Preparation of Germanium Photo Detectors and Photovoltaics

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Abstract – **The design and technology of Germanium based photo devices are described. They could work as photo detectors – resistors and diodes, and in photovoltaic mode. The main laboratory works are made using mono crystal Ge for photo resistors and the system nGe–Metal (Ag) Schottky junction. The photo parameters are measured in the range of 0.6 ÷ 2.0 micrometer.**

Key words - **photo detectors, germanium, infrared detectors, germanium photocell.**

I. INTRODUCTION

Germanium is one of the first semiconductor materials for electron devises (p/n junctions). The distance between E_C and E_V, $\Delta E = 0.65(eV)$ makes germanium suitable for photo devices in infrared range of light – $\lambda > 0.8\ \mu m$ [1].

Under cooling in liquid nitrogen germanium photo devises can work up to $\lambda = 4 \div 5\ \mu m$ [2].

There are several types of germanium devises:

- Ge - photo resistors;
- Ge - photodiodes;
- Ge avalanche photodiodes, as infrared detectors– Fig. 1 [3, 4, 9];
- Ge – photovoltaic.

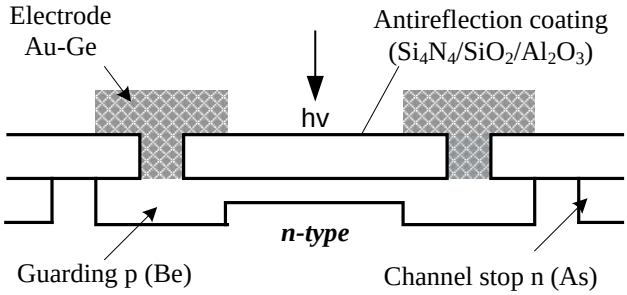

Fig. 1. Typical germanium avalanche photodiode.

Avalanche germanium diodes have the best parameters but very complicated technology.

The advantages and disadvantages are connected with price, construction and the area of application.

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The goal of this work are germanium photo devises – resistors and diodes.

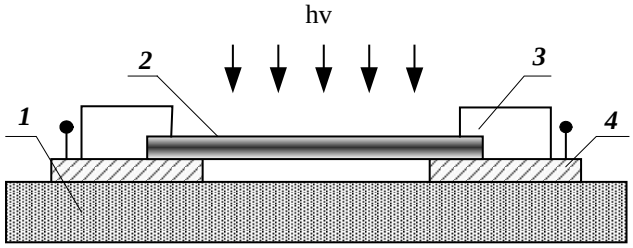
The last ones are based on the system Ag-Ge which is not classical p/n junction but metal – semiconductors barrier Schottky.

The samples have been prepared for student laboratory classes and for laboratory use in infrared range of the light.

II. DESIGN AND TECHNOLOGY OF GE - PHOTO DEVISES

A. Germanium photo resistors

The most popular construction of Ge photo resistors is a rectangular plate with two electrical contacts at the opposite ends - Fig. 2.



1 – Insulating substrate; 2- Ge crystal–detectors;
3 – Ohm contacts; 4 - External leads.

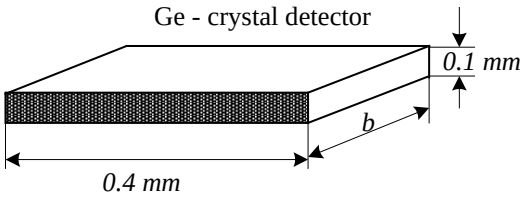


Fig. 2. Rectangular plate with two electrical contacts at the opposite ends

The nominal value of the resistance (T=20 ^{0}C without light) can be calculated as $R_0=\rho_{Ge}.A$ (where A is coefficient of the geometry).

The germanium used in the experiments are crystals (size 0.4×b×0.1 mm), *n* - type and specific resistance – ρ = 0.1÷10 (Ωcm). It is clear (Table 1) that the nominal values of R_0 are between 10÷8000 ohms.

The electrical (ohm) contacts are made using eutectic Au – Ge plus Sb.

