NSTX-U

Supported by U.S. DEPARTMENT OF ENERGY Office of Science

Study of the chemical evolution during transition from B to Li-based conditioning on D retention in NSTX-U with the Materials Analysis Particle Probe (MAPP)

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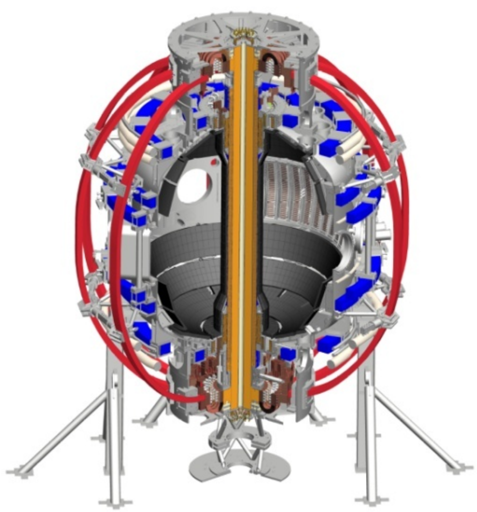
X Science LLC

Jean Paul Allain

Rajesh Maingi, Felipe Bedoya, Robert Kaita, Robert Ellis, Matt Lucia, Charles Skinner

NSTX-U Research Forum
PPPL
February 24-27, 2015



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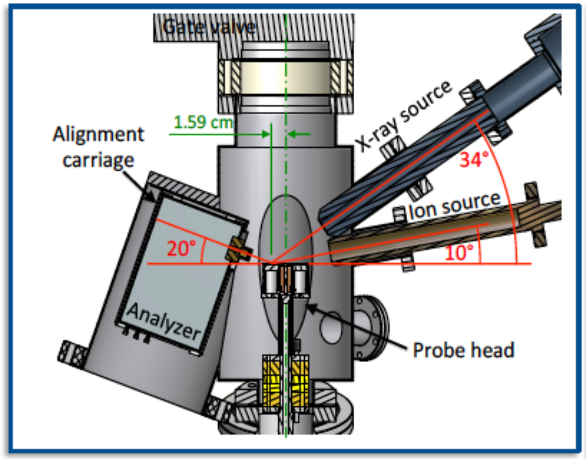
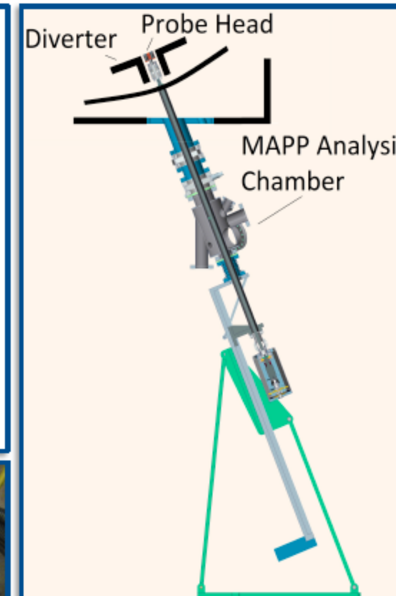
Background

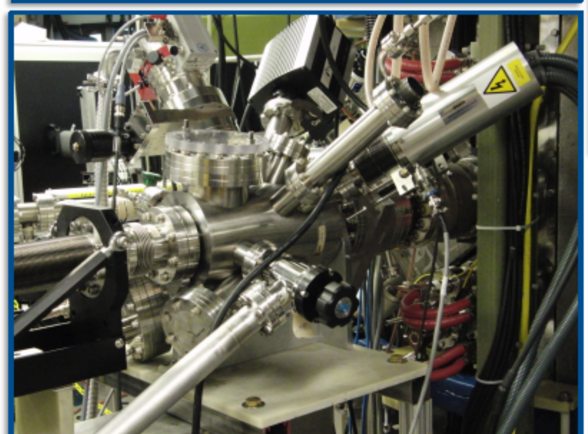
The Materials Analysis Particle Probe (MAPP) is an in situ characterization device for diagnosing samples exposed to fusion reactor plasmas.

