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Review

of foreign scientific consultant 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"

The thesis of Japashov Nursultan is devoted to the development, research and application of the new spectrometric instrument, intended for the registration of X-rays. As a part of this work, a new method for double-sided diffusion of lithium atoms and double-sided drift of lithium ions into a monocrystalline silicon plate was proposed, to obtain a Si (Li) p-i-n detector structure, with a sensitive surface diameter more than 110 mm and thickness more than 4 mm. As an initial material for silicon detector, p-type monocrystalline silicon grown by Czochralski method and monocrystalline silicon obtained by the floating zone method were taken. An optimized, high-speed low-noise readout electronics for these detectors has also been developed. To implement the dissertational work, Nursultan was given the following tasks:

-To choose suitable initial materials for detectors.

-To study experimentally electro-physical characteristics of initial material for detectors.

-To develop the technological modes of double-sided diffusion of lithium atoms in silicon wafers of large sizes;

- To develop the technological modes of a double-sided drift of lithium ions in silicon wafers of large sizes;

- To develop suitable and high efficient readout electronics for large size Si(Li) p-i-n detectors;

- Hardware implementation for highly efficient spectrometric system

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based on large sized Si(Li) p-i-n detectors;

Nursultan has worked very well on these tasks and received significant scientific results that are described in the dissertation.

The structure of the dissertation of Japashov consists of four chapters.The first chapter provides an overview of the current state of the radiation detection system based on the silicon detectors. An analysis was made of various types of detectors, such as strip detectors, surface barrier detectors, scintillation detector, pixel detectors, etc. Here defined main problems in the manufacture of silicon detecting systems and indicated to their possible solutions.

In the second chapter it considers the manufacturing technology of detecting system based on a large-size silicon detectors (surface diameter more than 110 mm) with a thickness about 4 mm, which have Si (Li) p-i-n structure.

Third chapter deals with physical features of a double-sided diffusion of lithium atoms and the double-sided drift of lithium ions into mono-crystal silicon. The theoretical assumptions and experimental characteristics of the double-sided diffusion and drift processes also considered in this chapter.

Finally, in the fourth chapter, hardware and software of a detection system based on a silicon-lithium p-i-n detector is described.

The author obtained the following scientific results:

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

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

- 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.

- 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

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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.

According to the materials of the dissertational work, Nursultan has published 10 publications. From which 7 are articles (one article 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, six 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.

In my opinion, the dissertational work of Japashov Nursultan satisfies all the requirements for works submitted for the degree of Doctor of Philosophy (PhD). The author has proved himself to be a qualified specialist in the field of Radio engineering electronics and telecommunications. I recommend the Academic Council to accept the dissertation work of Japashov N for public defense for a PhD degree in Radio engineering electronics and telecommunications, and I wish him further success.

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