The Material Analysis Particle Probe (MAPP) as an in-situ plasma-material interaction diagnostic in NSTX

BP9.88

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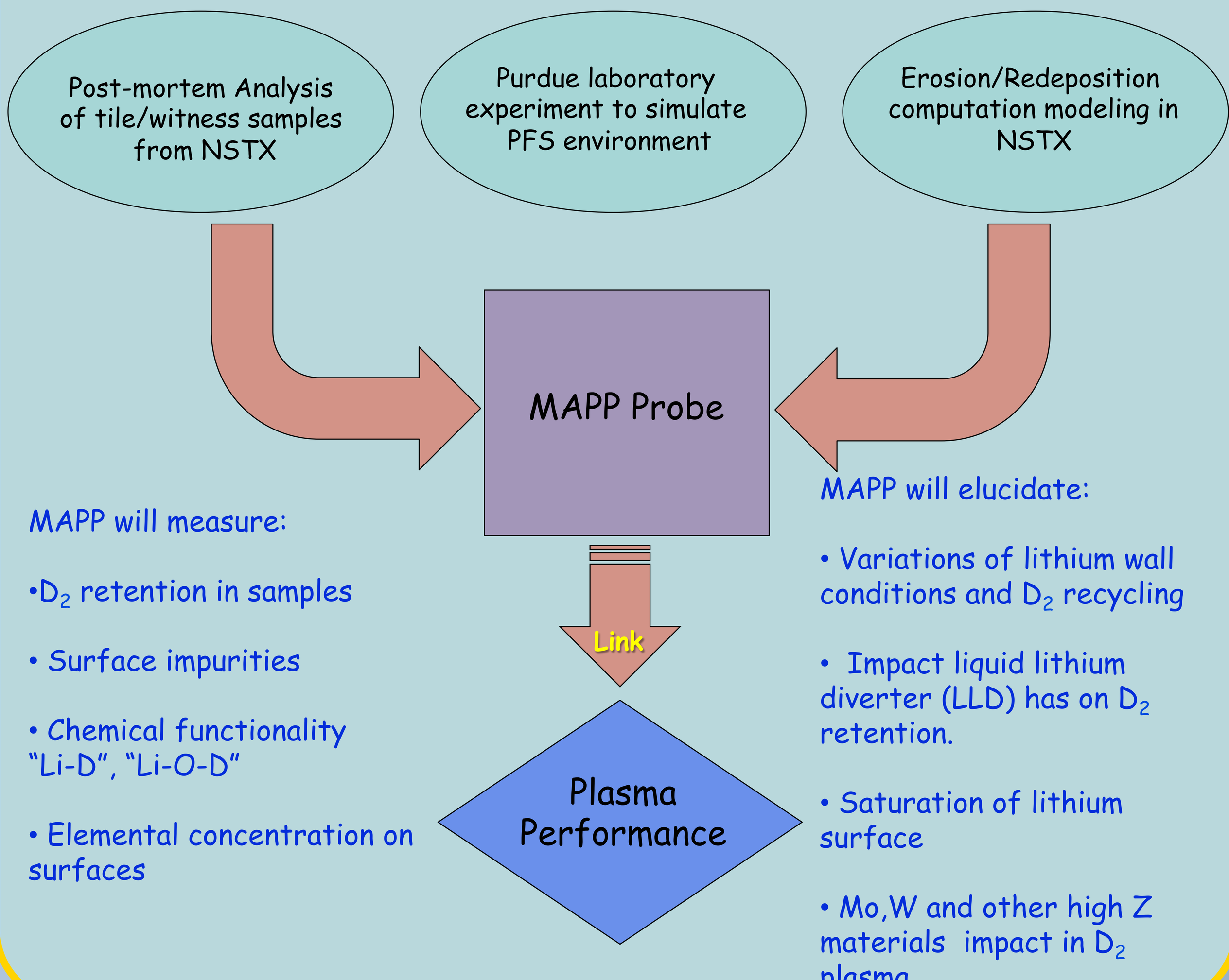
Abstract

