Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

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SRNL-STI-2020-00510

X-Ray Photoelectron Spectroscopy of CdZnTe and CdMnTe Materials for Nuclear Detectors

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ABSTRACT

Cadmium zinc telluride (CdZnTe) and cadmium manganese telluride (CdMnTe) semiconductor nuclear detectors have the ability to operate at room temperature without cryogenic cooling. Thus, they can be fabricated into portable nuclear detection devices that can be used at seaports and border security, and at nuclear facilities to monitor radiation levels. In this paper, we present results from the use of X-ray photoelectron spectroscopy (XPS) to study the surface compositions of CdZnTe and CdMnTe wafers. Our results showed that Cd, Te and TeO_2 are the dominant species on these materials. Zn was also present on CdZnTe and Mn on the CdMnTe wafer. Samples that were etched with high-energy ion beam did not show the presence of TeO_2.

RESULTS

TeO_2 Present Before Ion-Beam Etching

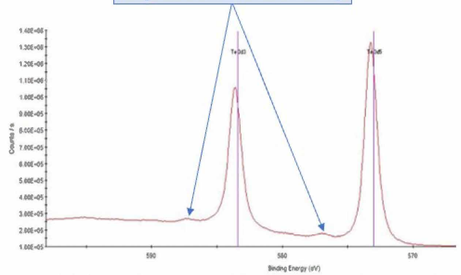


Figure 1. CdZnTe sample before ion-beam etching. XPS single scan showing the $Te3d_{3/2}$ and $Te3d_{5/2}$ peaks of tellurium and $Te3d_{3/2}O_2$ and $Te3d_{5/2}O_2$ peaks of TeO_2.

Absence of TeO_2 Present After Ion-Beam Etching

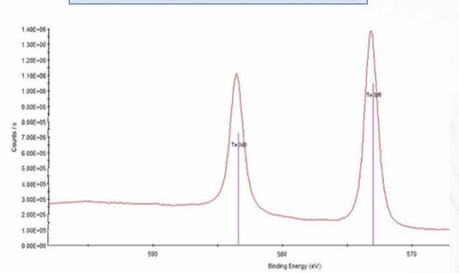


Figure 2. CdZnTe sample after ion-beam etching. XPS single scan showing the $Te3d_{5/2}$ and $Te3d_{3/2}$ peaks of tellurium. No TeO_2 peaks.

$\frac{TeO_2}{Te}$ Peak Height Ratios is Higher Before Ion-Beam Etching for the CdMnTe Sample

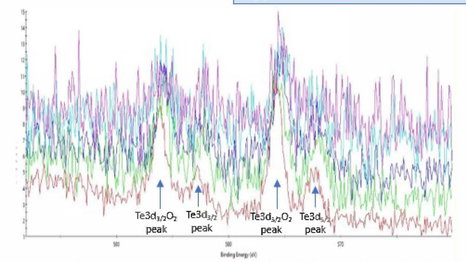


Figure 3. CdMnTe sample before ion-beam etching. XPS multiple scans showing the $Te3d_{3/2}$ and $Te3d_{5/2}$ peaks of tellurium and $Te3d_{3/2}O_2$ and $Te3d_{5/2}O_2$ peaks of TeO_2.

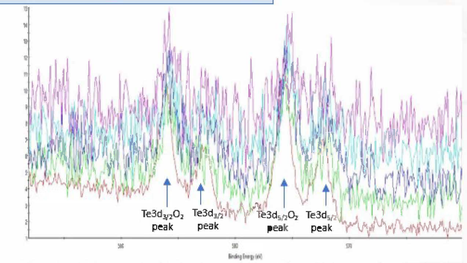


Figure 4. CdMnTe sample after ion-beam etching. XPS multiple scans showing the $Te3d_{3/2}$ and $Te3d_{5/2}$ peaks of tellurium and $Te3d_{3/2}O_2$ and $Te3d_{5/2}O_2$ peaks of TeO_2.

