

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
KYIV NATIONAL UNIVERSITY OF TECHNOLOGIES AND DESIGN  
INTERNATIONAL SOCIETY OF ELECTROCHEMISTRY  
IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE

**PROMISING MATERIALS  
AND PROCESSES  
IN APPLIED ELECTROCHEMISTRY**

Monograph

The monograph was recommended for publication by the Scientific  
Council of Kyiv National University of Technologies and Design

Kyiv 2017

**UDC 621.35=111**  
**BBC 24.57**  
**P 93**

*Monograph has been recommended by the Scientific Council of Kyiv National University of Technologies and Design (KNUTD) for the wide range of lectors, scientists, PhD students, holders of a master's degree and students of Universities, engineers and technicians of various electrochemical enterprises.*  
(Protocol No 9 of 19.04.2017)

*Editor's Board:*

*V. Z. Barsukov – Prof.Dr., head of department for KNUTD, ISE member;*  
*Yu. V. Borysenko – PhD, senior lecturer for KNUTD;*  
*O. V. Linyucheva – Prof.Dr., head of department for Igor Sikorsky Kyiv Polytechnic Institute, ISE member;*  
*I. V. Senyk - PhD, researcher for KNUTD, ISE member;*  
*V. G. Khomenko – PhD, Postdoc for KNUTD.*

*Reviewers:*

*Ye. V. Kuzminskiy – Prof.Dr., head of department for Igor Sikorsky Kyiv Polytechnic Institute;*  
*O. A. Pud – Prof.Dr., head of department for Institute of Bioorganic Chemistry and Petrochemistry of the National Academy of Sciences of Ukraine, ISE member.*

**P93** Promising Materials and Processes in Applied Electrochemistry: Monograph / V. Z. Barsukov, Yu. V. Borysenko, O. V. Linyucheva, I. V. Senyk, V. G. Khomenko; editor-in-chief V. Z. Barsukov. Kyiv.: KNUTD, 2017. – 270 pages.

ISBN 978-966-7972-79-0

The promising processes and materials have been considered in such key directions of applied electrochemistry as electrochemical power sources, electroplating, corrosion protection, electrochemical sensors, modern electrochemical and related technologies during the last years. A state of art in these key directions of electrochemistry determines a progress in general development of science and engineering of XXI century and promotes to creation of essentially new types of production and technologies. Monograph has been recommended for scientists, lectors, PhD students, engineers and technicians.

**UDC 621.35=111**  
**BBC 24.57**

ISBN 978-966-7972-79-0

© V. Z. Barsukov, Yu. V. Borysenko,  
O. V. Linyucheva, I. V. Senyk,  
V. G. Khomenko, 2017  
© KNUTD, 2017

THANK  
YOU

# Our Sponsors:



INTERNATIONAL SOCIETY OF  
ELECTROCHEMISTRY

<http://www.ise-online.org/>



AMETEK ADVANCED  
MEASUREMENT TECHNOLOGY

<http://www.ameteki.com>

Brands:



MATERIALS LAB Ltd.

[www.materials-lab.com.ua](http://www.materials-lab.com.ua)

# The Next Level of Bipotentiostat Design

Introducing the

## PARSTAT 3000A-DX

- Dual channel potentiostat and hardware synchronized bipotentiostat in one
- Combine with our rotator, accessories, and software for a complete RRDE analysis solution
- Compact design featuring two independent potentiostats each with EIS capability as standard
- A high performance system with  $\pm 30$  V polarization/compliance and  $\pm 2$  A current



 Princeton  
Applied  
Research



 solartron  
analytical

 AMETEK®

[www.princetonappliedresearch.com](http://www.princetonappliedresearch.com)

[www.solartronanalytical.com](http://www.solartronanalytical.com)

[si.info@ametek.com](mailto:si.info@ametek.com)

