

Proposals

for cooperation
of **Department of Technical
Electrochemistry**
of NTU “KhPI”

Department of Technical Electrochemistry

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Speciality for Bachelors:

- Chemical Technology & Engineering

Specialities for Masters:

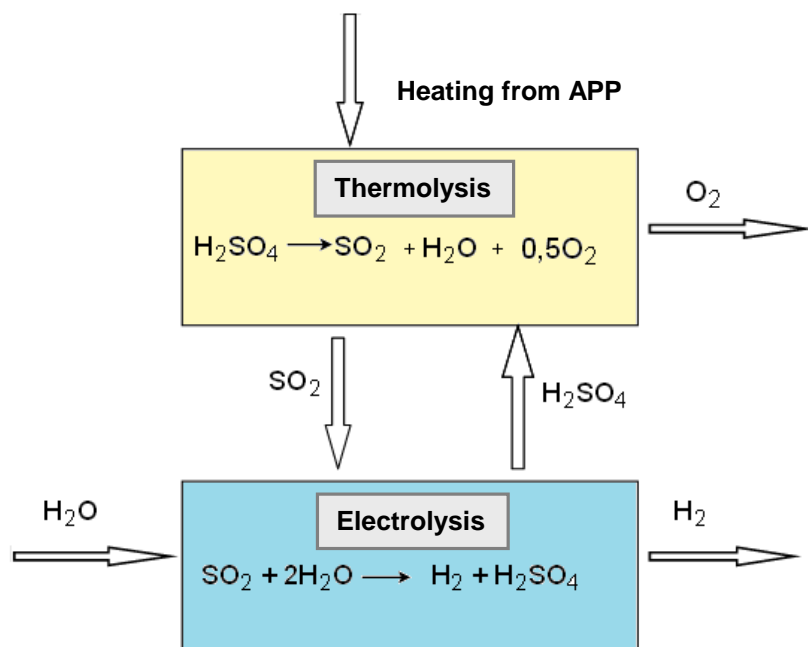
- Technical Electrochemistry
- Chemical Technologies of Rare Dispersed Elements & Materials

Areas of research:

- Electrochemical synthesis
- Hydroelectrometallurgy
- Galvanotechnics
- Electrochemical ecology
- Anodic metal processing
- Chemical current sources
- Corrosion monitoring and corrosion protection of metals

ELECTROCHEMICAL SYNTHESIS OF HYDROGEN IN SULFATE ACID CYCLE WITH DEPOLARIZATION OF ANODIC PROCESS BY SO₂

The membrane electrolysis cell with gas-diffusion anode is developed for realization of the sulfate-acid technology. The possibility of significant reduction of the specific electric energy consumption in the electrochemical hydrogen synthesis is shown. The SO₂ oxidation is carried out in a gas-diffusion anode with coating of "active carbon" and RuO₂ composition.



The performance of the laboratory electrolyzer:

№	Parameter	Current density, A·m ⁻²	
		500	1000
1	Initial concentration of H ₂ SO ₄ in anolyte, g·dm ⁻³	100...250	100...250
2	Final concentration of H ₂ SO ₄ in anolyte, g·dm ⁻³	600...750	600...750
3	Average voltage drop of the cell, V	1,09	1,30
4	Cathode potential, V	-0,25	-0,30
5	Anode potential, V	0,59	0,71
6	Specific electric energy consumption , kW·h·nm⁻³ of H₂	2,63	3,14
7	The reduction of specific electric energy consumption in comparison with alkaline electrolysis, %	39	33

Publications:

- Composite gas-diffusion anodes for hydrogen generation by the sulfate-acid procedure / Bairachnyi B. I., Tul'skaya A. G., Bairachnyi V. B // Russian Journal of Applied Chemistry. – 2013. – V. 86. – №. 11. – P. 1729-1734.
- Electrochemical synthesis of hydrogen with depolarization of the anodic process / [G. Tul'skiy, A. Tulskeya, L. Skatkov, V. Gomofov, S. Deribo] // Electrochem. Energy Technol. – 2016. – V. 2. – P. 13–16. 3.
- Electrochemical Synthesis of Hydrogen with Depolarization of the Anodic Process / [L. Skatkov, G. Tul'skiy, A. Tulskeya, V. Bayrachniy, V. Gomofov, S. Deribo] // Abstract MA. – 2016. – P. 1451.