- MAPP is the first in-vacuo surface analysis diagnostic directly attached to a tokomak, capable of shot-to-shot chemical surface analysis of plasma facing surfaces (PFS)
- MAPP can study the role of hydrogen recycling dependence on lithium deposition thickness on graphite and metallic substrates.
- X-ray photoelectron spectroscopy (XPS) and low energy ion surface spectroscopy (LEISS) can show the relative chemical functionalities of low-energy D2 interactions with thermal lithium in ATJ graphite matrix as well as Li thin-films on porous Mo used in the LLD
- Past Studies of post-mortem analysis of tiles/witness samples from NSTX and Purdue offline control experiments show a discernable correlation between D2 irradiation dose and a chemical functionality associated with Li-O and Li-C dipole interactions.
- MAPP data can strengthen Erosion/Redeposit ion modeling in NSTX
- MAPP also allows the exposure of variety of material compositions (solid Li, liquid Li, W etc) samples to variety of NSTX plasma configurations
- MAPP will enable the correlation of plasma facing component (PFC) surface chemistry with plasma conditions and point the way to improved plasma performance.

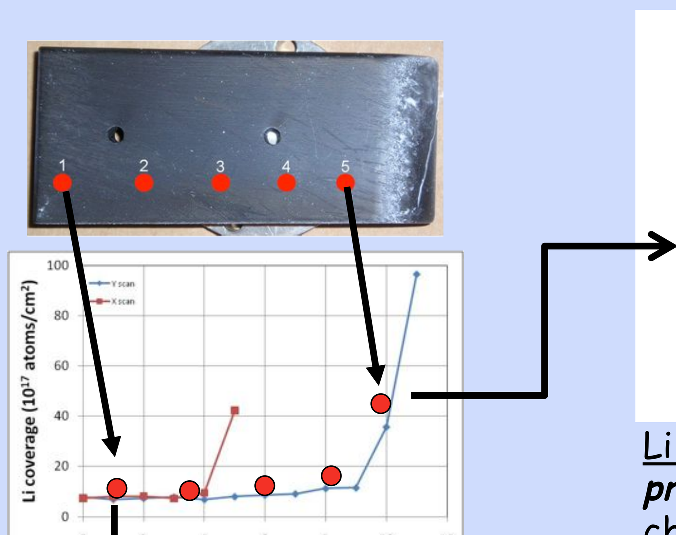
Surface Characterization Methods



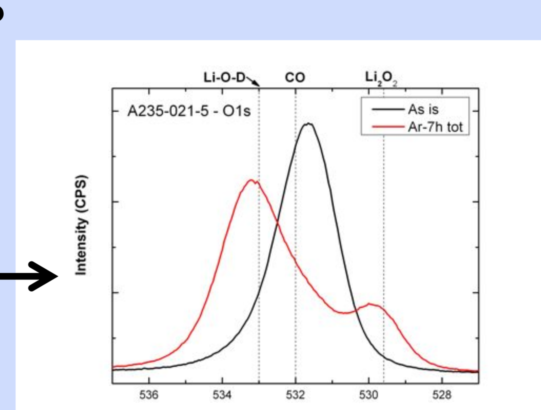
Post Mortem Analysis of Diverter Tile Samples

Previous results showed Lithium "thickness" affects the degree to which D bonding is observed

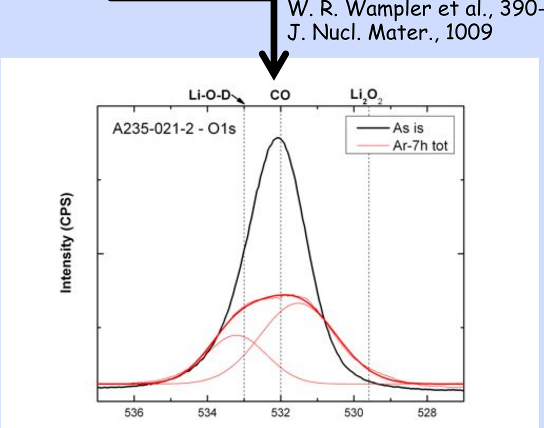
NSTX TILE POST MORTEM ANALYSIS



W. R. Wampler et al., 390-391 J. Nucl. Mater., 1009



Li rich region on the same tile ***produces*** the functionalities characteristic of deuterium retention.