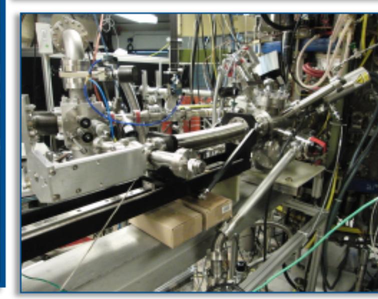
Scientific Objective

Correlate plasma performance to the chemical and compositional state of the plasma-facing surface





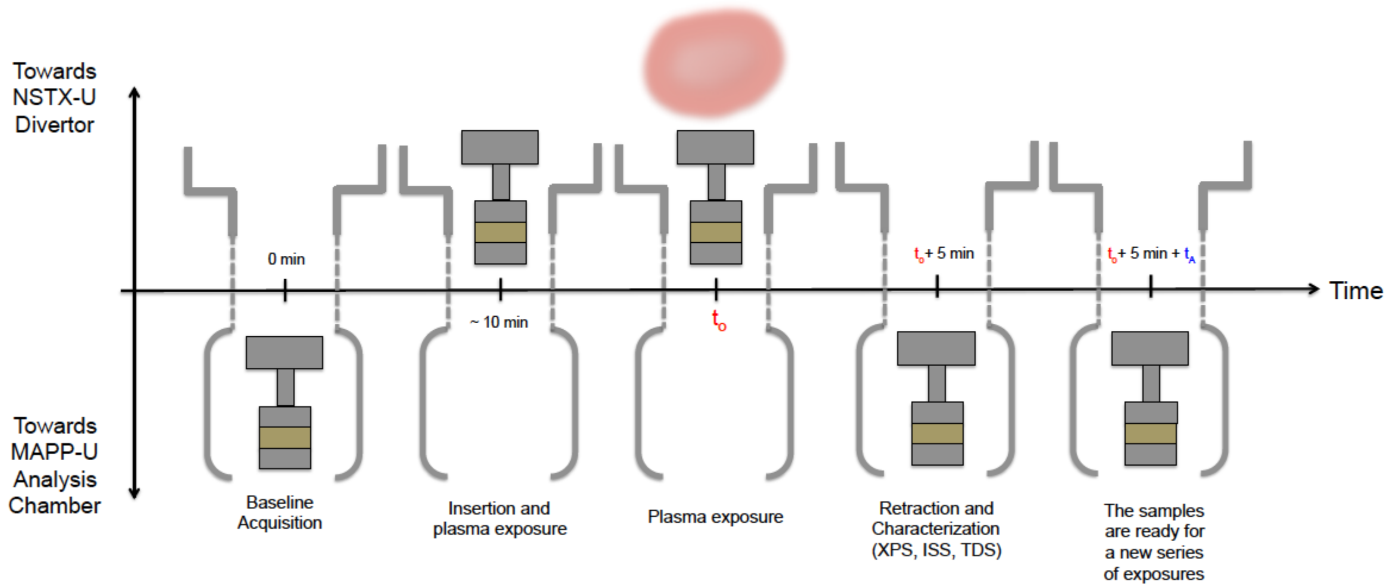




Background

Main Objectives of MAPP:

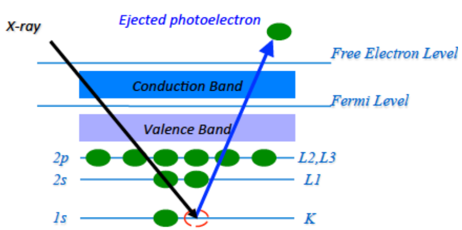
- In-vacuo analysis of materials exposed to plasma discharge.
- Provide immediate, shot-to-shot analysis.
- Remote Control interface.
- Operate within 12 min minimum between-shot time window⁺



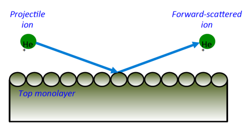
⁺This sequence can be modified if remote control of insertion/retraction is not available. Manual insertion (beginning of day) and retraction (end of day) must be performed then. Access to test cell required.

