Exploration of Plasmonic Defect Tungsten Oxide Through X-Ray Photoelectron Spectroscopy

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Introduction

Working under Catherine Fabiano, a graduate student in the lab, we are studying the synthesis of plasmonic semiconductor nanocrystals via a microwave machine. Once these nanocrystals are synthesized, we will analyze the particles using XPS to determine the concentration of tungsten oxide in each (this will show us the degree to which tungsten oxide concentration relates to the conduction of materials).

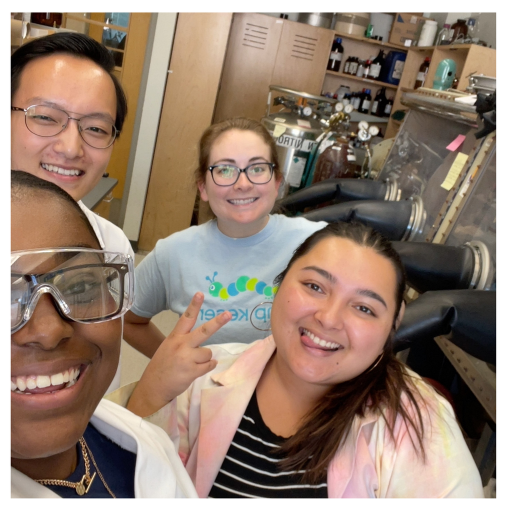


Figure 1. Strouse Group Members: Jonathan Rider, Catherine Fabiano, Shania Folkes, Yuri Mariano

This is done it is believed to be the cause of the plasmonic effect (the change in the light absorbance of a particle/substance). Semiconductor nanoparticles are important, as applications range from targeting tumors using semiconductor lasers to specialized semiconductor windows that only let certain energy waves penetrate (for example, heat waves can be blocked, but light can be let in).

Nanoparticle Synthesis

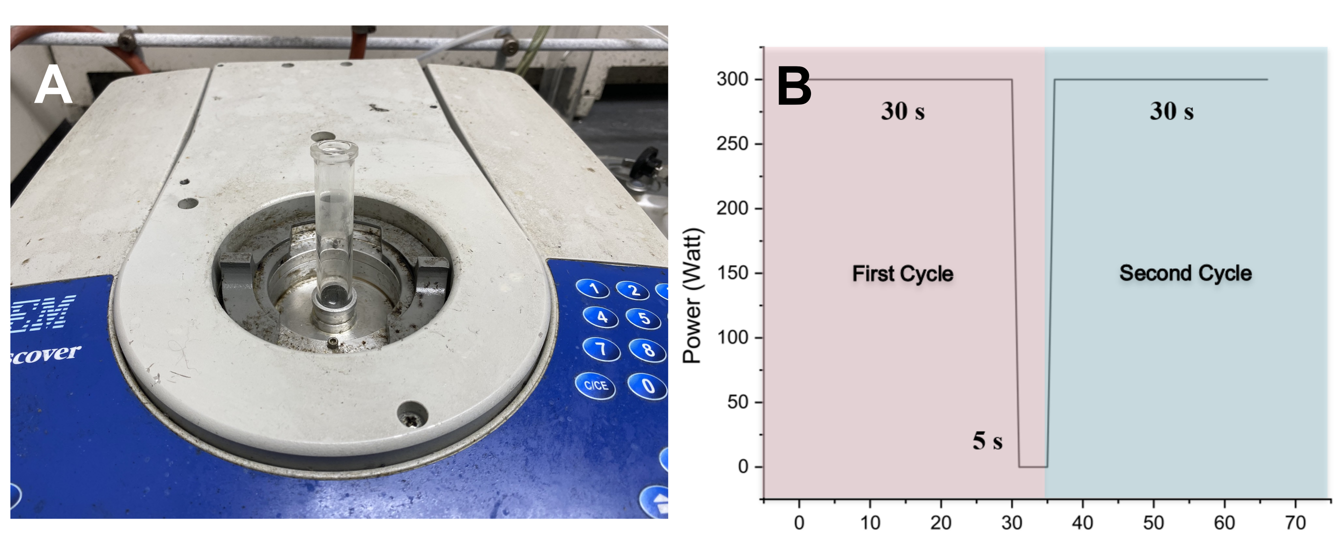


Figure 2. (A) CEM Microwave reactor with quartz synthesis vial (B) A single pulse sequence in the microwave consists of thirty seconds of continuous power at 300 W and five seconds of 0 W power and air cooling.