Low Li region on tile ***did not*** produce the functionalities characteristic of deuterium retention.

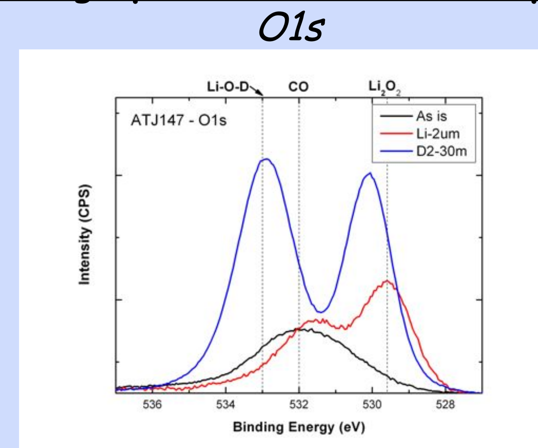
Notes:

- Ion beam analysis for Li coverage. Analysis shows a single tile having Li rich and low Li regions. *W.R. Wampler*
- Ion beam analysis shows that both regions have comparable D coverage.

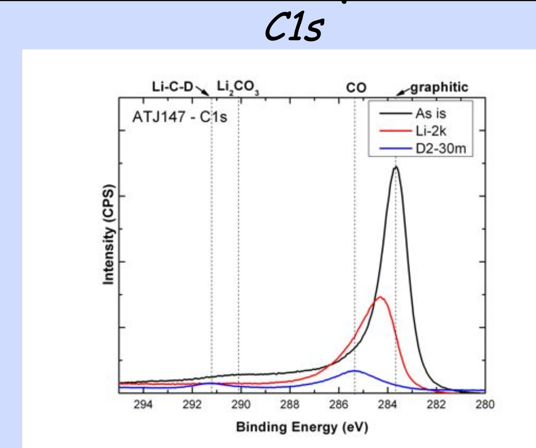
Previous Deuterium-Lithium Surface Chemistry Laboratory Experiments

ATJ graphite surface chemistry with 2μm lithium deposition and D^+:

O1s



C1s



ATJ graphite sample substrate (black) with 2μm lithium conditioning (red), and 30 min 1 KeV deuterium bombardment (blue). Control studies isolate the effect of each process

What happens?

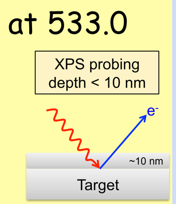
Oxygen:

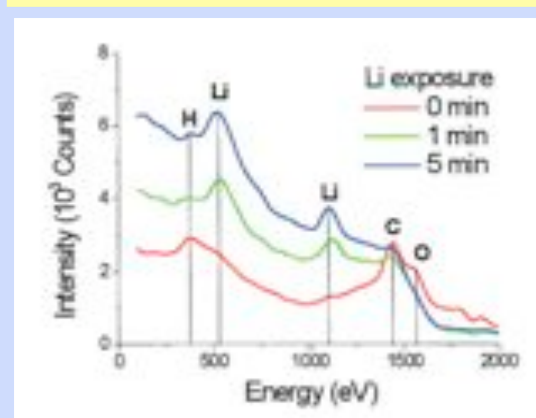
Li and O interactions are manifest at 530.1 eV in the XPS spectrum.

Li, O, and D interactions, on a graphite substrate, are manifest at 533.0 eV.

Carbon:

Li, D, and C interactions are manifest at 291.4 eV.





