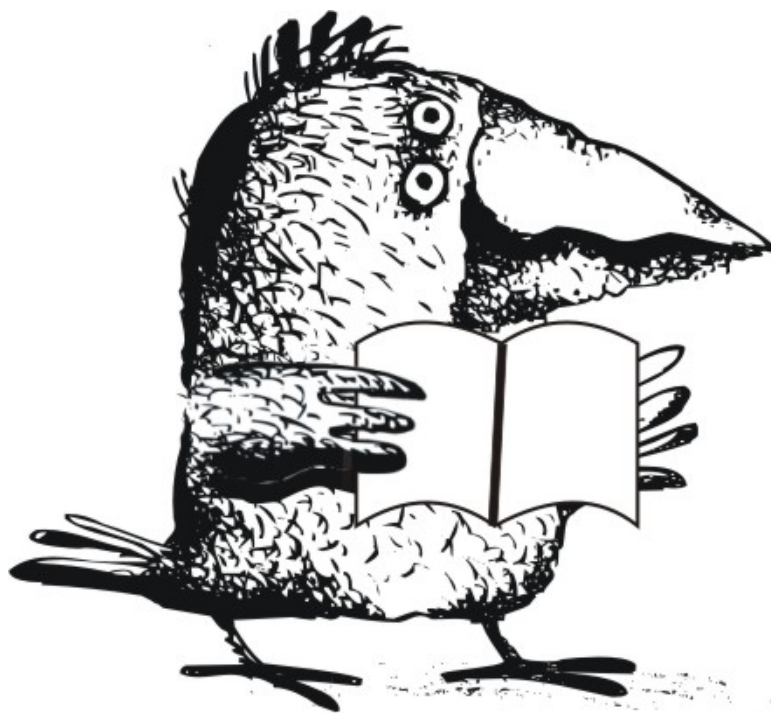


«Saint Petersburg OPEN 2021»



BOOK of ABSTRACTS

**8th International School and Conference
on Optoelectronics, Photonics,
Engineering and Nanostructures**

May 25-28, 2021 • Saint Petersburg, Russia

“Saint Petersburg OPEN 2021”

8th International School and Conference on
Optoelectronics, Photonics, Engineering and
Nanostructures

St. Petersburg, Russia, May 25 – 28, 2021

BOOK of ABSTRACTS



Academic University Publishing
St. Petersburg, 2021



NATIONAL RESEARCH
UNIVERSITY

Copyright © by 2021 National Research University Higher School of Economics - St. Petersburg and individual contributors. All rights reserved. No parts of this electronic publication may be multiple copied, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the written permission of the publisher. Single photocopies of single articles may be made for private study or research.

8th International School and Conference “Saint Petersburg OPEN 2021” on Optoelectronics, Photonics, Engineering and Nanostructures carries on the tradition of annual conferences and schools organized at St Petersburg Academic University for students, PhD students and young scientists.

More detailed information on the School and Conference is presented on <https://spb.hse.ru/spbopen/>

The Book of Abstracts includes abstracts of contributed works accepted for presentation at the Conference.

The volume was composed by HSE University - St. Petersburg from electronic files submitted by the authors. Only minor technical corrections were made by the composers.

Chief Editor: A. E. Zhukov

Published by
HSE University - St. Petersburg,
Soyuza Pechatnikov 16, 190121, St Petersburg,
Printed in Russian Federation

Organizers



NATIONAL RESEARCH
UNIVERSITY



St Petersburg Academic University

Acknowledgements



SPIE.