2 nm WO_{3-x} nanoparticle synthesis

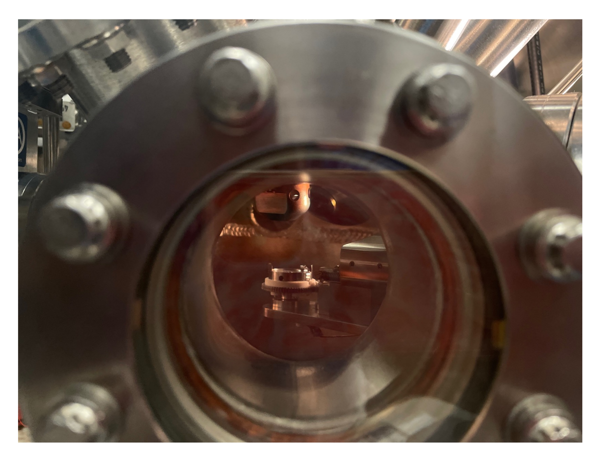
- A microwave vial was filled with 30 mg of W_4Cl and 0.4 mL of Oleic Acid. A pulse sequence in the microwave was utilized to obtain the nanoparticles (Figure 2)
- WO_{3-x} nanoparticles are cleaned via centrifugation with toluene and methanol

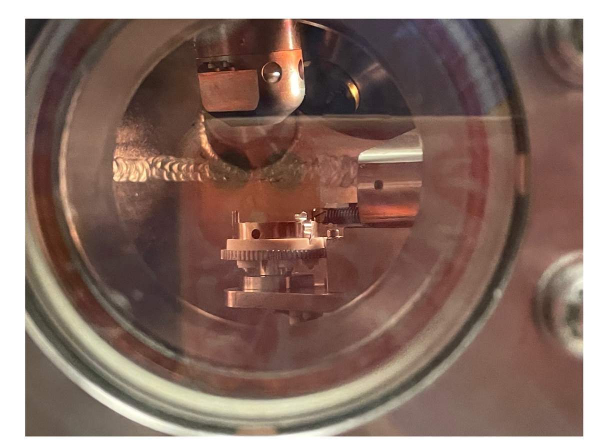
WO_{3-x} nanoparticle characterization

- UV-Vis Spectroscopy was obtained Perkin Elmer Lambda 950 UV/VIS/NIR
  Double Beam Absorption Spectrophotometer.
- X-Ray Photoelectron Spectroscopy was measured on a PHI 5100 spectrometer
  - Samples were prepped in a GloveBox on Carbon Tape to ensure nanoparticle stability.

X-Ray Photoelectron Spectroscopy

X-ray photoelectron spectroscopy (XPS) is an instrument available in FSU Physics. The PHI 5100 XPS is a machine that we utilize in the Strouse lab to examine oxidation states of WO_{3-X}. The instrument uses a beam of X-rays to excite electrons in a sample in order to quantify the composition. This occurs when the electrons in a sample absorbs enough energy to eject an electron electrons which have a unique kinetic energy. Electrons vary in energy, causing them to be analyzed via kinetic energy in the detector; this produces the data that we receive from the XPS instrument.





