XPS at Lehigh

Dr. Alfred C. Miller
Overview

• Principles
• Instrumentation
• Examples
• Limitations
• Resources at Lehigh
Principles of XPS and AES

Maximum escape depth for electrons is less than 10 nm
30 cm radius electrostatic analyzer

carrousel

CCD camera

electrostatic electron lens

sample

high-power fine focus electron gun

30 cm diameter rotating anode

SCIENTA ESCA-300
PRINCIPLE OF OPERATION
Spectral information

- Elemental identification
- Chemical state
- Quantitative surface composition
- In-Depth Composition (ARXPS, sputter depth profiles)
- Lateral distribution of surface elements and chemistry (XPS imaging)
Zr41.2Ti13.8Cu12.5Ni10Be22.5
Thin oxide on Si

![Graph showing thin oxide on Si with peaks at Si2p3/2 and Si2p1/2, indicating the presence of SiO2.](image-url)
XPS imaging

Edge resolution of 3 microns or less for the best instruments
Detection Sensitivity - Ge implanted in Si

![Graph showing detection sensitivity for Ge implanted in Si](image-url)
Detection Sensitivity

Float glass

Sn ~ 50ppm estimated sensitivity
Metals

$5 \times 10^{-4} \text{ Pa oxygen at 973K for 45 minutes}$

**Graph:**
- Nb metal
- NbO$_x$
- NbO
- NbO$_2$

**Axes:**
- Y-axis: Intensity, counts x 1000
- X-axis: Binding Energy, eV

**Legend:**
- Nb metal
- NbO$_x$
- NbO
- NbO$_2$
Polymers

Fluropolymer Film

C(1s)

Binding Energy, eV

Counts
Catalysts

Zn-Cu Catalyst
- As Prepared
- Treated
- Used

Counts

Binding Energy, eV

Cu$^{1+}$

Cu$^{2+}$

Cu$^{1+}$/Cu$^{2+}$
Pd loading of 0.05 wt.%
Insulators

Te-K-W Glass
Fractured in situ

Te(3d)
Te(3p)
O(1s)
K(2p)
W(4d)
Valence Band
Depth Profiles

Be Oxide on Be-Ni Alloy

Concentration (at.%) vs. Sputtering Time (min)

- O
- Be
- Ni
- C
Fluorocarbon Monolayer on Si
Effects of washing on cotton

![Graph showing the effects of washing on cotton. The x-axis represents binding energy in eV, and the y-axis represents counts x10^3. Different lines represent different washing conditions: blank cotton, 5 w, 10 w, 5 w, 40°C, 10 w, 40°C, 5 w, 80°C, and 10 w, 80°C.](image-url)
Advantages

- Sensitive to 2-20 monolayers
- Can detect ca $10^{-3}$ atomic fraction
- Is especially useful for chemical shifts from the same element in different compounds
- Is the least destructive of the surface analysis techniques
- Has sensitivity range within a factor of 20
- Has minimal sample charging
Limitations

• Has moderate lateral resolution
• Is slower for sputter depth profiling than other methods
Lehigh Scienta ESCA300

Instrument features

• High power rotating anode x-ray source
• Multi-element monochromator
• High throughput analyzer and lens
• Channel plate detector
• Small spot and imaging capability
• Automated stage for multi-position analyses
• Charge compensation for insulators
Lehigh Scienta ESCA300

- In-situ heating and cooling
- Fracturing and scraping
- Argon ion etching
- Thin film deposition
- Gas exposures (low and high pressures)
- Residual gas analysis
- LEED available