

Lithium thin-film coatings erosion and H-retention in NSTX module A applications

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*Plasma Facing Components (PFC) Meeting
Oak Brook, Illinois
November 19, 2003*



Argonne National Laboratory



A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago



Lithium thin-film coatings erosion and H-retention in NSTX module A applications

- **Near-term application of lithium walls in NSTX**
- **Erosion processes from solid and liquid Li**
- **Li thin-films on graphite: erosion**
- **Li thin-films on graphite: H-retention**
- **Kinetics of lithium-carbide surfaces**
- **Modeling issues for near-term Li applications in NSTX**

Near-term application of lithium walls in NSTX

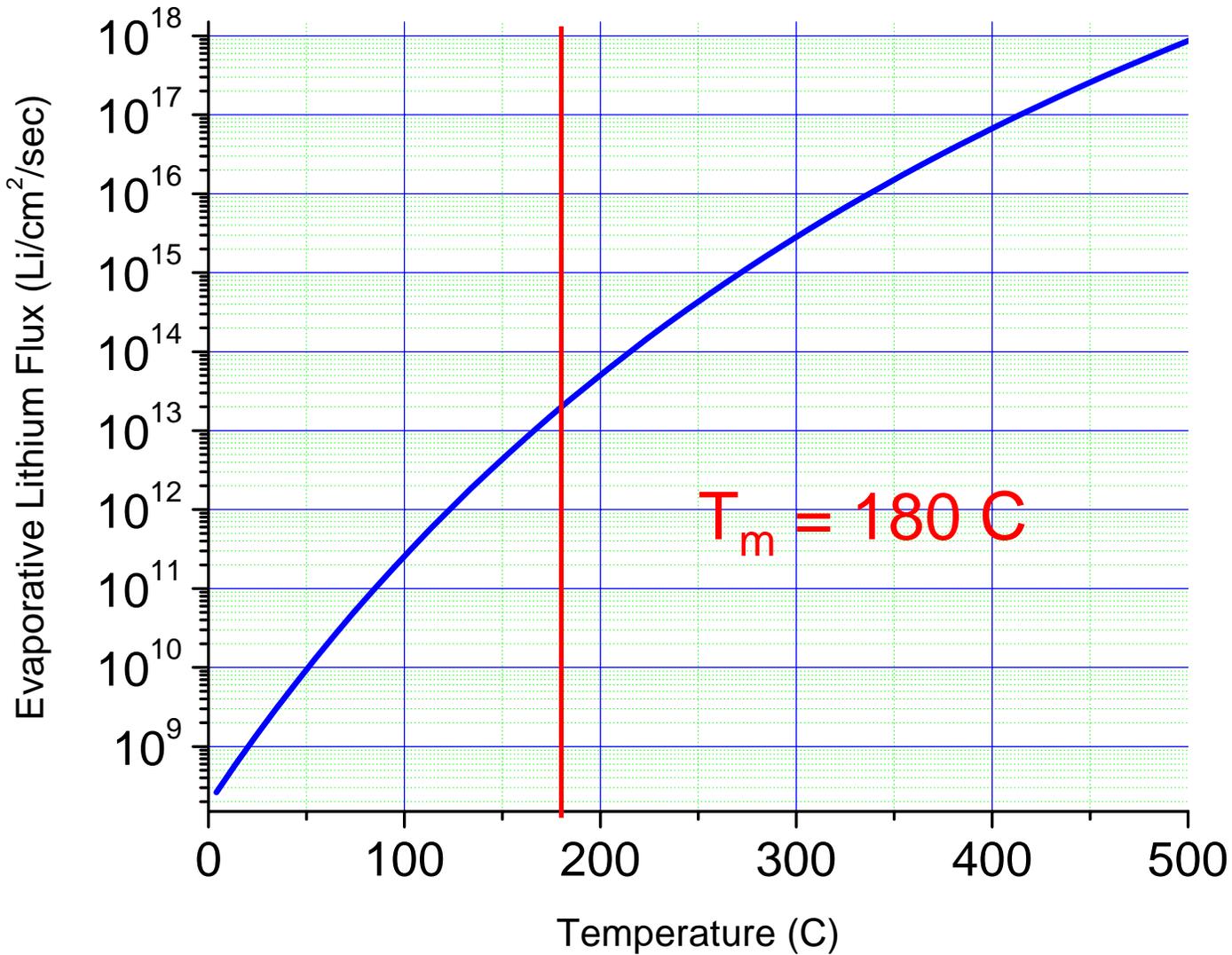
- **Lithium wall coatings on graphite tiles of NSTX**
 - Thin films of 100-1000 Angstroms
 - Using e-beam source technology
- **Use lithium-carbon chemistry to obtain low-recycling regimes**
 - Depends on implantation/diffusion/chemistry of hydrogen in lithium-coated graphite surfaces
 - Bombardment-induced effects on implanted hydrogen and lithium/carbon surface concentration
 - Intercalation of lithium atoms in graphite basal planes: DO NOT EXPECT 100% Li films on graphite

