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Fabrication of the CdZnTe detector for γ-ray measurement

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1. Introduction

CdZnTe (Cadmium Zinc Telluride) can be the promising semiconductor as the next generation X-ray and γ-ray detector. The energy band gap of CdZnTe is large enough that it can be operated in room temperature. Also it can give the enough energy resolution to detect the radioactive material such as uranium or plutonium. The atomic numbers of the composing material of CdZnTe is larger than other popular semiconductor detectors such as Si and Ge that the high energy radiation can be measured with thinner crystal. Therefore one can fabricate the compact radiation detector with CdZnTe.

Great attention has been paid to the surface and contact processing of CdZnTe. The CdZnTe detectors are commonly fabricated by first polishing and etching with dilute bromine/methanol mixture, and afterwards applying electrical contacts, usually with electroless noble metal salt solution, such as $AuCl_3$, $AgNO_3$, or $PtCl_4$. The previous study established the correlation between the surface roughness of CdZnTe and the dark current of the detector. It was generally concluded that the CdZnTe detector with the smoother surface gives the lower dark current. The most of the previous study of the surface and contact process was based on the CdZnTe detector with Au contact.

In our study, we investigated the detector fabrication process with indium. The metal contact of the commercially available CdZnTe detector is usually made of Au or Pt contact. We are interested in the contact process with the indium since the work function of indiums is smaller than the work function of gold and Pt. The indium can be easily evaporated, and it is inexpensive comparing to other metals.

2. Surface treatment of CdZnTe

The CdZnTe wafers with the dimension of 10*10*8, and 5*5*5 mm^3 are employed in our work. The large wafer is from Bicron, and the small wafer is from eV products. The wafer was mechanically lapped and polished. The final mechanical polishing was done with 5 μm alumina.

The surface conditions after different etching process was investigated with the microscope and Atomic Force Microscope (AFM). That is, at first the wafer was just mechanically polished, the state of the surface was investigated. The wafer was etched with bromine/methanol solution after the mechanical polishing. And, the surface condition was studied. The bromine/methanol etchants, with which we used, were 2 % Br in Methanol, 5 % Br in Methanol, and 2% Br and 20 % lactic acid in ethylene-glycol. The surface of CdZnTe after each etching process was studied with microscope and AFM. The roughness of CdZnTe surface was obtained with AFM. From these studies, we could see that the surface roughness gets smaller when the CdZnTe surface was etched with bromine/methanol solution. It is consistent with the previous studies. However, when the surface was treated for a long time with the strong etchant, the surface roughness became larger.

3. Measurement of Dark current

The dependency of the dark current on the surface condition was measured. Three different surface conditions were studied in our work. In the first case, the surface was treated only with the mechanical polishing. In the second case, the surface was treated with 2% Br in methanol. In the third case, the surface was treated with 2% Br, 20 % lactic acid in ethylene-glycol. The chemical etching time was 2 minutes. After the surface treatment, indium was evaporated with a thermal evaporator. After the CdZnTe was installed inside the evaporation chamber, the chamber was evacuated to $6*10^{-6}$ Torr. The evaporation rate was kept 10 Å/sec.

The dark current was measured with Keithley 6517-A electrometer. After changing the bias voltage on the CdZnTe wafer, the dark current was measured after passing 5 minutes. One could see that the CdZnTe wafer with only the mechanical polishing showed the lowest dark current in large CdZnTe case.

4. Thermal treatment of CdZnTe

The dependency of the thermal treatment on the dark current was also studied. The wafer was installed inside the evaporation chamber, and the chamber was evacuated. After that, the wafer was heated. In our study, the wafer was heated up to 150°C and 300 °C. The heating condition was kept for 3 hours and the indium was evaporated on both sides of the wafer. The dark current was measured after the evaporation process. The dark current got smaller when the wafer was treated thermally. Also the metal electrode became more stable for the thermal treatment.

5. Measurement of the energy spectrum of gamma ray

Fig. 1 shows our fabricated CdZnTe detector. The energy spectrum was measured with our fabricated CdZnTe detector. 60 keV gamma-ray from Am source incidents on the detector, and the signal from the detector was processed through the Pre-Amplifier, Amplifier, and MCA (Multi Channel Analyzer).

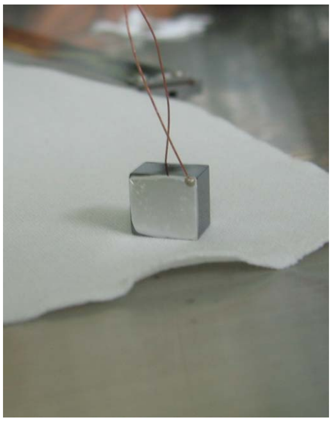

Fig. 1 The photograph of the indium contact CdZnTe detector

6. Conclusion

The CdZnTe has been regarded as a promising semiconductor material for the next generation radiation detector. Its application areas include the radiation safeguard, the homeland security, the medical imaging, X-ray and gamma-ray astronomy. We studied the dependency of the dark current on the surface treatment and the thermal annealing. Also the energy spectrum of the 60-keV gamma-ray was measured with our fabricated detector.

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