**STUDENT
CHAPTER**

SAINT-PETERSBURG
ACADEMIC UNIVERSITY
RUSSIAN ACADEMY
OF SCIENCES

IOP Institute of Physics

НАЦИОНАЛЬНЫЕ ПРОЕКТЫ РОССИИ

**НАУЧНЫЙ ЦЕНТР МИРОВОГО УРОВНЯ
«ПЕРЕДОВЫЕ ЦИФРОВЫЕ ТЕХНОЛОГИИ»**

Санкт-Петербургский политехнический университет Петра Великого (координатор консорциума)	Санкт-Петербургский государственный морской технический университет	Тюменский государственный университет	НИИ гриппа имени А.А. Смородинцева Минздрава России

Head of Program Committee

Alexey E. Zhukov

corr. member of the RAS, *HSE University, Russia*

Program Committee

Aleksandr V. Omelchenko (HSE University- St.Petersburg)

Andrey A. Lipovskii (Peter the Great St.Petersburg Polytechnic University, Russia)

George E. Cirlin (Alferov University, Russia)

Valentina V. Zhurikhina (Peter the Great St.Petersburg Polytechnic University, Russia)

Natalia V. Kryzhanovskaya (HSE University- St.Petersburg)

Anna Baldycheva (University of Exeter)

Kate Berseneva (University of Exeter)

Head of Organizing Committee

Alexey E. Zhukov (HSE University- St.Petersburg)

Organizing Committee

Mikhail V. Maximov (Ioffe Institute, Alferov University, Russia)

Andrey A. Lipovskii (Peter the Great St.Petersburg Polytechnic University, Russia)

Valentina V. Zhurikhina (Peter the Great St.Petersburg Polytechnic University, Russia)

Vladimir V. Korenev (Alferov University, Russia)

Eduard I. Moiseev (HSE University- St.Petersburg)

Anna S. Dragunova (Alferov University, Russia)

Svetlana A. Kadinskaya (Alferov University, Russia)

Yulia S. Balezina (Alferov University, Russia)

Elizaveta O. Kotko (HSE University- St.Petersburg)

Invited Speakers

Will it be possible to make room temperature THz quantum cascade lasers? R.A. Khabibullin, D.S. Ponomarev, D.V. Ushakov, A.A. Afonenko.....	18
Towards International Year of Glass: from Vessels to Photonics A A Lipovskii.....	20

Crystal growth and structural properties of semiconductor materials and nanostructures

