U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

Recent progress in fundamental surface science for improved plasma performance in NSTX-U

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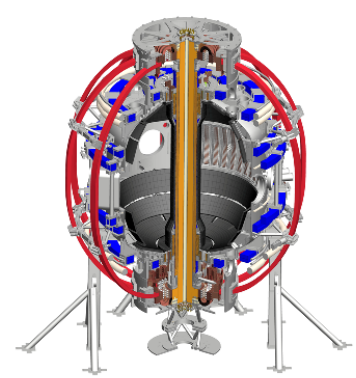
NSTX-U Results Review
Princeton Plasma Physics Laboratory
September 21, 2016

PRINCETON
Chemical and Biological Engineering

PPPL



Fundamental surface science of PFCs for improved plasma performance in NSTX-U

Goal 1: Deeper understanding of how boron and lithium affect the performance of NSTX-U

Goal 2: Develop predictive basis of how Li, Sn, or Li/Sn will perform under the plasma conditions of future fusion devices such as FNSF-ST with increased heat and particle flux, ion energy, surface temperature, etc. in terms of:

- ***H isotope intake***
- ***Impurity segregation***
- ***Evaporation (operational temperature range)?***

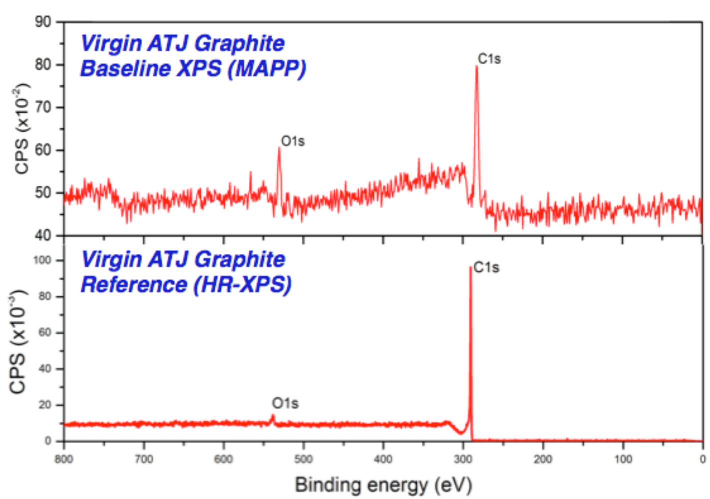
Deepen understanding of PMI processes by measuring:

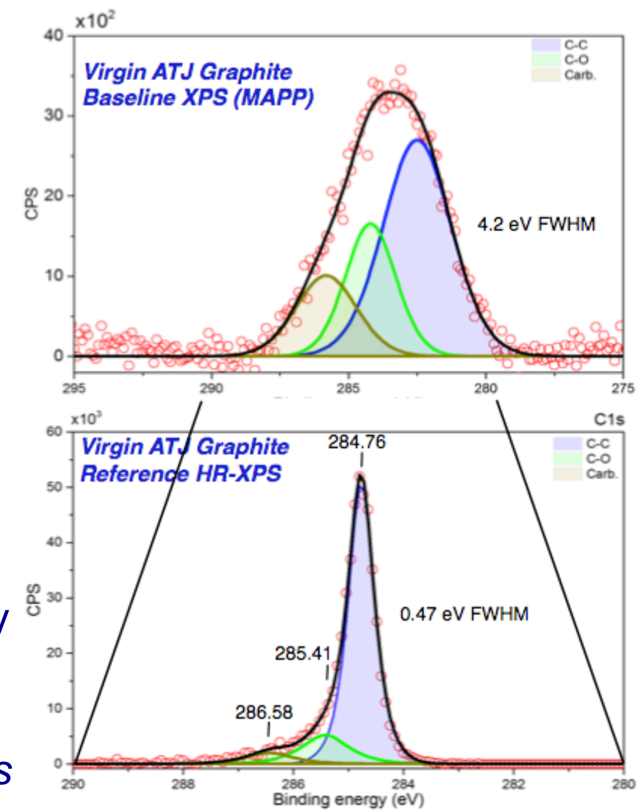
- D retention in Li films as a function of impurity level (C, O) and surface temperature (on Mo substrates)
- Boron and Lithium conditioned plasmas performance, D retention and surface chemistry in Mo-B-O-C and Mo-Li-O-C layers: *a comparison with MAPP results*
- Diffusion coefficient of O in Li and its temperature dependence; developing strategies for the removal of contaminants
- Li and Sn wetting of TZM; Investigations with TPD to determine Li-Mo and Sn-Mo adhesion energies
- Composition and surface chemistry of Sn and Sn-Li alloys for alternative PFC solutions
  - Thermally induced segregation mechanisms of Sn-Li alloys
  - D retention in Sn and Sn-Li alloys
- D^+ sputtering coefficients of Li and Li-C-O layers