## CONTENT

INTRODUCTION	11
COLLECTIVE MONOGRAPH AUTHORS	12
<b><u>Part 1. ELECTROCHEMICAL POWER SOURCES</u></b>	
1.1 <b>CARBON MATERIALS FOR HIGH POWER NEGATIVE ELECTRODES OF LITHIUM-ION BATTERIES AND CAPACITORS</b> KHOMENKO V.G., BARSUKOV V.Z., MAKYEYEVA I.S., CHERNYSH O.V.	16
1.2 <b>COMPOSITION OF INTERMEDIATE PHASES SHOWING UP UPON DELITHIATION OF LITHIUM-MANGANESE SPINEL</b> POTAPENKO A.V.	22
1.3 <b>THE DENSITY GRADIENT THERMAL AGING MODEL OF THE ALKALINE Zn-Mn BATTERIES</b> RIABOKIN O.L., BOJCHUK O.V., PERSHINA K.D.	29
1.4 <b>THE ELECTROCHEMICAL REDUCTION OF OXYGEN ON ELECTRODEPOSITED PALLADIUM CATALYST</b> KATASHYNSKI A.S., KHOMENKO V.G., BARSUKOV V.Z.	35
1.5 <b>ORR STUDY ON Fe- AND Co- DOPED MANGANESE DIOXIDE WITH RAMSDELLITE STRUCTURE</b> ZUDINA L.V., SOKOLSKY G.V., BOLDYREV E.I., GAIUK N.V.	42
1.6 <b>MANGANESE DIOXIDE AS A CATHODE CATALYST IN METAL-AIR CELLS</b> MAKYEYEVA I.S., KATASHINSKII A.S., ANDREITSEVA M.V.	49

- 1.7 **CATHODE PROCESSES OF HYDROGEN EVOLUTION ON VANADIUM-CONTAINING MATERIALS** 56  
MAIZELIS A.A., RUDENKO N.O., VORONINA O.V.,  
FINOGENOV O.M., BAIRACHNIY B.I.
- 1.8 **CONDUCTIVITY AND VISCOSITY OF TETRAMETHYLAMMONIUM BIS(SALICYLATO)BORATE IN SOLUTIONS OF APROTIC DIPOLAR SOLVENTS** 61  
DIAMANT V.A., PERSHINA K.D., KAZDOBIN K.A.
- 1.9 **THE EFFECT OF SURFACE MODIFICATION OF CATHODE MATERIALS ON THEIR ELECTROCHEMICAL CHARACTERISTICS** 66  
KRAVETS Y.A., POTAPENKO A.V.

## Part 2. ELECTRODEPOSITION

- 2.1 **USING PULSE MODES IN NON-CHROMIUM ELECTROLYTES FOR ELECTROPOLISHING** 74  
ANTSIKHOVICH I.V., CHERNIK A.A.
- 2.2 **THE INTENSIFICATION OF COMPACT COPPER ELECTROWINNING PROCESS BY INCREASING VERTICAL CURRENT DENSITY AND DISTRIBUTION UNIFORMITY** 81  
USHCHAPOVSKYI D.Yu., MOTRONYUK T.I., LINYUICHEVA O.V.,  
TSYMBALIUK A.S.
- 2.3 **FUNCTIONAL TERNARY Fe-Co-Mo(W) COATINGS** 89  
YERMOLENKO I. Yu., VED' M. V., SAKHNENKO N. D.,  
SACHANOVA Yu. I., LAGDAN I. V., PROSKURINA V. O.
- 2.4 **DYNAMICS OF REDOX PROCESSES IN THE ELECTROLYTE FOR ELECTRODEPOSITION OF Cu-Sn ALLOY** 98  
MAYZELIS A.A., OVCHARENKO G.V.

- 2.5 **INFLUENCE OF ELECTROLYSIS PARAMETERS ON THE PROPERTIES OF Ni-P ALLOYS OBTAINED FROM METHANESULFONATE ELECTROLYTES** 104  
SAVCHUK O. O., SKNAR Yu. E., SKNAR I. V.,  
BEZIK A. O., CHEREMYSINOVA A. O.

**Part 3. CORROSION PROTECTION**

- 3.1 **INFLUENCE OF STRENGTH PROPERTIES OF PIPE STEEL ON ITS CORROSION RESISTANCE AND ELECTROCHEMICAL CHARACTERISTICS IN SOLUTIONS OF DIFFERENT CORROSIVITY** 110  
NYRKOVA L.I., MELNYCHUK S.L., BORYSENKO Yu.V.
- 3.2 **ELECTROCHEMICAL SYNTHESIS OF PROTECTIVE CERIA LAYERS USING METHANESULFONATE ELECTROLYTES** 119  
TSURKAN A.V., VASIL'EVA E.A., PROTSENKO V.S., DANILOV F.I.
- 3.3 **THE INFLUENCE OF ULTRASOUND VIBRATION ON THE PITTING CORROSION OF AISI 316 STAINLESS STEEL** 127  
VASYLIEV G. S., KUSHNIRCHUK S. A.
- 3.4 **VOLTAMMETRIC STUDY OF CORROSION OF MILD STEEL IN DEEP EUTECTIC SOLVENTS** 135  
KITIK A.A., RUBLOVA Y.D., PROTSENKO V.S., DANILOV F.I.