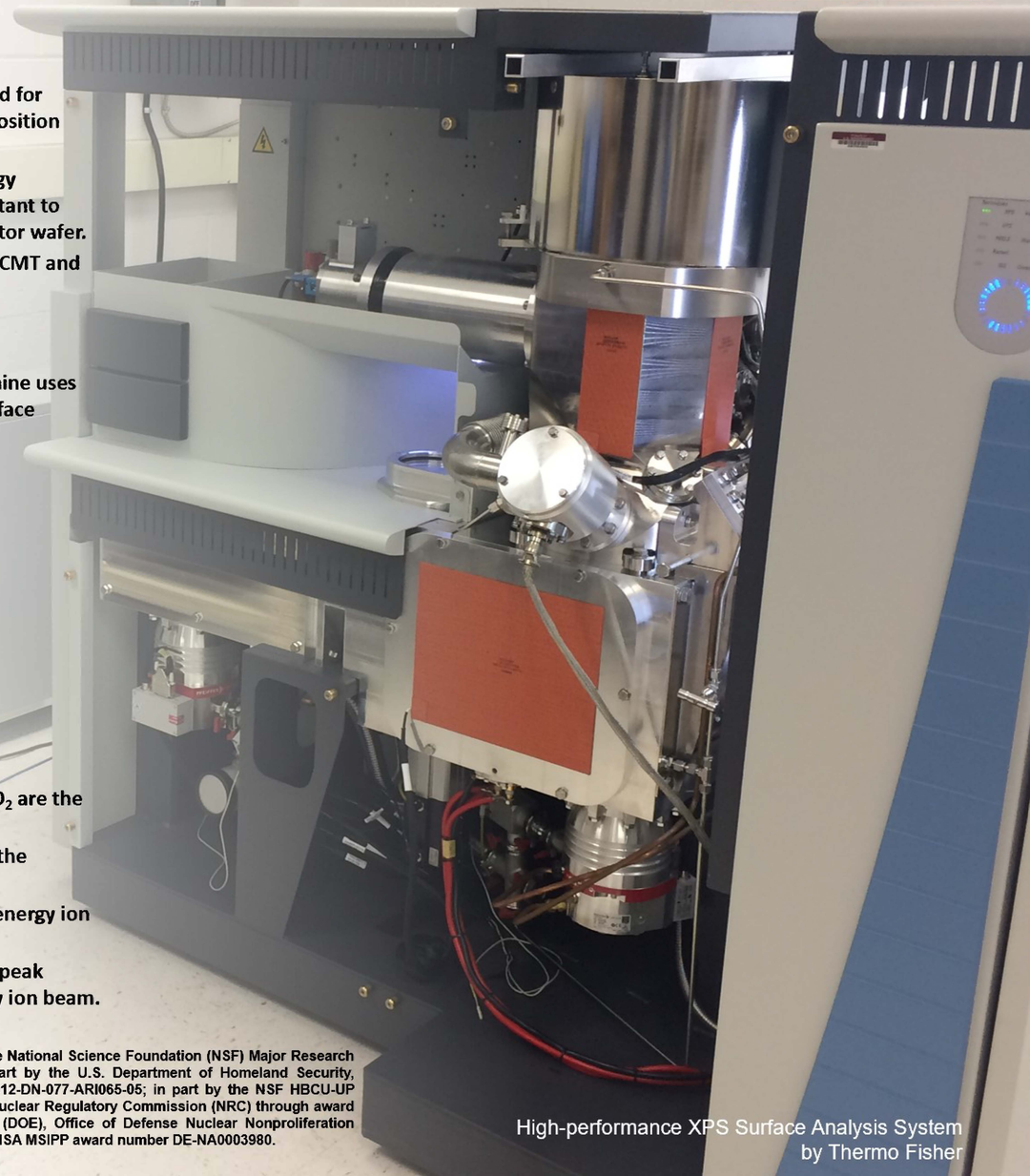
EXPERIMENT

- X-Ray Photoelectron Spectroscopy was used for surface composition studies. Surface composition affects surface current.
- High surface current is detrimental to energy resolution of the detector. Thus, it is important to study the surface composition of the detector wafer.
- We used two different CdTe-based wafers, CMT and CZT, in this experiment.
- Two sets of data were collected:
  - Unetched sample and Etched sample.
  - Etching is a process where the XPS machine uses high-speed ions to remove very thin surface layers from the sample.

CONCLUSIONS

- The XPS results showed that Cd, Te and TeO_2 are the dominant species on these materials.
- Zn was also present on CdZnTe and Mn on the CdMnTe wafer.
- CdZnTe sample that was etched with high-energy ion beam did not show the presence of TeO_2.
- CdMnTe sample showed smaller TeO_2 e/Te peak height ratios after etching with high-energy ion beam.

ACKNOWLEDGMENT – This work was supported in part by the National Science Foundation (NSF) Major Research Instrumentation (MRI) through award number 1726901; in part by the U.S. Department of Homeland Security, Domestic Nuclear Detection Office through award number 2012-DN-077-ARI065-05; in part by the NSF HBCU-UP Program through award number 1818732; in part by the U.S. Nuclear Regulatory Commission (NRC) through award 31310018M0035; and in part by U.S. Department of Energy (DOE), Office of Defense Nuclear Nonproliferation Research and Development, the DNN R&D (NA-22), and DOE NNSA MSIPP award number DE-NA0003980.



High-performance XPS Surface Analysis System by Thermo Fisher