Initial results and operation of the Materials Analysis Particle Probe (MAPP) on NSTX-U

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57th Annual Meeting of the APS Division of Plasma Physics
November 16–20, 2015 • Savannah, Georgia
GP12.00097

Abstract

MAPP is the first in-vacuo surface-sensitive compositional/chemical analysis diagnostic to elucidate plasma-material interactions at a tokamak plasma edge. MAPP enables inter plasma-shot in-vacuo diagnosis of PFCs positioned in the outboard divertor far SOL of NSTX-U.

The diagnostic provides surface composition during the time scale of plasma-induced modification in the critical region of incident hydrogen implantation. MAPP can expose four samples to plasma discharges and retract them to its chamber for analysis. MAPP's capabilities include XPS, TDS, LEISS and DRS. This work summarizes the commissioning of MAPP for the NSTX-U FY15 experimental campaign.

NSTX-U will use boronization and lithiumization sequentially to prepare its graphite PFCs. MAPP will carry four samples; two ATJ graphite, one TZM and one gold sample that will be exposed to the same conditioning as the walls of the tokamak.

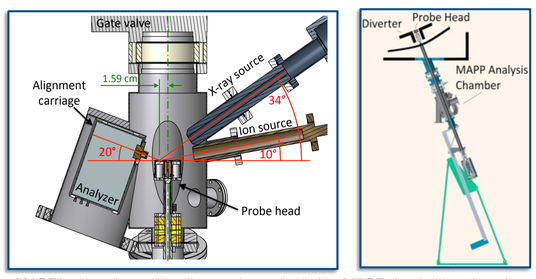
The Materials Analysis Particle Probe (MAPP)

Scientific objective

Correlate plasma performance to state of the plasma-facing surface

Main Features

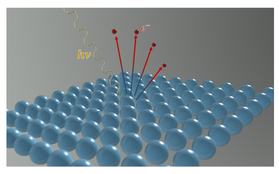
- *In-vacuo* analysis of materials exposed to plasma discharge
- Provide immediate, shot-to-shot analysis
- Remote Control interface



MAPP's chamber with diagnostic tools (left). MAPP is designed to be installed under the divertor region in NSTX-U, the figure on the right shows MAPP installed under the machine

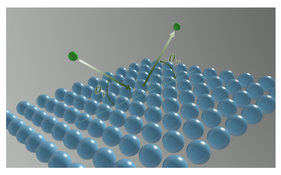
X-ray photoelectron spectroscopy

Purpose
Identify elemental and chemical composition of samples.



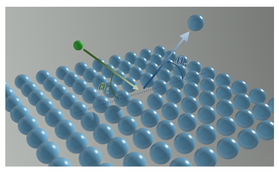
Ion scattering spectroscopy

Purpose
Provide qualitative identification of *surface* species.



Direct recoil spectroscopy

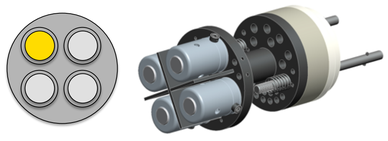
Purpose
Like ISS it provides identification of surface species, but is capable of detecting low Z elements such as hydrogen.



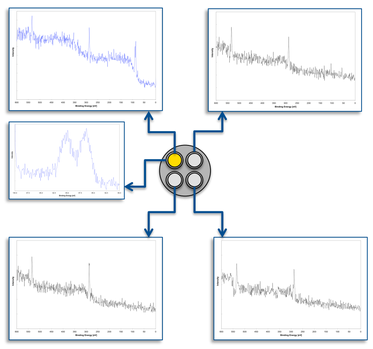
Fully developed capabilities

Ion irradiation and controlled heating

MAPP is equipped with four independently heated sample holders. Li was on samples at 20˚C and 200˚C.
XPS depth profile analysis and ion irradiation cleaning are available thanks to a focused ion source.

