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Surface Composition Studies of CdZnTe Material Using X-Ray Photoelectron Spectroscopy

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Outline

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- High-Performance XPS Surface Analysis System
- XPS Data Collection
- Results
- Summary and Conclusion

Introduction

- Cadmium zinc telluride (CdZnTe or CZT) is widely used for the detection of X-rays and gamma rays at room-temperature without cryogenic cooling.
- It has many applications in the areas of nuclear and radiological threat detection, medical imaging, gamma spectroscopy, and astrophysics.
- The composition of the detector wafer surfaces is a very important factor in detector device fabrication.
- The stoichiometric composition of the detector surfaces affects its surface current which in turn contributes to the electronic noise.
  - High electronic noise is detrimental to the energy resolution of the detector device.
- The mechanical stability at the interface of the electrical contacts and the detector material is an important factor in terms of durability and shelf-life of detector devices.

Experiments and Methods – Sample Preparation

- CdZnTe sample of size 6.4 x 6.9 x 2.4 mm^3 was cut using a machine equipped with a diamond impregnated wire saw.
- After cutting, the sample was mechanically polished on a silicon carbide abrasive paper using distilled water.
  - Large grain of 800-grit paper was first used, followed by polishing on 1200-grit paper.
- The wafer was further polished on a MultiTex paper using alumina power and distilled water to get mirror-shine surfaces.
  - A 3.0-µm alumina powder was first used.
  - This is followed with successive polishing in decreasing sizes of powder down to 0.1 µm.
  - A separate MultiTex pad was used for each alumina powder size.
  - After each polishing, the sample is thoroughly rinsed in distilled water.

