Role of new ohmic electrode meta
bulk semi-insulating GaAs

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llizations in detection performance of imaging radiation detectors

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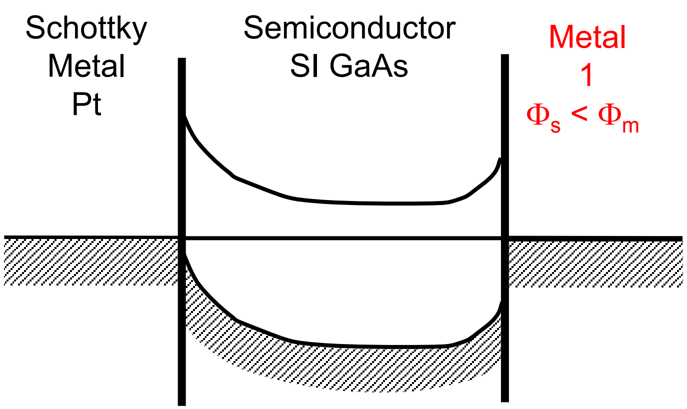
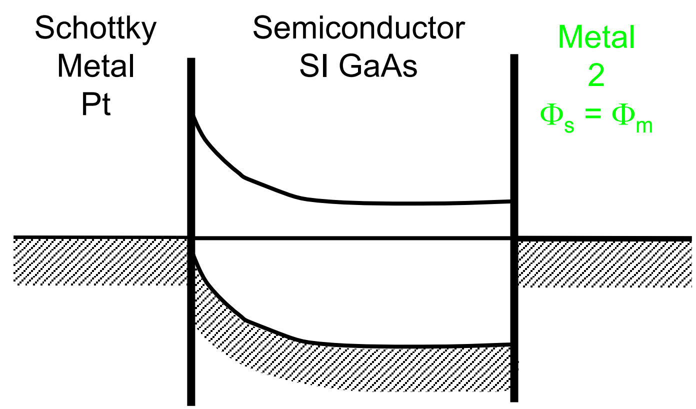
Introduction

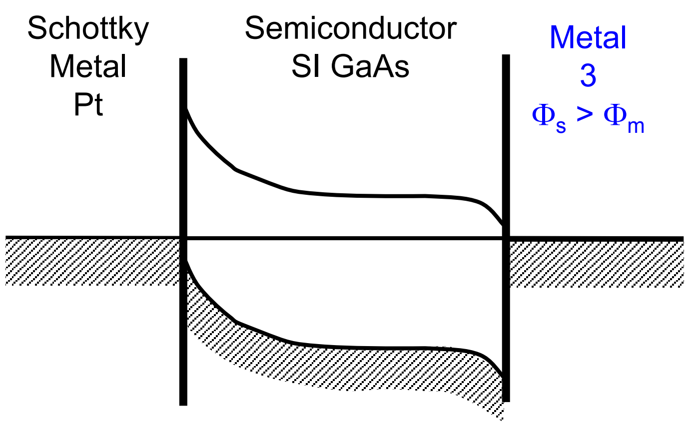
The importance of a good quality of the bulk SI GaAs substrate, like low content of chemical impurities, high Hall mobility and optimal value of resistivity (about 1×10^7 Ωcm at room temperature), low dislocation density, space charge inhomogeneities and another crystallographic imperfections was presented in our previous works [1, 2]. Another crucial task related to the detector quality is the electrode metallization. In our previous research, we have focused mainly to the blocking contacts (Schottky, PN, hetero- and homojunctions) of the structure and the surface passivation [3, 4].

In this paper we concentrate to find simple technology of non-injecting ohmic contact preparation. One solution consists in creation of metal-semiconductor junction using metal with lower enough work function in comparison with semiconductor (GaAs in our case). Such a contact should block injecting holes from anode detector contact and possible representation of non-injecting ohmic behavior. We fabricated SI GaAs detectors with three different types of ohmic contact metallization (AuGeNi – ohmic standard contact , In/Au – work function of In 4.12 eV and Mg/Au – work function of Mg 3.68 eV and Gd/Au – work funktion of Gd 3.10 eV). The detection properties of the SI GaAs detectors are evaluated through measured pulse-height spectra of radioisotope ^{241}Am.

