Performance of semi-insulating
Role of electro

F. Dubecký, P. Boháček, B. Zaťko,

Institute of Electrical Engineering, Slovak Academy of Sciences
Slovak University of Technology, Faculty of Electrical Engineering and

GaAs radiation detectors: des metallizations

T. Lalinský, M. Sekáčová and V. Nečas

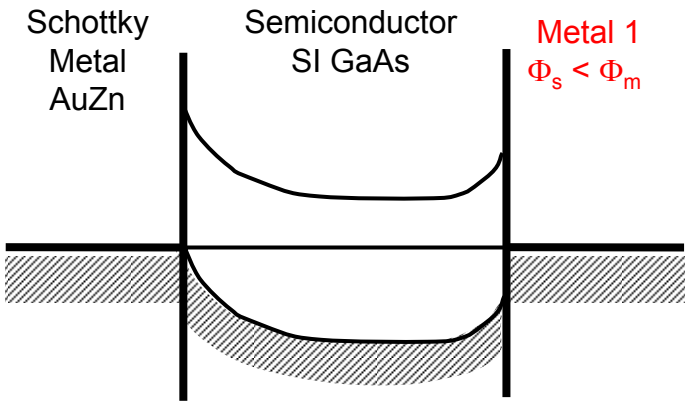
Dúbravská cesta 9, SK-841 04 Bratislava, Slovakia
Information Technology, Ilkovicova 3, SK-812 19 Bratislava, Slovakia

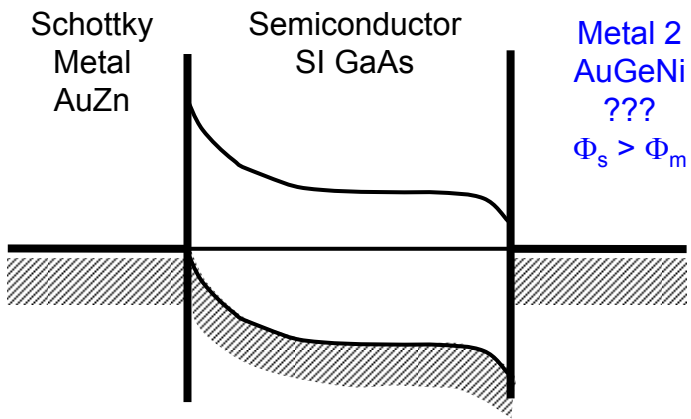
Introduction

The importance of a good quality of the bulk SI GaAs substrate, like low content of chemical impurities, high value of the Hall mobility (> 6500 cm^2/Vs at room temperature, RT) and optimal value of the resistivity (about 1×10^7 Ωcm at RT), low density of dislocations, space charge inhomogeneities and another crystallographic imperfections was demonstrated in our previous works [1, 2]. Another crucial task related to the detector operation performance relates to the used metal and technology of electrodes metallizations. In our previous study we have focused mainly to the technology of blocking contact (Schottky, P-N, hetero- and homojunctions) of the structure and the surface passivation [3, 4]. Recently we compared performances of detectors fabricated using sophisticated and a low cost technologies [3].

In this paper we continue in the electrode technology study using AuZn eutectic to form unalloyed blocking Schottky-like contact. On the ohmic side we used two different ohmic electrode metallizations: (i) AuGeNi eutectic, unalloyed (Schottky-like) and (ii) In/Au multilayer as a new investigated system. Electrical performance of fabricated detectors are evaluated by measurement of I-V characteristics and long-term current rms noise and stability testing. The detection properties of the detectors are evaluated through measured pulse-height spectra of radioisotope ^{241}Am. Obtained results are compared with detectors having TiPtAu blocking electrode presented by Boháček et al. [5] at this workshop.

