XP: Influence of outer strike-point location on lithium-deuterium chemistry observed in MAPP

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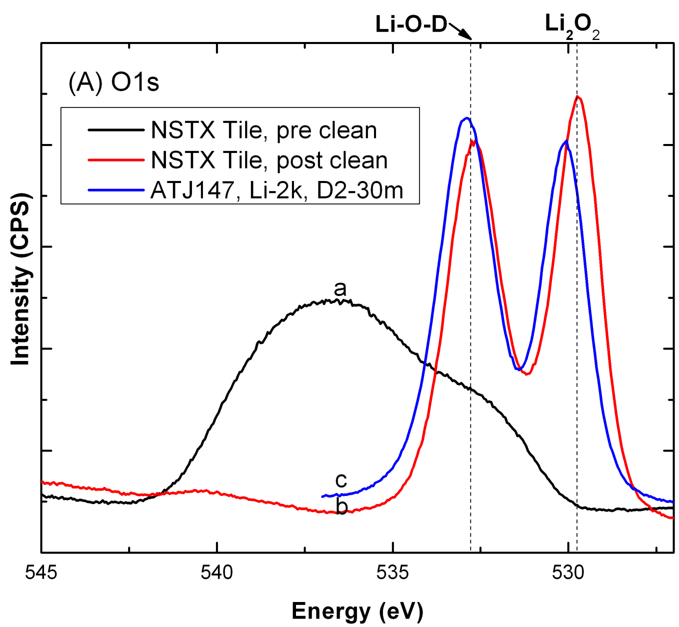
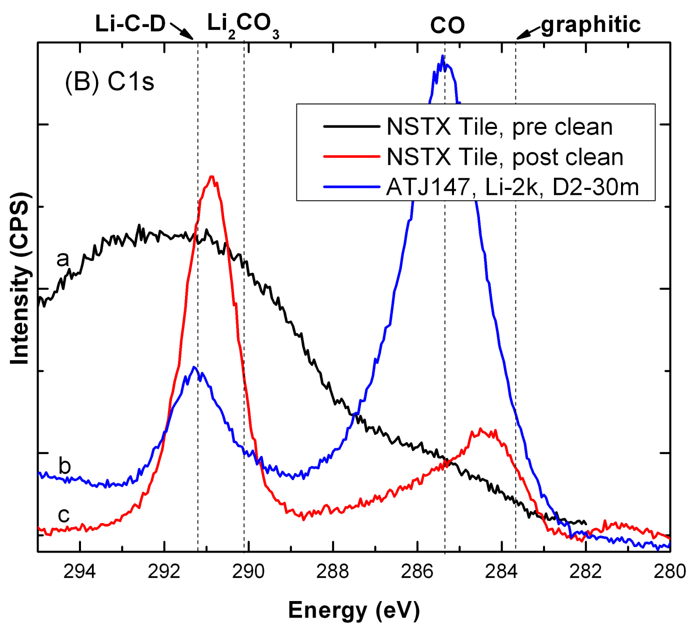
MAPP Motivation:

- Offline experiments connect back to NSTX
  - To elucidate the role of surface chemistry on D retention in ATJ graphite surfaces offline experiments must be linked as close as possible with conditions of ATJ graphite tile surfaces in NSTX.
  - Offline experiments using in-situ XPS on both controlled samples and post-mortem NSTX tiles have closed this gap.
  - **However,** this connection falls short of closing the gap of plasma performance *correlated to surface behavior*, thus the need for an in-vacuo surface analysis system allowing for characterization of material surfaces between shots.





MAPP Capabilities

- Thermal Desorption Spectroscopy (TDS)
  - Heat samples to desorb deuterium.
  - Results used to determine deuterium retention.
- X-ray Photoelectron Spectroscopy (XPS)
  - X-ray interact with sample causing core photoelectron to eject. Photoelectron energy is characteristic of sample material/element.
  - Chemical information about top 5-10 nm.
- Low Energy Ion-Scattering Spectroscopy (LEISS)
  - Ions scatter from top monolayers (2-5 Å). Those projectile ions that survive neutralization are detected.
  - In the forward-scattering orientation, low z elements have large energy dispersion (easy identification/interpretation).
  - Provides qualitative identification of surface species when target elements are more massive than the projectile.
    - If we use He as ion source, we see Z > He (not hydrogen).
- Direct Recoil Spectroscopy (DRS)
  - Projectile ions (Ne) should be higher mass than target atom. Recoil cross-section increases with higher target/projectile mass ratio.
  - Can detect low Z hydrogen on surface.

