

INESS

ABSTRACT BOOK

The 8th International Conference on Nanomaterials
and Advanced Energy Storage Systems
(INESS-2020)



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The 8th International Conference on Nanomaterials and Advanced Energy Storage Systems (INESS-2020)

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Novel and Pragmatic Approach to Design Silicon Alloy Anode by Equilibrium Method

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Silicon is honored as one of the most promising anode materials for Lithium-ion Batteries (LIBs) because of its high theoretical specific capacity (4200 mAh/g) compared to commercially available graphite anodes (370 mAh/g). Over 20 years, Si has been intensively investigated due to considerable volume expansion of up to 300% upon electrochemical lithiation, leading to electrode cracking and rapid capacity fading. Numerous strategies have been reported with excellent cycle performances in lab-scale [1]. However, up today, many material manufacturers and start-up companies failed to scale-up those technologies for mass-production, in particular, due to the lack of reproducibility, economical feasibility, etc.

Herein, we demonstrate a novel and pragmatic approach for the mass-producible synthesis of Si-alloys with homogeneous microstructure and improved electrochemical performances. Namely, we have designed and optimized amorphous phase Si-alloy composition using reliable and mass-producible melt-spinning process (Fig.1). Further, amorphous alloy is subjected to the thermal annealing process to size-controllable recrystallization and homogeneous growth of nano-Si grains in inactive matrix. As a result of breakthrough strategy the Si-alloy electrode delivered a high specific capacity of 900 mAh/g for 100 cycles at 0.1 A/g with nearly 99% capacity retention [2].

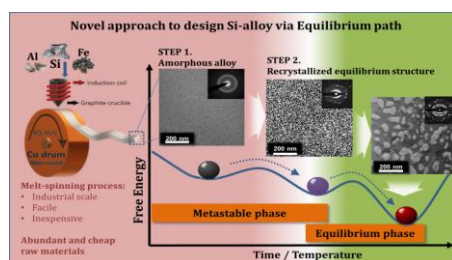


Fig. 1. Schematic illustration of Si-alloy fabrication process [2].

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High mobility 2D holes in strained epitaxial Germanium quantum well heterostructures

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Carrier mobility is one of the most important parameters of any semiconductor material, determining its suitability for applications in a large variety of electronic devices including field effect transistors (FETs). Bulk or 3D, Germanium (Ge), with its very high intrinsic hole and electron mobilities of 1900 and 3900 cm²V⁻¹s⁻¹ at room temperature, respectively, is the most promising candidate material to replace Si channels in future complementary metal oxide semiconductor (CMOS) devices. When one or more of the dimensions of a solid are reduced sufficiently to nanometer range, its physicochemical characteristics notably depart from those of the bulk solid. With reduction in size, novel electrical, mechanical, chemical, magnetic, and optical properties can be introduced. The resulting structure is then called a low-dimensional structure or system.

Biaxial compressive strain in nm scale thick Ge epilayer narrows its band gap and causes the appearance of a quantum well (QW) in the valence band. Holes confined in the strained Ge QW form a two-dimensional hole gas (2DHG) and have an increased mobility due both to their lower effective mass and reduced scattering factors in this material system. During the recent years a major breakthrough have been achieved in enhancement of carrier mobility in strained epitaxial Ge grown on a standard Si(001) substrate. Extremely high room- and low-temperature 2DHG mobilities of up to 4,500 cm²V⁻¹s⁻¹ [1] and 1,500,000 cm²V⁻¹s⁻¹ [2], respectively, have been demonstrated. These hole mobilities are the highest not only among the group-IV Si, SiGe, Ge, SiC and Diamond semiconductors, but also among p-type III–V, II–VI and emerging 2D materials.

Appearance of so high 2DHG mobility in strained epitaxial Ge has already led to demonstration, for the first time, of various quantum phenomena and unique properties in it. They include strong Rashba SO interaction [3], fractional quantum Hall effect [4], Terahertz quantum Hall effect [2], quantum ballistic transport [5], self-organised fractional quantisation [6], electronic transport anisotropy [7], ballistic holes with strong g-factor anisotropy [8] and 2DHG with very low effective mass of 0.035m₀ [7]. The obtained effective mass is not only the lowest for holes among all known semiconductor materials, but also lower than electron effective mass in GaAs. Without any doubts, epitaxial strained Ge material will be an excellent platform for scientists and engineers to discover new quantum phenomena and applications.

