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Effect of NH_4F/H_2O_2 Passivation on CdZnTe Detector

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1. Introduction

CdZnTe is the most promising material for X-ray and γ-ray detector. Many researchers have studied the fabrication process of CdZnTe detector. Generally, the CdZnTe crystal was grinded, mechanically polished, and chemically etched. After that, the metal electrodes were deposited on the crystal. Bromine/Methanol etchant is widely used for the chemical etching of the CdZnTe surface. The chemical etching is very important process to fabricate the CdZnTe radiation detector. The mechanical polishing would make the scratch on the CdZnTe surface, and remain the dangling bonds on the surface. The chemical etching could remove the mechanical scratch on the surface. However, the CdZnTe surface would remain non-stoichiometric after the chemical etching with Bromine/Methanol etchant, because the bromine reacts with cadmium more easily. The passivation is very important process to remove the non-stoichimetry of the CdZnTe surface. Also, the passivation could make the CdZnTe detector electrically inert to its environment.

Various methods have been employed for the passivation of the CdZnTe surface. Among these, the NH_4F/H_2O_2 was identified as the promising agent for the passivation of CdZnTe. Wright proposed the effectiveness of NH_4F/H_2O_2 as the surface passivation agent for the CdZnTe crystal, and showed that NH_4F/H_2O_2 surface passivation significantly decreased the leakage current and improved the sensitivity and the energy resolution of the CdZnTe detector [1]. Kargar used the NH_4F/H_2O_2 as the passivation agents to fabricate a high-resolution CdZnTe detector [2]. However, some researchers, which include another work of Wright [3], have reported that the leakage current of the CdZnTe detector was increased when NH_4F/H_2O_2 was used as the passivation agent. Also the previous work showed that the characteristic of the metal-semiconductor contact could be changed due to the passivation with NH_4F/H_2O_2. More works are necessary to understand the effectiveness of NH_4F/H_2O_2. passivation on the CdZnTe detector.

2. Experiment

The CdZnTe detector was fabricated in our work. The CdZnTe crystal was obtained from eV products. It was known as the discriminator grade. The major charge carrier was measured to be electron. When the CdZnTe was obtained from eV products, Pt electrodes were deposited on both sides of the crystal, and the insulating layer was deposited on the lateral surface. At first, these layers were removed away by the grinding. The CdZnTe was grinded and polished. Silicon carbide paper of 4000 grit was used for the grinding . The CdZnTe crystal was hand lapped with alumina powder. It was started with 1 μm alumina powder and ended with 0.05 μm alumina powder. The sample was treated with DI water after the mechanical polishing. The CdZnTe was treated with chemical etching with Bromine/Methanol 1 % for 1 minute. It could remove the mechanical scratch on the CdZnTe surface. Gold was deposited on both sides of the CdZnTe with the electroless deposition technique.

Experimental method to see the effectiveness of NH_4F/H_2O_2 agent was as follows. The CdZnTe detector was fabricated with grinding, polishing, chemical etching , and the electrode deposition. The leakage current and the detector performance were measured with the detector. The electrodes and the lateral sides are grinded away. The CdZnTe detector was fabricated again with the processes of the grinding, polishing, chemical etching, and electrode deposition. After that, the CdZnTe detector was passivated with NH_4F/H_2O_2. The leakage current and the detector performance were measured and compared with the previous measurements.

We also studied whether the NH_4F/H_2O_2 agent could affect the characteristics of the gold metal electrode. The NH_4F/H_2O_2 agent could affect the lateral sides of the detector and the metal contacts. Therefore, the above results could be from the change of the resistivity of the lateral sides and the characteristics of the electrode. The CdZnTe detector was made again with the grinding, mechanical polishing, chemical etching, and the electrode deposition. After that, the lateral sides were grinded away. The leakage current and the detector performance were measured with the detector. The detector was passivated with NH_4F/H_2O_2. The lateral sides of the detector were grinded away, and the leakage current and the detector performance were measured and compared. Our method could remove the effect of the resistivity of the lateral surface on the detector performance and could only see the effect of the metal contact on the detector performance.

3. Results and Conclusion

Fig. 1 shows the leakage current of the CdZnTe detector when the leakage current was measured before the passivation and after the passivation.

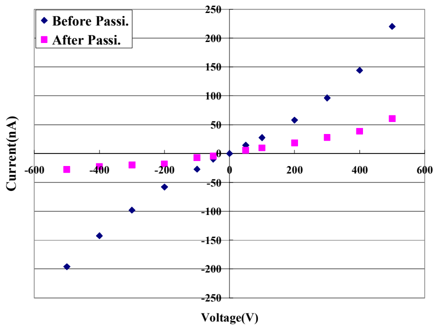

Figure 1. Leakage currents of the CdZnTe detector. The leakage currents were measured before and after the passivation of the detector.

As one can see from Fig. 1, the leakage current was reduced with the passivation. Fig. 2 shows the passivation effect on the metal contacts. The leakage currents were measured after side-lapping and the passivation and side-lapping. The leakage currents of the two processes were the same. Therefore, one could see that the passivation did not affect the characteristics of the metal electrode. Our work could clearly see the effect of the NH_4F/H_2O_2 agent on the detector performance.

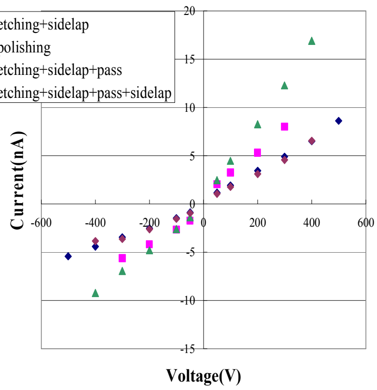

Figure 2. Leakage currents of the CdZnTe detector. The leakage currents of the detector were measured after side-lapping, and after the passivation and the side-lapping.

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