Termo induced functional material based on Mie-resonant silicon nanoparticles covered with polymer shell 1-1 Anna A. Nikitinaa, Valentin A. Milichko, Artem O. Larin, Mikhail V. Rybin, Yuri S. Kivshar, Ekaterina V. Skorb.	22
Study of the effect of plasma frequency on the parameters of vertically oriented CNT 1-2 N N Rudyk, O I Il'in, M V Il'ina, O R Polyvyanova, A A Fedotov.....	24
Nanostructuring at oblique incidence deposition of cobalt 1-3 A A Akulov, O S Trushin, A A Popov, A N Pestova and L A Mazaletsky.....	26
Synthesis of gold nanoparticles by the spark discharge method for ultraviolet plasmonics 1-4 V I Borisov, A A Lizunova, D Malo, A A Ramanenka and V V Ivanov.....	28
Growth of lithium niobate thin films by PLD on SiO₂/Si structures 1-5 Z Vakulov, D Khakhulin, A Geldash, V S Klimin, O A Ageev.....	30
Influence of magnetron sputtering modes on the parameters of ZnO:Ga films 1-6 A A Geldash, E Yu Gusev, V N Dzhuplin, O A Ageev.....	32
Method for the modification of graphite to a solid mixture of single crystals of silicon carbide and graphite 1-7 A S Grashchenko, S A Kukushkin, A V Osipov and A V Redkov.....	34
The scalable production of high-quality nanographite by organic radical-assisted electrochemical exfoliation 1-8 E Grushevski, D Savelev, L Mazaletski, N Savinski and D Puhov.....	37
Estimation of thermodynamic stability of isoperiodic epitaxial structures whith GaInSbAs and GaInAsP solid solutions 1-9 E M Danilina, A S Paschenko.....	39
Study of In/GaAs nanodroplet formation in conditions of nonstationary supersaturation during droplet epitaxy 1-10 D D Dukhan, S V Balakirev, N E Chernenko, M M Eremenko and M S Solodovnik.....	41
Stress relaxation mechanisms in hybrid SiC/Si(111) substrates grown by the atomic substitution method 1-11 I.A. Ereemeev, A.A. Koryakin and S.A. Kukushkin.....	43
Study of the initial stage of GaAs growth on FIB-modified silicon substrates 1-12 M M Eremenko, M S Solodovnik, S V Balakirev, N E Chernenko and O A Ageev.....	45
The Structure of a Multilayer Heterogeneous System [(Co₄₀Fe₄₀B₂₀)₃₄(SiO₂)₆₆/ZnO/SnO₂]₃₃ 1-13 O.V. Zhilova, S.Yu. Pankov, V.A. Makagonov, I.V. Babkina, D.N. Mosolov.....	47
Effect of the Young's modulus of polycrystalline silicon on the characteristics of MEMS accelerometer 1-14 J Y Jityaeva, E Yu Gusev.....	49
Development of epitaxial PbS layers obtaining method for photoelectric transducers 1-15 T O Zinchenko, E A Pecherskaya, A V Volik, O A Timohina, V S Alexandrov, V V Antipenko.....	51
Optical and structural properties of the GaAs heterostructures grown using AlGaAs superlattice buffer layer on compliant Si(100) substrates with the preformed porous-Si (por-Si) layer 1-16 Zolotukhin D, Seredin P, Lenshin A, Goloshchapov D, Khudyakov Y, Radam Ali O, Arsenteyev I, Leiste H.....	53
Core-shell InGaN nanowires on Si substrates: MBE growth and physical properties 1-17 V O Gridchin, R R Reznik, K P Kotlyar, A S Dragunova, D A Kirilenko, N V Kryzhanovskaya, G E Cirlin.....	55
Effect of the ultra-low arsenic flux on characteristics of In(As) nanostructures formed during droplet epitaxy 1-18 D V Kirichenko, S V Balakirev, N E Chernenko, M M Eremenko and M S Solodovnik.....	57
Quantitative analysis of metastable wurtzite phase into the self-catalyzed GaP NWs 1-19 Koval O Yu, Fedorov V V, Eliseev I E, Bolshakov A D, Burkovsky R G, Mukhin I S.....	59
Laser sintering of oxidized copper nanoparticles deposited by dry aerosol printing 1-20 D V Korniyushin, A A Efimov, A I Buchnev, E I Kameneva and V V Ivanov.....	62

4-23	Vinyl group content as a tool to govern the properties of modified hyaluronic acid for scaffold fabrication via photoinduced crosslinking A.V. Sochilina, A.G. Savelyev, V.P. Zubov, E.V. Khaydukov, A.N. Generalova.....	428
4-24	Femtosecond laser synthesis and comparative analysis of fluorescent carbon dots from L-lysine aqueous solution A A Astafiev, A M Shakhov, A A Gulin, A A Vasin, M V Gubina, M S Syrchina and V A Nadtochenko.....	430
4-25	Computational modeling of schedule-specific chemotherapy outcomes in mouse tumor models I.N. Terterov, V. A. Chubenko, N.A. Knyazev, V.V. Klimenko, A.A. Bogdanov, V.M. Moiseyenko, A.A. Bogdanov.....	433
4-26	Investigation of the polymerization rate of hydrogel microparticles in microfluidic device A A Tushkevich, N A Filatov, A S Bukatin.....	435
4-27	Synthesis of Calcium Carbonate Particles with Different Geometries L.I. Fatkhutdinova, H. Bahrom, A.A. Goncharenko, O. Peltek, A. Muslimov, A. Manchev, I. Shishkin, R.E. Noskov, A. S. Timin, P. Ginzburg, M.V. Zyuzin.....	437
4-28	Analysis of the limiting behavior of a biological neurons system with delay E G Fedorov, I Yu Popov.....	439
4-29	A split flavin binding fluorescent reporter to detect proteinprotein interactions A N Yudenko, A Smolentseva, I Maslov, O Semenov, I Kaiumov, A A Remeeva and I Gushchin.....	441
4-30	Comparison of the effectiveness of blood transfusion and reinfusion E V Pimakhina, A A Pimakhin, N V Vishnykov, N M Tolkach, S B Arsentiev.....	443