Background

XPS
Identifies elemental and chemical composition.

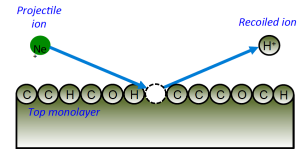


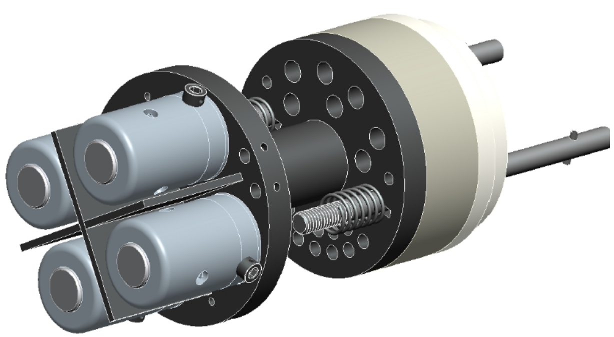
ISS
Provides qualitative identification of surface species.



TDS
Provides information of binding energies and allows us to identify desorption products.

DRS
Similar to ISS, but capable of detecting low Z such as H.





Sample Holder

- Holds four samples.
- Independent heating of each sample.
- Quick release probe head.
- Built in Molybdenum alloy to prevent unwanted sputtering.

