Review

of official reviewer for a doctoral thesis of Japashov Nursutan on the topic "Development of high-sensitive detection system based on large-sized silicon lithium structures", submitted for the degree of Doctor of Philosophy (PhD) in the specialty "D071900 - Radio engineering electronics and telecommunications"

1. The relevance of the research topic and its connection with general scientific and national programs (the requirements of practice and the development of science and technology).

Due to their potentially wide area of application, silicon detection systems remain promising measuring instruments and the object of study of many scientific research groups. One of the main problems in modern science and technology is to increase the sensitivity of measuring instruments. Like all other measuring instruments, radiation detectors require special attention. Among them, a special place is occupied by detection systems, based on nuclear radiation with high energy, good positional resolutions, signal linearity in a wide range of energy for various types of ionizing particles. One of the important technological, scientific and technical stages of obtaining highly efficient detection systems is the correct understanding of physical, technological and structural solutions. As the detector is an integral part of spectrometric systems, the process of formation of detector structures, plays very important role in development of spectrometric systems. The high energy resolution of the detector, the linearity of the output signal and the high operating ability of the detector ensures the successful operation of the whole system. In this matter, a special place is occupied by the quality of the initial crystal material for the detectors. In our study, monocrystalline silicon was chosen as the initial material. Comparing with other materials Silicon meets all of the above requirements.

Considering doctoral thesis of the applicant Japashov N, is aimed to study of silicon lithium detecting system of alpha, beta radiation.

2. Scientific results in the framework of the requirements for dissertations (paragraphs 2, 5, 6 of the "Rules for the award of scientific degrees").

In the thesis of Japashov N. the following new scientific results were obtained:

1 Experimentally, the regimes of diffusion of lithium atoms in a silicon single crystal were detected, for the manufacture of a detector with a sensitive area greater than 110 mm^2 and a thickness of 4 mm.

2 Technological regimes of two-sided drift of lithium ions into silicon single crystal were experimentally determined, including a synchronous step change in temperature and reverse bias voltage leading to a reduction in the drift path of penetration of lithium ions and to a more homogeneous detector structure, thereby reducing the energy resolution of the detector for beta particles by 5 keV and for alpha particles at 7 keV.

3 Theoretical calculations and experimental data showed that the technology of double-sided drift reduces the manufacturing time of the Si (Li) p-i-n structure by four times.

4 The developed charge-sensitive preamplifier for a Si (Li) p-i-n structured detector showed a low noise level; for detectors with an output capacitance of 300 pF, the mean square deviation of the noise current is 45 nA and the minimum delay time is up to 8 ns. Also, it is established that the preamplifier is fully compatible with other, alternative, silicon detectors with an output capacitance from 10 to 1300 pF.

3. The degree of validity and reliability of each scientific result (scientific provision), conclusions of the applicant, formulated in the thesis.

The validity and reliability of scientific results are confirmed by the large amount of own research, performed using a complex of physical and technological methods of analysis, the logical interrelation of the experimental results and their consistency with generally accepted scientific principles.

The validity of the conclusion, that the optimal diffusion regime of lithium for obtaining large-diameter detectors is confirmed by the obtained electro-physical characteristics measured by special equipment.

The validity of the conclusion that the method of conducting a double -sided drift of lithium ions into a monocrystalline silicon is carried out by a simultaneous stepwise increase in temperature is confirmed by the obtained current-voltage, capacitance-voltage characteristics.

The validity of the conclusion that the technology of double-sided drift of lithium ions into a monocrystalline silicon improves spectrometric characteristics, increases the efficiency of the detecting system and shortens the detector manufacturing time, is confirmed by the improved spectrometric characteristics of the detecting system.

The validity of the conclusion that the developed charge-sensitive preamplifier for silicon detectors has a high speed, low sensitivity to the input capacitance, which ensures its stability due to low-noise amplifiers with a noise level not exceeding 0.45 nV / $Hz^{1/2}$, as well as matching the impedance of the connected line and the input of the amplifier, is confirmed by the results of the measuring instruments.

The conclusions formulated in the thesis are justified, logically follow from the content of the work and are the result of the generalization of a large amount of experimental data.

