
National Academy of Sciences of Ukraine
V. Lashkaryov Institute of Semiconductor Physics

International Scientific Journal

Semiconductor Physics Quantum Electronics & Optoelectronics



Volume 21, N 4
2018

**The 21st volume of SPQEO is dedicated to the 100-year anniversary
of the National Academy of Sciences of Ukraine**

During this 100-year period, a huge cohort of Ukrainian scientists, engineers and researchers made an immense contribution to development of our country in all fields of economics. And it is a great pleasure to be aware of the fact that our journal for the recent 20 years has been taking part in this progress by helping the researchers to exchange information on their ideas and results of investigations. The journal was, is and will be focused at up-to-date achievements in semiconductor physics, nano- and heterostructures, linear and nonlinear solid-state optics, quantum electronics, optoelectronics and sensorics.

Registered by the Ministry of Justice of Ukraine. Certificate KB #23200-13040.

Published since 1998. ISSN 1560-8034 ISSN 1605-6582 (On-line)

SPQEO has been selected for coverage in Clarivate Analytics products and services since 2018 Volume 21 №1.

© V. Lashkaryov Institute of Semiconductor Physics
National Academy of Sciences of Ukraine
Web: www.journal-spqeo.org.ua



Editorial Board Address:
41, prospect Nauky, 03680 Kyiv, Ukraine
Phone: +380 (44) 525 6497; Fax: +380 (44) 525 8342
E-mail: journal@journal-spqeo.org.ua
E-mail: journal@isp.kiev.ua

EDITORIAL BOARD

EDITOR-IN-CHIEF

A.E. Belyaev V. Lashkaryov Institute of Semiconductor Physics (ISP), National Academy of Sciences of Ukraine (NASU), Kyiv

DEPUTY EDITORS-IN-CHIEF

V.P. Kladko V. Lashkaryov Institute of Semiconductor Physics (ISP), NASU, Kyiv, Ukraine
V.A. Kochelap V. Lashkaryov Institute of Semiconductor Physics (ISP), NASU, Kyiv, Ukraine
M.V. Strikha V. Lashkaryov Institute of Semiconductor Physics (ISP), NASU, Kyiv, Ukraine

INTERNATIONAL ADVISORY COUNCIL

S. Asmontas	Semiconductor Physics Institute, Vilnius, Lithuania	W. Knap	CNRS, France, Poland
M.S. Brodyn	Institute of Physics, NASU, Kyiv, Ukraine	Z.F. Krasilnik	Institute for Physics of Microstructures, RAS, Russia
M.L. Calvo	Complutense University of Madrid, Spain	A.P. Litvinchuk	University of Houston, USA
D. Flandre	Institute of Information and Communication Technologies, Louvain-la-Neuve, Belgium	St. Lucyszyn	Imperial College London, United Kingdom
F.J. Gamiz Perez	University of Granada, Spain	H. Lüth	Institute of Semiconductor Nanoelectronics, Julich, Germany
S.V. Gaponenko	B. Stepanov Institute of Physics, National Academy of Science of Belarus, Minsk, Belarus	A. Medvids	Riga Technical University, Latvia
I. Grzegory	Institute of High Pressure, Poland	J.R. Morante	Institute of Renewable Energy Catalonia, Barcelona, Spain
		G. Salamo	University of Arkansas, USA
		M.S. Soskin	Institute of Physics, NASU, Ukraine
		D.R.T. Zahn	Chemnitz University of Technology, Germany

EDITORIAL BOARD MEMBERS

I.V. Blonskii	Institute of Physics, NASU, Kyiv, Ukraine	V.M. Poroshin	Institute of Physics, NASU, Kyiv, Ukraine
I.M. Dmytruk	T.G. Shevchenko National University, Kyiv, Ukraine	I.V. Prokopenko	V. Lashkaryov ISP, NASU, Kyiv, Ukraine
V.I. Grygoruk	T.G. Shevchenko National University, Kyiv, Ukraine	O.G. Sarbei	Institute of Physics, NASU, Kyiv, Ukraine
L.S. Homenkova	V. Lashkaryov ISP, NASU, Kyiv, Ukraine	F.F. Sizov	V. Lashkaryov ISP, NASU, Kyiv, Ukraine
I.Z. Indutnyy	V. Lashkaryov ISP, NASU, Kyiv, Ukraine	V.M. Sorokin	V. Lashkaryov ISP, NASU, Kyiv, Ukraine
R.V. Konakova	V. Lashkaryov ISP, NASU, Kyiv, Ukraine	V.I. Sugakov	Institute of Nuclear Research, NASU, Kyiv, Ukraine
A.M. Morozovska	Institute of Physics, NASU, Kyiv, Ukraine	P.M. Tomchuk	Institute of Physics, NASU, Kyiv, Ukraine
V.S. Lysenko	V. Lashkaryov ISP, NASU, Kyiv, Ukraine	M.Ya. Valakh	V. Lashkaryov ISP, NASU, Kyiv, Ukraine
A.G. Naumovets	Institute of Physics, NASU, Kyiv, Ukraine	O.I. Vlasenko	V. Lashkaryov ISP, NASU, Kyiv, Ukraine
A.I. Nosich	Institute for Radiophysics and Radioelectronics, NASU, Kharkiv, Ukraine	Yu.I. Yakimenko	National Technical University «KPI», Kyiv, Ukraine
P.F. Oleksenko	V. Lashkaryov ISP, NASU, Kyiv, Ukraine	V.M. Yakovenko	Institute for Radiophysics and Radioelectronics, NASU, Kharkiv, Ukraine
V.V. Petrov	Institute for Information Recording, NASU, Kyiv, Ukraine		

SENIOR EXECUTIVE EDITOR

P.S. Smertenko V. Lashkaryov Institute of Semiconductor Physics (ISP), NASU, Kyiv, Ukraine

EXECUTIVE SECRETARY

A.A. Kudryavtsev V. Lashkaryov Institute of Semiconductor Physics (ISP), NASU, Kyiv, Ukraine