What we know about liquid-lithium surface mechanisms

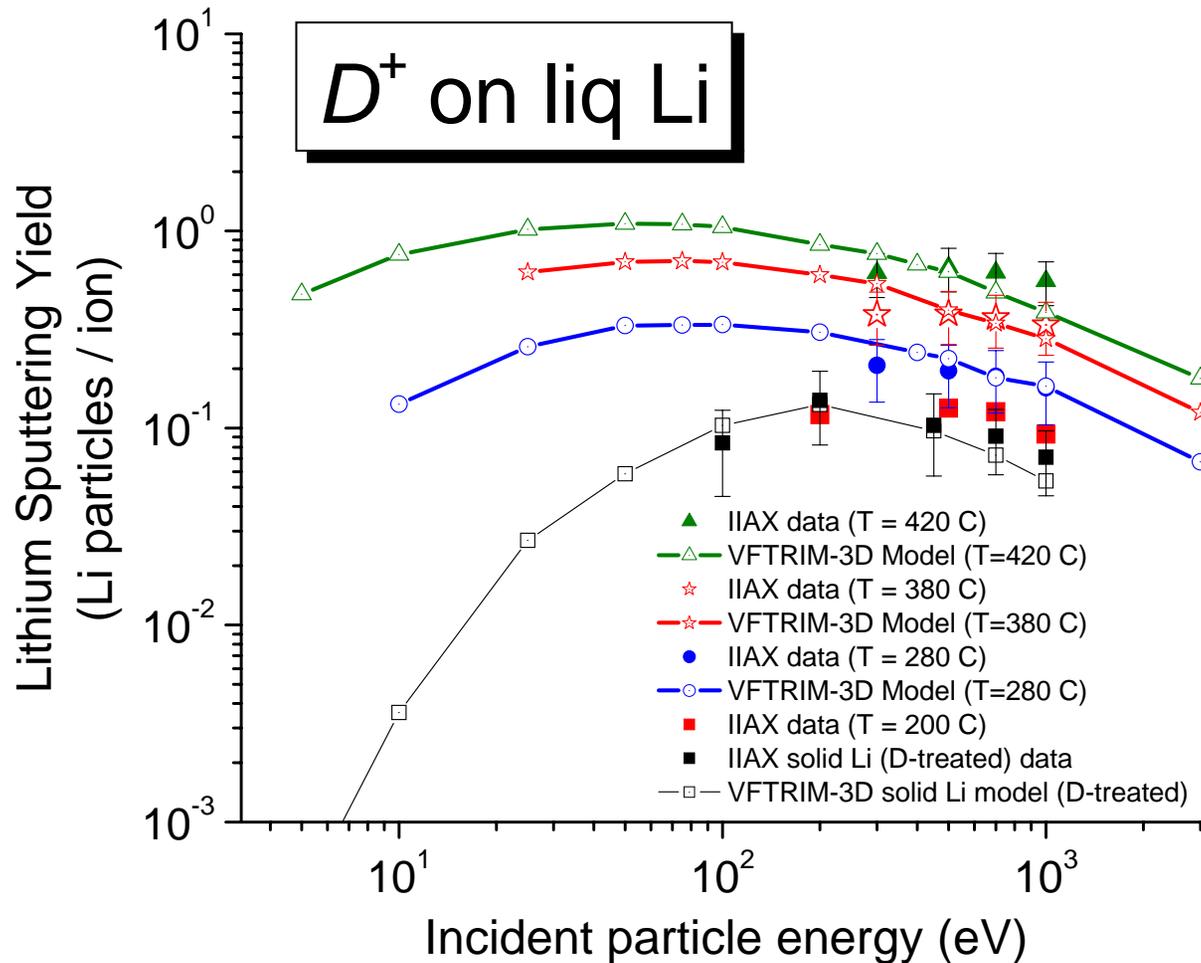
- No significant difference in sputtering from the solid to liquid state when temperature is near melting point
- Non-linear increase in sputtering from liquid-metal when temperature is about 50% higher than melting point (accounting for evaporation)
- Two-thirds of lithium sputtered particles are in the charged state
- Implanted hydrogen leads to a ~ 40% decrease in *lithium* sputtering
- High retention of hydrogen in liquid lithium (PISCES-B results)