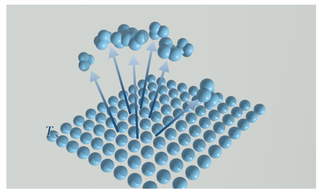


X-ray photoelectron spectroscopy

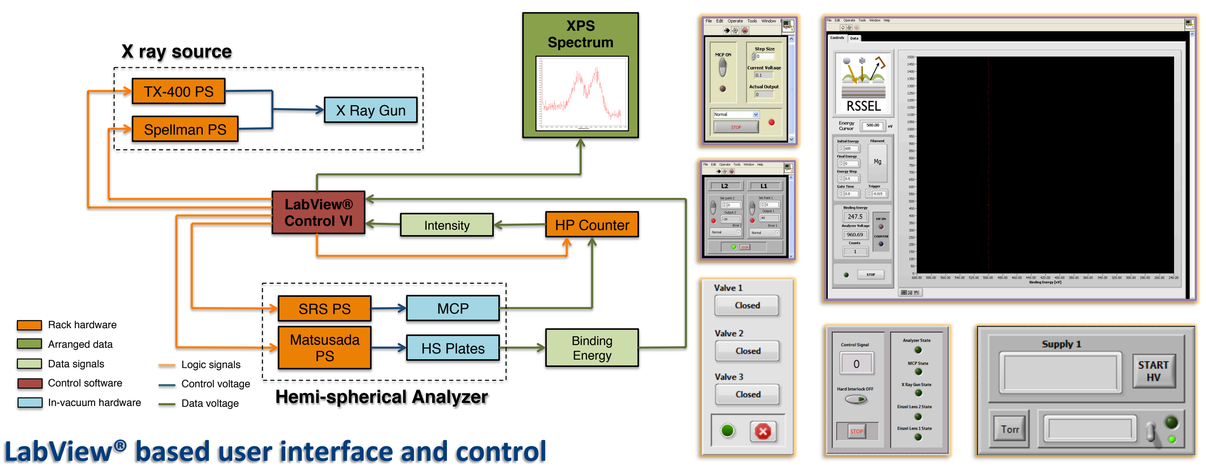


Thermal desorption spectroscopy

Purpose
Allows identification of desorbed species from materials' surfaces.



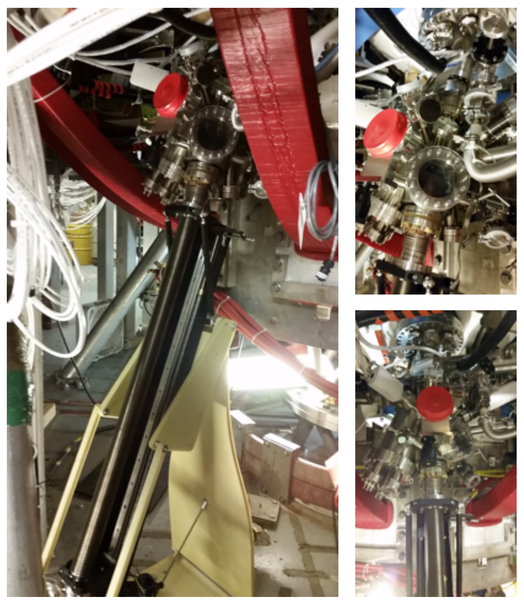
Remote control system



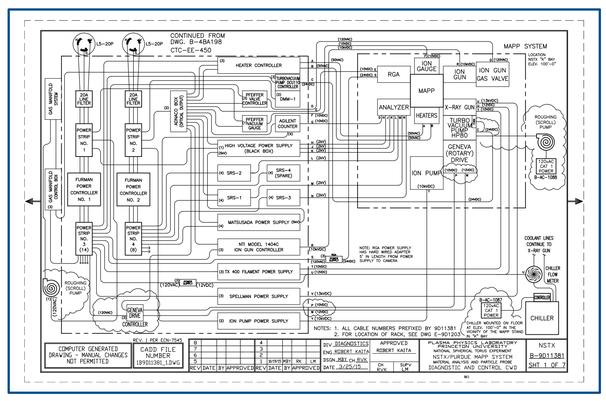
LabView® based user interface and control

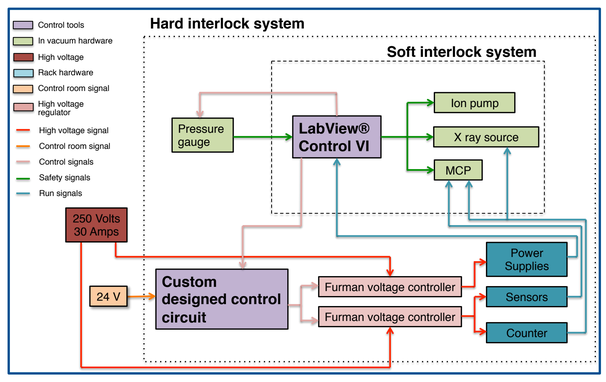
MAPP-U software was upgraded and remade in LabView® interface. The new software allows fast and accurate data acquisition and synchronization of different devices.
Several safety interlocks were added to the system to protect fragile pieces of equipment of possible abrupt changes in the operational conditions. The user interface was improved to be more intuitive and friendly.

NSTX-U Installation



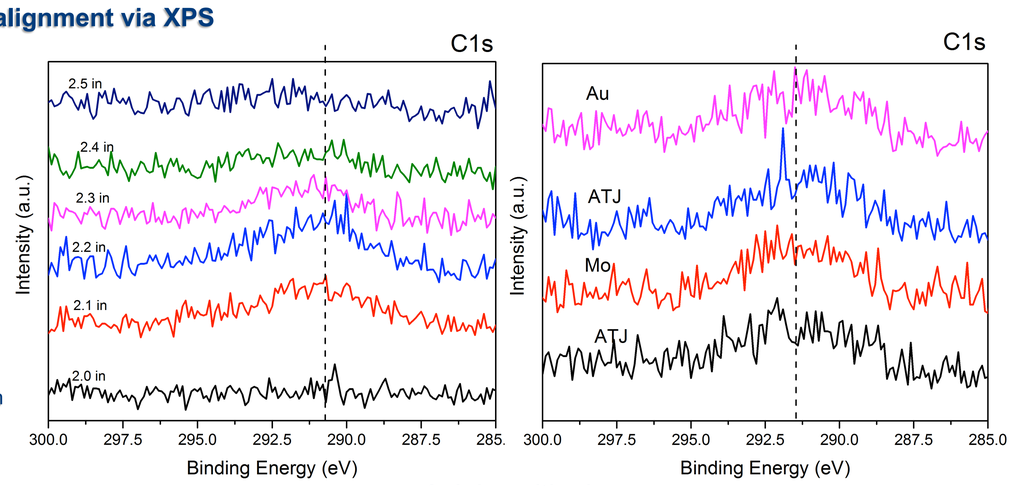
- MAPP installed on NSTX-U (bay J) in June 2015 (up).
- MAPP's installation was carried out with full compliance of safety and documentation procedures (up-right)
- MAPP is equipped with soft and hard interlock systems to protect its hardware from extreme pressures magnetic fields (right).