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Synthesis, characteristics and electrochemical performances of N, N-(*p*-phenylene) bismaleamate and its fluoro-substitution compound on organic anode materials in lithium-ion battery

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Traditional lithium ion battery composes lithium transition metal oxide as a cathode and graphite as an anode. Due to the global warming and the increment of electric vehicle marketing, the reduced-carbon policy and the requirement of high energy density, several techniques have been studied in order to replace the graphite such as metalloid and organic compounds. However, metalloid suffers tremendous problems when alloys with lithium ions, including the huge volume expansion and the electrochemical irreversibility. The organic compounds also present some drawbacks such as low electronic conductivity and low thermal stability, respectively. In this research, the bismaleamate and its fluoro-substitution polymer have been synthesized and studied in order to prevent above problems. The calculation and electrochemical performance show that the fluoro-substitution on bismaleamate significantly decreases the energy band gap around 0.02 eV and provides 430.0 mAh g⁻¹ after 350 cycles. The c-rate performance improves with the low energy band gap when operates at 10C/ 10C (190 mAh g⁻¹). The Brunauer-Emmett-Teller analysis shows that the fluoro-substitution bismaleamate has four times higher of surface area and ten times bigger of pore size compares with the bare bismaleamate. The fluoro-substitution incurs the obvious three-dimensional steric effect and unsymmetrical structure, which is able to provide the excellent ionic transfer. The X-ray photoelectron spectroscopy shows the weak electron-withdrawing effect on fluoro-substitution dramatically inhibits the formation of solid electrolyte interphase (SEI) and delivers an interesting reaction mechanism for its structure rearrangement. *Operando* X-ray diffraction pattern confirms the changes of crystal phase of bismaleamate and its fluoro-substitution. New organic anode material, bismaleamates have excellent performances concerning the capacity, c-rate, and cycle life, which are eligible for enabling high potential applications in lithium-ion and beyond-lithium secondary batteries.

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Morphological Peculiarities from Lithium Plating and Stripping

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Enabling metallic-Li negative electrodes is motivated by a significant increase of energy density, both gravimetric and volumetric (Fig. 1), despite the excess of metallic Li accounted to ensure a stable potential. The projected gain in energy density for post-Li-ion batteries with metallic Li is twice than that possible to achieve with graphite, whereas with current and potential positive electrodes of Li-ion batteries it is about 30 % [1]. However, Li-metal as an anode is prone to dendritic growth and, therefore, is considered an unsafe option. It has been under investigation since early 1970s and the interest declined with the invention of Li-ion battery technology, which was considered safer alternative. However, recently interest in the metallic Li has

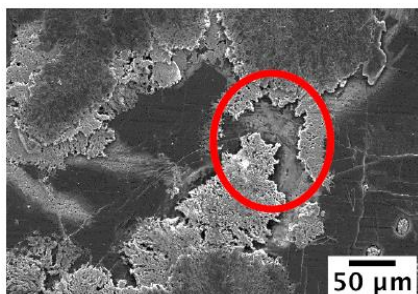


Figure 2. Li deposits after two platings and one stripping in-between them. The red ellipse highlights an area where 'dead' Li surrounds empty space, where previously active Li has been.

Li plates sporadically, where some of the regions are preferred for plating, despite 'dead' Li agglomeration on those particular spots, while the other regions are free of Li deposits (Fig. 2). The most interesting morphological changes are obtained during the initial stages of stripping and plating.