Metal – semiconductor interfaces





Possible metals to solve indicated task

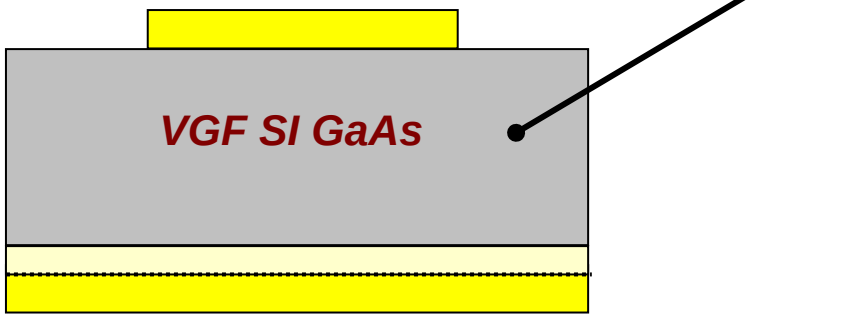
Metal	In, 1	AuGeNi, 2	Au
Work function (eV)	4.12	??	5.2
Electronegativity (eV)	1.78	??	2.35

Detector fabrication

BLOCKING side:

AuZn (120 nm) *eutectic alloy*

□ = 0.75, 0.5, 0.3 and 0.2 mm



- VGF SI GaAs wafer
- Resistivity – 2.0 x 10^7 Ωcm
- Hall mobility – 7050 $cm^2V^{-1}s^{-1}$
- Thickness 250 μm
- Both-sided polished

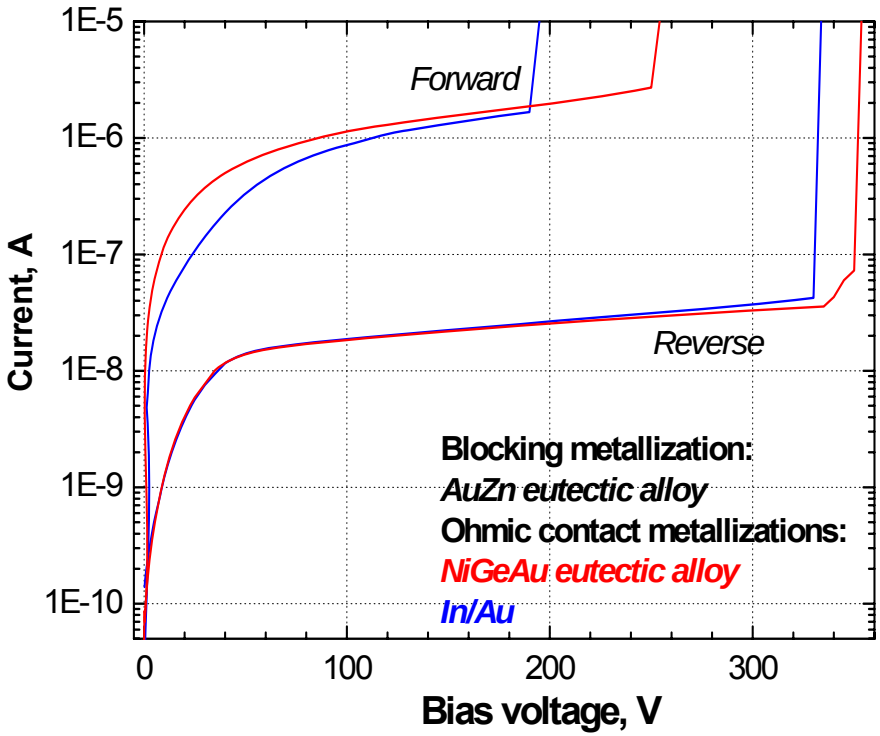
OHMIC side:

Full area contact 1. NiGeAu (120 nm) *eutectic alloy*

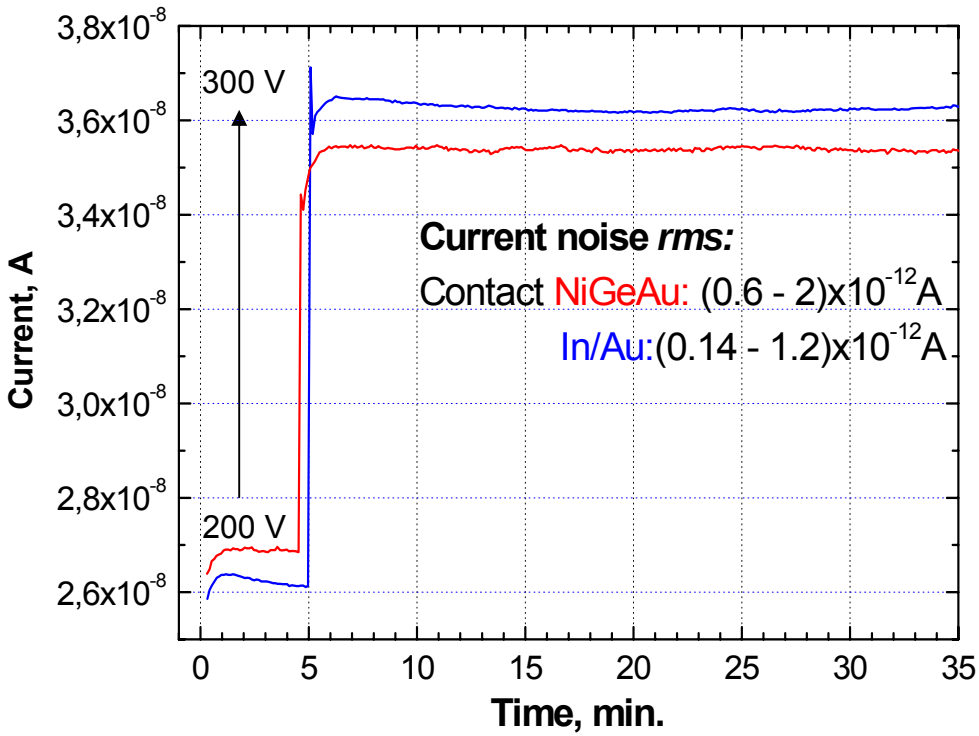
2. In/Au (50/70 nm) *multilayer*

Current – voltage measurements