High-Performance XPS Surface Analysis System

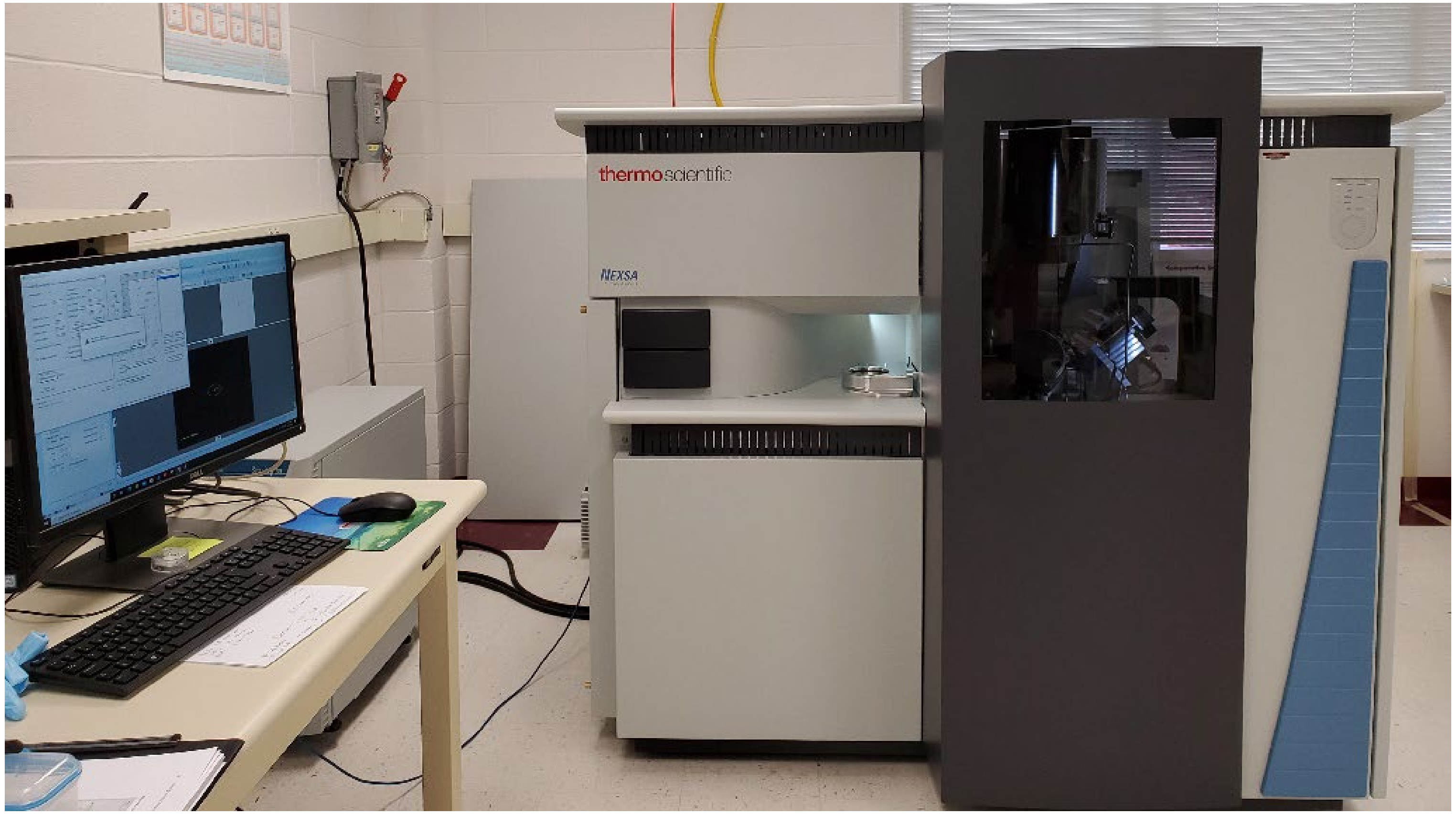

Figure 1. High-performance XPS Surface Analysis System by Thermo Fisher.

Experiments and Methods – XPS Data Collection

- The CdZnTe wafer was mounted on a sample holder and loaded to the XPS machine.
  - The XPS machine is equipped with an X-ray source gun type Al-K-Alpha.
- A spot size of 400 μm was used on the sample.
- The photoelectrons ejected from the sample surface are collected in the analyzer.
- A survey analysis was first made to scan for all elements that could be present on the surface.
  - In the survey scan, the analyzer mode was set at a pass energy of 200.0 eV, and the energy step size was 1.00 eV. The scan took 68 seconds.
- Scans were made for specific energy regions of the dominant surface species.
  - The specific elements of interest studies in this experiment include Zn, Cd, and Te.
  - The analyzer mode for these scans was set at a pass energy of 50.0 eV, and the energy step size was 0.100 eV.