LEISS data of lithium conditioning of ATJ graphite surfaces

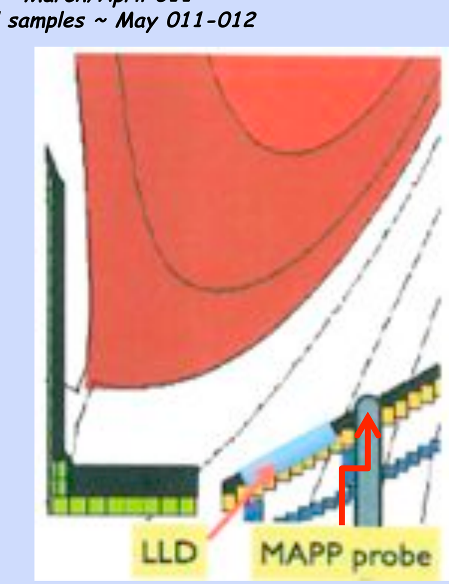
Both XPS and LEISS can give qualitative data to the concentration and chemical functionalities lithium has on the surface

Details on deuterium-lithium surface chemistry (**see C.N. Taylor BP9.44**)

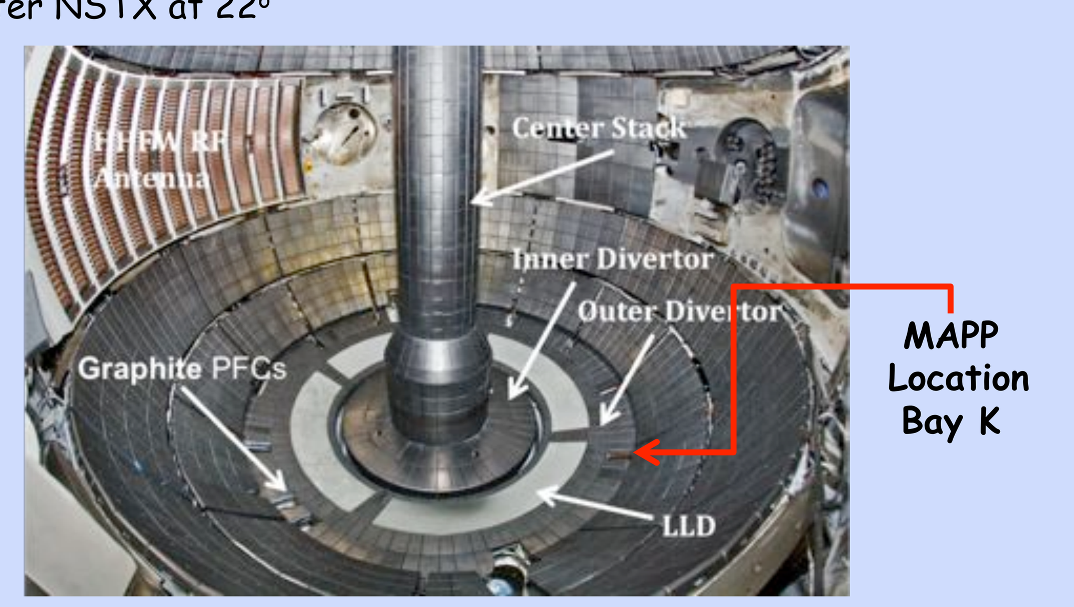
MAPP Location in NSTX

