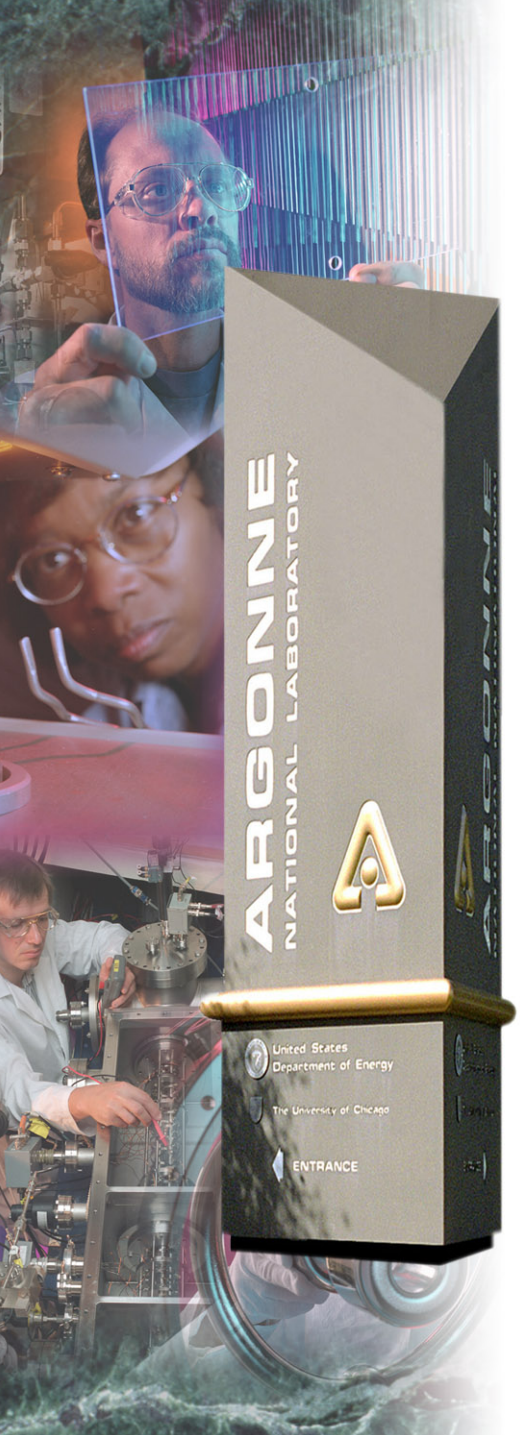

Critical-Issues Experiments on Lithium Thin-film Coatings Erosion Response and Hydrogen Trapping for Module A Application

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Critical-issues Experiments on Lithium Thin-film Coatings Erosion Response and Hydrogen Trapping for Module A Application

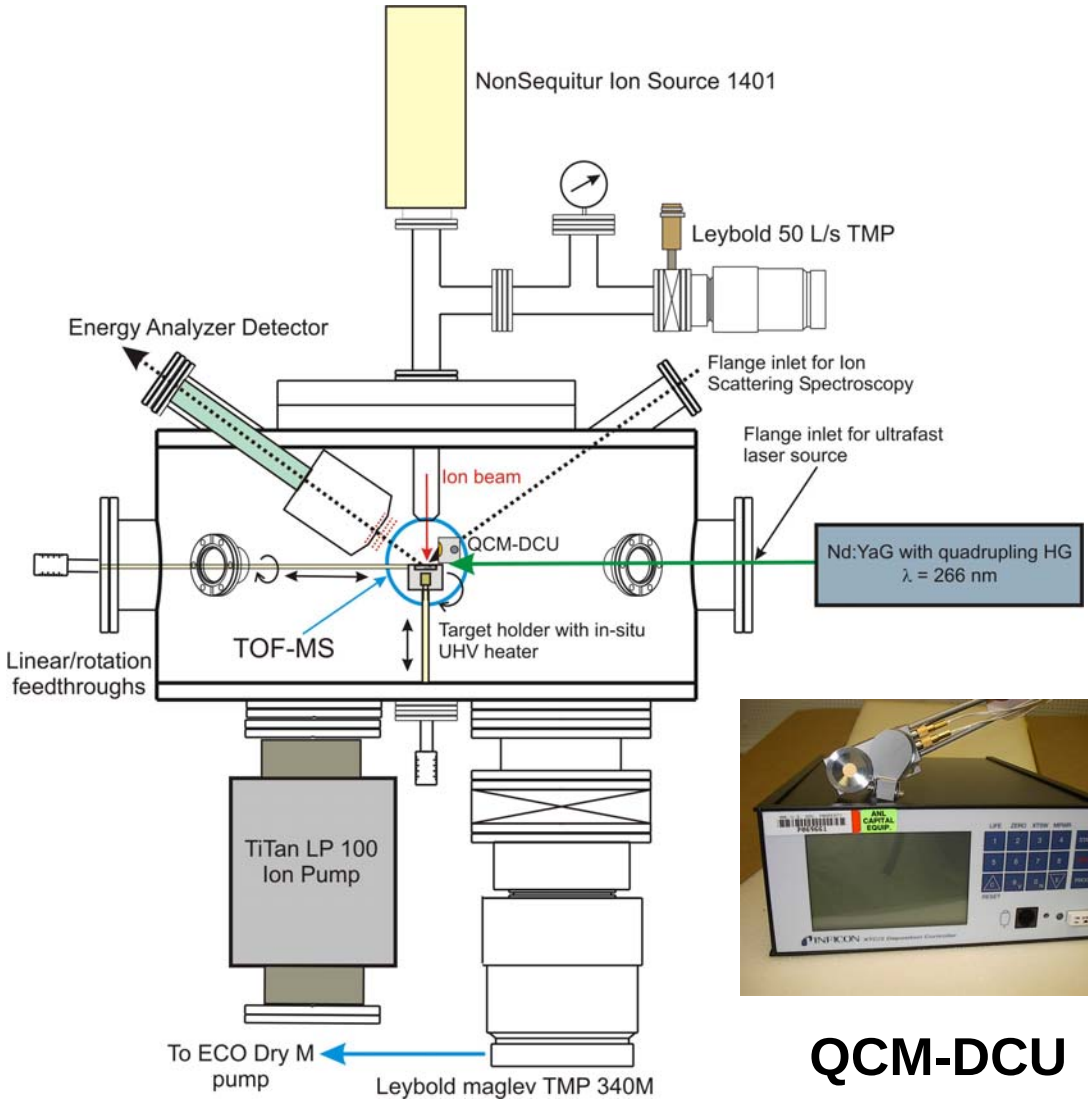
- Motivation for proposed work
- Brief description of IMPACT
- Brief description of ARIES
- Proposed lithium thin-film experiments in IMPACT and ARIES experimental facilities
- Benefits of proposed work
- Timeline and Budget