Results

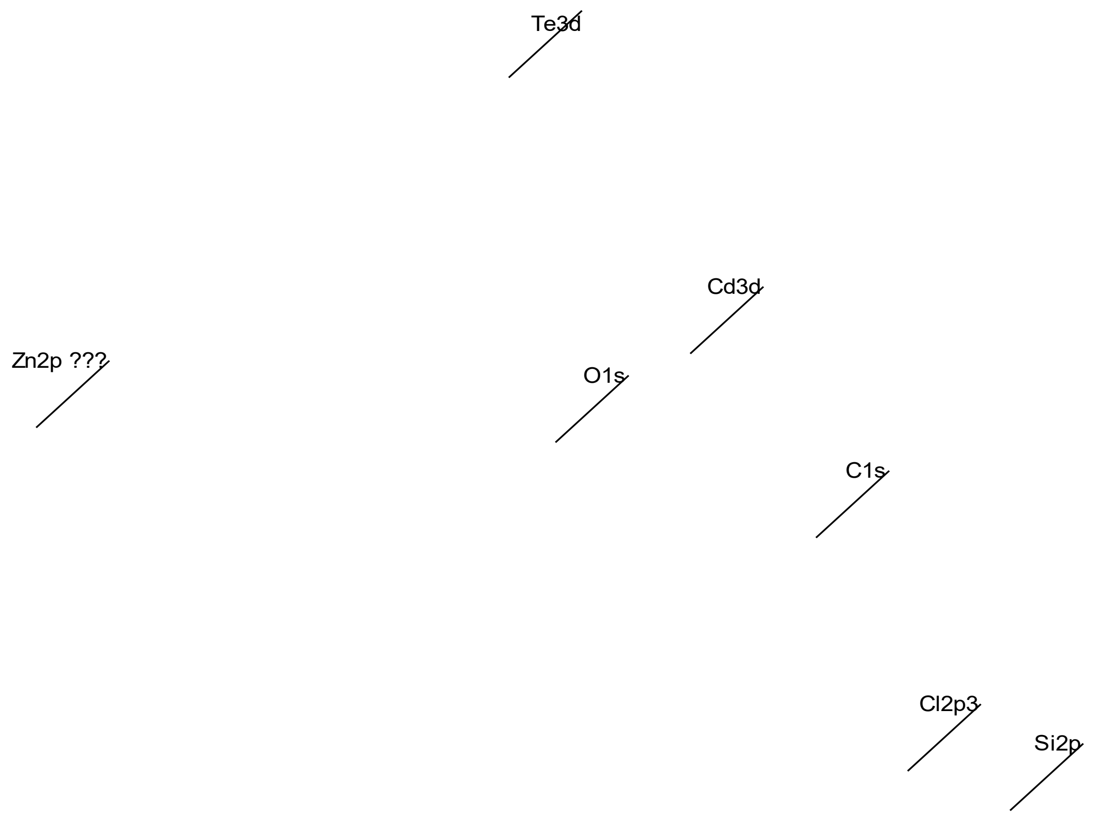

Figure 2. XPS survey scan showing the presence of Zn, Te, O, Cd, C, Cl, and Si.

Cadmium Peaks

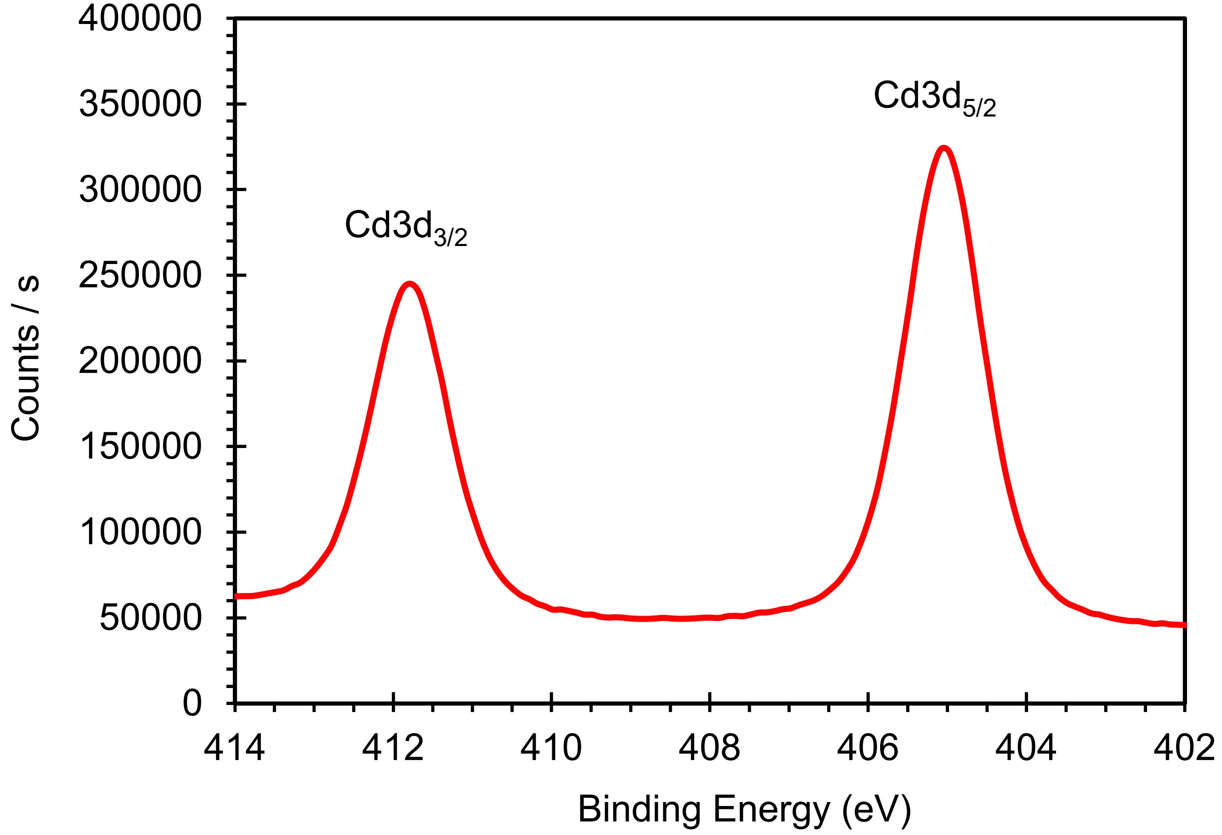

Figure 3. XPS scan showing the $Cd3d_{5/2}$ and $Cd3d_{3/2}$ peaks of cadmium.