Electric, Magnetic and Microwave Devices

5-1	Double slot aerosol jet printed antenna for X-band applications P V Arsenov, A S Sobolev, A A Efimov and V V Ivanov.....	445
5-2	Terahertz Detector Utilizing a SiO₂/Graphene/SiO₂ Sandwich Suspended at the Feed of a Planar Antenna I Belikov, M Rybin, A Prikhodko, D Mikhailov, I Gayduchenko, A Shurakov, G Goltsman.....	447
5-3	The use of digital data processing to improve the metrological characteristics of the rubidium frequency standard A P Valov, K G Arinushkina, V V Davydov, V Yu Rud.....	449
5-4	Method for reducing phase fluctuations of a precision frequency response meter for microwave quantum generators M A Vodopyanov, K A Menzorov, V V Davydov and V Yu Rud.....	451
5-5	Improving the accuracy of the method for measuring the electrophysical parameters of soft magnetic materials A V Volik, E A Pecherskaya, Yu A Varenik, T O Zinchenko, D V Artamonov, O A Timohina.....	453
5-6	Graphene FET detector as THz mixer A. Gazaliev, M. Moskotin, V. Belosevich, M. Rybin, I. Gayduchenko and G. Goltsman.....	455
5-7	Features of the formation of the frequency of the microwave excitation signal in the quantum frequency standard on rubidium atoms - 87 A S Grevtseva, V V Davydov and V Yu Rud.....	457
5-8	Scanning ion-conductance microscope with modulation of the sample position along the Z-coordinate and separate Z-axial and lateral (X, Y) scanning M V Zhukov, S Yu Lukashenko, I D Sapozhnikov, M L Felshtyn, O M Gorbenko, A O Golubok.....	459
5-9	The influence of the lower electrode materials of aligned carbon nanotubes on their piezoelectric response M V Il'ina, O I Il'in, O I Osotova, N N Rudyk and O A Ageev.....	462
5-10	Research and calculation of dynamic characteristics of a microelectromechanical device I E Lysenko, N F Kidyayev, O A Ezhova, D Y Sevostyanov.....	464
5-11	Study of characteristics of n-p-n type bipolar power transistor in small-sized metalpolymeric package type SOT-89 D A Knyagin, E A Kulchenkov, S B Rybalka, A A Demidov.....	466
5-12	GaN power IC normally-on and normally-off transistors technology and simulation V A Bepalov, V I Egorkin, O B Kukhtyaeva, V E Zemlyakov, V V Kapaev, A A Zaitsev.....	468
5-13	Information and measuring system for monitoring the parameters of overhead power lines V A Listyuhin, E A Pecherskaya, O A Timokhina.....	470
5-14	Modified quantum frequency standard on Hg-199 ions N A Lukashov, V V Davydov, V Y Rud.....	472
5-15	Development of a fiber-optic microwave signal transmission system for an X-band receiving module with dual frequency conversion A V Moroz, V V Davydov, D V Gubareva and V Yu Rud'.....	474