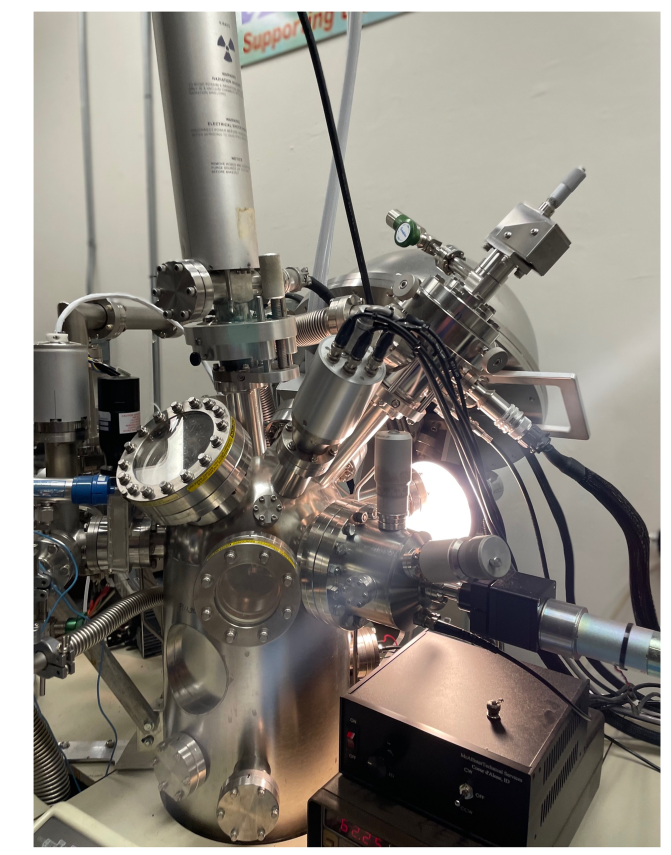


Figure 3. PHI 5100 XPS spectrometer in use (located in the FSU Physics)