MAPP Commissioning timeline

- MAPP arrives at PPPL – mid May
- Thermionic probe arrival – mid/late May
- Rotary dive – June
- Gas manifold – Requires higher priority! – June
- *Testing* of XPS/ISS/DRS (w/o probe) – July
- Integrating probe and MAPP – July/August
- TDS and XPS *commissioning* (MAPP Lite) – August
- MAPP piggybacks – August/September
- ISS and DRS *commissioning* (MAPP Total) – September/October
- Fully operational MAPP for dedicated XPs – November/ December

Shot-to-shot analysis details

NSTX	MAPP	
Shot ends		
Open TIVs, insert LiTER	Open TIV insert MAPP	
Evaporate	Evaporant received on MAPP samples	
Retract LiTER, close TIV	Retract MAPP, close TIV	Leave MAPP inserted
Plasma shot		MAPP samples exposed to shot
Shot ends		Retract MAPP, close TIV
Open TIVs, insert LiTER	Power up diagnostics	
Evaporation	Analyze samples	
Retract LiTER, close TIV	Power down diagnostics, open TIV, insert MAPP	Power down diagnostics
Plasma shot	MAPP samples exposed to shot	
Shot ends		
Open TIVs, insert LiTER	Power up diagnostics	

MAPP Experiments

- Two phase approach for MAPP experiments:
  - MAPP commissioning to take place in FY11.
    - Piggyback experiments will be essential in brining MAPP fully online and understanding the operational parameters.
      - Li recognition, D recognition, etc.
    - The results from piggyback experiments may affect proposed future XPs.
  - MAPP dedicated XPs in FY12.
    - *Influence of outer strike-point location on lithium-deuterium chemistry observed in MAPP*

Influence of outer strike-point location on lithium-deuterium chemistry observed in MAPP

Purdue University

- B. Heim, C.N. Taylor, J.P. Allain, S. Ortoleva, M. Gonzalez, E. Yang, S. Gonderman

- Brief description
  - This XP will expose ATJ graphite samples via MAPP to NSTX plasmas with varying strike-point locations.
  - The aim of this XP is to use MAPP to develop a direct correlation between PFC surface chemistry/surface D retention and plasma parameters such as strike-point location.
- Milestone
  - R(12-1): Investigate the relationship between lithium-conditioned surface composition and plasma behavior.
  - "Correlations between the surface composition and plasma behavior will be explored and compared to laboratory experiments and modeling…. The results will deepen the understanding of plasma-wall interactions and inform the plans for particle control in NSTX-Upgrade."

RSSEL

PURDUE ENGINEERING

Background

- From previous work, we have seen that lithiated ATJ graphite saturates with deuterium at fluences $<10^{18}$ cm^{-2}. These initial studies indicate that a lithium dose of 2μm will saturate during one plasma discharge.
  - Laboratory experiments have examined fluences $<10^{18}$ cm^{-2}.
  - Upcoming laboratory experiments will introduce fluences $>10^{18}$ cm^{-2} for more relevant NSTX-U conditions.

- MAPP is located far from the lower divertor and private flux region and is expected to see much smaller particle fluxes than the divertor regions.
  - By sweeping the OSP closer to MAPP samples in discrete steps, we will be able to correlate the lithiated ATJ graphite surface composition to OSP location and ultimately D incident flux.

- Post-mortem experiments show unique surface chemistry in the PFR. However post-mortem analysis introduces uncertainties due to surface passivation. By sweeping the PFR closer to MAPP samples, we will be able to examine these unique effects in-vacuo.

- By using XPS to look at the saturation of the lithiated ATJ graphite samples (as well as W and Mo), a strike-point threshold location can be identified that corresponds to the location where saturation occurs. TDS will also be performed to correlate strike-point location with deuterium retention.

Draft experimental plan

1. Expose MAPP ATJ graphite samples to LiTER evaporation (*quantity determined by prior piggy back*). Expose MAPP to single plasma discharge with outer strike point positioned at R_1 = LLD. Perform XPS and TDS end of day.

2. Load a new set of samples and expose to same lithium conditioning as previous samples. Expose MAPP to single plasma discharge with outer strike-point at R_2 > LLD. Perform XPS and TDS end of day.

3. Load a new set of samples and expose to same lithium conditioning as previous samples. Expose MAPP to single plasma discharge with outer strike-point at $R_3 > R_2$. Perform XPS and TDS end of day.

4. Load a new set of samples and expose to same lithium conditioning as previous samples. Expose MAPP to single plasma discharge with outer strike-point at $R_4 \approx$ MAPP. Perform XPS and TDS end of day.

- Because this XP will require loading new samples prior to each experiment, we recommend splitting dedicated runtime to cover the last 5 shots of 5 consecutive days. By running discharges at the end of the day, and loading new samples during early evening, MAPP will have nearly a 20+ hours to recover vacuum in order to open TIV by the next day.

Draft experimental plan

- Machine time requested
  - 4 practice discharges (without MAPP) + 1 discharge on MAPP for 4 samples. Total 20 discharges over 4 days.
- Minimum useful machine time: (run days)
  - Four sets of 1-2 hour periods near the end of the experimental day.
- Required prior piggybacks
  - Minimum LiTER evaporation threshold to see Li-O (529.5 eV in XPS) on virgin samples. Expose MAPP to consecutive 10 minute LiTER evaporations to observe the development of a “conditioned” surface.
- Special requirements
  - MAPP probe
  - Optical spectroscopy
  - Multi array probe and other Langmuir probes
- Operation/Development
  - Requires full commissioning of MAPP.
- Analysis
  - Measure D particle flux to MAPP via Langmuir probes and D-alpha, lithium and carbon emission profiles via optical spectroscopy.
  - Use XPS to determine the effect of strike-point location on lithium-deuterium chemistry and deuterium retention. Compare with laboratory experiments and modeling.

EXTRA SLIDES

MAPP Photo