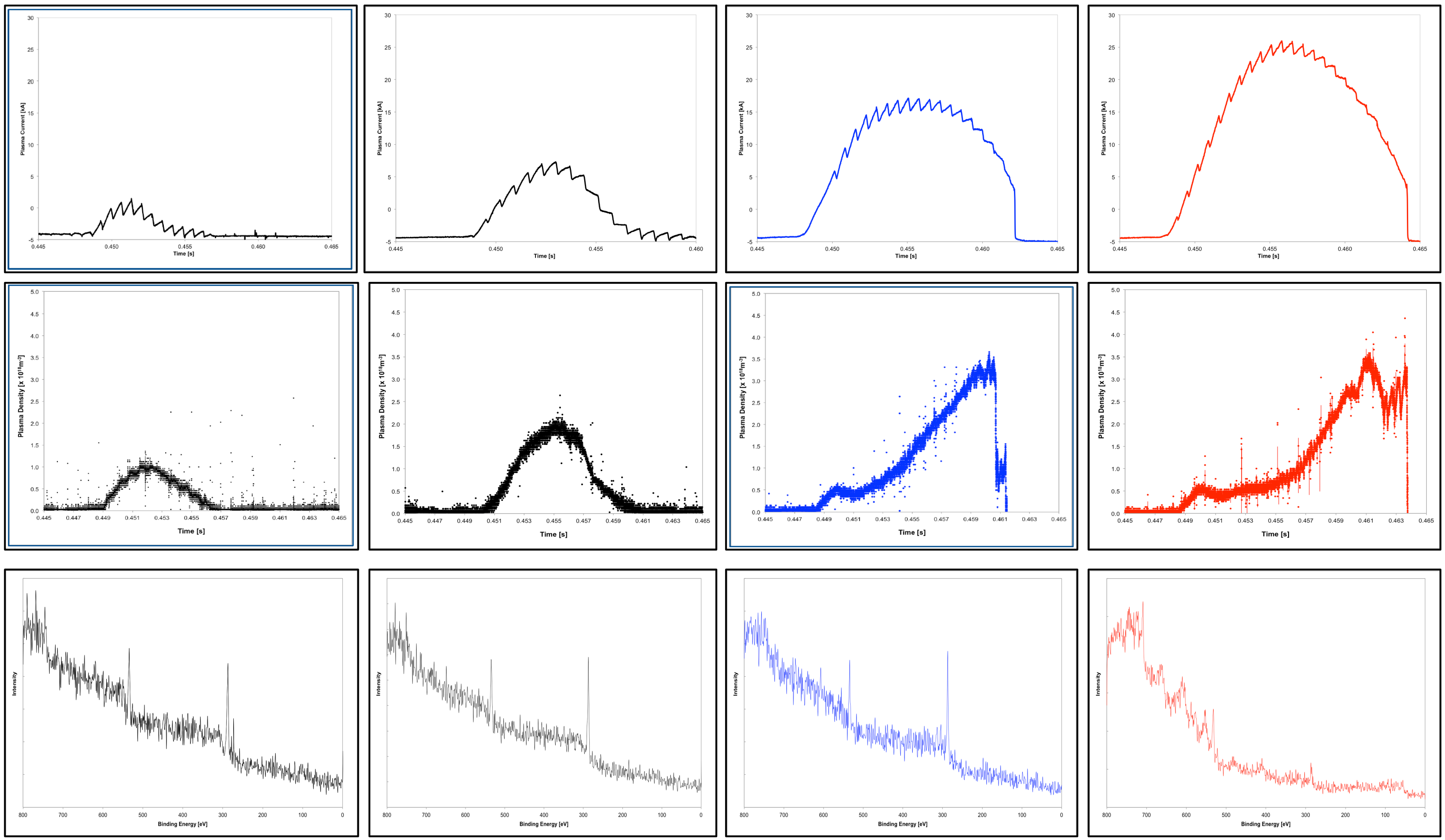
Initial results from LTX

Baseline Scans | Ar glow cleaning followed by Li deposition | 9 hours of Ar glow discharge cleaning (ArGDC) | 4 hours of additional ArGDC with samples exposed