HOW DO THESE AND OTHER MECHANISMS CHANGE FOR A THIN-FILM OF LITHIUM ON GRAPHITE OR OTHER SUBSTRATE?

Evaporation from lithium

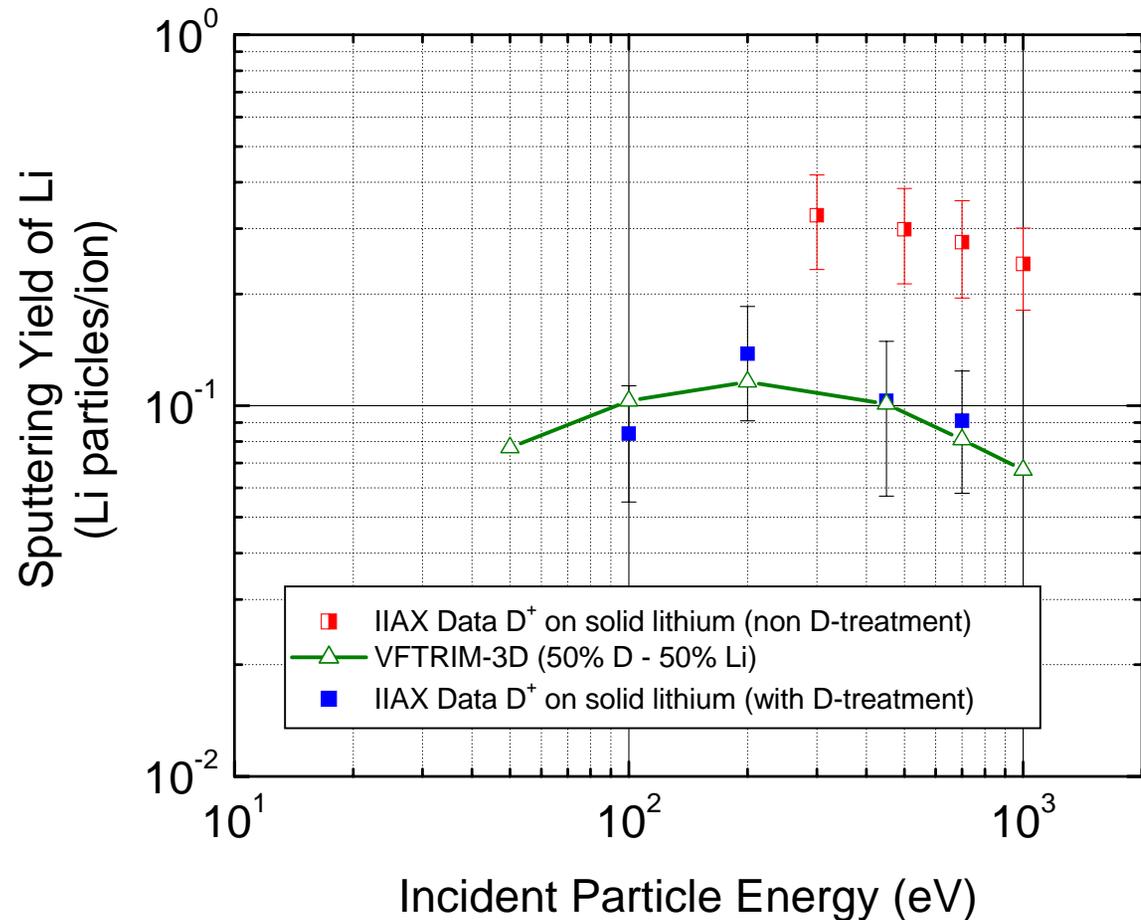