Interpretation of MAPP results and surface spectroscopy to complement MAPP analysis

- Working closely with Felipe Bedoya (also Hanna Schamis) to interpret MAPP XPS results, *e.g., meeting Felipe 2X/week for long sessions of instruction and assistance.*

- Samples taken for additional spectroscopic characterization and surface science studies to SSTL after removal from MAPP, *e.g. HR-XPS to benchmark determination of chemical states present in samples.*

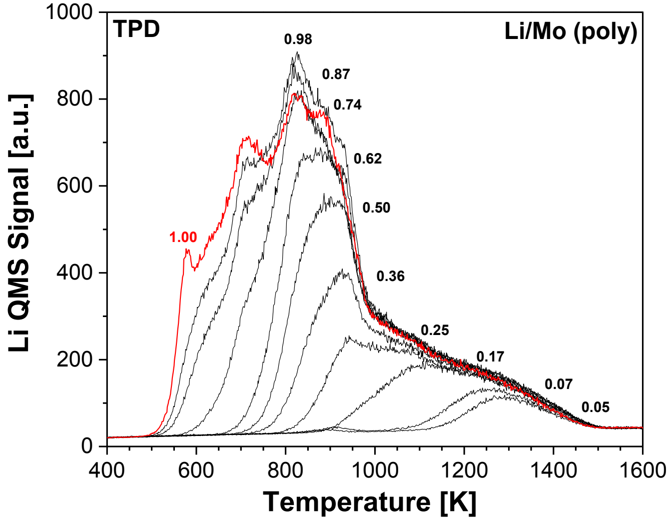




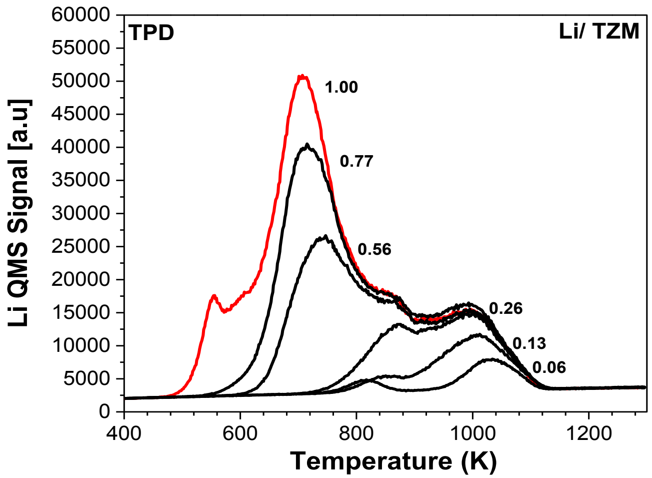
Improvements of 10X in resolution and 100X in sensitivity provided by ex-situ HR-XPS analysis, *e.g. shows initial MAPP analysis incorrect on amount and type of oxidized carbon present; key to understanding boronization results*