Results

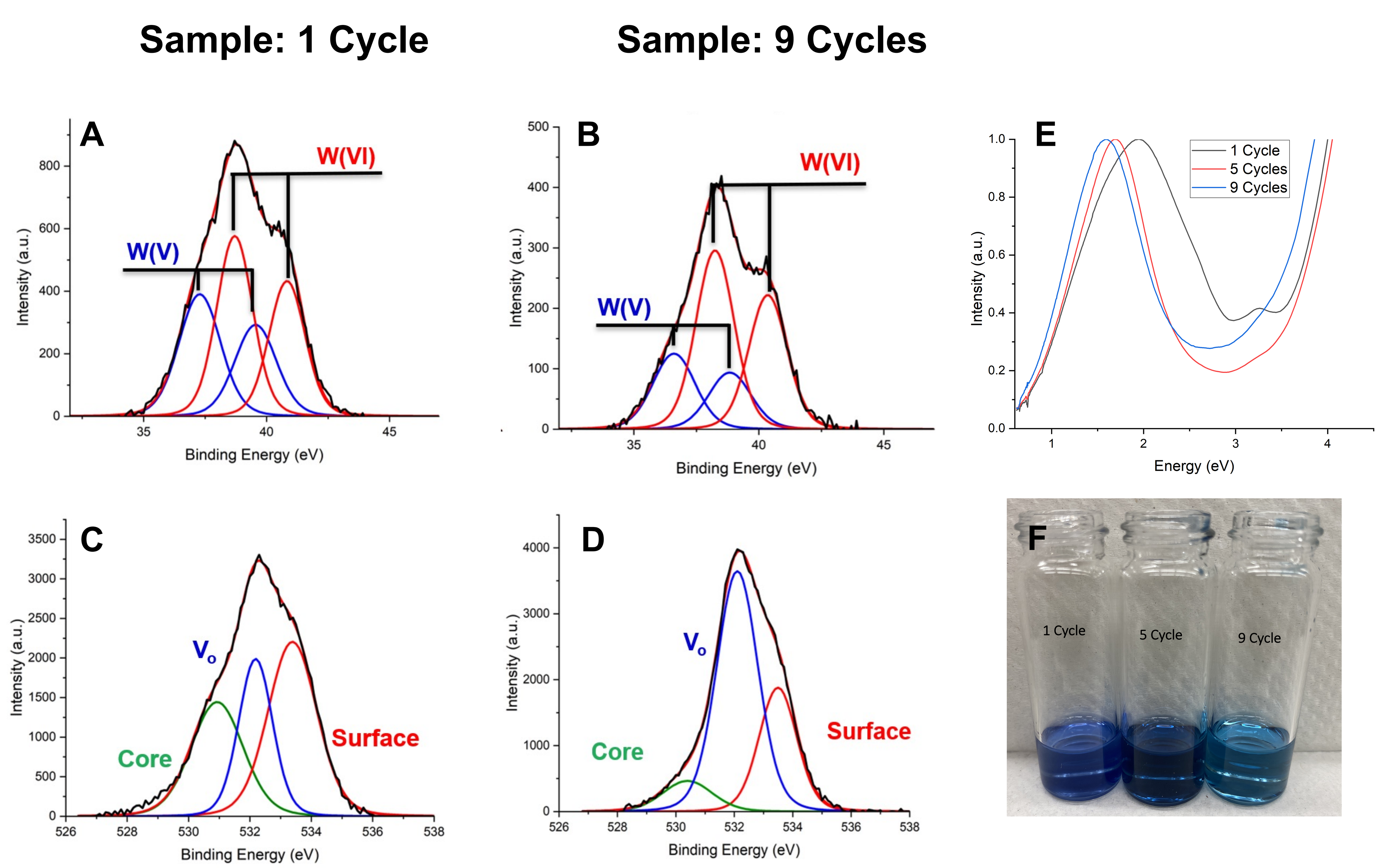


Figure 4. XPS W 4f and O 1s core level spectra of tungsten oxide powders on carbon tape (A),(B) show the W 4f spectra of tungsten oxide samples 1 pulse and 9 pulses respectively (C),(D) show the O 1s spectra of tungsten oxide samples 1 pulse and 9 pulse respectively (E)the UV-Vis spectrum of the plasmon energy shift in tungsten oxide samples 1,5,9 pulses (F) image of cycles 1,5,9 tungsten oxide samples dissolved in toluene.

Applications

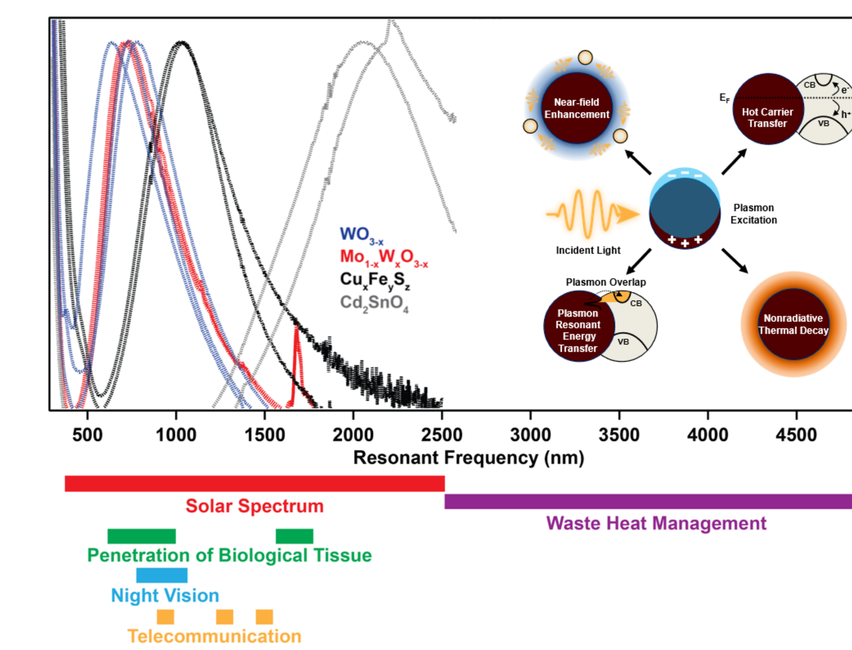


Figure 5. Applications of plasmonic semiconductor nanocrystals

Electrochromic Windows
Materials can be created using plasmons in order to build temperature-controlled windows. These electrochromic materials alter the color, which in turn alters the type of light rays that the material absorbs, preventing heating of a room (through absorption of UV rays).

Photothermal therapy, Tumor detection; noninvasive treatment to shrink tumors
Plasmonic nanocrystals offer strong absorption properties. When these properties are utilized, the absorbed light can be released as heat, which is useful in photothermal therapy and imagery.

- ultra small tungsten oxide has shown promising effects in this application
- "Doped tungsten oxide exhibit plasmonic absorption between 500 and 1000 nm wavelength, and thus are promising for such applications (Agarawl, et. al)"

Catalysis
Plasmonic nanocrystals can be used to enhance catalysis; one of the applications include reducing CO2 (this can be used to form hydrocarbon fuel)

References

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Acknowledgments

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