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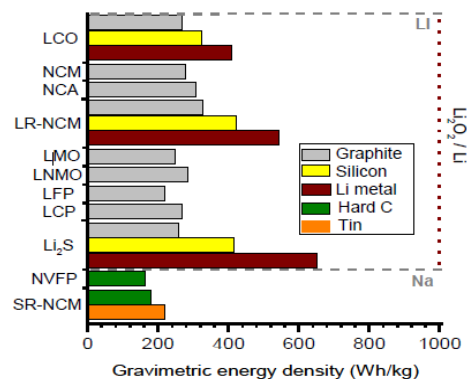


Figure 1. Gravimetric and volumetric energy densities of various positive electrodes paired with negative electrodes [1]. Energy density vs metallic Li electrode is denoted in bordeaux.

been again on a sharp rise [2]. There is still insufficient fundamental understanding about the fundamental principles, governing electrochemical lithium plating/stripping, which often results in dendrite growth, electrolyte consumption, other undesired effects. [3]

The present study aims to gain a comprehensive fundamental understanding of metallic-Li behaviour upon plating/stripping. As a first step, we performed post-mortem SEM analysis during the first two cycles in various electrolytes, in addition to studying the cycling performance in Li-Cu and symmetric Li-Li cells. Our post-mortem SEM study revealed that



Controlled Oxygen Redox for Excellent Power Capability in Layered Sodium-Based Compounds

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Recently, anionic oxygen redox ($O^{2-/1-}$) become a main research subject for realizing high power capability [1]. Unfortunately, although the delivered capacity obtained from the transition-metal redox and oxygen redox is one of highest among sodium cathodes, the system suffers from not only serious capacity fading but also poor rate capability because of the sluggish kinetics of the oxygen redox [2]. To come up with this drawback, cobalt substitution in layered sodium-based compounds is conducted to achieve a high-rate of oxygen redox. The rationally designed $Na_{0.6}[Mg_{0.2}Mn_{0.6}Co_{0.2}]O_2$ exhibits outstanding electrode performance, delivering a discharge capacity of 214 mAh g⁻¹ (26 mA g⁻¹) with capacity retention of 87% after 100 cycles. High rate performance is also achieved at 7C (1.82 A g⁻¹) with a capacity of 107 mAh g⁻¹. Surprisingly, the $Na_{0.6}[Mg_{0.2}Mn_{0.6}Co_{0.2}]O_2$ compound is able to deliver capacity for 1000 cycles at 5C (at 1.3 A g⁻¹), retaining 72% of its initial capacity of 108 mAh g⁻¹. X-ray absorption spectroscopy analysis of the O K-edge indicates the oxygen-redox species ($O^{2-/1-}$) is active during cycling. First-principles calculations show that the addition of Co reduces the bandgap energy from ≈ 2.65 to ≈ 0.61 eV and that overlapping of the Co 3d and O 2p orbitals facilitates facile electron transfer [3], enabling the long-term reversibility of the oxygen redox, even at high rates. To the best of the authors' knowledge, this is the first report on high-rate oxygen redox in sodium-based cathode materials, and it is believed that the findings will open a new pathway for the use of oxygen-redox-based materials for sodium-ion batteries.

Acknowledgement

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Extremely stable zeolites developed via liquid-mediated self-defect-healing

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The successful application of zeolites in diverse fields largely relies on their high stability compared with other porous materials. However, the property requirements for zeolites have become stringent due to their diverse and demanding applications. Aluminosilicate zeolites are utilized for adsorptive and catalytic applications, wherein they are sometimes exposed to high-temperature steaming conditions (~1000 °C). Zeolites are exposed to severe steaming conditions in regenerators to remove coke, and over 400,000 t/y of catalysts are discarded due to degradation during the FCC process [1]. Recently, zeolites have been used in exhaust gas treatment processes, such as the selective catalytic reduction of NO_x, catalytic oxidation for diesel engines, and hydrocarbon trapping [2], wherein they degrade due to interactions with high-temperature (>800 °C) steam. In automotive applications, degradation is often severe because zeolites are continuously exposed to steam without replacement. Therefore, the development of highly stable zeolites has become an important issue. As the degradation of high-silica zeolites originates from the defect sites in their frameworks, feasible defect-healing methods are highly demanded. Herein, we propose a method for healing defects to create extremely stable high-silica zeolites. High-silica ($\text{SiO}_2/\text{Al}_2\text{O}_3 > 240$) zeolites with *BEA-, MFI-, and MOR-type topologies could be stabilized by significantly reducing the defect sites via a liquid-mediated treatment without using additional silylating agents. Upon exposure to extremely high-temperature (900–1150 °C) steam, the stabilized zeolites retain their crystallinity and micropore volume, whereas the parent commercial zeolites degrade completely (Figure 1). The proposed self-defect-healing method provides new insights into the migration of species through porous bodies and significantly advances the practical applicability of zeolites in severe environments.