CORROSION PROTECTION OF UNDERGROUND CONSTRUCTIONS

We investigated the theoretical foundations of electrochemical processes of corrosion protection of underground facilities (gas, oil and water pipelines) by improving the composition of anode materials (grounding devices for cathodic protection, protectors and activator solutions).



Applications:

- ✓ **Advanced anode materials: magnesium protectors and groundings for cathodic protection stations**
- ✓ **Protection of oil and gas pipelines, water systems**

Advantages:

- ✓ **More uniform dissolution due to the fine crystalline structure of alloys**
- ✓ **Increasing of the service life by up to 60%**

Publications:

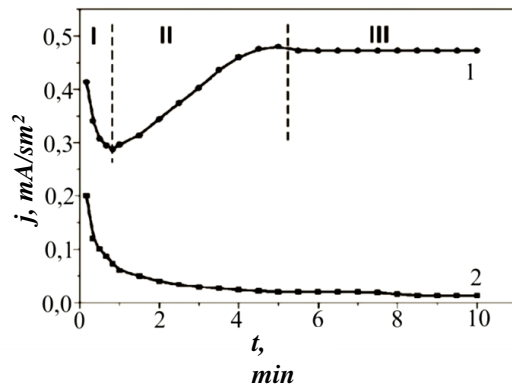
- Patent of Ukraine № 45654, IPC (2009) C23F 13/00. Anodic grounder for cathodic protection stations / Bairachniy B.I., Zabara V.F., Kovalenko Yu.I.; App. № u 200903030, 30.03.2009; Publ. 25.11.2009, Bul. №. 22.
- Patent of Ukraine № 86202, IPC (2006.01) C23F 13/12. Anodic grounders for electrochemical protection / B.I. Bayrachniy, V.F. Zabara, Yu.I. Kovalenko, O.L. Gofman; App. № u 2013 03354, 19.03.2013; Publ. 25.12.2013, Bul. № 24.



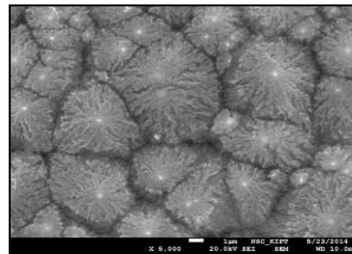
SENSOR SYSTEM BASED ON THE NANOSTRUCTURED OXIDE MATRIXES

The technology of electrochemical synthesis of porous oxide coatings on Nb, Ti, Al with desired functional properties was developed. The coatings can be used to create composite electrodes, modified with Pd, as indicator for hydrogen detecting in amperometric type sensors.

Electrochemical synthesis of oxide coatings



Microphotograph of the oxide electrode surface



Crystalline Nb₂O₅



Crystalline Nb₂O₅ + Pd

The advantages of using porous oxide matrices based on Nb, Ti, Al:

- ✓ Long service life of the matrix;
- ✓ Resistance to degradation due to a change of its volume during the absorption of hydrogen by palladium;

The technical characteristics of the sensor system model is proposed according to the research.

Publications:

- L. Skatkov, L. Lyashok, V. Gomofov, I. Tokareva, B. Bayrachniy Anodic formation of nanoporous crystalline niobium oxide. J. Electrochem. Sci. Eng. 4(2) (2014) 75-83; doi: 10.5599/jese.2014.0050.
- Patent of Ukraine № 90354. IPC C25D 11/00. Electrolyte for formation of nanostructured oxide coatings on niobium / Bayrachniy B.I., Lyashok L.V., Tokareva I.A.; App. № u201314080, 03.12.2013; Publ. 26.05.2014, Bul. № 10.
- B. I. Bayrachniy, L. V. Lyashok, I. A. Tokareva Formation of nanoporous niobium oxide. Journal Perspektivnye materialy. 2 (2014) 66-70 (in Russian)

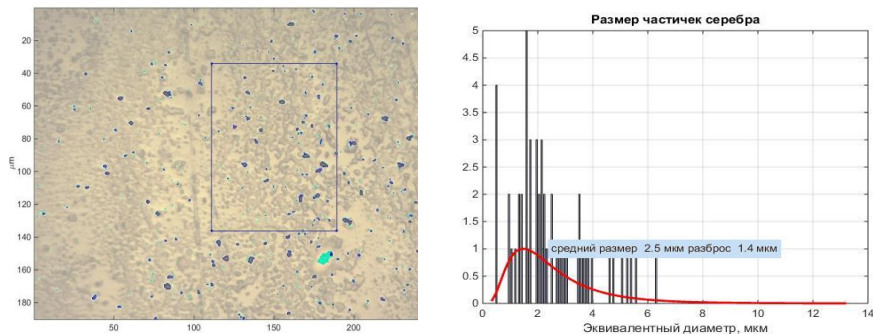


Scheme of the indicator electrode of the sensor system for the detection of hydrogen