Thermal stability of Li on Mo(poly) and TZM

- Li more tightly bound on the Mo (poly) substrate relative to TZM

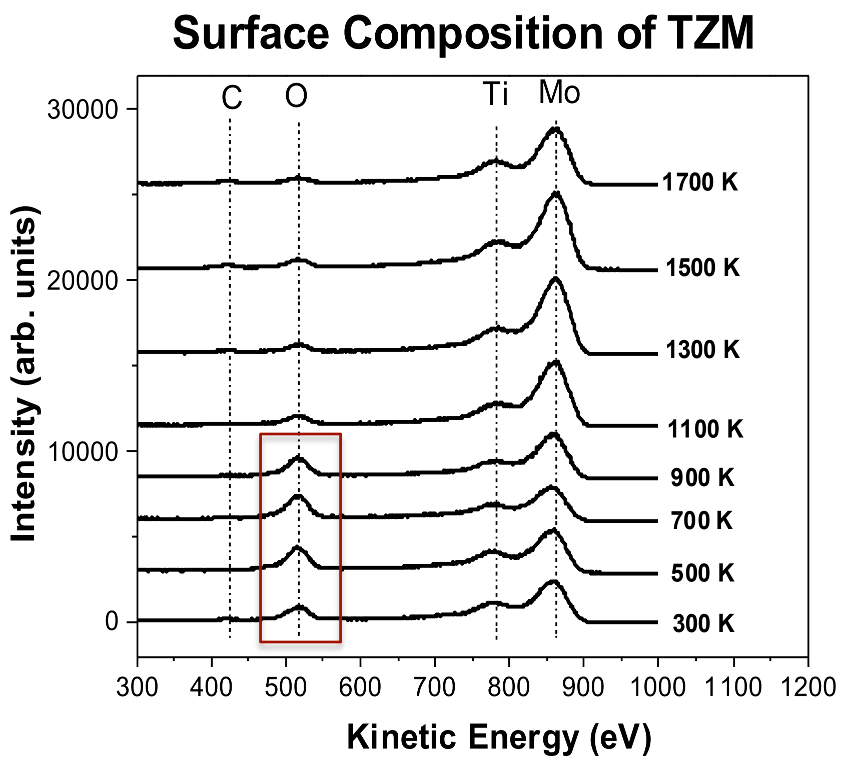


* Data is flux-corrected



* Data has been flux corrected

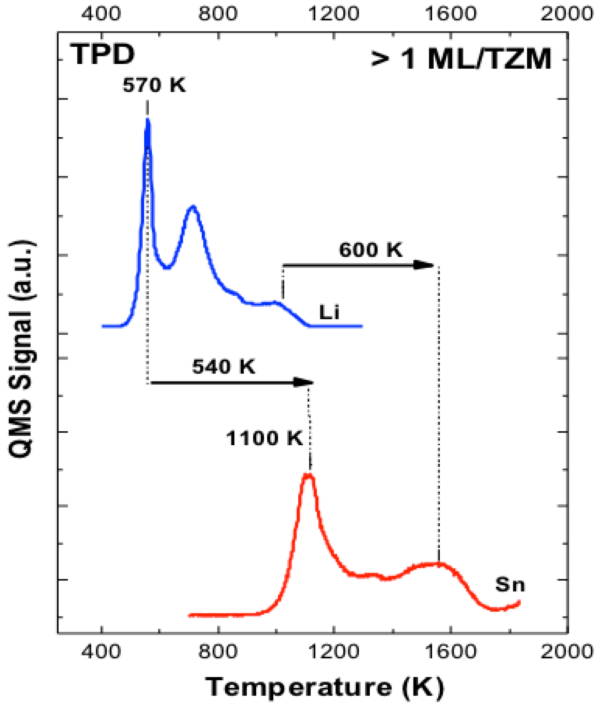
- Surface composition studies show that Oxygen increases from 300-900 K due to diffusion from the bulk or oxidation from background

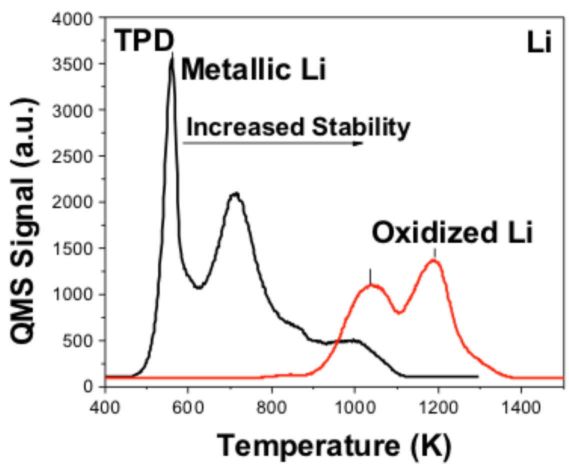


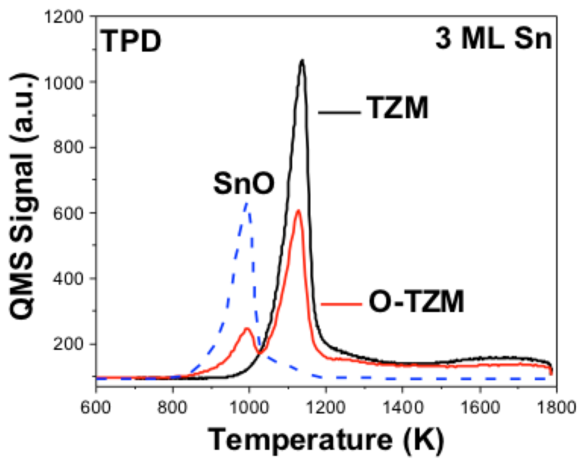
Thermal stability of Li and Sn on high-Z plasma facing materials