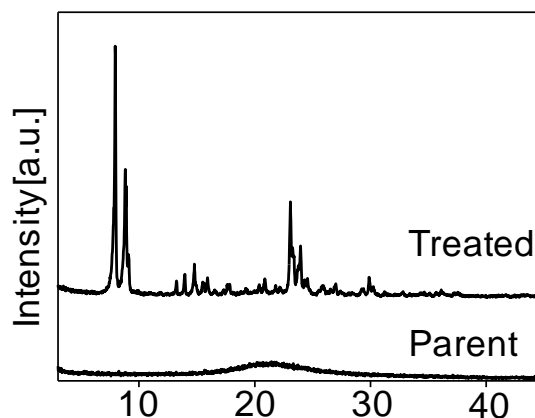


Figure 1 XRD patterns of MFI-type zeolite after 1150 °C steaming for 3 hours.

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All-Purpose Electrode Design of Flexible Conductive Scaffold toward High-Permanence Li-S Batteries

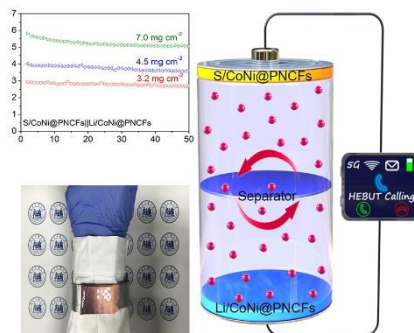
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The main obstacles that hinder the development of efficient lithium sulfur (Li-S) battery are the polysulfide shuttling effect in sulfur cathode and the uncontrollable growth of dendritic Li in the anode. Herein, we report an all-purpose flexible electrode that can be served both in sulfur cathode and Li metal anode, and meanwhile the application in wearable and portable storage electronic devices is discussed. The flexible electrode consists of a bimetallic CoNi nanoparticles embedded porous conductive scaffold with multiple Co/Ni-N active sites (CoNi@PNCFs). Both experimental and theoretical analysis show that, when used as the cathode, the CoNi and Co/Ni-N active sites implanted on the porous CoNi@PNCFs significantly promote the chemical immobilization towards soluble lithium polysulfides and its rapid conversion into insoluble Li₂S, and therefore effectively mitigate polysulfide shuttling effect. Meanwhile, the 3D matrix constructed with porous carbonous skeleton and multiple active centers successfully induce homogenous Li growth, realizing a dendrite-free Li metal anode. The Li-S battery, assembled with S/CoNi@PNCFs cathode and Li/CoNi@PNCFs anode, achieve a high reversible specific capacity of 785 mAh g⁻¹ and long cycle performance at 5 C (capacity fading rate of 0.016 % over 1500 cycles).





Valorization of biomass waste into high efficient materials for CBRN protection

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Nowadays, the cleaning of aspiration and ventilation emissions from harmful substances is one of the main air protection measures for most of the industrial enterprises. The specific feature of most of the industrial emissions refers to the content of a large number of harmful gaseous components in addition to solid and liquid particles (dusts, gases, mists) [1]. The cleaning of the gas flows from such contaminants requires corresponding knowledge of the theory to develop gas purification methods. The adsorption method becomes more and more valuable among other known methods of industrial emissions cleaning as it allows almost complete removal of the contaminations of the gas flows.