I – V characteristics at 305 K

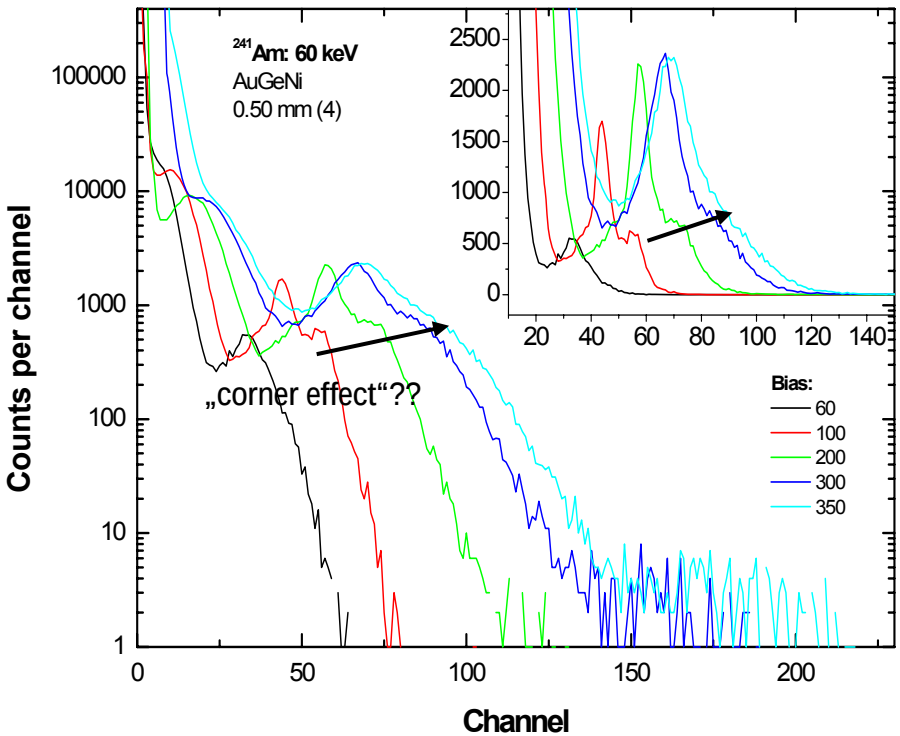


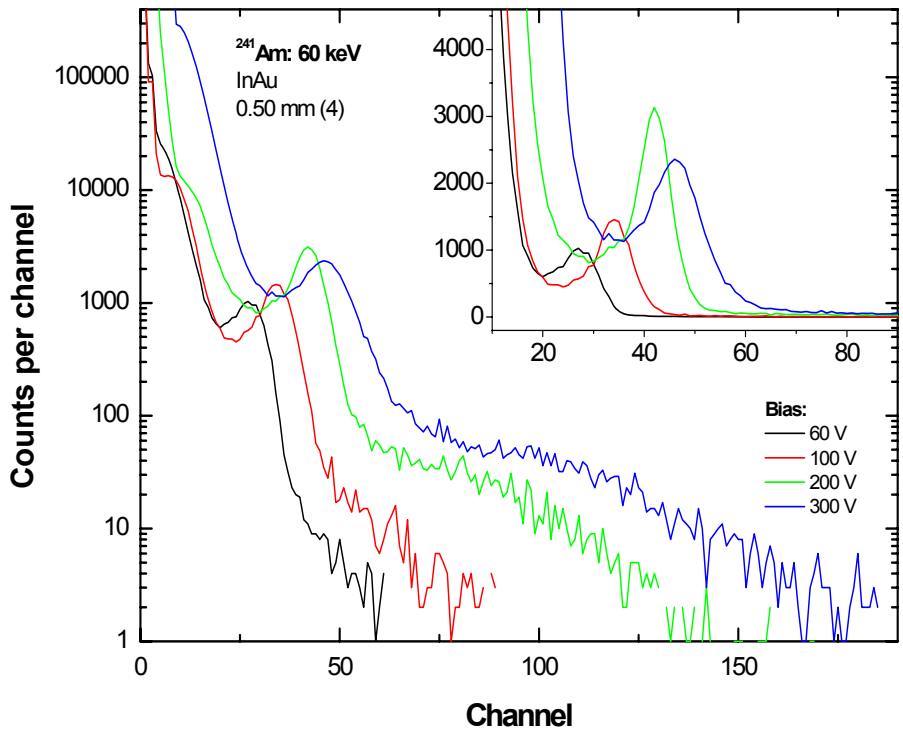
Low frequency RMS noise:
Time measurements at 200 and 300 V