Metal – semiconductor interfaces





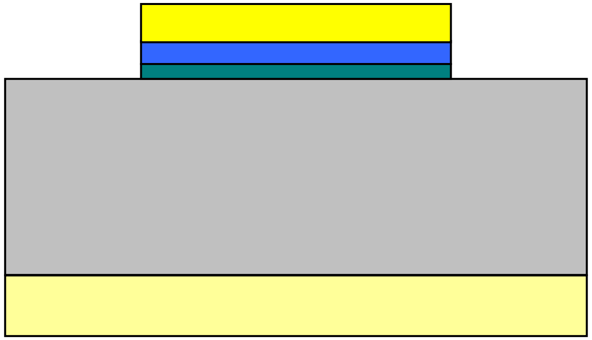


Possible metals to solve indicated task

Metal	In (1)	Mg (2)	Gd (3)	Pt
WF (eV)	4.12	3.68	3.10	6.35
EN (eV)	1.78	1.31	1.20	2.30

Detector fabrication

Ti/Pt/Au (15/30/65) multilayer
ϕ = 0.50 mm



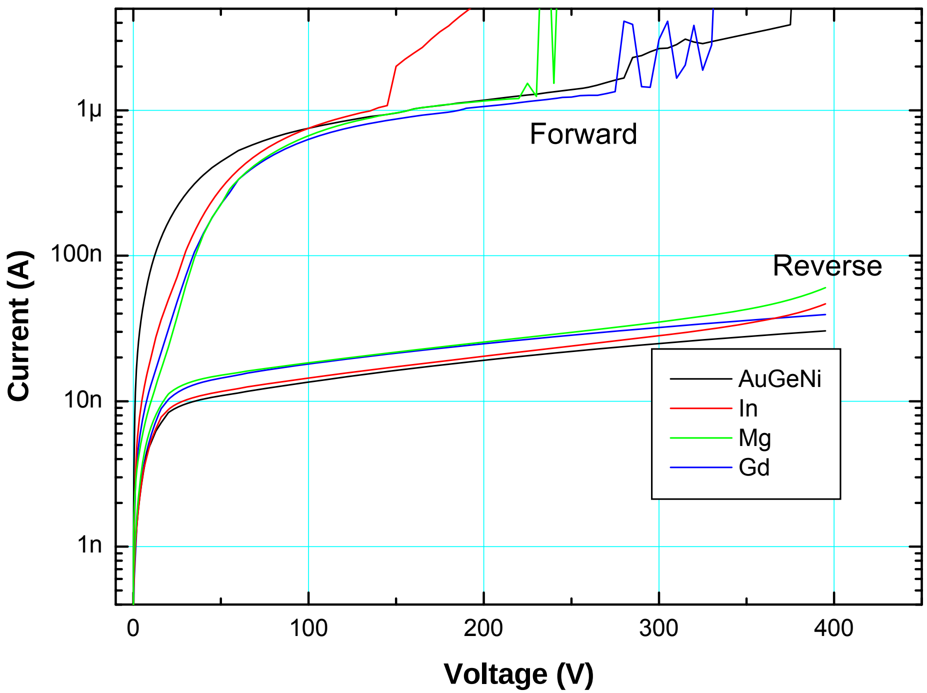
- VGF SI GaAs wafer
- Resistivity ~ 2.0 x 10^7 Ωcm
- Hall mobility ~ 7050 $cm^2V^{-1}s^{-1}$
- Thickness 250 μm