Many countries (Russia, USA, China, etc.) study intensively the problem of air cleaning. The scientists from the Institute on Combustion Problems perform studies [2-3] connected with the manufacture of modified carbon adsorbents for medical applications, waste waters cleaning from heavy metals ions, biomolecules division, etc. But the elaboration of carbon sorbents for toxic gases sorption has not been studied so far. This omission is treated in the present communication.

This work is dedicated to the development of a method for the manufacture of modified carbon sorbents made for absorption of organic and inorganic vapors. The microstructure analysis of the samples reveals that the activation promotes the formation of a higher number of small pores and the development of a spongy texture of the sorbents leading to carbon content increase when compared to that of the initial sample. The final samples have apparent mesoporous confirmed by the form of the isotherms referring to the low-temperature adsorption of nitrogen and the results of pore size distribution using the DFT method.

Acknowledgement

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“Quenched” Polyampholytes as Catalysts and Supercapacitors

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The “quenched” or strongly charged polyampholytes represent amphoteric macromolecules consisting of static positive and negative charges [1,2]. The volume-phase, swelling-deswelling, self-healing, viscoelastic, and mechanical properties of „quenched” polyampholyte gels are discussed in aqueous-salt solutions together with their stimuli-responsive character [3]. Application aspects of „quenched” polyampholytes cover biotechnology, biomedicine, oil recovery, desalination, catalysis and supercapacitors [4,5]. Understanding of the fundamental relationships between the microstructure and property of crosslinked amphoteric macromolecules will open renewed interest to polyampholytes in whole and „quenched” polyampholytes in particular.

Acknowledgements

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Investigating the Feasibility of Energy Harvesting using Material Work Functions

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There is an on-going search for miniaturized efficient energy harvesting devices which will capture energy from the environment and transform and supply enough electrical power for the autonomous operation of small low power-demand electronic devices [1]. The concept of energy harvesting is especially attractive as it could be applied when battery replacement is difficult or when recharging in a conventional sense may prove to be not cost effective. Also this concept could be used successfully when continuous operation without maintenance is required.

Electronic devices, with low power demand, can be energized using vibration energy harvesters which gather and transform energy from mechanical vibrations. This investigation looks at the feasibility of a method of energy harvesting from mechanical vibrations using the naturally occurring charging phenomenon within a system of two bodies which possess different work functions. A work function is defined as the minimum thermodynamic work (i.e. energy) needed to remove an electron from a solid to a point in the vacuum immediately outside the solid surface. A work function is not a characteristic of the bulk material but rather is a property of the surface of the material and depends on the material crystal face and presence of contaminants. The critical difference between a work function energy harvester (WFEH) and the electrostatic harvester is that the former does not require any electrets (dielectric materials that has a quasi-permanent electric charge or dipole polarisation) or external power sources.

In this work, a brief review of similar technologies, namely piezoelectric, electromagnetic and electrostatic energy harvesters is first given. This is followed by the development of a theoretical model and an investigation of different WFEH operation modes and miniaturization of a WFEH, with conclusions on a possible optimum mode of operation and method of miniaturization. The design of an experiment to test the developed theory is then presented followed by some preliminary results. Generally it is found that WFEH has potential for use in energy harvesting applications with the possibility of giving equal or better output power when compared to traditional electrostatic harvesters.

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Smart window design with aerosol trap, greenhouse gardening and powered by solar panels

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Photovoltaic panels usage in urban conditions only for energy production is unprofitable, since energy from traditional energy sources is much cheaper and the infrastructure for transporting energy to consumers in cities has already been formed. Fundamental difference between the proposed device in social and economic terms is that the individual consumer is offered not energy from the power plant, but a household device with a combination of LED illuminator with and sunlight-regulating external blinds [1, 2]. Along the way, it will help to solve global human problems of ecology, by cleaning the air from smog, contaminated aerosols and using "green" energy. Even when the solar panel is not lit, it can act as a dust and aerosol collector, a heat and light screen for the room.

The aim of this development is usage of solar energy in windowed household systems for the following consumer functions: 1) night and regulated daytime room lighting; 2) for cleaning the air basin of the city from smog and aerosols; 3) for additional heat and sound insulation. Relevance of the study is also associated with measures to reduce greenhouse gas emissions through the use of alternative sources and helps to solve the problem of their cost-effective use.