Measured spectra of γ – ray using radioisotope ^{241}Am

Contact ☐ 0.5 mm





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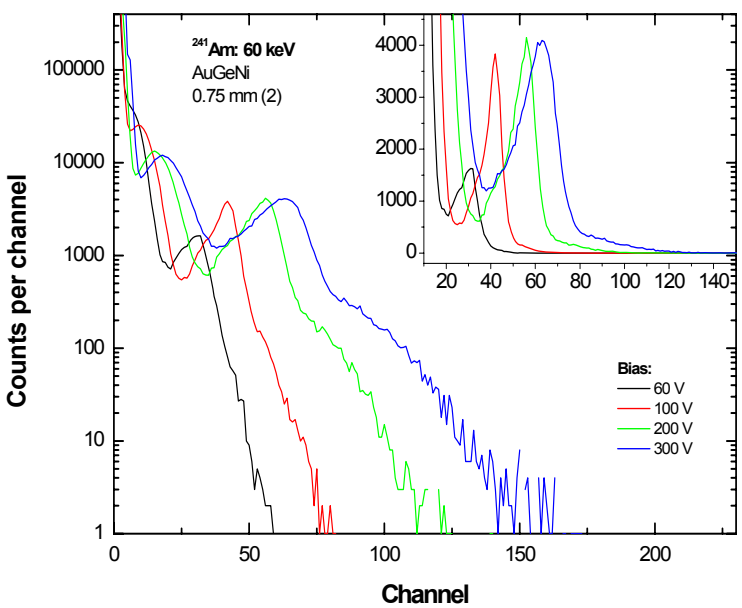
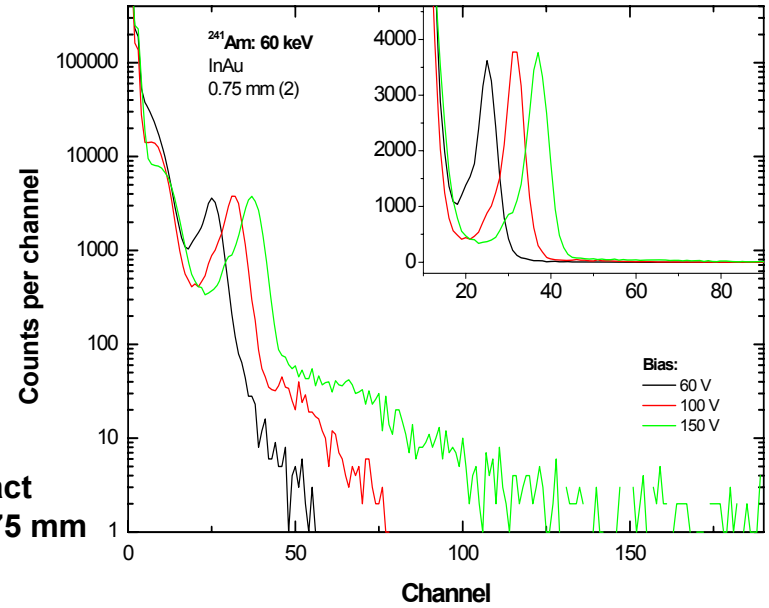
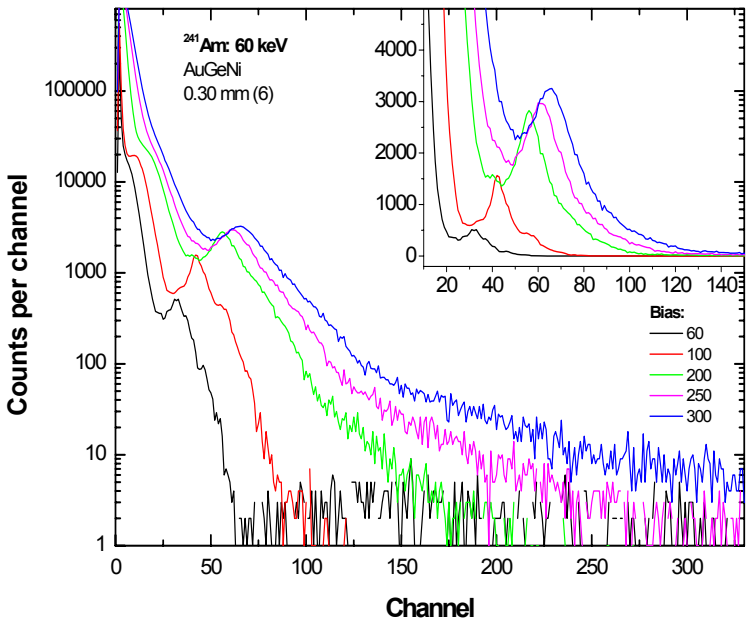
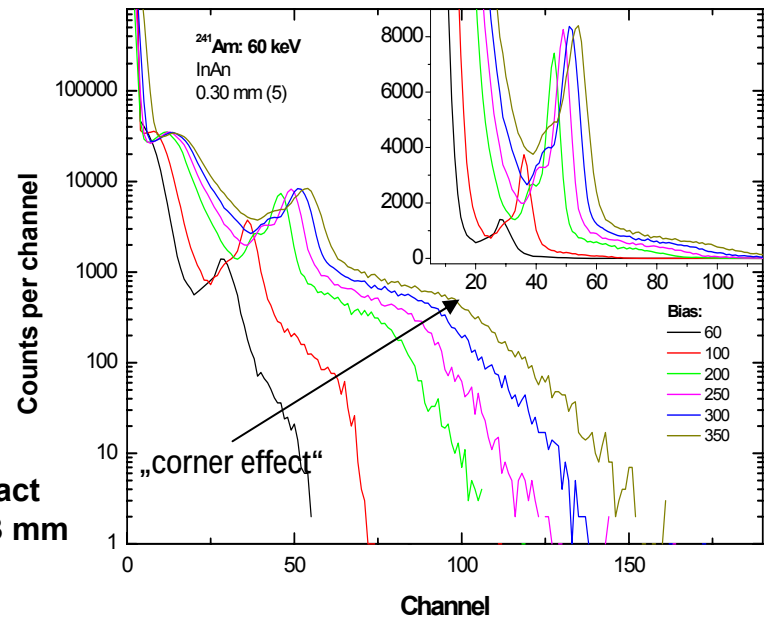