	New nuclear magnetic resonance magnetometer design for studying variations of the mid-field magnetic strength	
5-16	N S Myazin, V V Davydov	476
	Four-point probe stand for magnetoresistance measurement of unpatterned wafers	
5-17	A N Pestova, O S Trushin	478
	Towards Multipixel THz Schottky Diode Detector with a Single RF Output Line	
5-18	A Prikhodko, I Belikov, D Mikhailov, A Shurakov, G Goltsman	480
	The scalable production of high-quality nanographite by organic radical-assisted electrochemical exfoliation	
5-19	D Savelev, E Grushevski, N Savinski, M Soloviev, V Turov and V Krenev	482
	Research Of Dynamic Characteristics Of A Three-axis Micromechanical Gyroscope-Accelerometer	
5-20	I E Lysenko, D Y Sevostyanov, N F Kidyaev, A V Kovalev	484
	Silicon carbide of 4H-SiC type Schottky diode current-voltage characteristics in small-sized type metal-polymeric package SOT-89	
5-21	S V Sedykh, S B Rybalka, A A Demidov, E A Kulchenkov	486
	Structural, magnetic and electrical properties of the Co₂MnZ (Z = Al, Si, Ga, Ge) Heusler compounds – structural magnetic materials for spintronics	
5-22	A A Semiannikova, Yu A Perevozchikova, E B Marchenkova and V V Marchenkov	488
	Electrophysical properties of SnO₂-ZnO thin films prepared by sol-gel method	
5-23	V Yu Storozhenko, M G Volkova, A P Starnikova, V V Petrov, E M Bayan	490
	Monolithic transistor switch for microwave radiometry	
5-24	V G Tikhomirov, Y V Solov'ev, A G Gudkov, M K Popov, S V Chizhikov	492
	Design and analysis of the inline RF MEMS switch for application in 5G mobile networks	
5-25	A V Tkachenko, I E Lysenko, A V Kovalev, D V Vertyanov	494
	A seesaw-type MEMS switch with enhanced contact force: the first results	
5-26	I V Uvarov, N V Marukhin	498
	Design and simulation of the compact MEMS energy harvester based on aluminium nitride	
5-27	P S Shlepakov, I V Uvarov	500
	Single GaN nanowires for high current commutation devices	
5-28	K Yu Shugurov, A M Mozharov, V V Fedorov, G A Sapunov and I S Mukhin	502
	Supercapacitor with electrodes based on high-purity singlewalled carbon nanotubes	
5-29	A Shumilin, N Gorshkov, A Aman, A Fomin, S Palis	504
	Analysis of the possibility of creating an acoustic velocity sensor using GaN epitaxial films	
5-30	Y. Enns, A. Kazakin, A Mizerov, R Kleimanov	506
	LK-5 glass surface modification by glass blowing method based on microsystem technology	
5-31	A Dzhinikashvili, Y Enns, R Kleimanov and A Kazakin	508
	Study of thermal relaxation in thin NbN films by noise thermometry	
5-32	M D Soldatenkova, E M Baeva, A D Triznova, P I Zolotov, A I Lomakin, A I Kardakova, G N Goltsman	510
	Materials absorbing electromagnetic radiation with resistive coating (Co₄₀Fe₄₀B₂₀)_x(SiO₂)_{100-x}	
5-33	Tarasova Oksana, Sitnikov Alexandr, Klapanov Anton	512
	Prospective directions for the development of microwave frequency standards for satellite navigation systems	
5-34	Ding Wang, V V Davydov and V Yu Rud	514

Other Aspects of Nanotechnology

	Structure and characteristics of a thin-layer "aluminum - carbon nanotubes" sandwich structure	
6-1	A Fomin, V Koshuro, A Aman, S Palis	520
	Investigation of the thermal properties of In-doped Ge₂Sb₂Te₅ materials for phase change memory application	
6-2	A Bozhedomova, A Babich, A Yakubov, E Krivogina, I Voloschuk, A Sherchenkov	522
	Varieties of carbon nanostructures in a flame	
6-3	O V Vasilyeva, S I Ksenofontov and A N Lepaev	524
	Enhancing the physical and mechanical properties of tantalum by induction chemical thermal treatment	
6-4	A V Voyko, A M Gerasimov, M A Fomina and V A Koshuro	526
	Investigation of the effect of temperature on the energy spectrum of indium antimonide quantum dots	
6-5	M V Gavrikov, V F Kabanov	528
	Solid-state phase transition in n-alkanes of different parity	
6-6	S A Gureva, A K Borisov, V A Marikhin, V M Egorov	530