Energy-dependent sputtering yields for liquid lithium

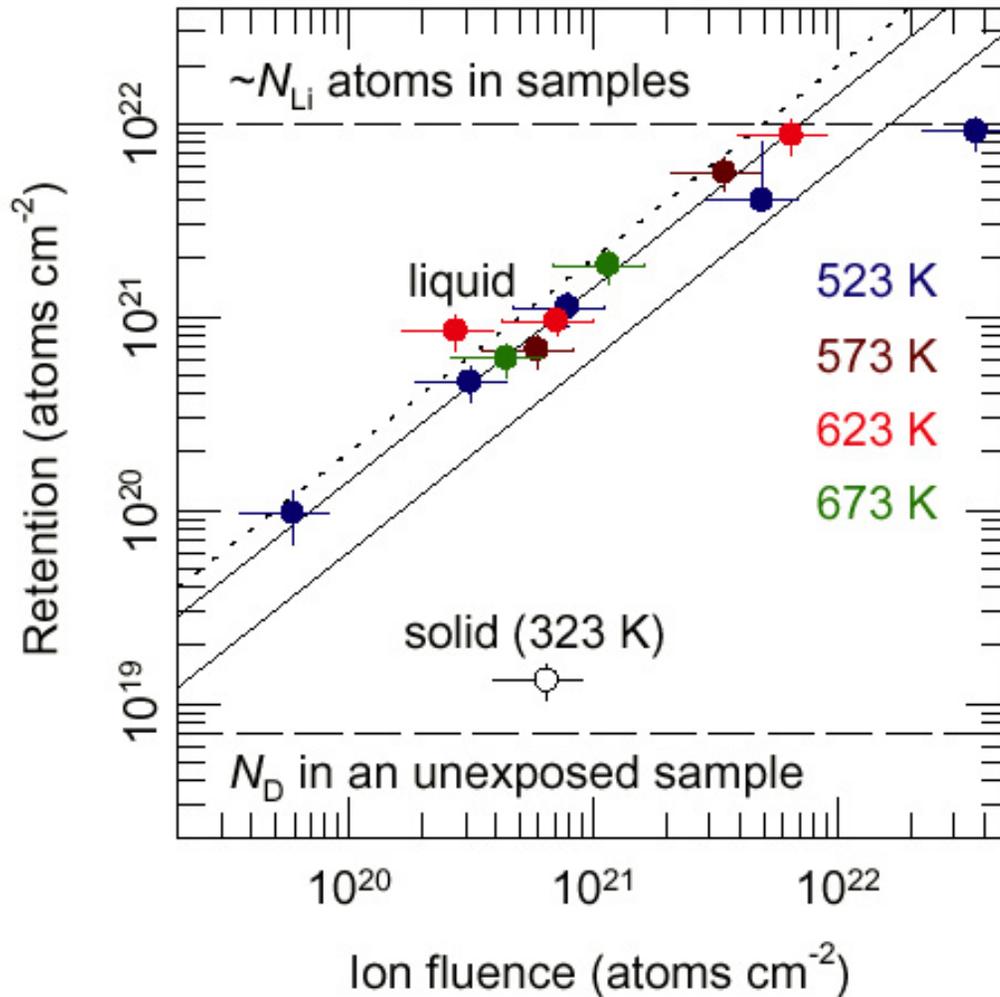


Experiments in IIAX found the chemical state on lithium surfaces have non-trivial effects on sputtering