A working designed model was created being scaled down 1:5, where consumer functions are tested and refined after modeling in AutoCAD. A device based on solar panels provides the combination of several consumer properties and a combination of three stand-alone modules placed on a single metal structure, fixed in the aperture and on the window frame. The model has five static and three dynamic modes of operation. Electromechanical and photoelectric part of the prototype device was manufactured and the study of the technical characteristics was carried out. Note that power calculations were performed for the full-scale prototype version. A full-size model of the device was made on the window at Faculty of Physics and Technology of al-Farabi KazNU.

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Dynamic Chemical Passivation of Absorber Layer Trap States and its Real-time Effect on the Device Performance in Back-Contact Perovskite Solar Cells

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Hybrid organic-inorganic perovskites have been identified as one of the most promising classes of materials for photovoltaic and optoelectronic applications, due to their excellent electronic and optical properties, combined with their ease of fabrication. The efficiency of perovskite solar cells (PSCs) has increased at a remarkably fast pace, with the current maximum certified power conversion efficiency (PCE) reaching 25.2%. Conventional solid-state hybrid organic-inorganic perovskite-based solar cells have a sandwich type structure in which the perovskite absorber layer is positioned between bottom and top electrodes, typically a transparent conducting oxide (TCO) layer on glass, and an evaporated thin layer of gold or silver, respectively. Such an architecture for PCSs allows illumination of the cells only from the TCO side. Alternatively, the back-contact architecture offers the possibility of positioning both electrodes on one side of the absorber layer and shining light directly on the photoactive layer [1, 2]. This helps to avoid the occurrence of transmission losses caused by the charge collecting TCO electrode in the conventional sandwich structure for PSCs, and may have some potential application in constructing four or two terminal tandem solar cell devices. The back-contacted device architecture is also useful for conducting fundamental studies as it has an exposed photoactive area, permitting in situ measurements on the effects of chemical treatment, passivation and annealing. I will present a successful application of back-contact PSCs in studying the dynamic effect of a chemical passivation of the perovskite absorber layer and its real-time influence on the device performance.

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Fabrication of back-contact solar cells by microsphere lithography

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The back contact solar cells are a promising alternative to the traditional sandwich type devices. The most convenient and low cost method to fabricate back-contact solar cell devices is using microsphere lithography [1] as it can be performed without expensive photolithography tools and cleanroom. The self-assembly of polystyrene microbeads [2] was performed on top of APTES (3-Aminopropyl)triethoxysilane functionalized surface of tin oxide layers on conductive glass substrates and deposited with magnetron sputtering. The deposition of microsphere beads on the substrates is achieved via electrostatic attraction forces between positively charged molecular monolayer-functionalized substrate and negatively charged micron-sized polystyrene microbeads with carboxyl surface groups. Resulting back-contact electrodes are used for fabrication of perovskite solar cell devices.

Copper was chosen as a cathode layer in order to adapt existing processes on plastic substrates due to lower oxidation temperatures [3] compared to nickel [4].

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Simulation of Antireflection Coatings System Based on DLC/Porous Si and TiO₂/SiO₂ for Si Solar Cells

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The exploitation of diamond-like carbon (DLC) films in a wide range of practical applications attracts scientific interest [1]. More than 35% of solar radiation reflects from the surface of a silicon solar cell. This phenomenon negatively affects the quantity of generation of electron-hole pairs. Inhibiting of reflection can be achieved by applying anti-reflection coatings (ARC) on the silicon surface, with refractive indices n between $n = 1$ (Air) and $n = 4.0$ (Si). In the visible spectrum $n = 1.5$ – 3 for porous silicon, $n = 2.4$ for the DLC film, $n = 1.5$ for SiO₂ and $n = 2.1$ – 2.5 for TiO₂ [2]. By changing the thickness of the layers, the minimum of Inhibiting can be shifted to different parts of the spectrum. The deposition of two-layer films allows for expanding the useful range. A porous silicon layer has important advantages: the textured surface, the possibility of changing the bandgap, the ease of manufacture of the layer, and the variation of the refractive index by electrochemical anodization. Silicon DLC films are characterized by high mechanical, chemical, and radiation resistance.