Plasma Density

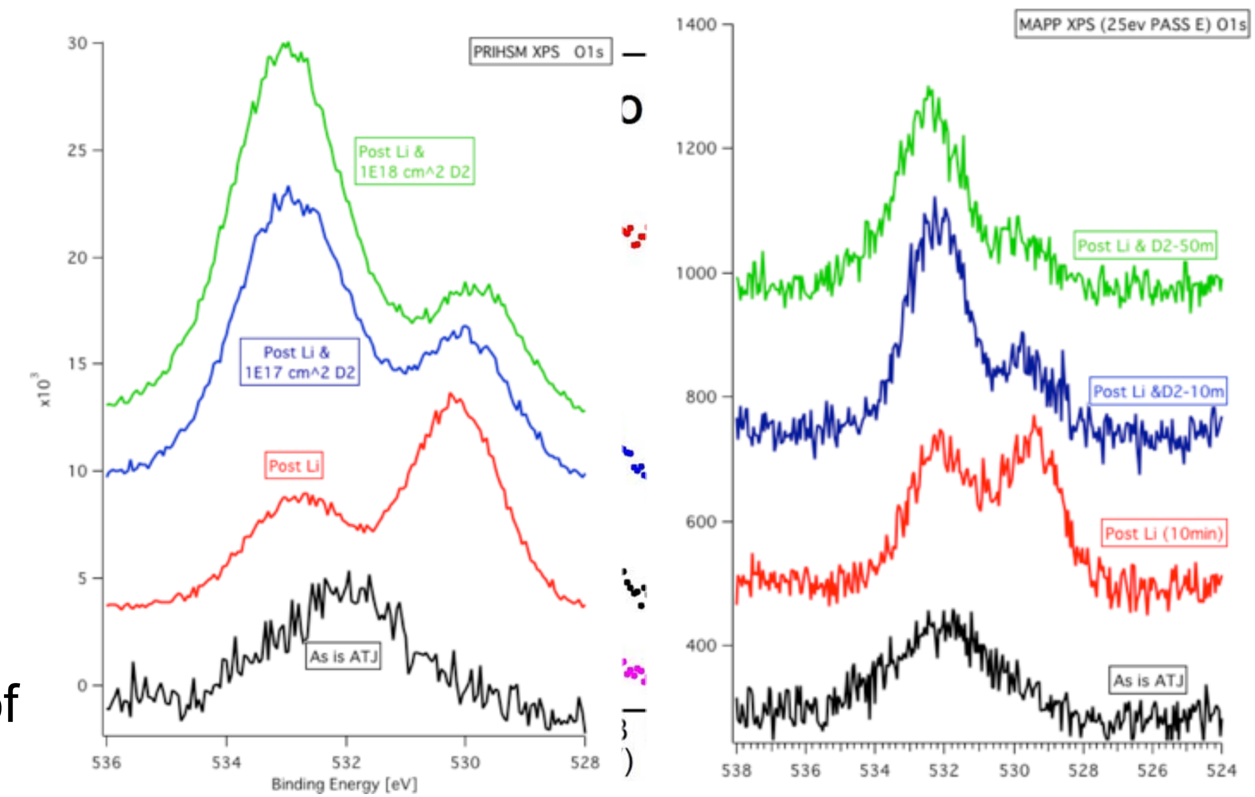
Plasma Current

XPS Spectrum



Results from LTX and current status

- **Energy resolution ~ 1.5-2.5 eV**
- Langmuir probes operational
- Thermal desorption spectroscopy 90% developed
- XPS operational
- Sputtering cleaning operational
- Temperature control of samples operational



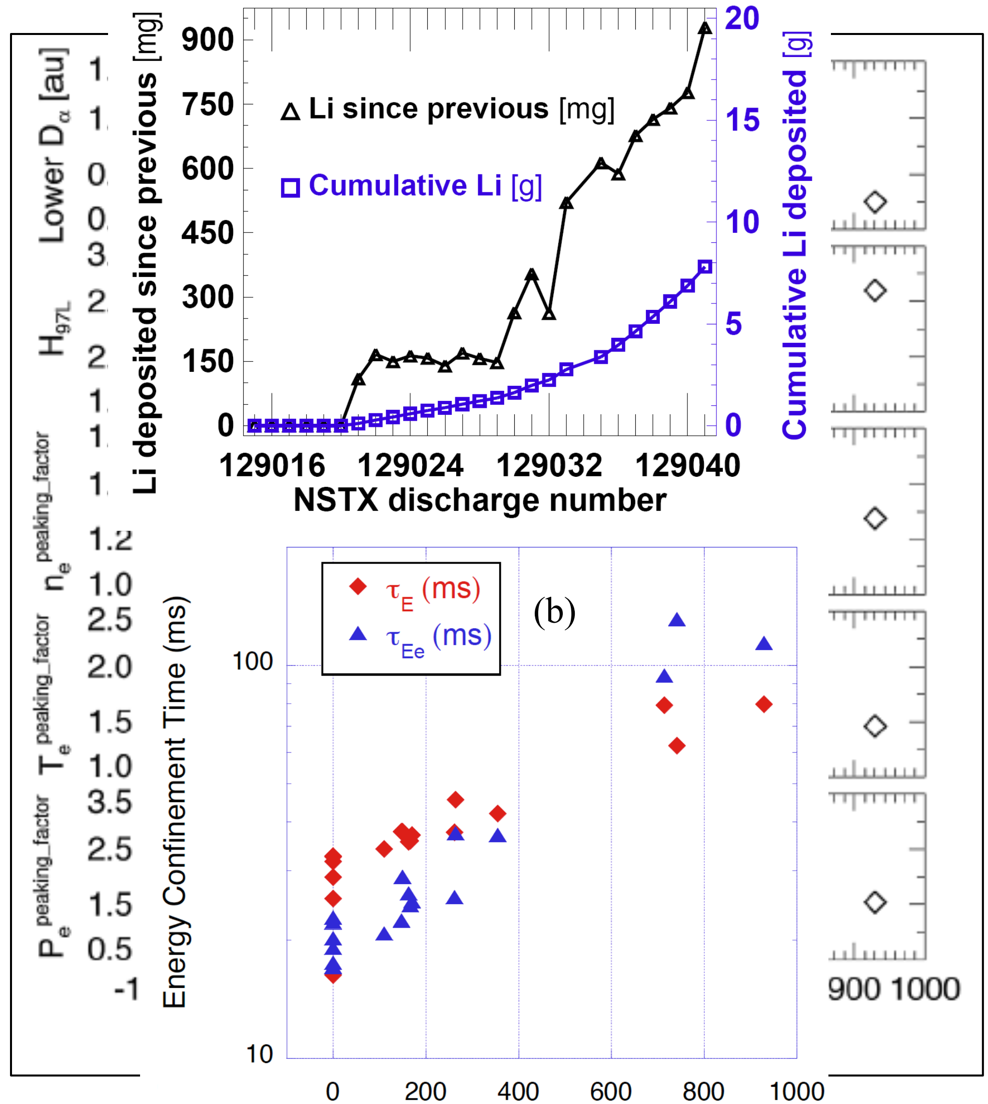
XPS scans of C-1s and O-1s photoelectron regions before and after MAPP sample exposure to an argon glow in LTX, showing the appearance of chemical shifts following the glow. **M. Lucia et al Rev. Sci. Instrum. 85, 11D835 (2014)**