TABLE I
VALUES OF R_0 (Ω)

ρ (ohm.cm)	b(cm)			
	0.05	0.1	0.2	0.4
0.1	80	40	20	10
0.2	160	80	40	20
0.5	400	200	100	50
1.0	800	400	200	100
2.0	1000	800	400	200
5.0	4000	2000	1000	500
10.0	8000	4000	2000	1000

B. Germanium Schottky photodiodes

The cross - section of germanium Schotky photo diodes is shown on Fig. 3.

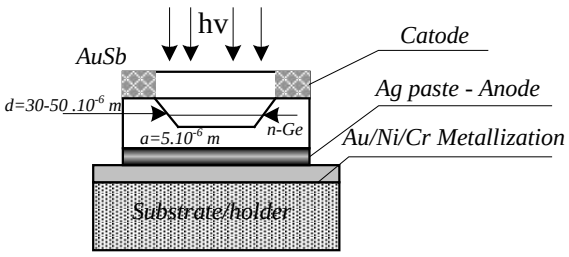


Fig. 3,a. – Cross section of Germanium Schottky devises.

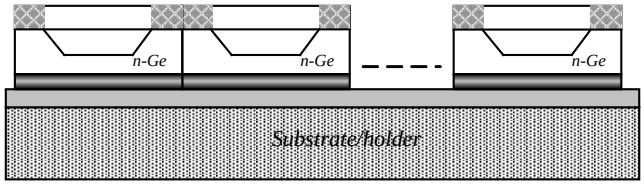


Fig. 3,b. Photocell with multiple photovoltaic – parallel and serial connection.

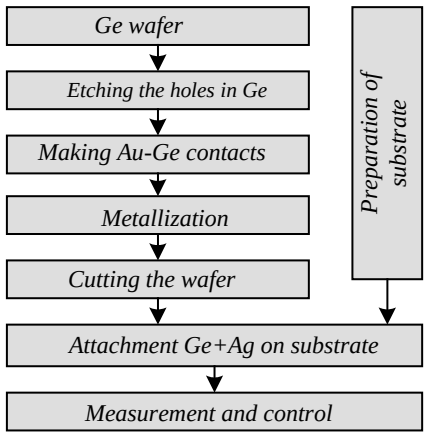


Fig. 4. Ge-Ag photo devises fabrication.

Usually, it is considered that Ge–Ag barrier is "sharp" p/n junction and parameters such as U_{BR}, I_S and C_O will depend only on Ge properties (ρ).

It could be calculated that $U_{BR}=83.4.\rho^{0.61}$. The technology consist next important steps - Fig. 4:

Metallization of Ge devises has two main applications: ohmic contacts and Schottky contacts [5 - 8].

III. CONCLUSION

The measurements of so prepared photo detectors show that the response in infrared light is sufficient for laboratory use and student education - Fig. 5.

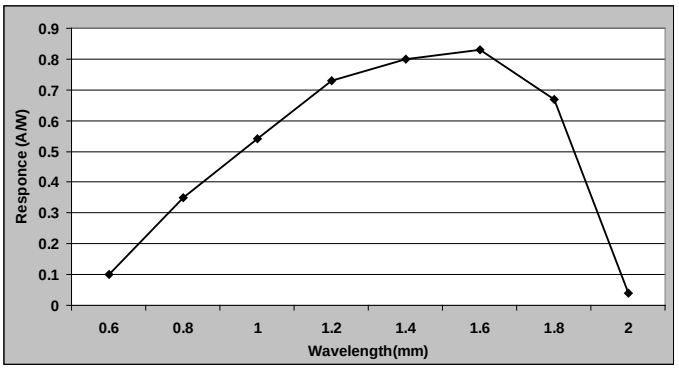


Fig. 5. The measurements of so prepared photo detectors

The measurements of so prepared photo detectors show that the response in infrared light is sufficient for laboratory use and student education - Fig. 5.

The voltage from single element is 0.1 V in visible light and 0.08 V if λ=0.8÷1.0 μm.

Photovoltaic based of germanium could be successfully used for space applications.

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