Contact
☐ 0.75 mm

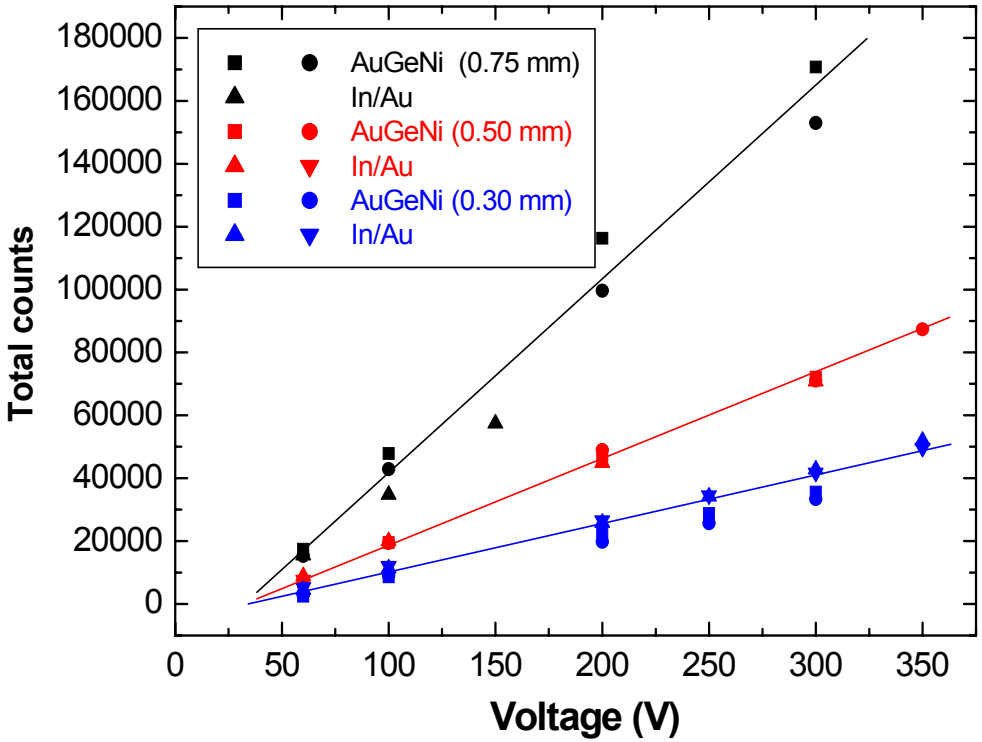




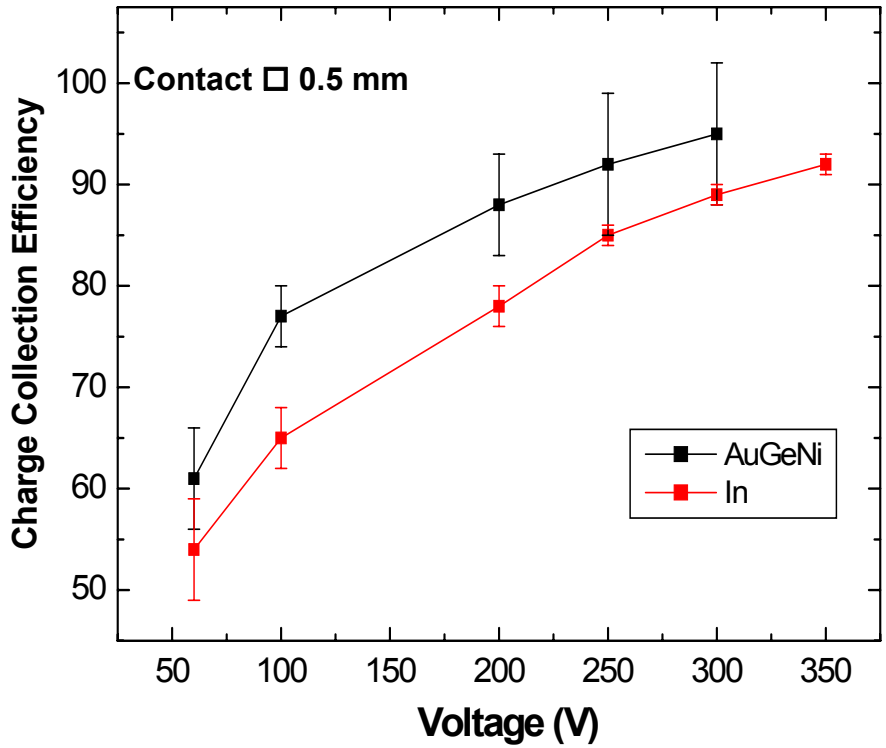
Contact
☐ 0.3 mm