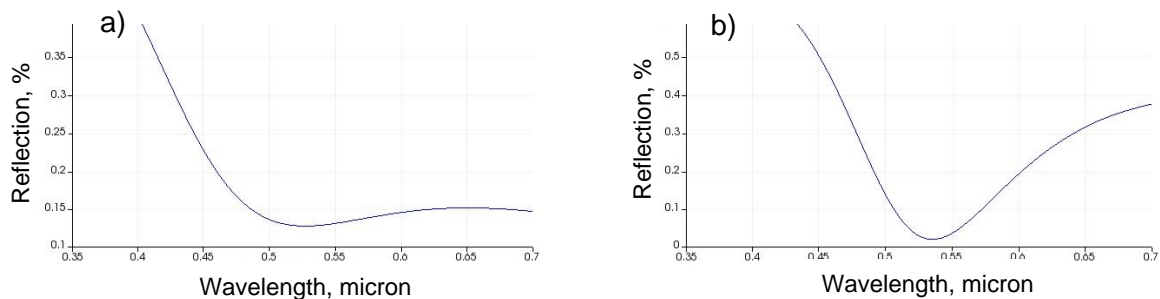


Figure 1 - Reflection spectra of a) DLC/Porous Si/Si and b) TiO₂/SiO₂/Si obtained using the Lumerical FDTD program.

The modeling of the reflection coefficient with a commercial simulation base revealed the optimum ratios of the thicknesses d of the DLC/Porous Si and TiO₂/SiO₂. Encouraging results were obtained with the following layer parameters: $n(\text{DLC}) = 2.4$, $d(\text{DLC}) = 90$ nm; and $n(\text{PS}) = 2.2$, $d(\text{PS}) = 50$ nm. Reflection in a wide range of 500–700 nm was about 10% (Fig. 1a). The following parameters were obtained for the two-layer TiO₂/SiO₂ system: $n(\text{TiO}_2) = 2.1$, $d(\text{TiO}_2) = 150$ nm; $n(\text{SiO}_2) = 1.5$, $d(\text{SiO}_2) = 90$ nm. The reflection was less than 1.5% in the range of 500–550 nm (Fig. 1b). It is possible to significantly reduce reflection and increase the efficiency of solar cells.

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**Investigation of SiC based antireflection coatings for Si solar cells
by numerical FDTD simulations**

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Amorphous silicon-based thin layers (SiO₂, SiN, a-SiC:H, and so on) for antireflection coatings, diffusion barriers, passivation layers have been broadly researched in the solar cell industry [1]. Such advantages of hydrogenated amorphous silicon carbide as a wide forbidden zone, excellent coefficient of thermal expansion, which corresponds to silicon wafers, relatively good thermal and mechanical stability [1,2], the possibility of being used as an antireflection and passivating layer simultaneously, make it an important material for use in solar cells. One of the key factors negatively affecting the efficiency of solar cells is the reflection of incident light. The use of antireflection coatings can significantly increase the amount of light involved in the generation of an electron-hole pairs, which in turn increases the efficiency of solar cells. Due to the effective refractive index n ranging from 2.560 to 2.832 and ease of synthesis [3], SiC has a high potential for use in antireflection coatings.

In this paper, a series of simulations of SiC based antireflection coatings was carried out. The reflections of a single SiC layer, double-layer SiC-MgF₂ coating and triple-layer SiC-ZnS-MgF₂ coating in the range of wavelength from 300 to 800 nm was compared. The optimization of the results showed that the double-layer structure reaches a minimum reflection of 0.006% at the level of 737 nm. Moreover, in the interval from 475 to 800 nm, the reflection does not exceed 1%. Subsequently, the double-layer structure was compared with more classical combinations of ZnS-MgF₂ and TiO₂-SiO₂. As the simulations show, SiC-MgF₂ antireflective coating achieves better results indicating its high prospective for future application.