**Part 4. ELECTROCHEMICAL SENSORS**

- 4.1 **ELECTROCHEMICAL DEVICE FOR ENVIRONMENTAL SAFETY MONITORING** 144  
MIROSHNYCHENKO Iu.S.,  
KOSOHIN O.V., LINYUCHEV O.G.

- 4.2 **ANODE MATERIAL OF COULOMETRIC GAS GENERATOR** 152  
MAZANKA V.M., MATVEEV O.M., KOSOHIN O.V.
- 4.3 **PREVENTION OF CARBONIZATION IN THE ALKALINE  
ELECTROLYTE OF OXYGEN SENSOR** 157  
VASHCHENKO O.M., BUKET O.I.
- 4.4 **DECREASE OF ELECTROCHEMICAL NOISE OF TITANIUM  
ELECTRODE** 163  
ZINCHUK O.V., BUKET O.I.

**Part 5. MODERN ELECTROCHEMICAL AND RELATED TECHNOLOGIES**

- 5.1 **MULTIFUNCTIONAL COMPOSITE MATERIALS FOR  
ALTERNATIVE ENERGY STORAGE** 170  
KHOMENKO V.G.
- 5.2 **ELECTROCHEMICAL INVESTIGATION OF QUANTUM DOTS  
BAND STRUCTURE** 175  
TYNKEVYCH O. O., OKREPKA G. M., KHALAVKA Y. B.
- 5.3 **ELECTROCHEMICAL SYNTHESIS OF 3-  
METHYLTHIOPHENE/3,4-ETHYLENEDIOXYTHIOPHENE  
COPOLYMERS AND THEIR ELECTROCHROMIC PROPERTIES** 184  
SYDOROV D.O., TOVKACH L.L., MOTRONYUK T.I., PUD A.A.
- 5.4 **THE EFFECT OF GROWTH TIME ON THE PROPERTIES OF  
LPCVD GROWN WO<sub>3</sub> THIN LAYERS FOR ELECTROCHROMIC  
APPLICATIONS** 190  
LOULOUDAKIS D., VERNARDOU D., SUCHEA M.,  
DAVAZOGLOU D., KOUDOUMAS E.
- 5.5 **ELECTROSYNTHESIS AND OPTICAL PROPERTIES OF  
CADMIUM SELENIDE NANOPARTICLES** 200  
FOMANYUK S.S., SMILYK V.O., ASAULA V.N., KOLBASOV G.Ya.,  
RUSETSKYI I.A., MIRNAYA T.A.



- 5.6 **ELECTROCHEMICAL OXIDATION OF TOXIC ORGANIC AROMATIC SUBSTANCES** 207  
SHMYCHKOVA O., LUK'YANENKO T., KNYSH V.
- 5.7 **COBALT AND MANGANESE OXIDE CATALYTIC SYSTEMS ON VALVE METALS IN ECOTECHNOLOGIES.** 214  
KARAKURKCHI A., SAKHNENKO M., VED' M., GOROHIVSKIY A., GALAK O., MENSHOV S., MATYKIN O.
- 5.8 **THERMOCHEMICAL AND ELECTROCHEMICAL DESCRIPTION OF THE Fe-C CATALYTIC SYSTEM** 224  
KRAVCHENKO A.V., PERSHINA K.D.
- 5.9 **THE CHOICE OF ANODE MATERIAL FOR THE ELECTROCHEMICAL SYNTHESIS OF PEROXYACETIC ACID** 230  
BILOUS T.A., TULSKAYA A.G., MATRUNCHYK O.L.
- 5.10 **SYNTESIS ROUTE FOR PREPARATION OF PRECURSOR SOLUTIONS** 235  
ZULFIGAROV A.O., ANDRIIKO A.A., POTASKALOV V.A.
- 5.11 **ELECTROMEMBRANE REMOVAL OF TOXIC IONS FROM DILUTED GALVANIC WASTES USING ORGANIC-INORGANIC ION-EXCHANGERS** 241  
PONOMAROUVA L.N., DZYAZKO Yu.S., ROZHDESTVENSKA L.M., VOLFKOVICH Y.M., SOSENKIN V.E.
- 5.12 **IONIC CONDUCTIVITY OF GRANULATED ORGANIC-INORGANIC ION-EXCHANGERS** 249  
KOLOMIYETS Ye.A., MALTSEVA T.V., VASILYUK S., DZYAZKO Yu.S.
- 5.13 **DEVELOPING COMPOSITE POLYMER SHIELDING MATERIALS FOR THE UHF RANGE** 253  
BUTENCO O.A., SENYK I.V., BARSUKOV V.Z.