Full area contact

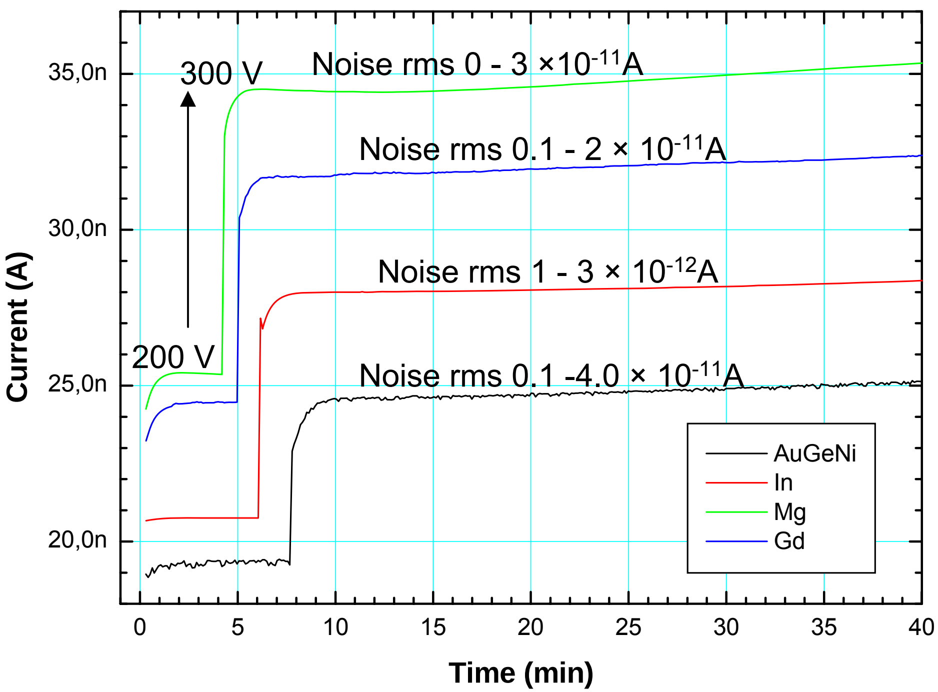
1. AuGeNi /Au (50/100 nm) eutectic alloy
2. In/Au (50/70 nm)
3. Mg/Au (50/70 nm)
4. Gd/Au (50/200 nm)