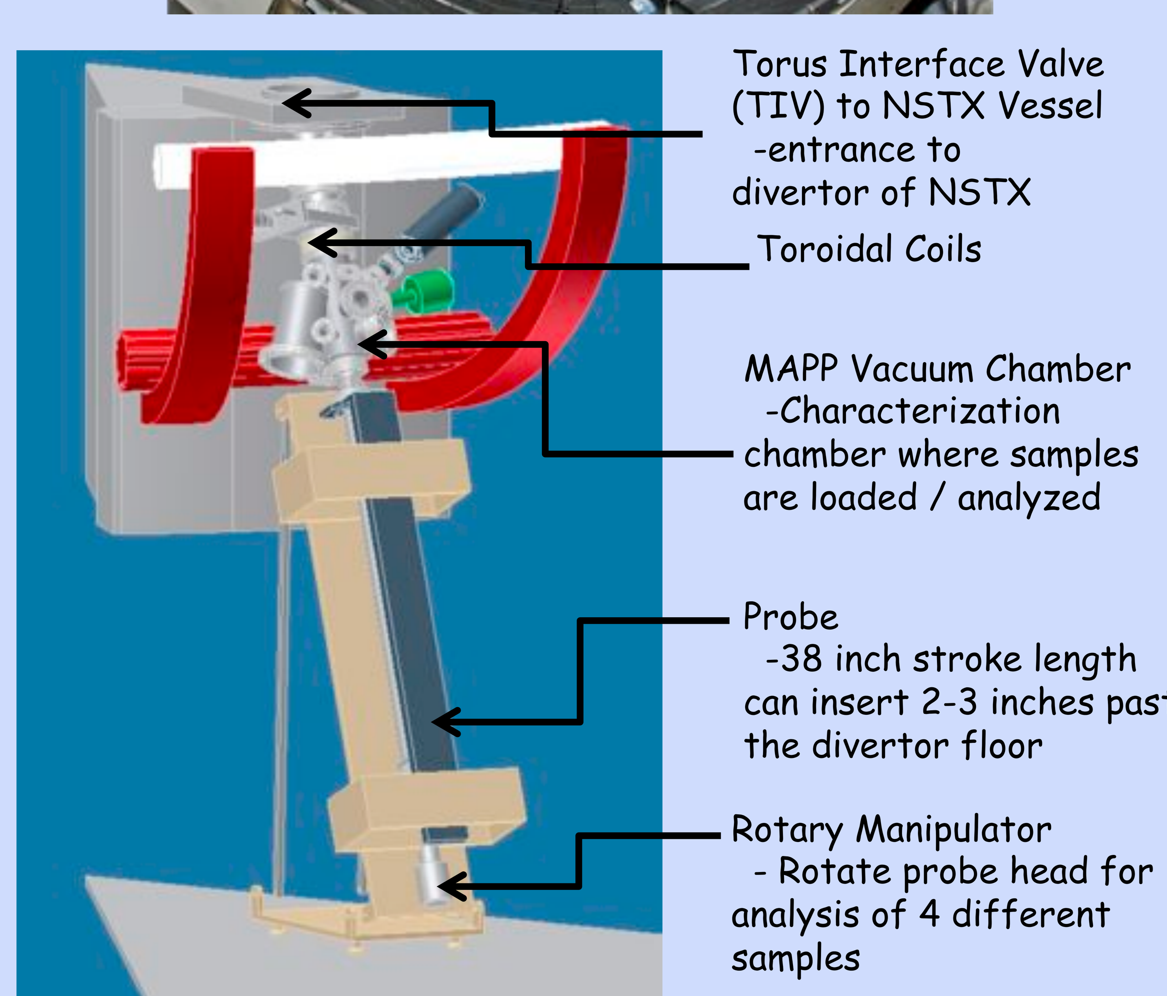
MAPP probe will be installed on NSTX in 2011
Install MAPP and probe assembly on NSTX ~ Feb 011
Calibration and testing MAPP ~ March/April 011
Characterization of plasma exposed samples ~ May 011-012

MAPP probe location with the outer strike point on the liquid lithium divertor (LLD), will enter NSTX at 22°

