

Different surface contacts on CdTe and R08-23 CdZnTe radiation detectors

J. Pekárek*, E. Belas, P. Praus and R. Grill

Institute of Physics, Charles University in Prague, Ke Karlovu 5, CZ-121 16, Prague 2, Czech Republic

*e-mail: pekarek.iakub@gmail.com



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Introduction and Theory

In the first part of this work we present the study of various chemical etching and surface passivation, before metal-semiconductor contact preparation, on four CdTe/CZT samples. The real MS contact contains the interlayer or a certain density of surface states (e.g. metal-oxidesemiconductor - the MOS structure). These surface states affect the electrical properties of the detector. In addition, dangling bonds and non-stoichiometric surface spices produce defects responsible for high surface leakage

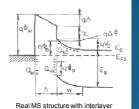
used to characterize their quality.

cathode side)

(kV/cm)

strength

Electric field



current [1]. We compare two samples with almost homogenous linear inner field (CZT1, 2) and two samples with greater slope of inner electric field (CdTe1, 2) which also shows the waveforms with dead layer under low biases. Transport properties, gamma spectrum and I-V characteristic are

BF

BE+P

BEBM KOH

/ surface states

In the second part, the effect of a DC bias field and pulsed bias field on the time-of-flight current waveforms of electron drift in CdTe is reported [2,3].

The linear profile of the electric field in CZT1 detector

obtained for various chemical surface treatments at

bias voltage of -800 V by TCT method [2]. The thinning of the sample between the all method was always of 100

nm, thus the difference between the initial value E_0 (at the

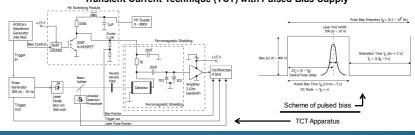
- 800 V

Experiment

Before we electrolessly deposit gold contacts from 1% AuCl₃ solution in water, we performed various surface treatments:

- Chemical etching (BM) 2 min in 3% bromine-methanol solution (KOH) 1 min in 50% potassium hydroxide solution (Di-Cr) 30 s in K₂Cr₂O₇ – potassium dichromate solution
- 2. Chemical-mechanical polishing (BE) – 1 min polishing in 3% bromine-ethylene glycol solution on silk pad
- Chemical-mechanical polishing with further chemical etching (BEBM)
- 3. 4. Surface passivation (P) - 5 min in 10% NH₄F/H₂O₂ - ammonium fluoride solution

Transient Current Technique (TCT) with Pulsed Bias Supply



Results and Discussion

Surface Treatments

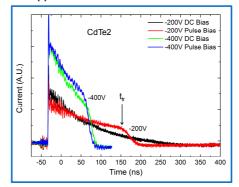
Values of current (I), resolution (R) and CCE for various surface treatment on CZT1 detector at bias voltage of - 800 V. It also shows the % reduction (-) or increase (+) of the leakage current compared to (BM) treatment which is standard method used in our laboratory

Surface treatment	R _g [%]	CCE _g [%]	I [nA]	% reduction(-)/ increase(+) of the leakage current
BM	31.4	91.1	-418	-
BE	49.4	87.5	-303	-28
BEBM	8	96.5	-61	-85
KOH	-	-	-598	+29
Di-Cr	-	-	-746	+78
Passivation	7.7	96.5	-20	-95

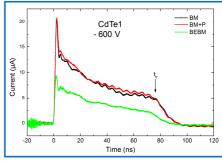
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TCT with DC/Pulsed Bias Field

Electron drift current waveforms of CdTe2 measured at a bias voltage of -200 V and -400 V with ΔT_L of 47ms and in DC mode. Due to depolarization of detector in pulsed bias mode, we can see appearance of transit time under low bias (-200 V) even if it is not there in DC mode [3].

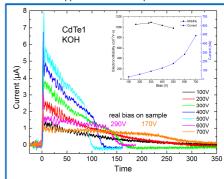


Transient current waveforms obtained with CdTe1 detector for various surface treatments at bias **voltage of -600 V.** The transit time $-t_{tr}$ (time of electron movement from cathode side to anode side) and the slope of the waveforms are very similar, thus the electron mobility would be similar in all three cases [2]. But it is visible the difference in intensity for different surface treatments which is caused by different thickness of contacts



Electron drift current waveforms of CdTe1 with (KOH) surface treatment measured at different biases.

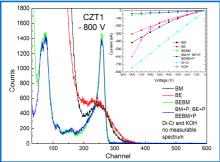
Corresponding electron mobility and current-voltage curves are shown in situ. Due to high leakage current the real values of applied biases on sample decreased.



Spectrum of Am²⁴¹ obtained with CZT1 detector for various surface treatments at bias voltage of -800 V. Best curves were obtained for surface passivation after different etching conditions. Corresponding currentvoltage curves are shown in situ. Best values were obtained for surface passivation.

800 1000 1200

Position (µm)



- ➡ The surface passivation by NH₄F/H₂O₂ solution after surface chemical etching gives the lowest value of the leakage current (thus better spectrum) and also gives the best transport properties of samples.
- The high leakage current decreases applied bias on samples which is lower then source meter output value
- The solution of K₂Cr₂O₇ or KOH is less useful for surface treatments.
- ➡ The polarization appearing in transient current waveforms can be influenced by the surface treatments.
- Detector polarization can be also suppressed using pulsed bias.

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- S. Belas, E., Grill, R., Praus, P. & James, R. B., "Determination of Electric-Field Profile in CoTe and nTe Detectors Using Transient-Current Technique," IEEE Transactions on Nuclear Science 59, 1-2406 (2012).
 - Suzuki, K., Sawada, T., Imai, K., "Effect of DC Bias Field on the Time-of-Flight Current Waveforms of CdTe and CdZnTe Detectors," IEEE Transactions on Nuclear Science 58, 1958–1963 (2011)

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