Detection efficiency and charge collection efficiency

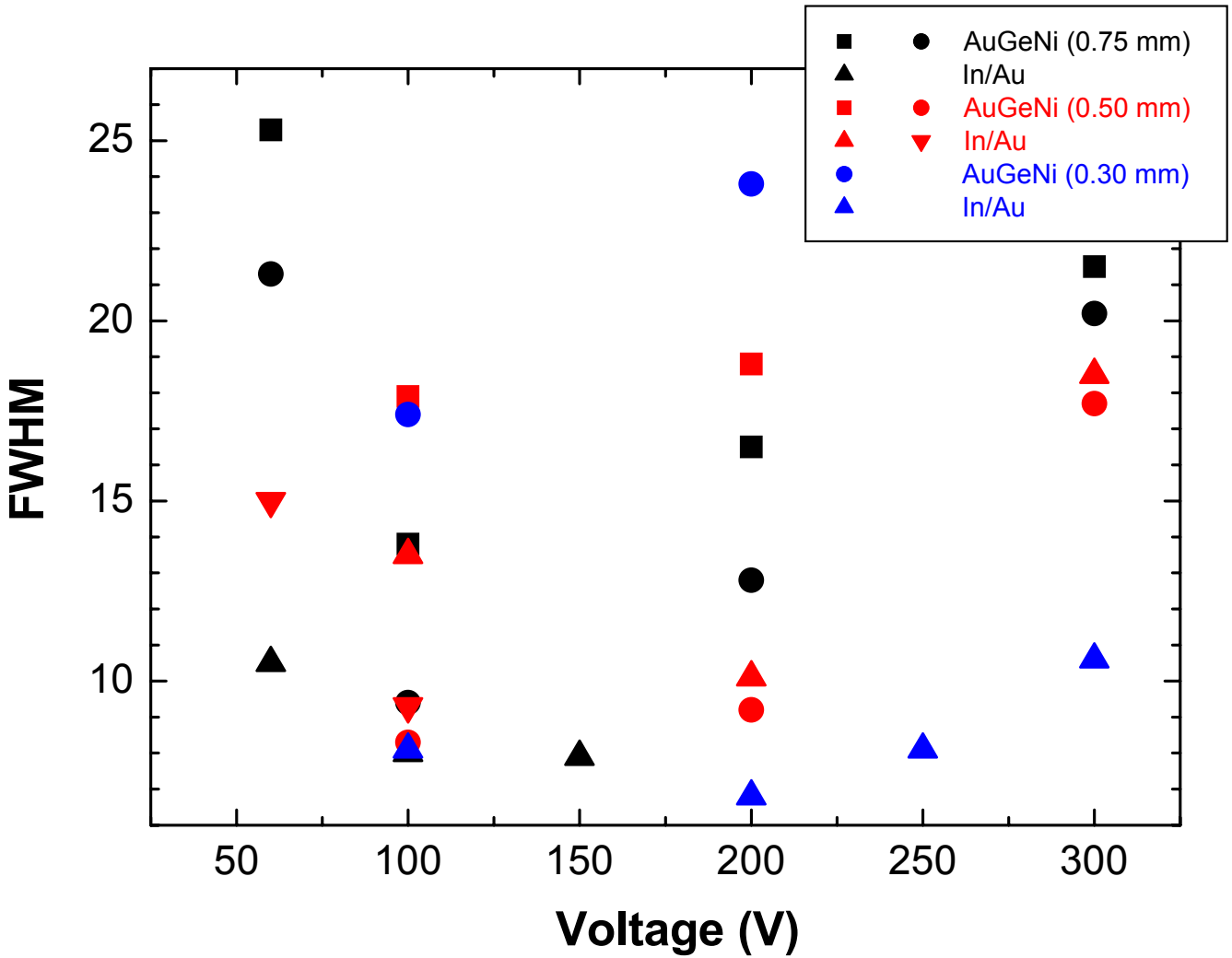
Total number of counts in photopeak versus reverse bias voltage