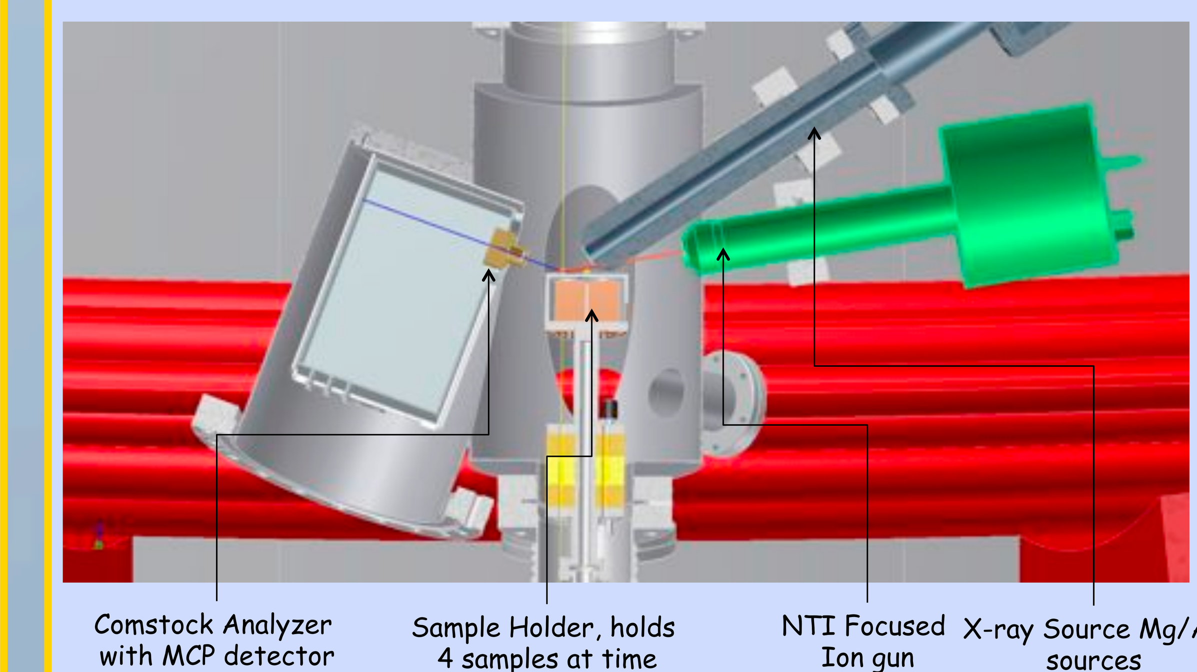


MAPP probe location with LLD in the flux expansion zone (high-triangularity NSTX plasma)





MAPP Surface Analysis Chamber



Characterization techniques:

X-Ray photoelectron spectroscopy (XPS) with Al and Mg sources

- 40 mm working distance at the magic 56 deg angle from sample normal, energy resolution <0.1ev
- Can show unique chemical functionalities such as "Li-O-D" seen in ATJ graphite, to identity D_2 chemical interactions in surface

Low energy ion scattering spectroscopy (LEISS) and direct recoil spectroscopy (DRS)

- Scattering angle Θ_s= 30°
- Shows elemental concentration (even hydrogen) on first few atomic monolayers

Thermal desorption spectroscopy (TDS)

- Residual gas analyzer (RGA) with individual sample heating up to 800 deg C
- Identity the D_2 and lithium retention in each sample

All characterization (four different samples) is conducted before and minutes after plasma exposure (in the time scale of modification)

Data Acquisition/ Equipment Operation

All Data acquisition and controlling of the equipment will be done remotely.

- Probe motion and surface analysis will be controlled remotely
- Operation and data acquisition of MAPP can be done remotely
- Data acquisition and processing conducted in parallel for rapid feedback of varying plasma conditions
- IGOR Pro will remotely command all systems via serial port links to all desired equipment
- Extensive hard and computer interlocks will be placed to prevent damage of NSTX vessel and MAPP equipment during plasma operation
- Plans to integrate remote control with nanoHUB at Purdue

MAPP Fusion Impact

MAPP will, for the first time, enable prompt and sophisticated surface analysis of materials exposed on an operating tokamak

- Exposure and surface characterization of future desired plasma facing materials (PFM) to tokamak plasma environment
- Study the chemical interactions liquid and solid metals have as plasma facing surfaces
- Overall impact the plasma facing components (PFC) community and provide insight into future fusion materials
- Provide insight on D_2 retention in surface-irradiated materials

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