- 5.14 **PHOTOBIOELECTROCHEMICAL HYDROGEN AND ELECTRICITY PRODUCTION FROM DIFFERENT ORGANIC WASTES** 260  
ZUBCHENKO L.S.

**THE SHORT ABSTRACTS OF SOME PRESENTED PAPERS**

- 5.15 **GLASS-FORMING CYANO-SUBSTITUTED CARBAZOLE DERIVATIVES FOR OPTOELECTRONICS** 267  
SKUODIS E., TOMKEVICIENE A., VOLYNIUK D., GRAZULEVICIUS J.
- 5.16 **ELECTROCHEMISTRY IN MICROSCALE. SCANNING ELECTROCHEMICAL MICROSCOPY: NEW POSSIBILITIES, NEW TECHNIQUES** 268  
PINI L., SIDES R.
- 5.17 **SILICON-BASED ELECTROACTIVE COMPOUNDS CONTAINING DIFFERENT DONOR MOIETIES AS POTENTIAL HOSTS FOR ORGANIC LIGHT EMITTING DIODES** 269  
GRYBAUSKAITE-KAMINSKIENE G., BUCINSKAS A., GRAZULEVICIUS J.

## INTRODUCTION

In May 2016, on the eve of Science Day in Ukraine, a remarkable tradition was established in the framework of cooperation with International Society of Electrochemistry (ISE). Under the auspices and sponsorship of this Society the ISE Satellite Student Regional Symposium on Electrochemistry – 1<sup>st</sup> ISE Regional Student Meeting in Ukraine was organized. In May 2017 this excellent tradition was further developed: 2<sup>nd</sup> ISE Regional Student Meeting in Ukraine "Promising Materials and Processes in Applied Electrochemistry" was organized.

Both these events gave the participants an opportunity to get better acquainted with the modern objectives and achievements in the field, to meet personally with leading electrochemists from Ukraine and abroad, to discuss their researches.

Such increasing creative activity of young Ukrainian electrochemists has stimulated the preparation of this collective monograph, which considers some modern problems and promising ways of solving them in the following key directions of applied electrochemistry: Electrochemical power sources (part 1), Electroplating (part 2), Corrosion protection (part 3), Electrochemical sensors (part 4), Modern electrochemical and related technologies (part 5).

The following major developments are only some examples of many more contributions to this monograph: promising anode, cathode and binder materials for effective lithium-ion accumulators and hybrid supercapacitors; effective catalysts for air-metal batteries and fuel cells; photo-bioelectrochemical fuel cells for electricity production from different organic wastes; new functional binary and ternary coatings; electrochemical sensors for monitoring of SO<sub>2</sub>, CO<sub>2</sub> and other toxic substances; effective coatings which can protect metals against corrosion and people and electronic equipment against unfavorable effects of electromagnetic radiation, etc.

You can see the list of all 84 authors of this collective monograph in alphabetical order at the next page. The papers which prepared by these authors, have shown in parentheses in concordance with the Content.

The monograph could be useful for a wide range of lecturers, scientists, PhD students, holders of a master's degree and students of universities, engineers and technicians of various electrochemical enterprises.

