NEUTRON SENSORS BASED ON SILICON-GRAPHENE NANOSYSTEMS ENRICHED BY BORON10 ISOTOPE

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Abstract. The aim of the paper is elaboration of precise and fast neutron sensors using B isotopes. The work's objectives include: Development of physical principles of work of 10B isotopes doped semiconductor sensitive nanoelements and basis of their fabrication technology; By using of modern technologies of preparation of Boron isotopes enriched elementary semiconductor - Si based sensory elements development of high-efficient prototypes of nanosensors of the new construction; To study the peculiarities of technology of growth the semiconductor Si thin films doped by 10B isotopes and their properties and investigating the usage of the Graphene FETs (GFET), as instruments to increase the sensitivity of measurement leading due to the importance of the target of ultra-sensitive neutron detection.

1. Introduction

For neutron radiation safety there is need of development of sensory elements and sensory systems for instantaneous responding to variation of nuclear radiation. In order to be useful as a part of Artificial Intelligence systems, the sensors and sensory systems will be designed as a miniature instrument providing information transmission and processing about neutron radiation.

The appearance of new advances in nanotechnology and nanosystems preparation is very important for the development of neutron detectors. The development of new technologies and the corresponding development of the proper microstructure and nanostructure with the required characteristics can be enhanced by the newly appearing nanomaterials.

2. Theoretical and experimental results.

Recognizing this need, we built the next generation of neutron detectors for security requirements. The main proposed novelty of work is related to a Silicon-Graphene ultrasensitive advanced radiation detector, able to detect single neutrons [1-2]. This new family of ionizing radiation sensors is based on the exceptional electronic properties of Graphene.

In a case of Sillicon(Boron10)- Graphene based detector sensitive to thermal and even fast neutrons, a Si(B10) absorber material can be used in order to achieve conversion of neutron to heavy charged particles. Boron which is a shallow acceptor for Silicon changes its charge because of n,α nuclear reaction stimulated by neutron irradiation to Lithium, which is a shallow donor for Silicon. Charge carrier concentration changes (1 neutron reverses 1 charge) are easy to fix by electrical measuring instrument very precisely. These give us opportunity to measure neutron fluence up to neutrons very high density[3,4]. A Graphene nanolayer has to be deposited on the bottom of the Si wafer (Fig.1) to act as amplifier of electron-hole pars born in Si as result of nα nuclear-chemical reaction [5-7]. The added graphene monolayer is trapping the carriers of the B10 isotope doped thin Silicon layer which is following by generation of a "depletion" layer in the Graphene-Silicon layer interface. Graphene also reduces the thermal fluctuations (thermal noise) of the doped Silicon thin layer and whole detector accordingly.

The limits of the ^{10}B isotope content in materials, from which should be made neutron detectors, are too high: (0.1–2.5) $10^{23}/cm^3$. It means that, the neutrons will be rapidly stopped in a10B-enriched material. If we build the model of evaluation the key physical characteristics of the neutron detectors, when E - energy released during a single act of B10 – n interaction, is spent only on the thermal generation of the electron–hole pairs, consequently, the rate of rise in the temperature in process of neutron absorption in material will be $dT/dt=EW/C$. As for the neutron detectors' typical operation time, apparently it can be estimated from the following relation: $\tau = l/v$, where W is the rate of releasing of the nuclear reaction products, C is the heat capacity per unit volume of the irradiated material and v is the neutrons mean velocity.

Research which is performed in the work is unique. It applies to create new sensor elements and devices with high parameters, which is useful for precise neutron radiation measurements. These devices could be unite in electronic and intellectual networks. They will be able to function in harsh environment pollution. Compared to the analogies, these nanosensory elements and sensory devices have high sensitivity and resolution capacity, small dimensions, much smaller power consumption, low voltage and power

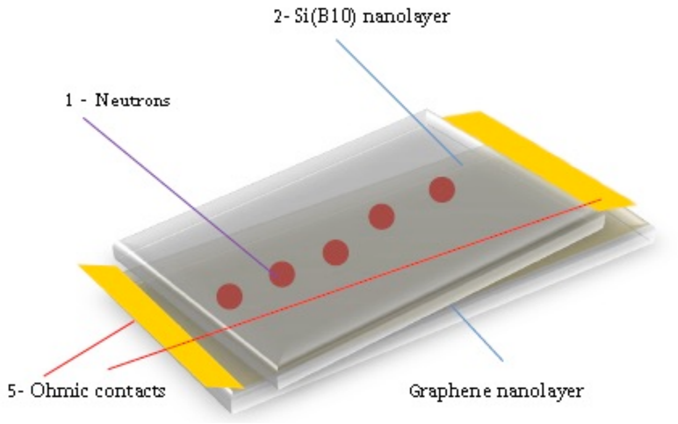

Fig.1. Scheme of Silicon(B10)-Graphene sensitive element of neutron detectors.

Conclusions

Among the main results of the work it is necessary to underline: development and characterization of the Boron nano-sensors; design and optimisation of the Graphene FET sensors; Investigations of parameters of testing of the Silicon –Boron- Graphene FET neutron sensor under different neutron flux conditions.

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