Motivation for proposed work

- **Lithium thin-films or conditioning is proposed as the next-step option for advanced PFCs in an existing fusion device: NSTX**
- **No directed studies have been done on surface evolution of lithium/graphite system with respect to:**
  - Bombardment-induced sputtering (He^+, H^+, etc…)
  - Hydrogen retention of a lithium thin-film on a graphite underlayer
  - Sputtering, evaporation of lithium/graphite system as a function of: incident flux, incident angle, surface temperature
- **Other issues:**
  - Hydrogen retention/kinetics in Li-C system

IMPACT Design and Experiment Setup

- Inficon Dual Crystal Unit XTC2/12014132 Dual Sensor
- NonSequitur Technologies Ion Source 1401 Ion Gun
  - **Fluxes: 10^{11}-10^{17} ion/cm^2/s**
- Leybold Vacuum Turbo Molecular Pump TMP 340M Magnetically Levitated
- Leybold Eco-Dry M15 Oil Free piston Pump
- HeatWave Labs Standard Series Cartridge Heater TB-175 UHV Substrate Heater
- L100 INFICON RGA-QMS system
- ISS system will have an additional Nonsequitur ion source with pulsing capability to couple to Time-of-flight Mass Spectrometry
- In-situ heating: up to ~ 1000 C and angle-of-incidence variation: 30-60 degrees