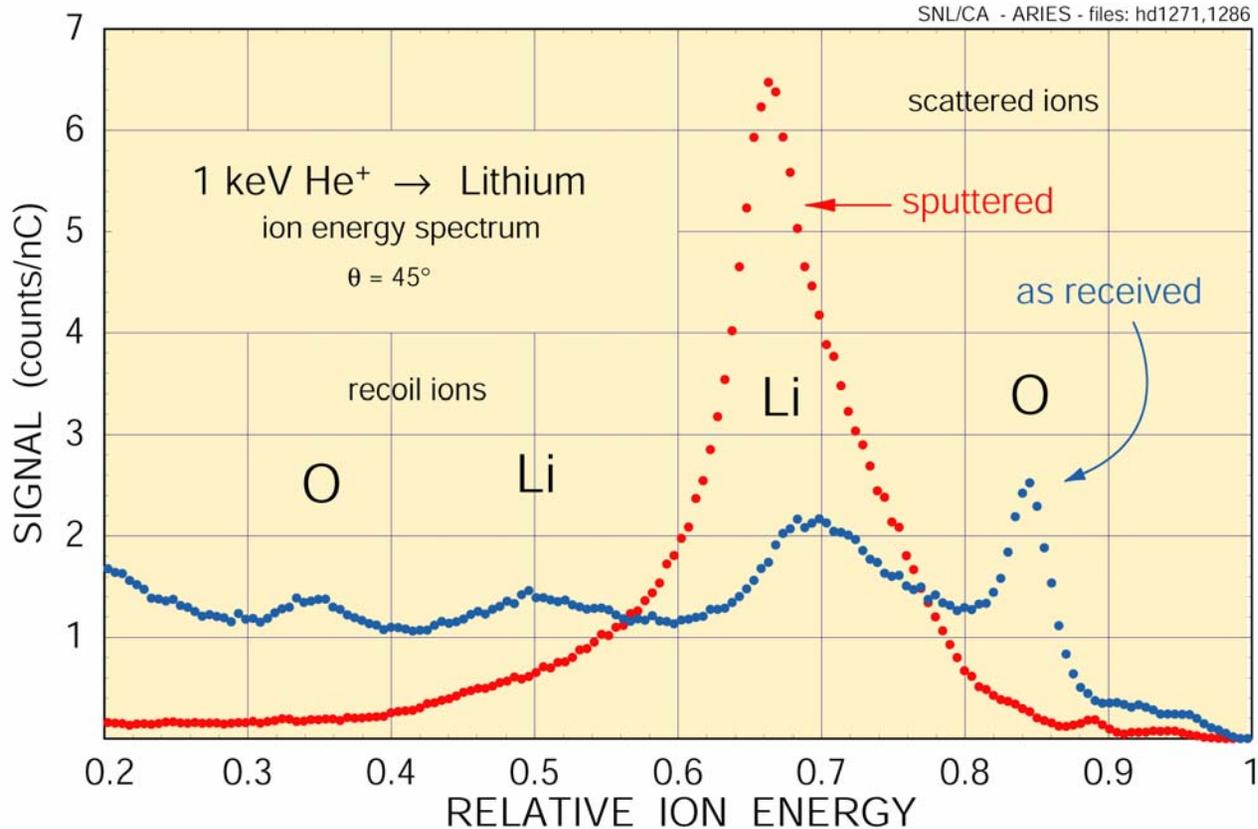
- How the surface evolves (e.g., multi-component levels) will play an important role on erosion/recycling effects
- This is especially true on systems where Li is highly active: e.g. graphite



Hydrogen retention experiments in PISCES at UCSD



Surface oxides important?



- Low-energy ion scattering spectroscopy measurements (LEISS) in the ARIES facility at Sandia/CA: R. Bastasz

Critical issues for near-term Li applications in NSTX: Module A

- **How does the lithium thin-film sputter as a function of incident energy?**
- **What is the role of lithium intercalation on sputtering, hydrogen retention, chemical sputtering?**
- **How does lithium evolve under D, He irradiation?**
- **What is the role of oxides in the Li, H, C system?**
- **How does lithium behavior change with surface temperature, incident particle flux and angle-of-incidence?**
- **How does the chemical state of the surface effect sputtering?**

Modeling NSTX Cases (Brooks, Rognlien) for liquid lithium surfaces

- **Surface Models coupled to WBC/REDEP and UEDGE**
- **High-Power Case:**
 - Overall self-sputtering is high but finite (non-runaway).
 - Lithium current to SOL/near-surface boundary is high.
 - Module area $\sim 1/16$ divertor area helps in limiting overall plasma lithium contamination.
 - Possible superheat runaway concern.
- **Low-Power Case:**
 - Solution is well behaved, moderate lithium sputtering predicted.