Comparisons between lab experiments and MAPP, **Taylor et al. Rev. Sci. Instrum. 2012**

Motivation

Maingi et al Nuclear Fusion (2011)

- Boronization and Lithiumization improve plasma performance, however:
  - Improvements are strongly dependent on:
    - Time
    - Plasma exposures
    - Li passivation
    - Li intercalation in graphite
  - The effect of longer pulses has to be considered now
    - On hydrogen retention
    - On stability of the coatings
    - On presence of impurities



Objectives

1. Study and relate to plasma conditions the effect of boronization in NSTX-U.

2. Chemical characterization of the Boron/Lithium transition in NSTX-U first wall conditioning.

3. Study evolution of plasma performance as a function of Li deposited on graphite surfaces.

Proposed experiments

Two graphite samples required (XPS and TDS) plus Au calibration sample. Remote insertion and retraction of probe required*.

1. Clean graphite:

- Obtain XPS baselines i.e. prior to boronization or plasma discharges
- Obtain XPS data after plasma discharges
- Step 2 can be repeated depending on the schedule of the machine. This set can be done in “piggyback” mode.
- Run TDS scan after last plasma exposure on TDS sample

* If second requirement is not fulfilled, insertion can be done at beginning of day, retraction and data collection at end of the day.

Proposed experiments

Same assumptions and requirements as in experiment 1 apply **.

2. Study of boronized surfaces

- Obtain XPS data after boronization procedures.
- Obtain XPS data after plasma discharges.
- Step two can be repeated depending on machine time availability. This step can be run in “piggyback” mode.
- Run TDS scan after last plasma exposure on TDS sample.

** Can be equally modified in case remote insertion is not possible

Proposed experiments

Assumptions and possible modifications apply as before

3. Study on Boron/Lithium transition

- Obtain XPS data after initial Li deposition (after a known amount of boron is deposited; e.g. amount of mg of TMB used)
- Obtain XPS data after plasma discharge
- Steps 1 and 2 can be repeated after each boron treatment, Li deposition or plasma discharge.
- Run TDS scan after last plasma exposure on TDS sample

Proposed experiments

Same assumptions and potential modifications

4. Study of lithium coatings

- Obtain XPS data after Li deposition
- Obtain XPS data after plasma discharges (varying time of discharge vs OSP location)
- Steps 1 and 2 can be repeated after each deposition or plasma discharge.
- Run TDS scan after last plasma exposure on TDS sample