Silicon carbide of 4H-SiC type Schottky diode current-voltage characteristics in small-sized type metal-polymeric package SOT-89

S V Sedykh, S B Rybalka, A A Demidov, E A Kulchenkov

Bryansk State Technical University, Bryansk, 50 let Oktyabrya 7, Russia

Abstract. The forward and reverse current–voltage characteristics of Ti/4H-SiC Schottky diode in small-sized (SOT-89) type metal-polymeric package have been obtained. On the base of analysis it is shown that Schottky diode corresponds to the “ideal” diode with ideality factor $n \approx 1.012$ and effective Schottky barrier height $\phi_B = 1.23$ eV.

1. Introduction

It is known that the silicon carbide (SiC) Schottky diodes are key component of power semiconductor electronics devices for high-temperature device applications because of its high breakdown voltage, low series resistance and stability under high temperature conditions [1]. Now modern power electronic industry comes down to use of small type of metalpolymeric package such as SOT (Small Outline Transistor), QFN (Quad Flat No-leads) and others [2], but in Russia manufacture of the main electronic components earlier was produced in standard large-sized package (DIP (Dual In-line Package), TO (Transistor Outline) and others) type. Therefore, recently by electronic company the «GROUP KREMNY EL» (Bryansk, Russia) the production of SiC Schottky diodes for power electronics began within the framework of import substitution program. In our previous studies were investigated some characteristics of the SiC Schottky type diodes made in small type of metalpolymeric packages [3]. In this study the main goal is establish current-voltage characteristics of Ti/4H-SiC Schottky diode made in small-sized (SOT-89) type of metalpolymeric package.

2. Materials and methods

In experiments was tested the following Ti/4H-SiC type Schottky diode DDSH411A91 (JSC «GRUPPA KREMNY EL», Bryansk, Russia) in small-sized SOT package type (SOT-89, package dimensions – 4.6×2.6 mm). The parameters of Ti/4H-SiC type Schottky diode were the following: the concentration of donors (nitrogen) in the substrate equals 10^{18} cm⁻³ (thickness of substrate is 300 μm), concentration of donors in the *n*-type epitaxial layer (nitrogen) equals 4.75×10^{15} cm⁻³, concentration of p+ donors in the guard rings (boron, depth of guard about 2 μm) regions 10^{18} cm⁻³, the guard p+ rings consist from one of big guard ring with width of 30 μm and five small guard rings with width of 5 μm (the distance between guard rings was 5 μm), JTE (Junction Terminate Extension) layer formed by boron implantation with p+ concentration 4.75×10^{17} cm⁻³ (extending 30 μm beyond the edge of the last p+ guard ring), anode material is Ti (titanium), the thickness of the epitaxial layer (4H-SiC) was 14 μm, the radius of the diode equals $r = 680$ μm. For measuring the direct and reverse current-voltage characteristic were used a programmable source AKIP 1144-160-40, Tektronix MDO3102 two-channel oscillograph (bandwidth 1 GHz, refresh rate 5 GS/s) and Fluke 8845A digital multimeter.

3. Results and discussion

In Figure 1 is shown the forward current-voltage characteristic for DDSH411A91 Schottky diode in small-sized SOT-89 type package obtained at temperature of 25°C. Further, in Figure 2 presents the reverse current-voltage characteristics for DDSH411A91 Schottky diode (25°C). As follows from current-voltage characteristic the fabricated DDSH411A91 Schottky diode in small-sized package operate with forward current up to 2 A and breakdown voltage 1200 V in reverse direction mode.