Current – voltage measurements

I – V characteristics at 305 K

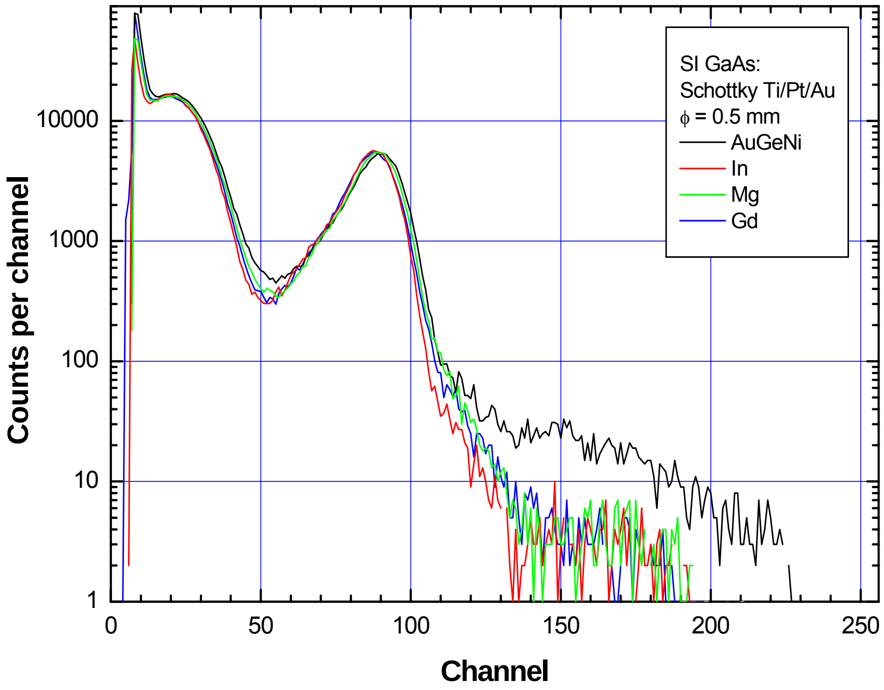


Time measurements at 300 V

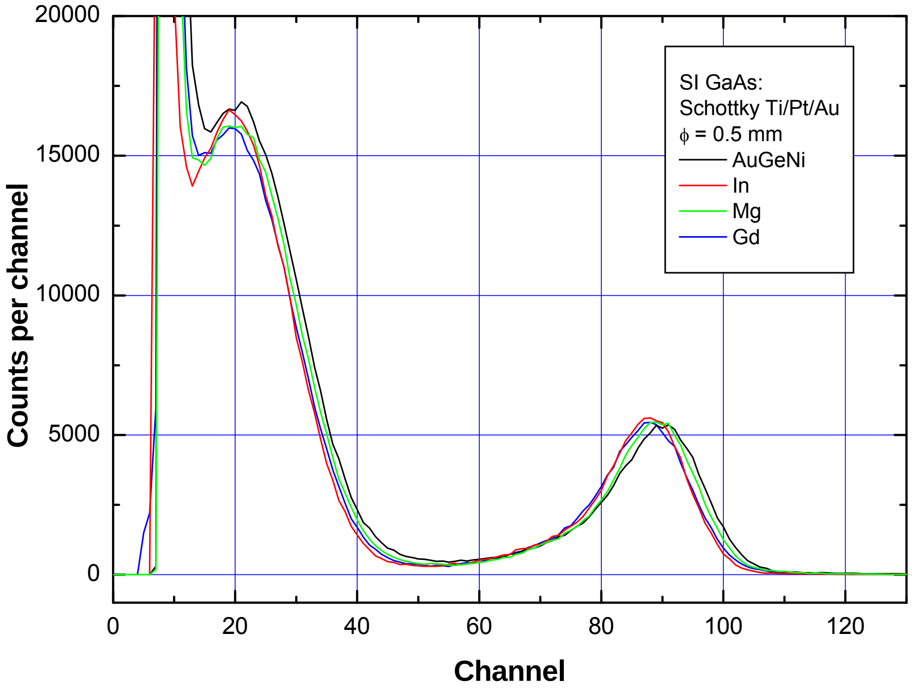


Measured spectra of γ – ray using radioisotope ^{241}Am

Log-log scale