***Prof.Dr. V. Barsukov***

**AUTHORS OF COLLECTIVE MONOGRAPH**

<b>Surname</b>	<b>Article number</b>
ANDREITSEVA M.V.	1.6
ANDRIIKO A.A.	5.10
ANTSIKHOVICH I.V.	2.1
ASAULA V.N.	5.5
BAIRACHNIY B.I.	1.7
BANNYK N.G.	3.4
BARSUKOV V.Z.	1.1; 1.4; 5.13
BEZIK A. O.	2.5
BILOUS T.A.	5.9
BOLDYREV E.I.	1.5
BORYSENKO Yu.V.	3.1
BOJCHUK A.V.	1.3
BUCINSKAS A.	5.17
BUKET O.I.	4.3; 4.4
BUTENKO O.A.	5.13
CHEREMYSINOVA A. O.	2.5
CHERNIK A.A.	2.1
CHERNYSH O.V.	1.1
DANILOV F.I.	3.2; 3.4
DAVAZOGLOU D.	5.4
DIAMANT V.A.	1.8
DZYAZKO Yu.S.	5.11; 5.12
FINOGENOV O.M.	1.7
FOMANYUK S.S.	5.5
GAIUK N.V.	1.5
GALAK O.	1.5; 5.7
GOROHIVSKIY A.	5.7
GRAZULEVICIUS J.	5.15; 5.17
GRYBAUSKAITE-KAMINSKIENE G.	5.17
KARAKURKCHI A.	5.7
KATASHINSKII A.S.	1.4; 1.6
KAZDOBIN K.A.	1.8
KITYK A.A.	3.4

KHALAVKA Y.B.	5.2
KHOMENKO V.G.	1.1; 1.4; 5.1
KNYSH V.	5.6
KOLBASOV G.Ya.	5.5
KOLOMIYETS Ye.A.	5.12
KOSOHIN O.V.	4.1; 4.2
KOUDOUMAS E.	5.4
KRAVCHENKO A.V.	5.8
KRAVETS Y.A.	1.9
KUSHNIRCHUK S. A.	3.3
LAGDAN I. V.	2.3
LINYUCHEV O.G.	4.1
LINYUICHEVA O.V.	2.2
LOULOUidakis D.	5.4
LUK'YANENKO T.	5.6
MAYZELIS A.A.	1.7; 2.4
MAKYEYEVA I.S.	1.1; 1.6
MALTSEVA T.V.	5.12
MATRUNCHYK O.L.	5.9
MATVEEV O.M.	4.2
MATYKIN O.	5.7
MAZANKA V.M.	4.2
MELNYCHUK S.L.	3.1
MENSHOV S.	5.7
MIRNAYA T.A.	5.5
MIROSHNYCHENKO Iu.S.	4.1
MOTRONYUK T.I.	2.2; 5.3
NYRKOVA L.I.	3.1
OKREPKA G.M.	5.2
OVCHARENKO G.V.	2.4
PERSHINA K.D.	1.3; 1.8; 5.8
PINI L.	5.16
PONOMAROUVA L.N.	5.11
POTAPENKO A.V.	1.2; 1.9
POTASKALOV V.A.	5.10
PROSKURINA V. O.	2.3
PROTSENKO V.S.	3.2; 3.4
PUD A.A.	5.3
RIABOKIN O.L.	1.3

ROZHDESTVENSKA L.M.	5.11
RUBLOVA Y.D.	3.3
RUDENKO N.O.	1.7
RUSETSKYI I.A.	5.5
SACHANOVA Yu. I.	2.3
SAKHNENKO N. D.	2.3; 5.7
SAVCHUK O.O.	2.5
SENYK I.V.	5.13
SHMYCHKOVA O.	5.6
SIDES R.	5.16
SKNAR I.V.	2.5
SKNAR Yu.E.	2.5
SKUODIS E.	5.15
SMILYK V.O.	5.5
SOKOLSKY G.V.	1.5
SOSENKIN V.E.	5.11
SUCHEA M.	5.4
SYDOROV D.O.	5.3
TOMKEVICIENE A.	5.15
TOVKACH L.L.	5.3
TSURKAN A.V.	3.2
TSYMBALIUK A.S.	2.2
TULSKAYA A.G.	5.9
TYNKEVYCH O.O.	5.2
USHCHAPOVSKYI D.Yu.	2.2
VASHCHENKO O.M.	4.3
VASIL'EVA E.A.	3.2
VASILYUK S.	5.12
VASYLIEV G. S.	3.3
VED' M. V.	2.3; 5.7
VERNARDOU D.	5.4
VOLFKOVICH Y.M.	5.11
VOLYNIUK D.	5.15
VORONINA O.V.	1.7
YERMOLENKO I. Yu.	2.3
ZINCHUK O.V.	4.4
ZUBCHENKO L.S.	5.14
ZUDINA L.V.	1.5
ZUL'FIGAROV A.O.	5.10