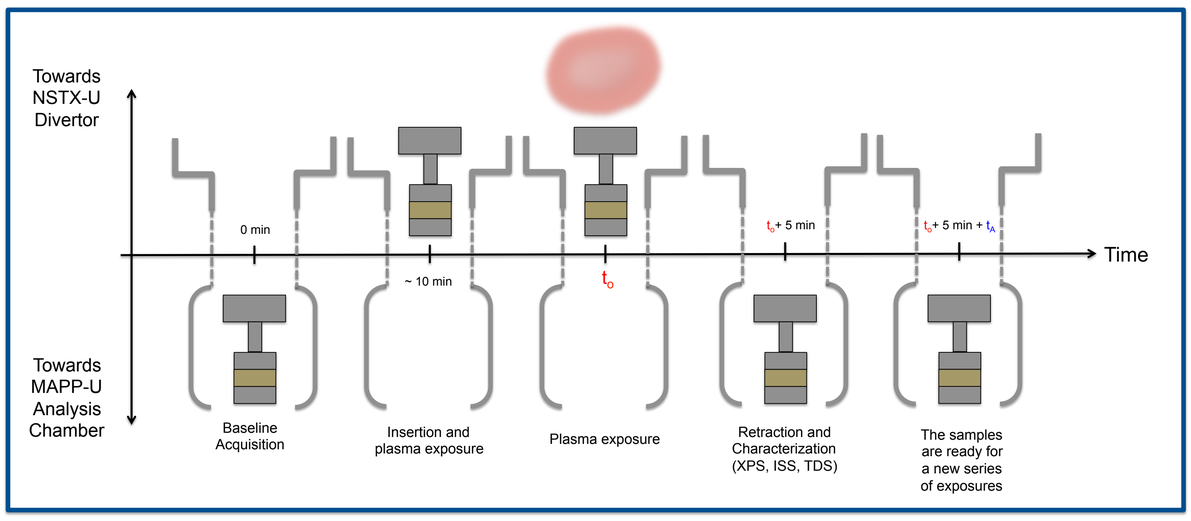
Samples holder alignment via XPS

Techniques as XPS, ISS and DRS require proper positioning of the samples with respect to the entrance of the analyzer. MAPP's samples holder has two degrees of freedom i.e. longitudinal and azimuthal. The axial DOF has been calibrated to define an optimal analysis position.



Axial positioning

Sequence of operation

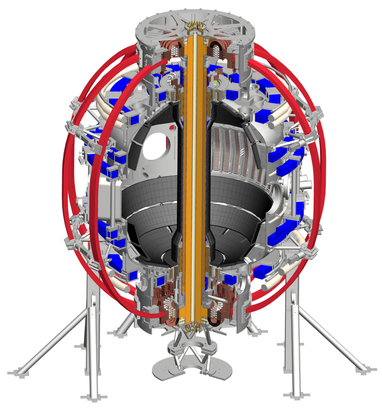


NSTX-U Experiments

2015 campaign starting in December:

XMPs:
- MAPP commissioning in NSTX-U
- Optimizing Boronization

XPs:
1. Effects of B➔Li transition on the pedestal structure.
2. Controlled introduction of Lithium into NSTX-U
3. Understanding the longevity of lithium coatings in NSTX-U.



Acknowledgments

This work was supported by the U.S. DOE contracts DE-AC02-09CH11466, DE-AC52-07NA2734, DE-SC0010717 and DE-AC52-07NA27344

References

1. C. N. Taylor, B. Heim, S. Gonderman, J. P. Allain, Z. Yang, R. Kaita, A. L. Roquemore, C. H. Skinner, and R. A. Ellis, "Materials analysis and particle probe: A compact diagnostic system for in situ analysis of plasma-facing components (invited)," Review of Scientific Instruments, vol. 83, no. 10, p. 10D703, 2012.
2. Lucia, M., Kaita, R., Majeski, R., Bedoya, F., Allain, J.P., Boyle, D.P., Schmitt, J.C., Onge, D.A.S. Development progress of the Materials Analysis and Particle Probe (2014) Review of Scientific Instruments, 85 (11), art. no. 11D835

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