- Both thick Sn films and the Sn/Mo monolayer are more thermally stable by about 600 K than the corresponding Li films, *e.g. complete Sn evaporation from TZM does not occur until 1700 K.*

- Oxygen impurities affect the thermal stability of Li and Sn films profoundly differently, *e.g. Li stability is increased due to oxidation by 400 K, while Sn stability is decreased by 200 K*

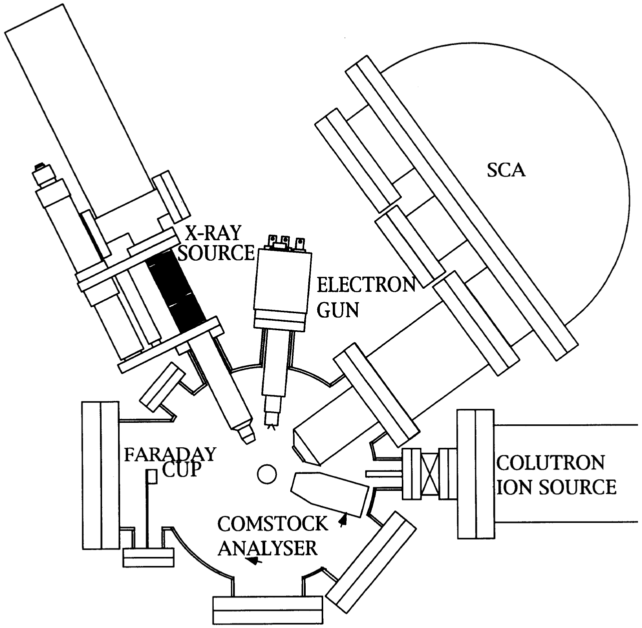


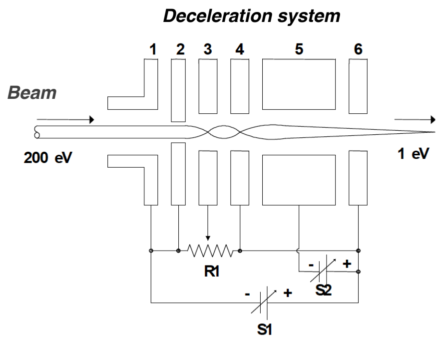


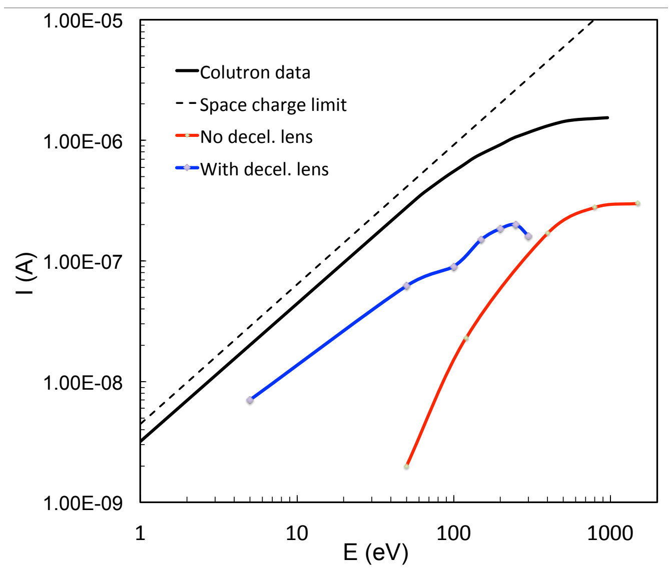


Chemical and physical erosion and implantation measurements for low energy ions

- Reconfiguration and upgrading of versatile instrument for mass and velocity filtered ion scattering measurements using Colutron ion source, *e.g. should now be possible to investigate surface processes of incident ions with energies of a few eV.*
- Successful installation of Model 400 deceleration lens consisting of six electrically insulated concentric cylinders mounted at the exit of the Colutron ion source.
- Renovation of a Comstock cylindrical sector electrostatic analyzer underway to enable forward-scattering detection of surface-bound hydrogen.