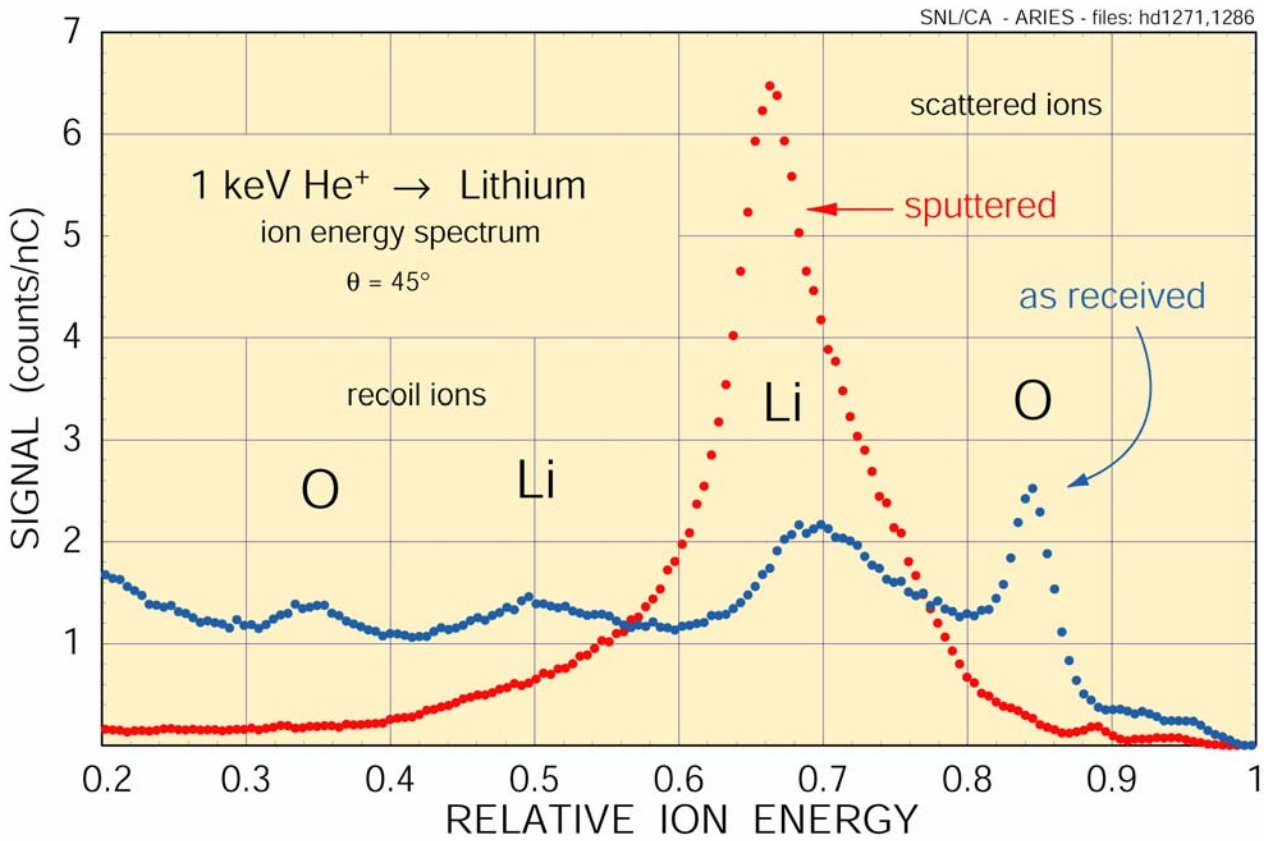


QCM-DCU

Angle-resolved ion energy spectrometer (ARIES) at SNL/CA

- **Experiment designed to provide detailed top atomic layer analysis of thin films and materials**
- **The system has two sections:**
  - A low-energy (0.1 – 3 keV) ion source differentially pumped chamber
  - UHV analysis chamber (P ~ 10^{-10} Torr)
- **In-situ heating is provided by UHV heater on a three orthogonal translation and two rotation axis manipulator**
- **Rotating energy analyzer**
- **Configured for low-energy ion scattering spectroscopy and direct recoil spectroscopy**

Ion Scattering Spectroscopy of as received and cleaned lithium



Capabilities of combined IMPACT/ARIES tools

- **Sputtering of H,D and He as a function of:**
  - Angle-of-incidence
  - Incident energy
  - Incident Flux
  - Surface temperature
- **Surface evolution of hydrogen and lithium in graphite system using:**
  - Low-energy Ion Scattering Spectroscopy with highly-sensitive TOF-MS techniques
  - Direct Recoil Spectroscopy
- **Hydrogen isotope retention/surface evolution**

What do we want to find out?

- 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?

Proposed lithium thin-film experiments in IMPACT and ARIES experimental facilities

- **Measure erosion of lithium thin-film coating (100 Å and 1000 Å) by H^+ or D^+ and He^+ bombardment at energies between 50-5000 eV at 45-degree incidence.**
- **Continue IMPACT experiments on erosion with variation in lithium coating temperatures of 200, 280 and 380 ºC, incident angle and incident ion flux. Complement these with H-retention measurements.**
- **In ARIES measure the surface composition evolution of lithium-coated graphite samples before and after hydrogen irradiation as a function of surface temperature (using same conditions as in IMPACT). The objective is to determine the quality and persistence of the Li coating under various sample treatments.**

Benefits of IMPACT/ARIES studies

- **Directed, controlled and well-diagnosed experiments on Module A-relevant issues**
- **Take advantage of IMPACT facility built with non-fusion funds**
  - The experiment is now operational and can be used with ARIES to study surface phenomena of lithium thin-films on candidate substrates: graphite, Mo and W
- **Use the experience of PIs and well-established diagnostic tools to conduct experiments relevant to Module A parameter space**

Additional Benefits of IMPACT/ARIES studies

- **Quantification of lithium thin-film response under NSTX simulated conditions**
  - Provide Module A PPPL group with valuable data (e.g., To be used in September ’04 decision timeline)
- **Module A concept studies in CDX-U**
  - Couple results from controlled experiments to understand/complement results in CDX-U
- **Leverage existing codes/models at Argonne to extend data from IMPACT/ARIES to desired NSTX regimes**

Proposed Timeline and Budget

Experimental Tasks	Jan-Mar			Apr-Jun			Jul-Sep		
Li thin-film preparation	■	■	■						
He^+ on tf Li/graphite experiments			■	■					
H^+ on tf Li/graphite experiments				■	■				■
He^+ on tf Li/graphite vary T, flux					■	■	■		
H^+ on tf Li/graphite vary T, flux						■	■	■	■
ARIES measurements					■	■	■		

IMPACT work: 75 K

ARIES (SNL/CA): 55 K

TOTAL = 130 K