Journal of ELECTRONIC MATERIALS, Vol. 42, No. 11, 2013
DOI: 10.1007/s11664-013-2649-1

Impact of Surface Treatment on the Structural and Electronic Properties of Polished CdZnTe Surfaces for Radiation Detectors

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We present the effects of surface treatments on the structural and electronic properties of chemomechanically polished $Cd_{0.9}Zn_{0.1}Te$ before contact deposition. Specifically, polished CdZnTe (CZT) samples were treated with four distinct chemical etchants: (1) bromine methanol (BM), (2) bromine in lactic acid, (3) bromine in methanol followed by bromine–20% lactic acid in ethylene glycol, and (4) hydrochloric acid (HCl). The surface structure and surface electronic properties were studied with atomic force microscopy (AFM) and x-ray photoelectron spectroscopy (XPS). AFM images showed that three of the four etchants significantly altered the surface morphology and structure of CZT. All etchants created smoother surfaces; however, all except HCl also introduced high densities of defects. HCl was found to not affect the surface structure. XPS measurements indicated that a thick, ~3 nm to 4 nm, TeO_2 layer formed about 1 h after etching; hence, it is very important to process devices immediately after etching to prevent oxide formation.

Key words: CdZnTe, radiation detector, etching, oxidation, surface, XPS

INTRODUCTION

Cadmium zinc telluride (CZT) is a promising material for high-performance semiconductor x-ray and gamma-ray radiation detectors that can operate at room temperature.[1–3] CZT bulk materials contain significant numbers of defects such as Cd vacancies, Te precipitates, impurities, and stoichiometric imbalances resulting in microcrystalline material. There is a comprehensive international effort to improve the crystalline quality of CZT.[4] However, the performance of a radiation detector depends not only on the quality of its bulk material but also on its surfaces and metal/CZT interfaces. Surfaces and metal/semiconductor interfaces can be the dominant factors influencing detector performance, especially for relatively soft x-ray photons and large, pixelated arrays, since they can significantly contribute to leakage currents, which in turn affect a detector's signal-to-noise ratio and energy resolution. Atomically smooth and defect-free surfaces may be needed for high-performance CdZnTe-based detectors. However, surface structure, oxidation, defects, and contamination can alter the surface electronic structure to a large extent and may diminish detector performance. There are a number of reports addressing surface passivation[5–8] and contact electrode[9–11] improvements to decrease detector leakage currents. The effect of the various chemical solutions on the relation between the surface roughness and the leakage current of CZT detectors has also been studied.[12]

Chemomechanical polishing (CMP) is typically performed on CZT to obtain a smooth surface. After the CMP process, CZT is chemically etched in order to remove scratches that result from abrasives used in the polishing slurry. However, the chemical etch may significantly alter the CZT surface and introduce defects. It is also not easy to create reproducible surfaces with chemical processes. The effects of polishing and etching of CZT surfaces have been recently reported.[13]

(Received December 14, 2012; accepted May 23, 2013; published online June 18, 2013)