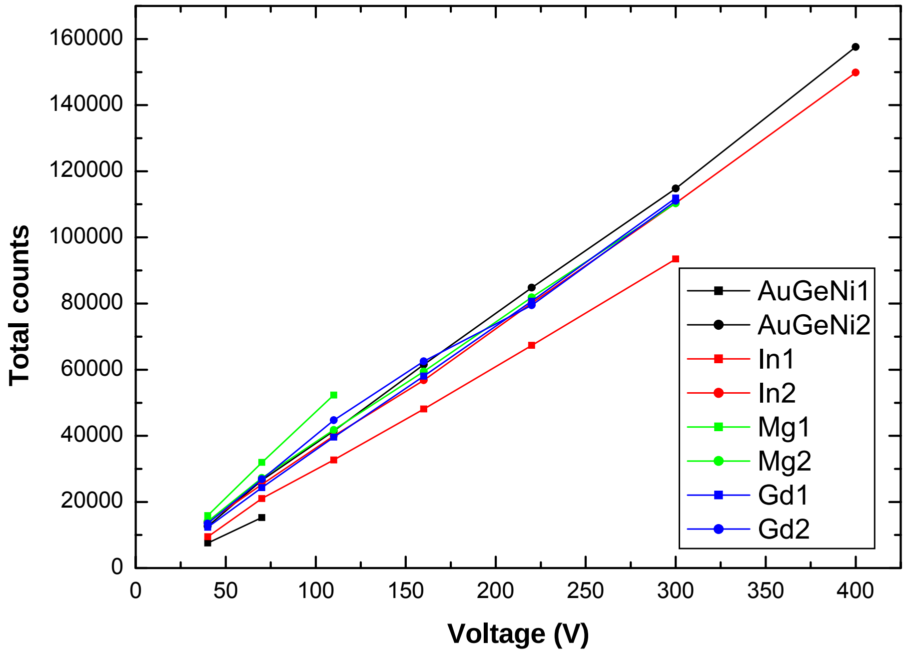


Lin-lin scale

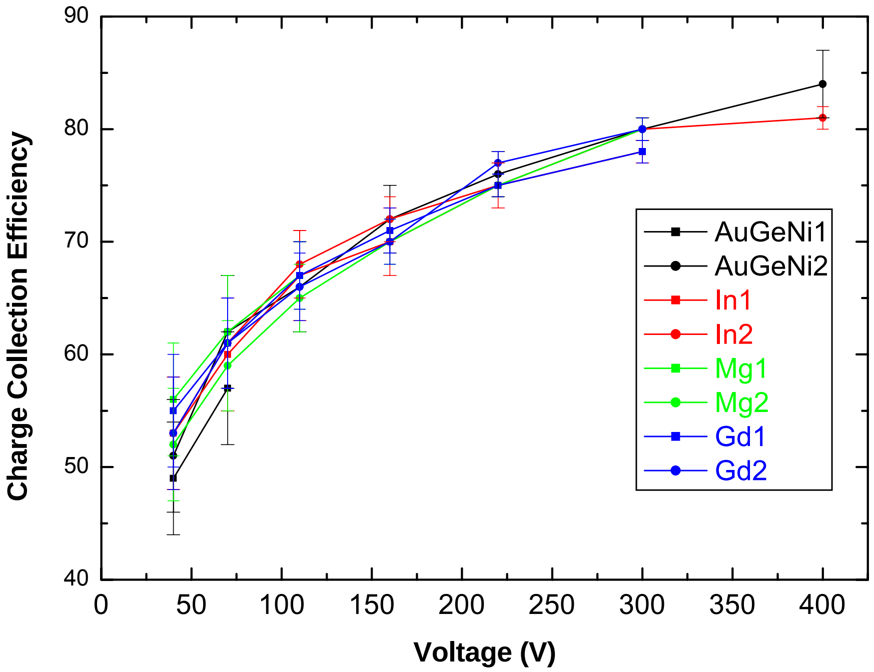


Detection efficiency and charge collection efficiency

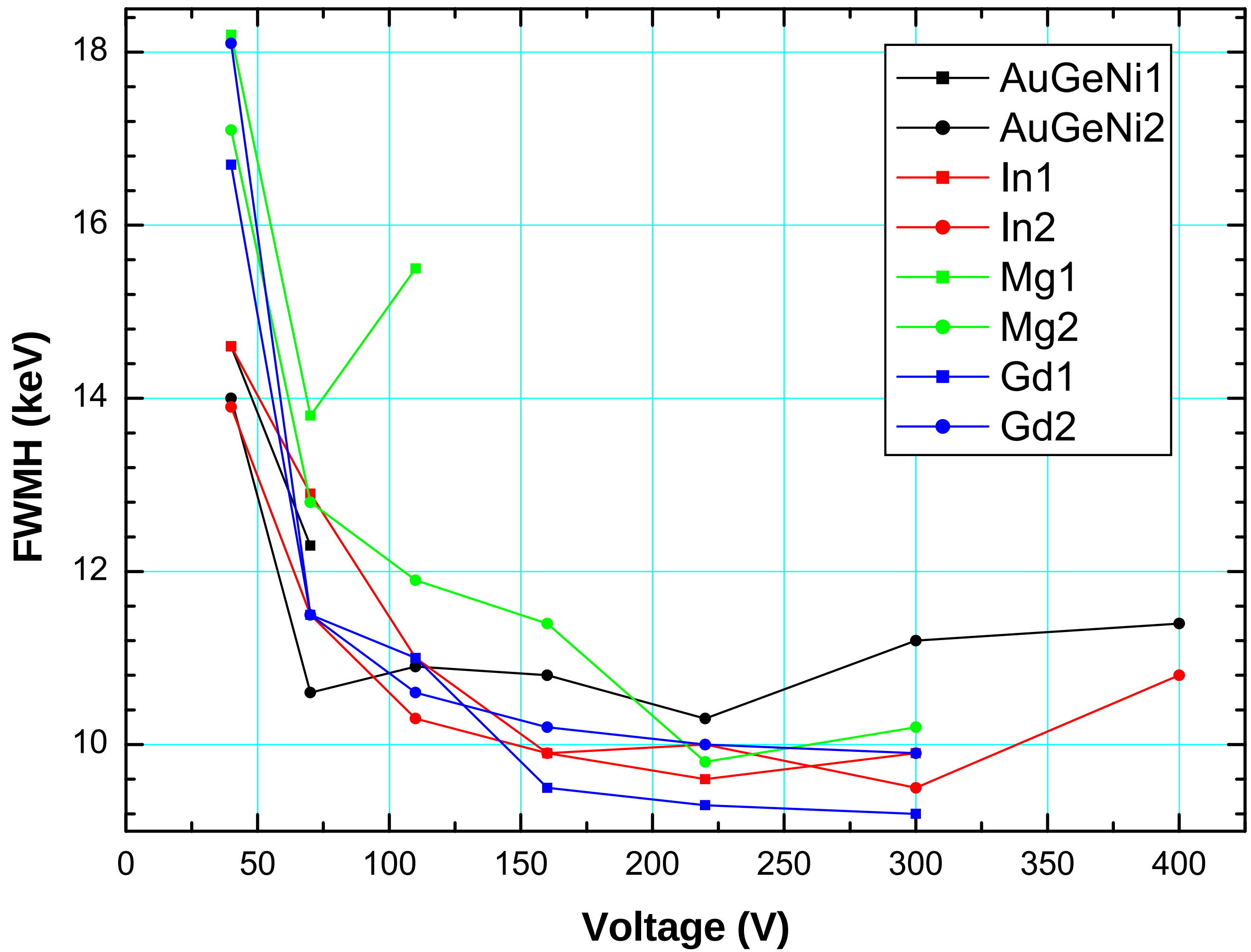
Total number of counts in photopeak versus reverse bias voltage