Zinc Peaks

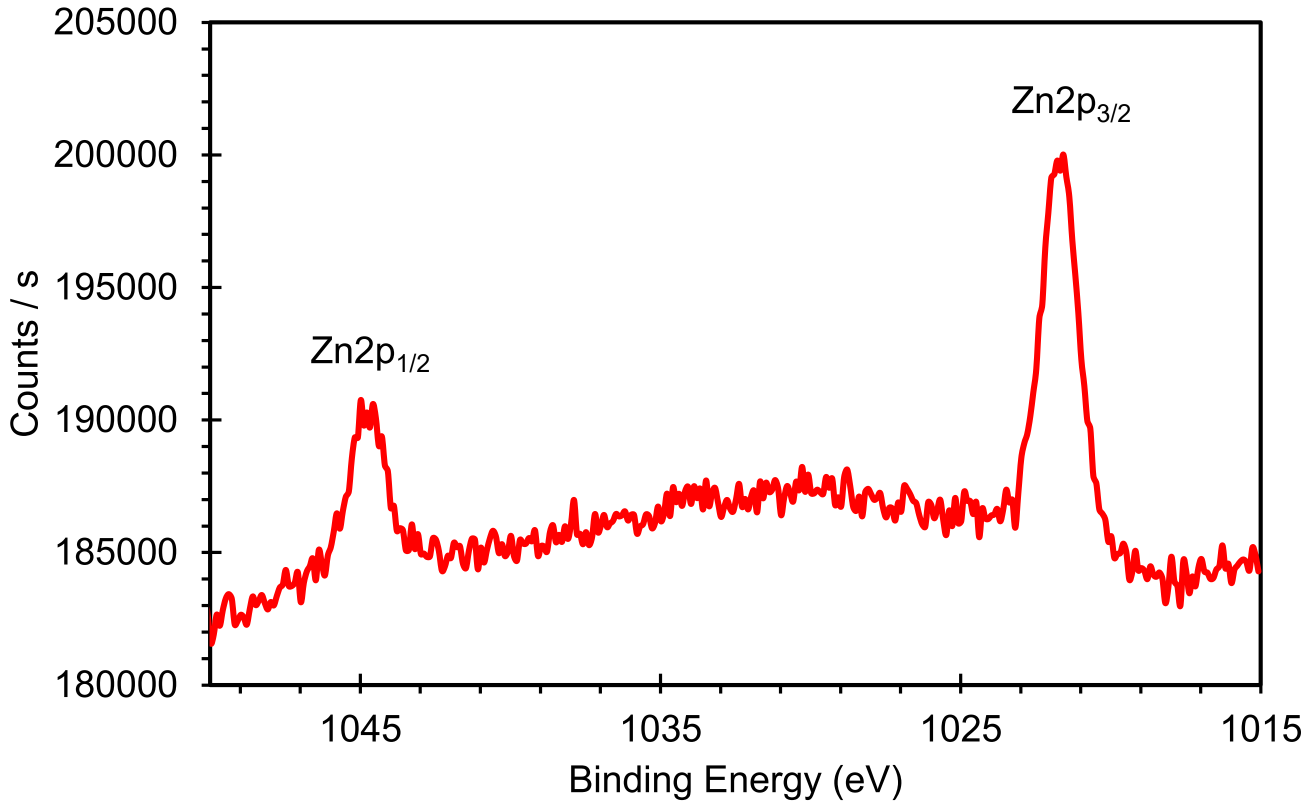

Figure 4. XPS scan showing the $Zn2p_{5/2}$ and $Zn2p_{3/2}$ peaks of zinc.