Charge collection efficiency versus reverse bias voltage



Energy resolution in FWHM



Results summary:
Comparison with Ti/Pt/Au blocking metallisation

AuZn blocking contact ☐ ***0.5, 0.3 mm***

Ohmic metal system	Voltage, Current (V, nA)	Size of contact (mm)	FWHM (keV)	CCE (%)
NiGeAu	100 @35	0.50	8.3	77
In/Au	200 @37	0.30	6.8	78

TiPtAu blocking contact ☐ ***0.5 mm***

Ohmic metal system	Voltage (V)	Current (nA)	FWHM (keV)	CCE (%)
NiGeAu	160	17	10.3	72
In/Au	300	28	9.5	80

Conclusion

We tested SI GaAs radiation detectors with square-shaped AuZn Schottky-like contacts with diameters: 0.75, 0.5 and 0.3 mm and two different ohmic metallizations (NiGeAu eutectic alloy and In/Au multilauer. Observed results were compared with the Ti/Pt/Au Schottky blocking contact coupled with the same ohmic systems.

- Current–voltage characteristics of fabricated structures measured at 305 K show almost the same saturation current, 35 - 38 nA at 300 V with a breakdown threshold between 310 and 350 V (RT). Tendency to slightly lower current and higher breakdown voltage shows NiGeAu metalizzation.
- Low frequency current noise and better long term operation stability performed detectors with In/Au metallization. Comparing the blocking system, Ti/Pt/Au multilayer show lower rms noise parameters.
- Detection performance as tested with ^{241}Am gamma source the higher CCE, about 95 % at 300 V and better energy resolution, 8.3 keV FWHM (0.5 mm contact side) was attained with the AuZn/NiGeAu metallizations.

Detectors with the blocking AuZn eutectic metallization in comparison with Ti/Pt/Au reached slightly better characteristics. It is worth to mention that AuZn/NiGeAu detector electrode system offers an unique choise: perfoming an additional annealing procedure P^+ and N^+ layers can be formet at the interfaces by difussion of Zn and Ge, respectively. Optimization of such procedure in relation to improvement of the detector performance could be object of future study.

Present study is still not finished and following electrode/device related technology processes have to be included into more detail study, particuarly: (i) wafer cooling during evaporation (lower temperature can restrict metal reactivity), (ii) lower kinetics of the metal evaporation process, (iii) wet processing prior metal evaporation, (iv) final detector topology. Another peculiar task is connected with the formation of a deffective interface on the ohmic electrode side e.g. by implantation.

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