Backup slides

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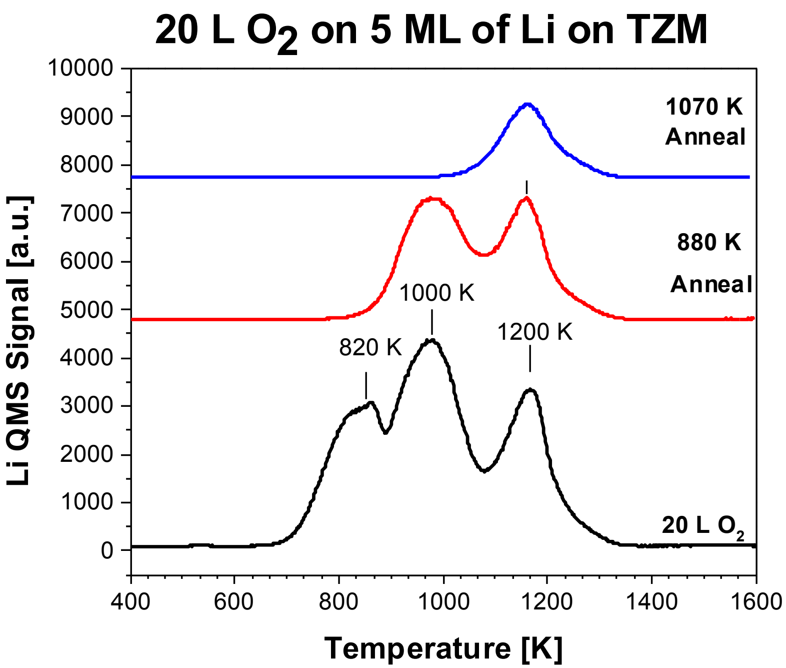
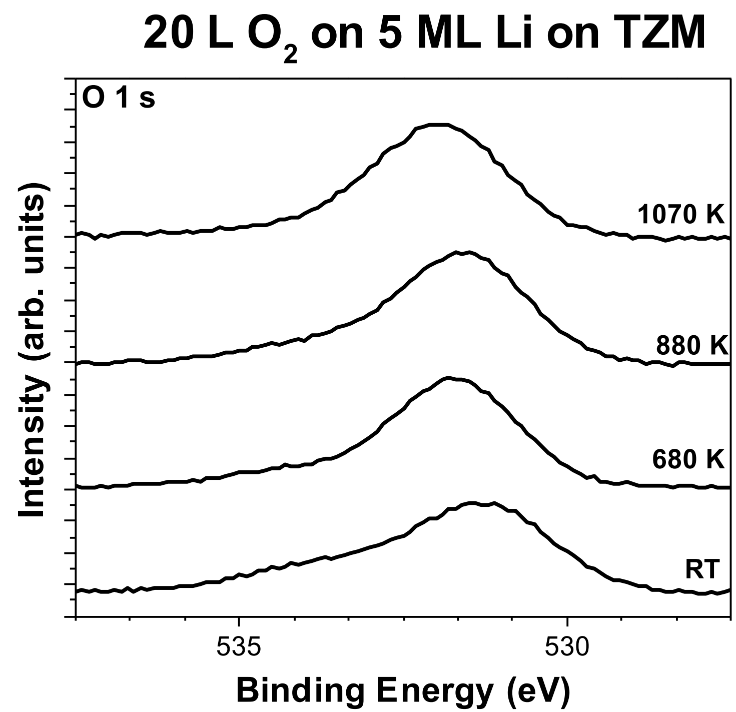
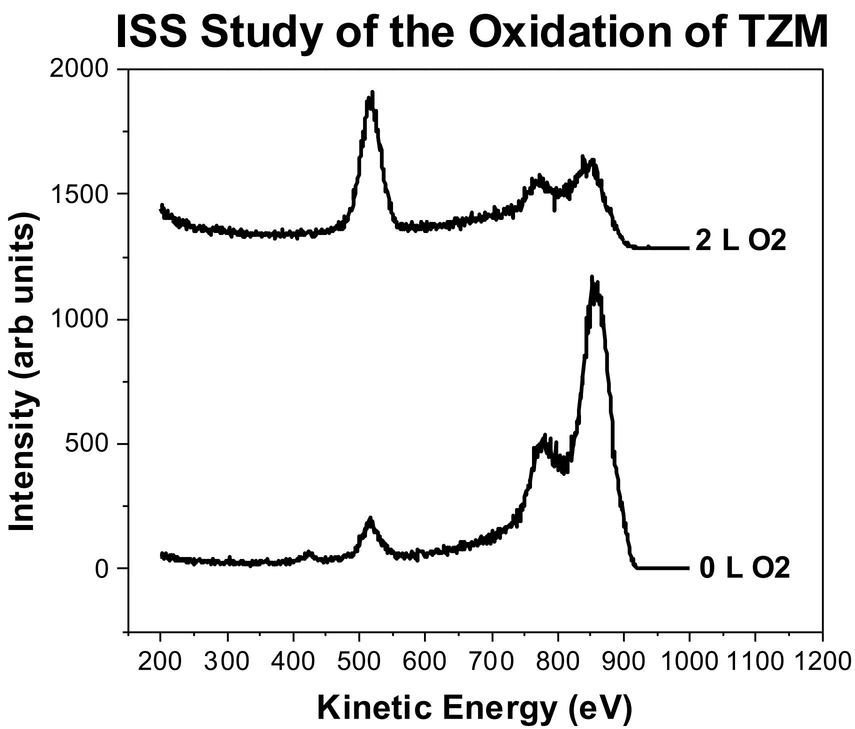
Oxygen impurities affect the thermal stability of Li