Tellurium and Tellurium Oxide Peaks

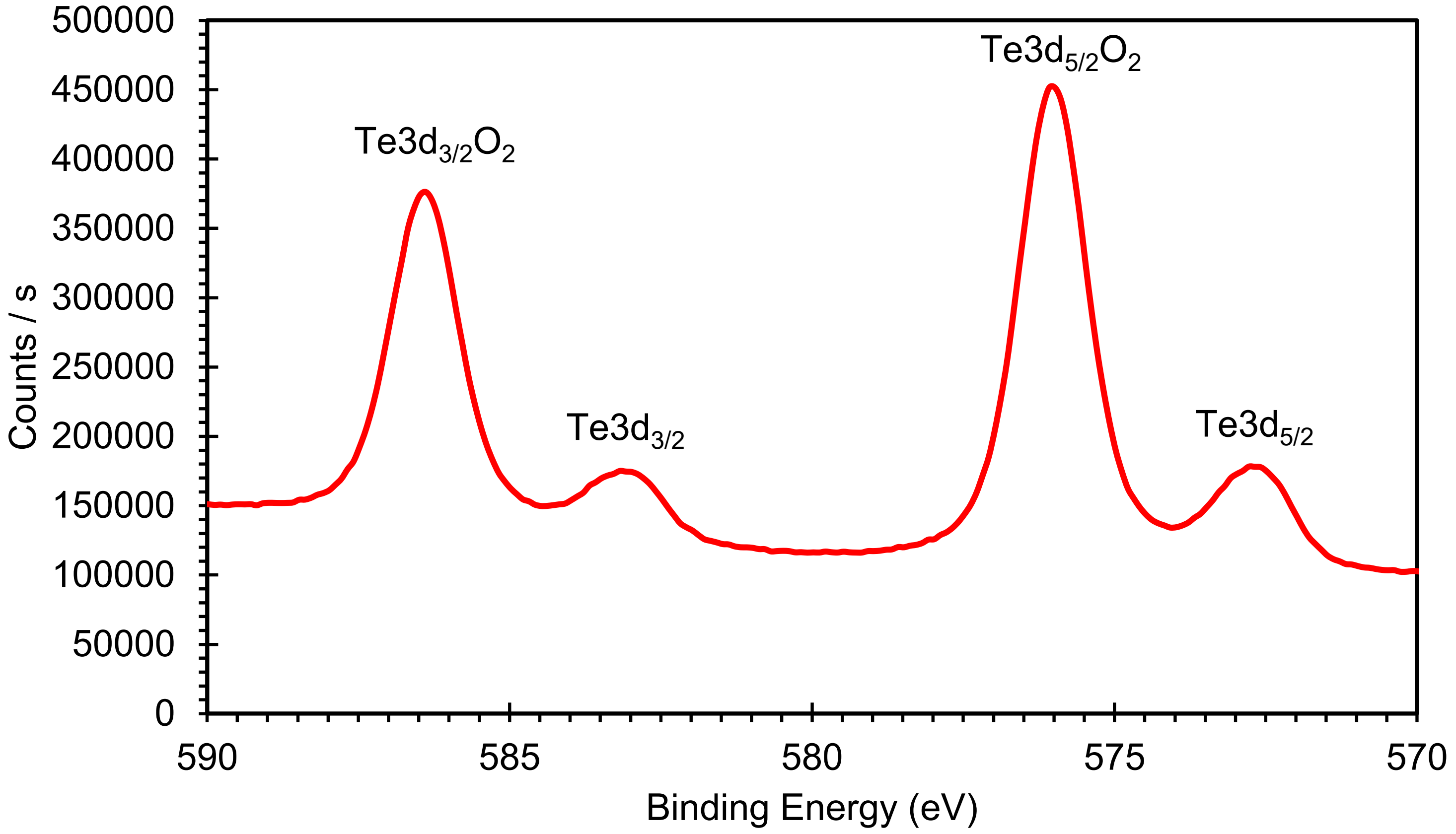

Figure 5. XPS scan showing the $Te3d_{5/2}$ and $Te3d_{3/2}$ peaks of tellurium and $Te3d_{5/2}O_2$ and $Te3d_{3/2}O_2$ peaks of TeO_2.

- The XPS scan for Te also showed TeO_2 peaks.
- This is an indication of the formation of TeO_2 on the surfaces of the CdZnTe wafers.

Tellurium and Tellurium Oxide Peaks

Table 1. Heights of the binding energy peaks identified for Cd, Zn, Te, and TeO_2.

Peak	Binding Energy (eV)	Peak Height Raw Counts
$Cd3d_{5/2}$	405.08	323697
$Cd3d_{3/2}$	411.78	245079
$Zn2p_{3/2}$	1021.58	200017
$Zn2p_{1/2}$	1044.98	190753
$Te3d_{5/2}$	572.78	178127
$Te3d_{5/2}O_2$	575.08	451401
$Te3d_{3/2}$	583.18	174938
$Te3d_{3/2}O_2$	586.38	376005

Summary and Conclusion

- We have used XPS to determine the dominant elements on CdZnTe wafer surface.
- The XPS results showed the presence of Zn, Te, O, Cd, C, Cl, and Si, and TeO_2.
- The XPS scans focused on the binding energies in the regions of Cd, Zn, and Te showed that these elements are significantly present as expected.
- The XPS scan for Te also showed TeO_2 peaks.
  - This is an indication of the formation of TeO_2 on the surfaces of the CdZnTe wafers.
- In future studies, we plan to investigate the near-surface compositional variation by using high-speed ions to remove very thin surface layers of the CdZnTe wafer

THANK YOU