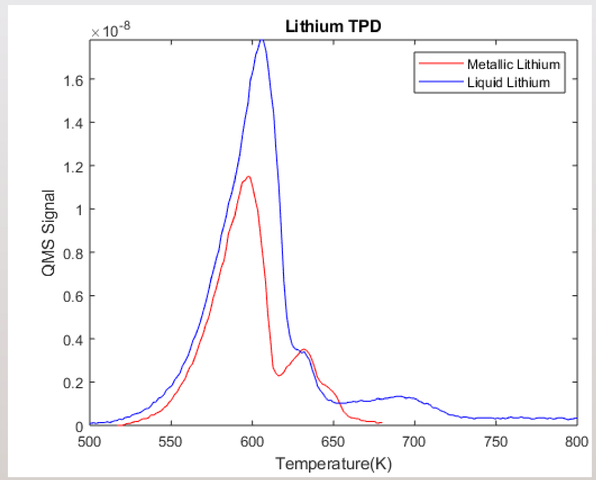
- UHV chamber:$1 \cdot 10^{-9}$ torr base pressure
- Li dosing, AES, and Quadruple Mass Spectrometry (QMS)
- 0.5 cm^2 Nickel (110) substrate in chamber

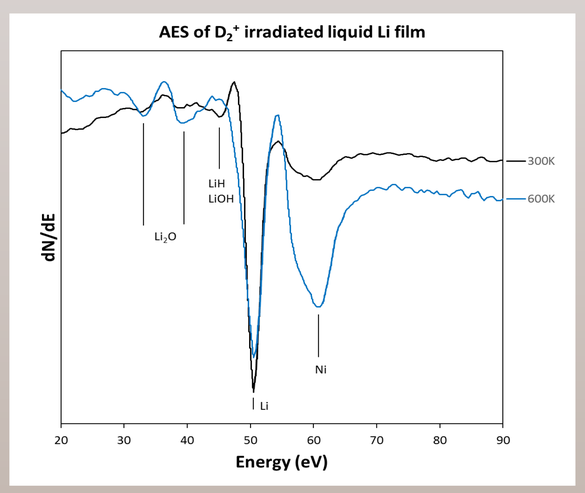
RETENTION STUDIES IN METALLIC AND LIQUID LI

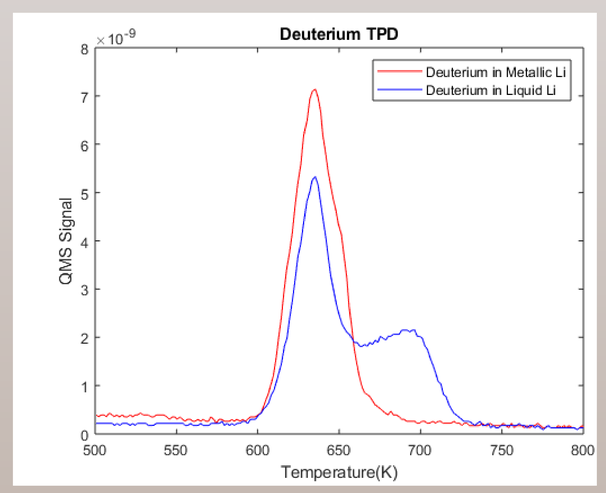
- The sticking coefficient of metallic and liquid Li were 0.81 and 0.79 respectively

$$\frac{Amount\ of\ D^+ retained}{Amount\ of\ D^+ incident} = sticking\ coefficient$$

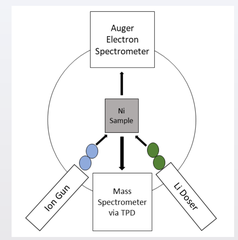








- Metallic Li at ~630K shows formation of lithium deuteride (LiD)
- Metallic and liquid Li desorbed at similar temperatures
- D_2^+ desorbed at similar temperatures in both trials
- A shoulder specific to liquid lithium appeared at ~700K
- AES confirms purity of sample and no sign of alloying



CONCLUSIONS

- Ultrathin liquid lithium (Li) films were irradiated with D_2^+ in UHV conditions
- Metallic and liquid Li have comparable D^+ retention capabilities
- New thermally more stable LiD state was formed in liquid Li
- LiD formed in tests with liquid Li are chemically identical to those formed with metallic lithium

FUTURE WORK

Reporting data on the time-dependent retention studies of D^+ ions in liquid Li in ultra-high vacuum conditions.

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REFERENCES

1. *Zinkle Fusion Sci. Tech. 64 (2013) 65-75*