XPS study of depth profiling induced chemistry in NSTX-U tile samples

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Motivation

Plasma performance is strongly influenced by the chemical state of plasma facing surfaces. X-Ray Photoelectron Spectroscopy (XPS) measures the atomic composition and chemical state of the top few nanometers of surfaces by measuring the energy of photoelectrons ejected by monochromatic X-ray radiation. The electron binding energy shifts slightly depending on the chemical environment.

Experiment

Thermo Scientific K-Alpha

The Thermo Scientific K-Alpha XPS/UPS instrument is a state of the art XPS system consisting of a monochromatic X-Ray source, hemispherical energy analyzer and a MAGCIS dual purpose gun capable of producing monatomic argon ions as well as gas clusters.

Tantalum Pentoxide

Tantalum pentoxide, or Ta₂O₅, is a sputtering standard. Commonly studied due to its optical and dielectric properties.

PEDOT:PSS

poly(3,4-ethyleneoxythiophene) polyethylene sulfonate is a conducting polymer. It was selected to mimic amorphous carbon-hydrogen-co-deposits which occur in plasma-materials interactions.

Results

Cluster Sputtering Tokamak Wall Sample Avoids Chemical Changes

During the 2015-2016 experimental campaign, boronization was used to condition PFCs (made of AT1 graphite).

Several tiles were removed from the NSTX-U tokamak to be analyzed with XPS and depth profiling to compare Ar ions with Ar clusters.

Sputtering Causes Chemical Modifications in a Polymer

The polymer PEDOT:PSS experiences major chemical modifications during monatomic argon ion sputtering, and less severe, although still present, modifications using an argon gas cluster beam.

Sputtering Creates Reduced Oxidation States in Metal-Oxides

When sputtering tantalum pentoxide preferential sputtering of oxygen creates reduced oxidation states. This effect is attributed to a higher sputtering yield of oxygen by argon due to the similarity in mass.

Conclusion

Different sputtering conditions appear to affect the sample surface differently.

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