Charge collection efficiency versus reverse bias voltage



Energy resolution in FWHM



Best obtained results

Ohmic metal	Voltage (V)	Current (nA)	FWHM (keV)	CCE (%)
AuGeNi/Au	160	16.8	10.3	72
In/Au	300	28.2	9.5	80
Mg/Au	220	27.1	9.8	75
Gd/Au	400	39.7	9.2	80

Conclusion

We tested SI GaAs radiation detectors with Ti/Pt/Au Schottky contact of diameter 0.50 mm and four different ohmic metallizations (AuGeNi/Au, In/Au, Mg/Au and Gd/Au). Current–voltage characteristics of structures were measured at room temperature and the saturated current varied from 24 to 35 nA at 300 V.

The lowest current and highest charge collection efficiency was attained with AuGeNi/Au metallization, but the best energy resolution was observed by detector with Gd/Au metallization.

We can conclude than all detectors with various metallization reached almost the same characteristics. However this study is not finished because following processes have to be included: optimization of substrate temperature during evaporation (lower temperature can restrict metal reactivity), kinetics of evaporation process, thickness of primary metal, contacts topology (symetric layout – same area of Schottky and ohmic contact, MESA etching of Schottky contact), annealing of contact, formation of defect layer between substrate and ohmic contact and also surface passivation.

References:

[1] KORYTÁR, D. et al., in: Z. Weber, C. Miner (Eds.), IEEE Proceedings of the SIMC-X Berkeley, Piscataway (1998). p. 331.

[2] DUBECKÝ, F. et al.: Performance of semi-insulating GaAs-based radiation detectors: Role of key physical parameters of base materials. *Nucl. Instr. and Meth. in Phys. Res. A 576, Issue 1*. (*2007)*. p. 27-31.

[3] DUBECKÝ, F. et al.: Role of electrode metallization in performance of semi-insulating GaAs radiation detectors. *Nucl. Instr. and Meth. in Phys. Res. A 576, Issue 1 (2007*). p. 87-89

[4] DUBECKÝ, F. et al.: Performance study of radiation detectors based on semi-insulating GaAs with P+ homo- and heterojunction blocking electrode. *Nucl. Instr. and Meth. in Phys. Res. A 563, Issue 1 (2006*). p. 159-162