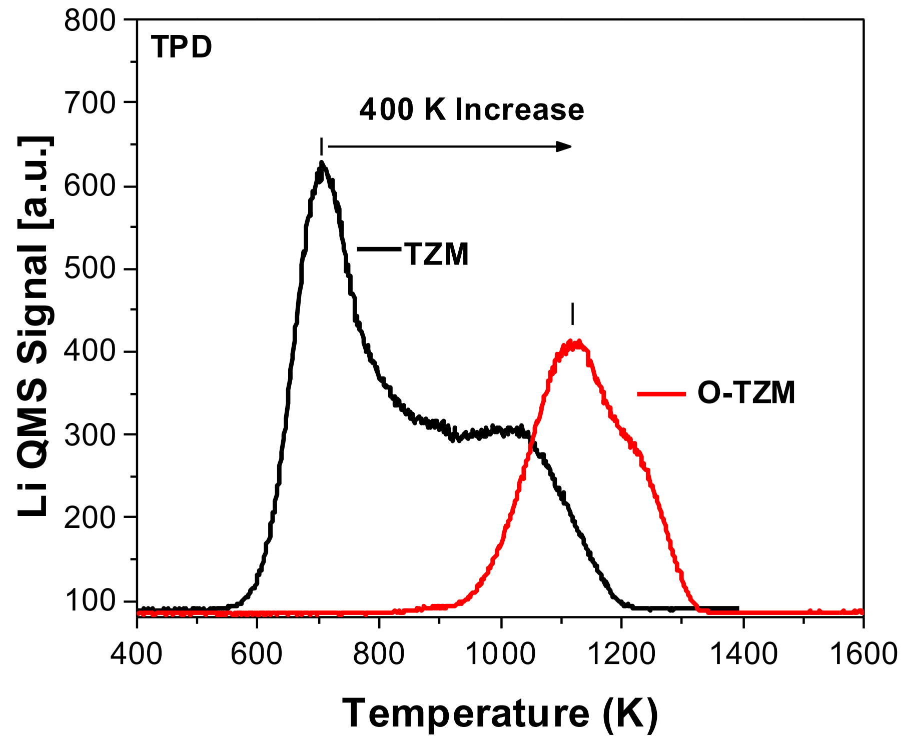




- TPD shows 3 Peaks at 820 K, 1000 K and 1200 K after 20 L oxidation of Li on TZM
- XPS shows new binding states for oxygen as the film is annealed to different temperatures

Thermal stability of Li increased on pre-oxidized TZM





- Oxygen saturation of the top layer of TZM occurs after 2 L of O_2 Exposure as shown by ISS
- Increased thermal stability of Li on O-TZM