4. The degree of novelty of each scientific result (scientific provision), conclusions of the applicant, formulated in the thesis.

The results of theoretical and experimental research presented in the dissertation are new.

1 It was found that the optimal regime for lithium diffusion into large-diameter silicon (≥110 mm) with a thickness of the sensitive region W ≥ 4mm is at a temperature T = (450 ± 20) ^{0}C, t = 3 min, h_{Li} = (300 ± 10) μm.

2 The method of conducting a double sided drift of lithium ions into a silicon monocrystal is performed by a synchronous stepwise increase in temperature from 55 °C to 100 °C and a reverse bias voltage from 70V to 200V.

3 The technology of double-sided drift of lithium ions into a silicon monocrystal improves spectrometric characteristics, increases the efficiency of the detection system and reduces the time to manufacture the detector.

4 The developed charge-sensitive preamps for silicon detectors have high speed (delay time no more than 5 ns), low sensitivity to the input capacitance, which ensures, as a result, a low-noise amplifier with a level of 0.43 $nV/Hz^{1/2}$ and its stability, and the possibility of matching the impedance of the connected line and the input of the amplifier.

5. Evaluation of the internal unity of the results.

The results of the thesis have an internal unity, since all sections are aimed at solving the problem of studying the structural, electrical and hardware implementation of the detecting systems and detector structures with the subsequent optimization of the technological conditions of their production and use for manufacturing for industrial purposes.

6. The focus of the results obtained by the applicant on the solution of the relevant actual, theoretical or applied problem.

The new scientific results obtained by the applicant and presented in the thesis are aimed at solving an important applied problem: spectrometric devices, based on Si (Li) p-i-n structured detectors with a sensitive surface diameter of more than 110 mm and a thickness of sensitive area more than 4 mm, intended for X-ray detection.

7. Confirmation of sufficient completeness of publications of the main provisions, results and the conclusion of the thesis.

The results of the work are fully described in the printed works, from which 8 are articles, 2 in an international scientific publication, having citations in Thomson Reuters database (ISI Web of Knowledge, Thomson Reuters), which is also included in the Scopus database, 6 articles in scientific publications recommended by the Committee on the Control of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 1 report at an international conference abroad and 2 reports at local international conference.

8. Disadvantages on the content and design of the thesis.

1 In Section 2.6.3 on page - 61 on Figure 2.5, Figure 2.6, Figure 2.7 and Figure 2.8. 8 it was shown schematic diagram of each electronic part of detecting system. However, a detailed description of the hardware implementation of these schemes is given in small volumes, it would be better to describe the process of assembling these schemes in detail.

2 In some graphs, for example, in Figures 1.19 (p. 35), 1.21 (p. 36) and in Figure 1.25 (p.42), in the captions along the axes, units of measure are not given. But, the text provides a fairly complete explanation and data of them.

3 The work presents the current-voltage characteristics of all the samples obtained. Many conclusions are based on their analysis. However, in the literature

review little attention is paid to this issue. Not enough literature data to compare with known materials.

4 In section 3.1, the author shows an analytical and numerical method for solving double-sided diffusion problems, but with very few conclusions and analysis of the data obtained, a comparative and qualitative analysis of the data obtained could be made in a more comprehensive way.

5 When solving problems of diffusion at the beginning of the text (p. 66), the author denotes the concentration of charge carriers by the letter N but from the middle of the text it is replaced by the letter C, it would be convenient to designate from the beginning the same letter.

However, these comments do not reduce the merits of the thesis.

9. Compliance of the dissertation with the requirements of section 2 of the «Rules for the award of scientific degrees».

The thesis "Development of high- sensitive detection system based on large-sized silicon lithium structures", meets the requirements of section 2 of the "Rules for the award of scientific degrees" to dissertations.

Protected scientific position can be qualified as a solution to an important applied problem.

The combination of new scientifically based theoretical and experimental results is an important achievement in the development of electronic devices.

Based on the above, I believe that the applicant, Japashov N., deserves to be awarded the degree of Doctor of Philosophy in the specialty 6D071900 - Radio Engineering, Electronics and Telecommunications.

Official reviewer
Doctor of physic-mathematical
sciences, professor Somsikov V.M.

Date: