Розглядається проблема розширення діапазону функціонування діодних термосенсорів в область високих температур та приводяться деякі з результатів досліджень авторів в даній області. Для вирішення цієї проблеми запропоновано використовувати діодні структури на основі широкозонних напівпровідникових сполук в системі А3В5. Розроблено технологічну методику виготовлення дослідних зразків високотемпературних діодних сенсорів температури на основі GaP. Представлена методика дозволяє виготовляти зразки діодних сенсорів температури, високотемпературна межа роботи яких на 200÷300 К перевищує межу функціонування серійних кремнієвих діодних сенсорів температури. Розроблено дослідні методики нарощування епітаксійних структур твердих розчинів AlGaAs і виготовлення на їх основі діодних сенсорів температури. Показано, що обраний у роботі підхід дозволяє розширити довжину термометричної характеристики таких діодів у високотемпературну область приблизно на 150÷250 К. Представлена методика формування приладових структур InGaN і виготовлення дослідних зразків високотемпературних діодних сенсорів температури на їх основі. Дана методика з доробками може застосовуватися для виготовлення діодних сенсорів температури та інших приладів для високотемпературних застосувань, практично усього ряду твердих розчинів у системі InN-GaN. Досліджено параметри й характеристики отриманих діодних сенсорів температури. Результати досліджень можуть бути використані спеціалістами в області електроніки та оптоелектроніки у розробках та виробництві напівпровідникових приладів.

Ключові слова: діодні сенсори температури, діодна термометрія, термометрична характеристика, термочутливість, рідиннофазна епітаксія

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DEVELOPMENT OF DIODE TEMPERATURE SENSORS WITH OPERATING RANGE UP TO 750 K

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1. Introduction

The distinctive feature of the development of the modern science and technology is a permanently existing trend in the growth of operating temperatures of the devices, units and various installations being exploited in harsh environments. This, in turn, conditions the need to control precisely their basic parameters in such conditions to provide reliable and long-term operation. In particular, there is an actual task to create semiconductor temperature sensors capable of uninterrupted operation in the range of high and ultra-high temperatures. The expansion of the operating interval of semiconductor devices in the range of high temperatures is the actual task of extreme electronics and optoelectronics [1]. Currently, these studies are most in demand in the diode thermometry [2, 3]. It is known [4] that the temperature range being measured is determined by the length of the temperature response characteristic (TRC) of the diode. It was shown earlier [2, 5] that the high-temperature limit of TRC increases with the increase of the band gap E_g of semiconductor material in the base area of the diode. Thus, the development of device structures, designs and technologies of wide-band semiconductor diodes has a certain practical perspective.

2. Literature review and the problem statement

For a long time, gallium phosphide epitaxial structures have been used in optoelectronics to fabricate light emitting diodes for visible spectrum of red and green light. At the same time, diode structures of wide bandgap GaP (E_g≈2.26 eV at 300 K) are promising for the creation of high-temperature optoelectronics and electronics devices [6]. In particular, these structures are promising for designing thermal sensitive elements (TSE) of high-temperature diode temperature sensors (DTS) [7]. However, there are some problems of manufacturing the diode base area with the level of background impurity and the concentration of deep level point defects less than 10^{16} cm^{-3} and 10^{14} cm^{-3} respectively [8]. This negatively affects the linearity of the TRC structures in the high-temperature range. Thus, the

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diodes application as temperature sensors in the range above 350 K is slowed down.

One of the well-known advantages of semiconductor devices based on $Al_xGa_{1-x}As$ solid solutions is the ability to regulate the value of E_g (including the creation of the graded band gap along the layer thickness) in the active area of a device. The other one is the commercial development of technologies mainly connected with the long-term industrial fabrication of light emitting diodes and solar photoelectric converters. DTS based on AlGaAs solid solutions has been used in thermometry relatively recently. The commercial samples are used in industry [9] as well as the other diode-type structures are studied to be used as the sensors [10, 11]. However, the length of their temperature response characteristics in the high-temperature region is limited practically by the temperature ≤400 K. The analysis of available literature sources conducted has shown that there are no published results of investigations of DTS based on AlGaAs and GaP at the temperatures above 500 K. This is mainly due to the excessive leakage currents of TSE of the DTS. So at present, such DTS are intended primarily for usage in cryogenic and low-temperature thermometry. As the authors showed [12], the decrease of the leakage currents of AlGaAs-based diodes might be achieved if the p-n junction would be located in the region of high AlAs content (x>0.3) in the active layer of $Al_xGa_{1-x}As$ device. In case of GaP DTS, this could be achieved by using the technique of isovalent doping of the DTS base layer.

III–V semiconductor nitrides (InN, GaN, AlN) and their solid solutions (InGaN, AlGaN, AlInGaN etc.) are being intensively developed by the industry for the production of visible-range up to ultraviolet spectrum range light sources (LEDs) and lasers (laser diodes) for superdense recording of information on optical disks and other state-of-the-art data carriers. III-V wide bandgap nitrides (E_{gInN}=1.9 eV, E_{gGaN}=3.39 eV, E_{gAlN}=6.1 eV at 300 K) are also promising for the creation of wide-range high-temperature DTS. However, there are also no published investigations of such structures as a DTS operating in a wide temperature range. In addition, the technologies of device structures of nitrides are complicated and expensive, since they are based on the methods of gas-phase epitaxy using metal-organic compounds (MOCVD) [13], molecular-beam epitaxy (MBE) [14, 15], various epitaxy variants based on chemical reactions in the vapor phase (CVD). All this makes the technologies unprofitable for low-volume fabrication of high-temperature DTS. Thus, the development of alternative, relatively simple fabrication technologies of device structures of III–V semiconductor nitrides for the creation of the new generation of high-temperature DTS is promising for modern thermometry.

In periodic scientific and technical literature, there are a huge number of works dealing with development, fabrication and investigation of diode structures based on phosphides, arsenides and nitrides of III-V compounds. However, there are still certain important issues concerning its application as high-temperature thermal sensors capable of operation at the temperatures above 500 K.

3. The aim and objectives of the study

The aim of this study was to develop experimental methods of obtaining epitaxial layers of III–V compounds as well as device structures based on solid solutions in this system. At the same time, the layers and structure mentioned above should be suitable for manufacturing DTS TSE for high-temperature thermometry in the range up to 750 K.

To achieve the aim, the main objectives of the study were the following:

– to elaborate the methods for obtaining and studying the electrophysical characteristics of n^+-n-p^+ GaP structures;

– to determine the technological stages of production of pilot DTS samples based on n^+-n-p^+ GaP;

– to develop the pilot technique of obtaining epitaxial structures and manufacturing AlGaAs/GaAs DTS;

– to establish basic technological conditions of the experimental technique for the formation of III–V nitride device structures for high-temperature DTS.

4. Materials and methods of studying semiconductor structures and devices for high-temperature electronics

4. 1. Methods of obtaining semiconductor structures and devices based on gallium phosphide

The technique of liquid-phase epitaxy (LPE) of n^+-n-p^+ gallium phosphide structures developed includes the following technological stages:

– preparation of the charge material and GaP wafers-sources;

– chemical treatment of substrates n^+-GaP <100>;

– LPE of the n-GaP base layer by the method of zone recrystallization in the temperature gradient (ZRTG) in the atmosphere containing ions of nitrogen;

– LPE of the p^+-GaP emitter layer by forced cooling of Ga-GaP solution-melt, crystallization start temperature is 900±5 °C;

– post-epitaxial chemical treatment of the structures.

The experimental technique of manufacturing DST based on GaP epitaxial structures has been developed. This complex technique includes a number of LPE stages of n^+-n-p^+-GaP structures as well as the stages of contact alloys deposition on epitaxial n^+-n-p^+-GaP structures, the assemblage and encapsulation of GaP chips into a case, the measurement of parameters and testing of the DTS. The technological process of the DST manufacturing includes the following stages:

(1) the stage of LPE of n^+-n-p^+-GaP structures;

(2) the stage of the contact alloys deposition:

(2^I) chemical treatment of the structures;

(2^{II}) Zn diffusion into p^+-layer;

(2^{III}) the deposition of Ti-Ni-alloy and the layer of Bi [16];

(2^{IV}) annealing of the contacts;

(3) the stage of assemblage and encapsulation:

(3^I) formation of mesa-structures and chipping of the wafers;

(3^{II}) manufacturing, tinning and reforming of the lead frames of the DTS, the chips fitting onto eutectic solder;

(3^{III}) sealing into the case (three variants of sealing were developed: sealing of the chips into the metal-glass case, unpackaged sealing by the thermoset plastics [17], unpackaged sealing using AlN ceramics);

(4) the stage of thermal and special testing of the DTS, outgoing inspection.

4. 2. Technique of studying the parameters and characteristics of GaP DTS

TRCs of the diodes were measured at three constant operating currents: 1, 10 (standard value) and 100 μA using the metrological test unit UGT-A [18] in the temperature range 77÷520 K. The accuracy of the operating current maintenance was not less than ±0.1%. The absolute error of the temperature measurement did not exceed ±0.03 K. In addition, the forward current-voltage (I–V) characteristics were measured on the automated test unit in the range of currents $10^{-11}÷10^{-2}$ A. The temperature maintenance error was ±0.1 K. The study was performed on the samples of experimental lots (≥10 samples per lot).

At the room temperature, the forward voltage (U) deviation from the nominal value for different diodes was in the range of ±4 mV. Knowing the value of thermal sensitivity (s) of the diodes at a given temperature, one can determine the degree of their identity as the ratio U/s. For the sample lots investigated, the value was ≤ ±1.1 K.

4. 3. Techniques of obtaining and assembling the DTS based on AlGaAs/GaAs epitaxial structures

Based on the research conducted, the authors have developed the LPE techniques of $Al_xGa_{1-x}As$ solid solution layers, (x≤0.45), which are used as the base and emitter layers of the diodes in the following variants:

– separate doping of layers (emitter, Zn, $1÷3\times10^{18}$ cm^{-3}, base, Sn, ~5×10^{16} cm^{-3});

– amphoteric Si doping (≤5×10^{17} cm^{-3}).

The techniques of assembling and sealing the chips of the DTS test samples in two variants of unpackaged sealing are also developed.

The technology of manufacturing AlGaAs DTS test samples includes the following stages:

(1) the stage of LPE of n- and p^+-AlGaAs layers:

(1^I) chemical treatment of GaAs substrates (n-GaAs: Sn, <100>, n≈$(3÷5)\cdot10^{17}$ cm^{-3}) and preparation of the charge material (Al, Ga, GaAs), doping impurities (Zn, Sn, Si);

(1^{II}) LPE growth of layers of n- and p^+-AlGaAs by forced cooling of the solution-melt in the atmosphere of high-purity H_2 flow (dew point temperature ≥70 °C) at the initial temperature of epitaxy ≤900 °C using “Vega-M” installation;

(1^{III}) the processes of post-epitaxial structure processing including finish chemical polishing of the structures surface;

(1^{IV}) the processes of measuring and testing the electrophysical characteristics of the layers and structures (the layers thickness, the dislocation density, major charge carriers concentration by $C–V$ method, Hall mobility of electrons and holes by Van der Pau method, AlAs solid solution composition control by measurement of the photoluminescence spectra etc.);

(2) the stage of contact alloys Bi-Ge-Sn (Ag) deposition and chipping of the wafers;

(3) the stage of assembly and unpackaged sealing of chips:

(3^I) variant of sealing by thermoset plastics;

(3^{II}) variant of sealing using ceramic compositions;

(4) the stage of measurements and tests of the DTS pilot samples.

4. 4. Technique of studying the parameters and characteristics of the DTS based on AlGaAs/GaAs epitaxial structures

Forward I–V characteristics of the DTS samples were measured using the automated test unit with a personal computer interface in the range of currents $10^{-9}÷10^{-2}$ A. The temperature maintenance error was ±0.1 K. The measurement and study of the diodes TRC were performed on the metrological test unit UGT-A with improved sample holder at three values of the constant forward current: 0.1 μA, 1.0 μA and 10.0 μA. The forward current maintenance accuracy was ±0.1 %. Temperature measurement absolute error made ±0.03 K.

4. 5. Experimental techniques of III–V nitride structures formation and assembling of the prototype samples of high-temperature DST

The methods of deposition of thin (including submicron) layers of GaN, InGaN, AlGaInN in a gaseous chloride-containing medium in high-frequency (HF) discharge and in a high-purity nitrogen flow at NH_3 leak-in into the chamber have been developed. Doping of the layers is carried out using the sources based on evaporating chlorides: $MgCl_n$, $ZnCl_m$ and SiH_pCl_q.

As the device structure for the DTS realization, a double heterostructure (DH) with active layer $In_xGa_{1-x}N$, x≤0.25 was selected.

The technique of the structures formation includes the following basic stages:

– GaN buffer layers deposition ≤2.0 microns on sapphire substrates <0001>;

– formation of n-GaN:Si working layer, n≈$(2÷5)\times10^{17}$ cm^{-3} in HF-discharge plasma and in the temperature gradient (>20 K·mm^{-1}) on the substrate;

– applying a contact mask on the planar surface of the structures;

– formation of the barrier layer n-$In_{0,15}Ga_{0,85}N$:Si, 0.3 μm, n≈$2\cdot10^{17}$ cm^{-3} in HF-discharge;

– formation of the active base layer n-$In_{0,25}Ga_{0,75}N$ (not doped), 0.1÷0.15 μm in HF-discharge;

– formation of the barrier layer p-$In_{0,15}Ga_{0,85}N$:(Mg, Zn), 0.3 μm, p≈$(5÷7)\cdot10^{16}$ cm^{-3};

– formation of the emitter layer p-GaN:(Zn, Mg);

– additional (post-epitaxial) diffusion of Zn in the emitter layer;

– the chip photolithography and vacuum-thermal deposition of the contact layers of metal alloys (Ni–Ag, Ni–Au) and its firing at the temperatures of 600÷650 °C;

– post-epitaxial processing of the device structures in “planar”.

The technique of DTS assembling consists of the following stages:

– the chipping of the planar structures by laser scribing;

– the chips fitting onto the kovar holder and the thermal compression of the leads;

– sealing of the chips into a case in the following variants: thermosetting plastic or ceramic compound;

– DTS testing by thermal cycling in the range of 20÷450 °C;

– measurement and study of parameters and characteristics of the DTS samples.

4. 6. Technique of studying the parameters and characteristics of the DTS based on III-V nitride structures

TRC of DST samples were measured at UGT-A test unit at three values of the forward current (0.1, 1.0 and 10.0 μA). The current maintenance accuracy was ±0.1%, absolute error of temperature measurement was ±0.03 K. A pilot batch of 12 samples that had passed the manufacturing cycle in identical conditions was selected for measurements and studies. Additionally, in some cases, I–V characteristics of the structures were measured in the range of currents of $10^{-9}\div10^{-3}$ A.

5. Research results

5. 1. Results of studies of DTS based on GaP structures

N-p$^+$-GaP device structures on the n$^+$-GaP substrate intended for high-temperature DTS implementation were developed. The formation of such structures is carried out in planar execution with the use of epitaxial technologies. The optimal structure parameters:

– substrate: n$^+$-GaP <100>, Czochralski method, electron concentration $n\approx5\cdot10^{17}\div2\cdot10^{18}$ cm^{-3}, thickness ≤400 microns, dislocation density $\leq5\cdot10^4$ cm^{-2}, diameter 40÷50 mm, chemical-mechanical polishing of the working side;

– parameters of the base (n-GaP) and emitter (p$^+$-GaP) layers are summarized in Table 1.

Table 1

Optimal parameters of n- and p$^+$ layers of GaP

Layer	Thickness of the layer, μm	Concentration of major charge carriers (C-V method), cm^{-3}	Hall's mobility of the charge carriers, cm^2·V^{-1}·s^{-1}		Density of dislocations, cm^{-2}
			77 K	300 K	
n-GaP	3÷7	$5\cdot10^{14}\div7\cdot10^{16}$	1,100÷1,250	220÷270	$\leq3\cdot10^4$
p$^+$-GaP	10÷15	$(2\div3)\cdot10^{18}$	–	–	$\leq5\cdot10^4$

Epitaxial GaP with the parameters given in Table 1 was characterized by high temperature stability of characteristics up to the temperatures of ≤800 K, which was confirmed by other studies [8] along with the data of the tests conducted. Parameters of Table 1 served as the starting point for the development of the experimental technological method of LPE of n$^+$-n-p$^+$ GaP structures.

The studies conducted have shown that growing of n-GaP layers by using the temperature-gradient zone melting method (TGZM) in an atmosphere containing nitrogen ions reduces the concentration of residual impurities in the layers down to the level of $\leq5\cdot10^{14}$ cm^{-3}.

The engineering solutions which were the basis of the LPE technique of n$^+$-n-p$^+$ gallium phosphide structures had allowed obtaining the necessary results. When testing the technique, the degree of reproducibility of the parameters of structures exceeded 85 %. Practical implementation is possible on the industrial LPE growth equipment.

5. 2. Results of research of DTS based on AlGaAs/GaAs epitaxial structures

To study the influence of the solid solution in the active area of the DTS on TRC, the samples of diodes made on the basis of DH with two values of AlAs composition (x=0.1 and x=0.35) in the narrow bandgap base layer were used. TRC of the samples were measured in the range of temperatures from room up to ~400 K according to the procedure given in subparagraph 4.4.

The analysis of TRC, I–V and other experimental data [19] allows concluding that the level of $U(T)$ values increases proportionally with the increase of the composition x of the solid solution (and, respectively, E_g in the active region of the diode). According to the studies [17], this leads to a substantial extension of the TRC length into the high-temperature region. In addition, there are new opportunities of the development of specific groups of DTS, in particular, DTS with a fixed level of thermal sensitivity for the operation in a given temperature interval.

5. 3. Results of research of DST on the basis of structures of III-V nitrides

The end-to-end yield percentage of the technological processes of the experimental DTS production was ~5÷7 %, which can be compared with the experimental technology of light-emitting diodes based on III-V nitrides at the development stage.

In order to refine the values of effective concentration of major charge carriers in DTS base layer ($n\approx N_D-N_A$, where N_D and N_A are the concentrations of donors and acceptors respectively), the authors have developed the method [21] based on measurement and processing of $C-V$ characteristics of diodes at the reverse bias. The values of n measured by this method were ~$(1\div5)\cdot10^{14}$ cm^{-3}.

The averaged TRC of the investigated diodes at fixed values of forward currents 0.1, 1.0 and 10.0 μA in the temperatures range of 300÷650 K are given in Fig.1.

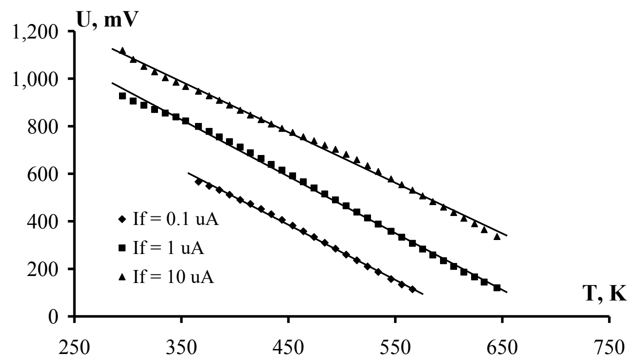

Fig. 1. TRC of InGaN DST at three values of the operation current

As it follows from Fig. 1, TRCs are almost linear in the whole temperature range investigated and characterized by constant values of the thermal sensitivity s. Here the values of s vary from ~2.5 mV/K at the current of 0.1 μA up to ~2.13 mV/K at 10 μA. The length of TRC is considerably higher as compared with DTS samples based on AlGaAs. However, it should be noted that at low values of the forward current, as a special study has shown, the character of TRC is affected by the series resistance of the structures. This will require further refinement of doping processes of the active and barrier layers of the DTS base and emitter.

The calibration of the experimental samples from the InGaN DTS lot was carried out using the method developed which was based on the plotting of $E_g(T)$ dependence for the diode base layer using the results of its TRC measurements [22].

6. Discussion of the research results

6. 1. Discussion of study results of DTS based on GaP epitaxial structures

Testing of the technique of DTS manufacturing which is based on GaP epitaxial structures has been carried out during the manufacturing processes of the experimental DTS lots. Here the end-to-end yield percentage was ~15÷17 %. The implementation of this method of DTS fabrication is intended for use in the standard technological processes of a semiconductor diode assembly at the semiconductor device manufacturing factories.

Typical TRCs and $s(T)$ dependencies of the diodes are presented in [16]. It should be noted that at the temperature of 500 K, the voltage drop across the diode (n-p$^+$ structure since the voltage drop across the series resistance and the contacts of the diode can be neglected) depending on the current value is 1.05÷1.3 V. This is much higher than in serial DTS based on Si [9].

Investigations of the time stability of the diodes showed that within 5 months the deviation of the temperature characteristics of the diodes did not exceed 1.2 %.

As it can be seen from the investigations carried out [16] for the current of 1 μA TRC in the temperature range 77÷520 K is characterized by high linearity with a constant thermal sensitivity value of ~2.5 mV/K. For the current of 10 μA, the deviation from the TRC linearity and subsequent increase of the thermal sensitivity are observed at the temperatures up to 170 K, and for 100 μA – up to 240 K.

By standard processing of measured *I-V* curves in the coordinates log$I=f(U)$, the thermal and current dependences of the ideality factor of the diodes are determined at different temperatures: 77 K, 129 K, 160 K, 208 K, 250 K, 471 K [16]. From these studies, it follows that for the current of 1 μA the recombination mechanism of current flow with the ideality factor close to 2 is dominant in the whole investigated temperature range. For the currents of 10 and 100 μA, the recombination mechanism keeps dominating at temperatures above 160 and 250 K respectively.

The magnitude of the activation energy found from the dependence of $I=f(1/T)$ at constant diode voltage values is ~1.15÷1.2 eV, which corresponds to approximately half of the gallium phosphide energy bandgap. In this connection, we carried out a study of the influence of the parameters of deep impurities in the diode base on the diodes high-temperature operation limit. It was found that the doping by the impurities creating deep levels in the GaP bandgap with a level of ~10^{15}÷10^{17} cm^{-3} allows increasing the high-temperature operation limit of the diode by ~30÷50 K.

The calibration of diode TRC is one of the major problems in applications of GaP thermodiodes as DTS. It was proposed [22] to use for this purpose the dependence of $E_g(T)$ in the base layer of the diode, which, in turn, was determined by processing and averaging of experimental TRCs of the diodes. This method of calibration (testing) will allow avoiding the usage of expensive sensors – standards (thermal resistors made of precious metal alloys are usually used) in a number of practical applications of DTS. In addition, there is an opportunity for the rapid calibration of DTS in practice to move from the individual graduation of sensors to the group one, when individual devices can be grouped into separate groups according to their structural and technological features.

6. 2. Discussion of study results of DTS based on AlGaAs/GaAs epitaxial structures

From the studies [19] it follows that the increase of the solid solution composition x leads to a rise of the thermal sensitivity at one and the same value of the forward current which can be seen on the respective TRCs from that work (Fig. 2).

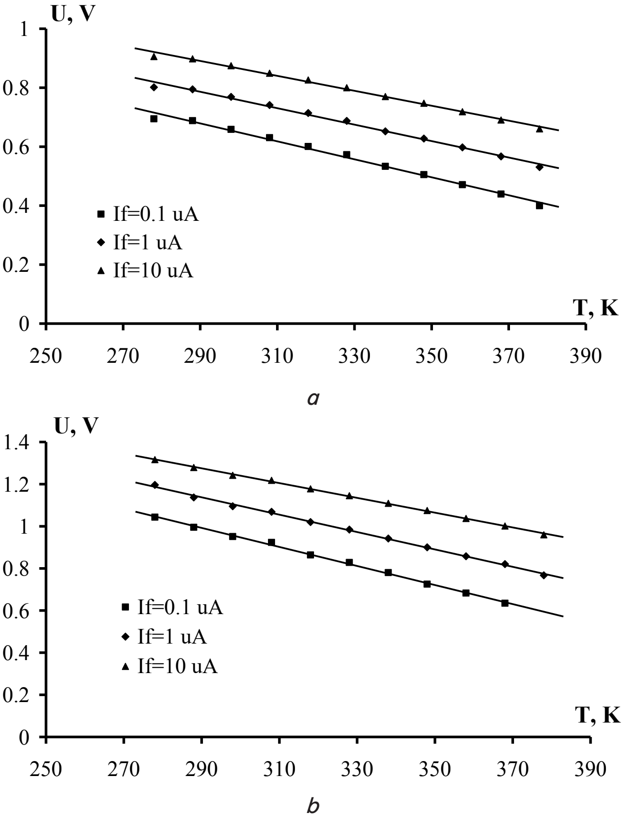

Fig. 2. Temperature response characteristics of the experimental samples of AlGaAs DTS with AlAs content in the diode base layer: *a* – x=0.1; *b* – x=0.35; separate points correspond to experimental measurement data; solid lines are the least-squares fit of the data.

For example, for $I=10^{-7}$ A, the value of $s=-2.92$ mV/K at $x=0.1$ and $s=-4.8$ mV/K at $x=0.35$. The latter may be connected with the current flowing mechanism in the diode DH with a low doped base [23].

It should be noted that according to the work [19], the TRCs are highly linear in the studied temperature range. Therefore, such DTSs are promising for applications as wide-range sensors. We should note that the TRC of DTS commercially produced on the basis of AlGaAs model TG-120 by Lake Shore Cryotronics Inc. [9] is nonlinear in the same range of temperatures, which is known to lead to complication of the temperature measurement equipment set in the exploitation process.

6. 3. Discussion of study results of DST based on III-V nitride structures

It should be noted that the identity index of DTS samples within the batch of diodes selected by calibration results did not exceed ±1.35 K, which, in particular, can be compared with the similar index of GaP diodes.

Thus, the technique of formation of InGaN device structures and manufacturing of pilot samples of high-temperature DTS has been developed and tested. This technique with some improvement can be used for manufacturing DTS and other high-temperature electronic and optoelectronic devices, practically the entire range of solid solutions in the InN-GaN system. At the same time, the main technological processes on which the proposed technique is based are substantially simpler and do not require the use of expensive equipment, as they do in case of analogue technologies of LEDs and lasers based on III-V semiconductor nitrides. The measurement of TRC of experimental samples also showed that the use of wide bandgap III-V nitride structures (InN-GaN) will make it possible to significantly extend the operation range of high-temperature DTS.

It is necessary to note that the well-known concept of the usage of wide bandgap semiconductor materials for the fabrication of diode temperature sensor structures applied in this work makes it possible to significantly extend the high-temperature limit of operation of these sensors as compared to existing analogs. However, the choice of the semiconductor materials for DTS proposed in this work is not limited just by phosphides, arsenides and nitrides of III–V compounds. Now there are a great number of prospective developments of semiconductor devices, including diodes, based on other wide bandgap materials such as II–VI compounds, silicon carbide of various polytypes, diamond, oxide semiconductors, etc. The results of investigations in this area look promising considering their usage in the applications of extreme electronics. Thus, further extension of the high-temperature limit of operation, thermal sensitivity increase and the linearity improvement can be achieved by development and fabrication of the DTS structures based on the new promising materials mentioned.

7. Conclusions

1. The experimental method of obtaining GaP diode structures of n^+-n-p^+-type by the LPE is elaborated for a wide spectrum of applications in high-temperature optoelectronics, electronics and thermometry.

2. The technological stages of fabrication of pilot high-temperature DTS samples based on n^+-n-p^+-GaP structures have been determined. It has been shown experimentally that the high-temperature limit of operation of the manufactured pilot DTS based on gallium phosphide exceeds the limit of functioning of the known commercial silicon DTS by 200÷300 K.

3. The experimental technique of obtaining epitaxial structures of AlGaAs solid solutions and manufacturing the DTS on their basis for high-temperature thermometry has been developed. It was shown that the increase of the composition x of $Al_xGa_{1-x}As$ solid solutions in the active region up to $x \approx 0.32 \div 0.4$ for the device realized on the DH-type structure allows extending the TRC length approximately by 150÷250 K into the high-temperature region and at the same time achieving the value of the sensor thermal sensitivity of ~4.5 mV/K at the forward current through the diode of 0.1÷1.0 μA.

4. Basic technological conditions of the experimental technique of formation of InGaN device structures for applications in high-temperature thermometry and manufacturing of pilot DTS have been established. It was shown that the TRC length of the investigated DTS in the region of high temperatures can achieve the values of 600÷750 K at the practical level of thermal sensitivity of ~2.0÷2.5 mV/K and forward currents through the diode of ≤10 μA.

On the basis of complex investigations conducted, the availability of the physical and technological concept of development of high-temperature DTS is determined. The main objectives assigned were resolved using commercially adapted technologies of semiconductor materials and device structures of GaP, solid solutions in the Al-Ga-As system and III–V nitrides.

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