ELECTROCHEMICAL SYNTHESIS OF FINE SILVER POWDERS FOR CREATION OF ELECTRICALLY CONDUCTING PASTE

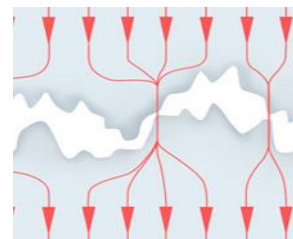
The unique microstructure of ultra-fine powders, characteristics of their microgeometry, high specific surface area, energy saturation, allow you to create electrically conductive adhesives and pastes on the basis of these powders.

Processing of silver powder photomicrographs

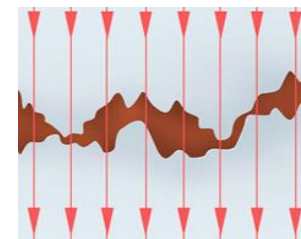


When applying the conductive paste the metal powder particles fill the cavities of the surface roughness. This increases the actual area of contact and thus the effective area for current exchange increases. As a result, contact resistance is reduced and stay stable in the operation process.

Using of ultra-fine powders



Without
conducting paste



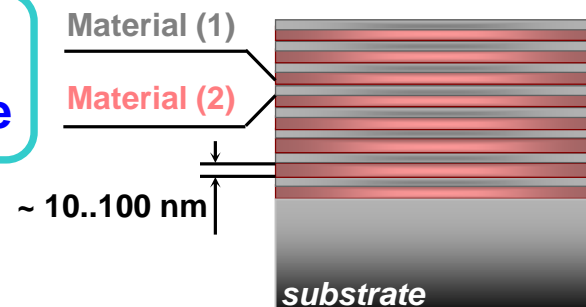
With
conducting paste

Publications:

- Bayrachniy B.I., Lyashok L.V. Technical electrochemistry. Part IV. Hydroelectrometallurgy, 2012. – 496 P. (in Ukrainian)
- Bayrachniy B.I., Lyashok L.V. Rare scattered, precious elements. Technology of their production and use, 2007. – 300 P. (in Ukrainian)
- Tereschenko A.A., Lyashok L.V., Leschenko S.A., Krepska O.N., Lugovaya L.A., Momot A.S. Tokaychuk T.M. Electrochemical synthesis of fine-dispersed silver powder and making compositions based on them / VII Ukrainian congress on electrochemistry, Kharkiv, 21-25 September 2015. – P. 214 – 215 (in Ukrainian)

ELECTROCHEMICAL FORMATION OF METALIC NANOLAMINATES

We developed technologies for formation of **nanostructured coatings** with the **given architecture**



Cu/(Ni-Cu) coatings are:

- Highly **corrosion**-resistant (particularly in sea water)
- **Wear**-resistant
- **Load**-resistant

Due to:

- High **adhesion**
- Low **porosity** (porousless at 2 μm thickness)
- High **microhardness** (500-800 HV)

Other **advantages** of technology:

- ✓ Reduction of the number of operations
- ✓ Reduction of water discharge and metal consumption

Example of application –
coating on **NdFeB magnets**



Publications:

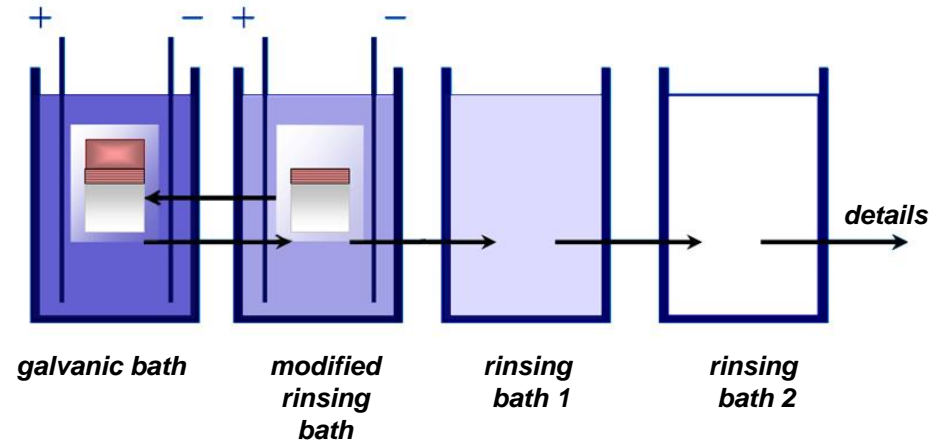
- Electrochemical Formation of the Multilayer Cu/Ni Deposits / L.V. Trubnikova, B.I. Bayrachniy, V.O. Savchenko, A.A. Maizelis // *XVIII Mendeleev Congress on General and Applied Chemistry*, 23–28 Sept. 2007: abstract Book. – Moscow, 2007. – V. 2. – P. 559.
- The influence of multilayered copper-nickel coatings formation circumstances on the corrosion resistance and mechanical properties / L.V. Trubnikova, B.I. Bayrachny, A.A. Maizelis // *Electrochemical Technologies and Materials for 21st century: 9th International Frumkin Symposium*, 24–29 Oct. 2010: abstracts. – Moscow, 2010. – C. 172.
- The effect of architecture of the Cu/(Ni-Cu) multilayer coatings on their microhardness / A.A. Majzelis, B.I. Bairachniy, L.V.Trubnikova, B.A. Savitsky / *Functional Materials*. – Kharkiv: ISMA STC “Institute of Single Crystals”. – 2012. – Vol. 19. – № 2. – P. 238–244.
- Patents of Ukraine № № 12162, 48590, 79556, 82252, 92430, 92836, 109585, 109624.

COMBINED SCHEMES OF RINSING WATER TREATMENT IN GALVANICS

We present **new approach** for metal **electrowinning from rinsing waters** of galvanic lines. We propose to produce layers of functional coatings (e.g. nanolaminates, sublayer or overlayer) in the modified first rinsing bath.

Advantage of the approach:

- ✓ High economic profit of the waste water treatment
- ✓ Decreasing of metal anode consumption by 20-30 % in main galvanic process,
- ✓ Decreasing of water discharge for rinsing in 2-10 times.



Publications:

- Trubnikova L.V. Formation of Additional Metal Layers from the Solutions of Catching Baths in Galvanic Lines as the Factor of Payback on Rinsing Waters Purification // XVIII Mendeleev Congress on General and Applied Chemistry, Moscow, September 23-28, 2007. - Abstract Book in 5 volumes. V.5. - P.441
- The local combined schema of purification of galvanic lines washing waters / L.V. Trubnikova, B.I. Bayrachniy, M. Pushpavanam // Books of Abstracts of "ISAEST-8" (India, Goa). – 28-30th of Nov., 2006 – P.151.
- Using of the first stage of waste water treatment of galvanic line for nickel electrodeposition for formation of underlayer on details / L.V. Trubnikova, B.I. Bayrachniy, A.A. Maizelis // Water and Ecology. Problems and solutions. (Вода и экология. Проблемы и решения). – 2010. – № 1, 2. – P. 3–11. (in Russian)
- Patents of Ukraine №№ 36690, 29214, 28846, 87730 88513, 89563.

ENVIRONMENTALLY SAFE ELECTROCHEMICAL PROCESSES IN THE RENEWABLE ENERGY

PROPOSAL

The aim of the research is to develop environmentally safe methods of electrochemical oxygen-free hydrogen synthesis

We propose to use fundamentally new electrochemical methods of hydrogen electrosynthesis, which involve application of depolarizing metals and alloys

We project to create small power experimental-industrial devices (up to 5 kW) for receiving heat from the hydrogen

The **novelty** of the electrochemical method of hydrogen production consists of using of Zn and Zn alloys as anodes, that possess the depolarizing effect. This results in reducing of cell voltage drop by 50% in comparison with existing methods of hydrogen electrosynthesis.

Impact.

The technological process of electrochemical production of hydrogen will be significantly improved. The energy consumption will be reduced and the level of ecological safety will be upgraded due to oxygen-free anodic process on the Zn and Zn alloys depolarization anodes. The construction of electrolyzer and electrolysis regimes will be simplified in the electrolyzer without separation elements.