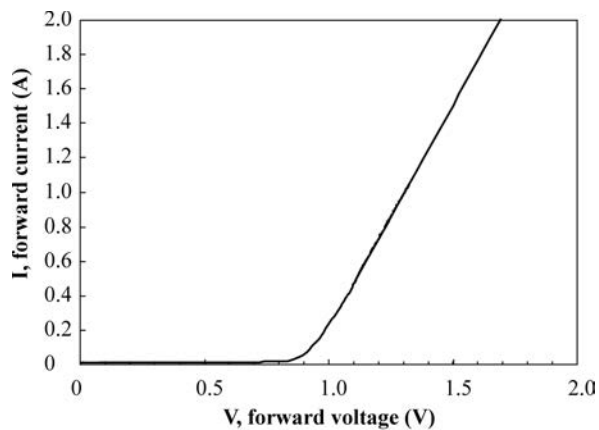


Figure 1. Ti/4H-SiC Schottky diode DDSH411A91 in small-sized SOT-89 type package forward current-voltage characteristic.

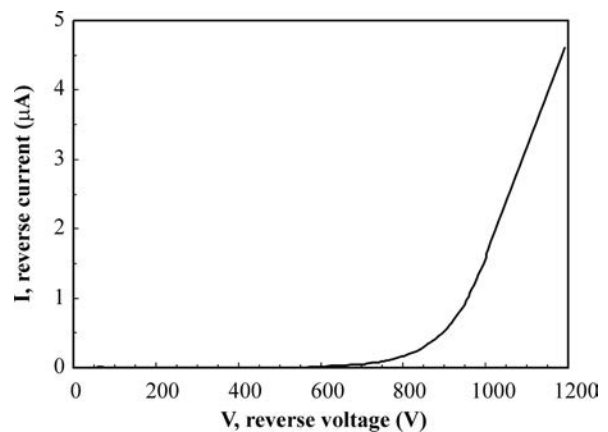


Figure 2. Ti/4H-SiC Schottky diode DDSH411A91 in small-sized SOT-89 type package reverse current-voltage characteristics.

Analysis of experimental results in framework of classical diode theory [1,4] shows that ideality factor of DDSH411A91 diode equal 1.012 and effective Schottky barrier height $\phi_B=1.23$ eV.

4. Conclusions.

Forward and reverse current-voltage characteristic for DDSH411A91 (Ti/4H-SiC) Schottky type diode in small-sized SOT-89 metalpolymeric package were obtained. It is shown that fabricated Ti/4H-SiC Schottky diode demonstrate current up to 2 A in forward direction and breakdown voltage 1200 V. It is established that ideality factor of diode is 1.012 and effective Schottky barrier height $\phi_B=1.23$ eV.

Acknowledgements

This work was carried out with financial support of the Russian Ministry of Science and High Education within the framework of complex project by creation of highly technological industry «Creation of highly technological industry of silicon and silicon carbide microelectronic technics products in small-sized metal-polymeric packages of the SOT, SO and QFN types» (agreement of 29 November No. 075-11-2019-035) at the organization of the leading performer of RDDTE (Research and Development Design and Technological Engineering) the Bryansk State Technical University.

References

- [1] Baliga B J 2019 *Wide Bandgap Semiconductor Power Devices: Materials, Physics, Design, and Applications* (Cambridge: Woodhead Publishing–Elsevier)
- [2] Lu D, Wong C P 2017 *Materials for advanced packaging* (Cham: Springer International Publishing)
- [3] Rybalka S B, Kulchenkov E A, Demidov A A, Zhemoedov N A, Drakin A Yu, Zotin V F, Shishkina O A 2020 *J. Phys.: Conf. Ser.* **1679** 022045
- [4] Ivanov P A, Grekhov I V, Il'inskaya N D, Kon'kov O I, Potapov A S, Samsonova T P, Serebrennikova O U 2011 *Semiconductors* **45**(5) 668