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Abstract

Full Text

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PHYSICS

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ON THE PROPERTIES OF THE *p*–*n* JUNCTION IN CADMIUM TELLURIDE

(Presented by Academician N. G. Basov on May 8, 1968)

Cadmium telluride has a number of advantages in comparison with other semiconductor materials. However, for its use in electronics it is necessary to achieve the possibility of creating a *p*–*n* junction in it. As a result of prolonged investigations, we have developed methods for obtaining *p*–*n* junctions in cadmium telluride, some properties of which are described in the present article.

To create a *p*–*n* junction, single-crystal cadmium telluride is used, obtained by various methods—above all by vertical and horizontal zone recrystallization. The synthesis of the material is carried out from high-purity starting components; the concentration of uncontrolled impurities in tellurium does not exceed 10^{-6}%, and in cadmium 10^{-4}%. Material with hole conductivity was used, with different specific resistivities ranging from tens of $\Omega \cdot$ cm to tens of thousands of $\Omega \cdot$ cm.

A region with electron conductivity can be obtained by alloying with indium or gallium, by diffusion of the same substances, or by bombarding the crystal surface with boron ions. The method for creating *p*–*n* junctions was described in brief notes ([1,2]). The first samples of *p*–*n* junctions had low reverse voltages, not exceeding 10 V at a current of 1-2 μa. With a further increase in voltage, a sharp increase in the reverse current was observed. The nature of the current increase indicated that its cause was surface conductivity. This assumption, expressed earlier, was subsequently fully confirmed. Careful treatment of the surface, especially of the ends of the sample, made it possible to sharply reduce the leakage currents, which led to a substantial improvement in the characteristics of the *p*–*n* junctions.

Figure 1 gives, as typical examples, the current-voltage characteristics of *p*–*n* junctions obtained by different methods. We see that the *p*–*n* junctions withstand reverse voltages up to $(100 \div 150)$ V with reverse currents up to $(10^{-8} \div 10^{-7})$ A and a junction area of ~ 0.5 cm^2. The forward currents reach tens of milliamperes at $(2 \div 3)$ V. The magnitude of the forward currents is limited by the large thickness of the base and the high resistivity of the material.

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Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

Indeed, as investigations have shown, the magnitude of the forward currents increases sharply at low voltages if a lower-resistivity material and a smaller base width are used. The reverse currents in this case retain their magnitude. More detailed investigations, for example, study of the influence of temperature on the current-voltage characteristic, make it possible to conclude that p-n junctions in cadmium telluride can be widely used in radio electronics.

Among the interesting features of the junctions obtained are the narrow bands of spectral sensitivity, whose half-width at room temperature may be 0.01 eV at a photon energy of 1.5 eV. Transition to the solid solution $Cd_xHg_{1-x}Te$ at $x =$ 0.95–0.97 will make it possible to obtain a selective radiation receiver sensitive to the radiation of a semiconductor quantum generator based on gallium arsenide.

The main objective of the studies we have carried out recently has been to create a nuclear-radiation detector. As has already been reported, heavy-particle detectors (α from Pu^{239}) based on the p–n junction in CdTe

Fig. 1. Current-voltage characteristics of p–n junctions in CdTe obtained by different methods: **I** –diffusion of In from the gas phase in Cd vapor; **II** –diffusion of In from the gas phase (in the absence of Cd); **III** –bombardment of the CdTe-p surface with boron ions (B)

Fig. 2. Capacitance-voltage characteristics of p–n junctions in CdTe obtained by different methods: **I** –diffusion of In from the gas phase in Cd vapor; **II** –diffusion of In from the gas phase in the absence of Cd; **III** –bombardment of the p-CdTe surface with boron ions (B)

have an energy resolution of about 6%. At present we have succeeded in improving the resolution to 5–4%.

After improving the characteristics of the junctions, which makes it possible to increase substantially the dimensions of the space-charge region, we succeeded in obtaining detectors sensitive to γ radiation. In Fig. 2 the capacitance-

the capacitance characteristic of the junctions, which makes it possible to estimate the thickness of the space-charge region and its dependence on the bias magnitude.

The studies showed that, under reverse bias (50–60) V, the detector has satisfactory sensitivity to γ-rays obtained from standard sources (cesium, cobalt) of low-activity radiation. The silicon-based detectors used by us for comparison, under the same conditions, did not detect γ-radiation. This is explained by

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the fact that, under conditions in which γ-quanta are absorbed as a result of the photoelectric effect, the effective photon absorption cross section is $\sim Z^5$, which provides a significantly higher sensitivity for a detector based on CdTe, for which $Z = 50$, whereas for silicon $Z = 14$. Detailed results of studies of γ-radiation detectors will be published in the near future.

In conclusion, the authors express their gratitude to V. I. Mitin for assistance in studying the counting characteristics of the detectors.

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REFERENCES

[1] L. I. Kalugina, P. S. Kireev, *Collection: Exchange of Experience in the Electronics Industry*, issue II, No. 4, 1968. [2] L. I. Kalugina, L. N. Streltsov et al., *Collection: Exchange of Experience in the Electronics Industry*, issue II, No. 4, 1968.

Note: Figure translations are in progress. See original paper for figures.

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