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Enhancement of photovoltaic properties of polymer solar cells by modifying a structure of PEDOT:PSS layer

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Demand for developing robust renewable energy systems is increasing due to expiring fossil fuel deposits and ecological issues caused by using traditional energy sources. Among different renewable energy resources, solar energy is more attractive due to it can be transformed directly to heat, electricity or chemical energy. Photovoltaic devices are rapidly developing technology and have attracted attention of researchers and engineers from different fields. Polymer solar cells (PSCs) are very promising photovoltaic devices owing to facile fabrication method and cost-effectiveness of photoactive and semiconducting polymer materials [1].

PEDOT:PSS is semiconducting polymer materials with p-type conductivity which has become key components of PSCs [2]. The main role of PEDOT:PSS layer in PSCs is to extract photogenerated holes from photoactive layer and transport them to an external electrode [3]. The efficiency of hole extraction and transport depends on the quality of interface between PEDOT:PSS and photoactive layer and crystallinity of PEDOT:PSS. Here, we modified PEDOT:PSS layers obtaining by a spin-coating method from aqueous solution by adding 2-proponal. The improvement of structure and surface morphology was investigated by atomic force microscopy. Also, impedance spectroscopy technique was used to analyze charge transfer and transport. The modified PEDOT:PSS layers revealed better structure and surface morphology, and showed improved hole extraction and transport in comparison to an unmodified layer. PSCs with modified PEDOT:PSS layer have improved photovoltaic performance, which leads to enhancing the short circuit current density by 1.7 times, and power conversion efficiency and quantum efficiency of cells by 1.6 times.

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Magnetic and electronic properties of PtSe₂ thin film

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Two-dimensional (2D) materials with single or few atomic layers have attracted significant attention from the scientific community due to their potential transport physics and prospects for technological applications. A variety of 2D materials beyond graphene with different bandgaps have been synthesized in recent years. One of them is platinum diselenide (PtSe₂) with the bandgap energy of 1.2 eV at one monolayer. However, the low throughput synthesis of high quality 2D thin films has thus far hindered the development of devices. The methods of molecular beam epitaxy (MBE) and chemical vapor deposition (CVD) have been used to achieve large-scale fabrication of PtSe₂ films, which were fabricated from Pt thin films with different thickness through selenization process.

We have grown Fe₃O₄ on MgO substrate by MBE system in order to fabricate even better epitaxial Pt thin films. After the fabrication of PtSe₂ on Fe₃O₄/MgO, the electronic and magnetic properties of the interface between two epitaxial grown thin films of platinum diselenide and magnetite have been studied.



Effect of annealing on the optical properties of TiO₂ films

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In this work, TiO₂ films, which were obtained by ion-plasma high-frequency magnetron sputtering of a polycrystalline rutile target in an argon atmosphere at 1 Pa pressure were studied. The TiO₂ films were annealed for 1 hour in air in the temperature range from 100 °C to 400 °C with 100 °C increment. It was found that the TiO₂ films have high transparency, which remains almost unchanged during annealing. The fundamental absorption edge of the films, which is located from 320 to 380 nm, also changes slightly with increasing annealing temperature up to 400 °C.

The refractive index $n(\lambda)$ of the films decreases with incident radiation increasing and, as a result, TiO₂ films are characterized by normal dispersion. With increasing annealing temperature, the refractive index n in the long-wavelength region of the spectrum increase in comparison with those in films without annealing.

When comparing the calculated values of $n(\lambda)$ with theoretical values, one can see that in the short-wavelength region of the spectrum, the dependences $n(\lambda)$ coincide, while discrepancies are observed with wavelength increasing. This may be due to the structural features of the films, which depend on their thickness. In a literature, the refractive index of titanium dioxide was measured for samples with ~ 1-2 μm thickness, while in this work the films with ~ 270 nm thickness were studied.

From the calculated $n(\lambda)$, we can conclude that for TiO₂ films the optical properties are stable up to a temperature of 600 °C. It was found that the absorption laws are equally well satisfied for the studied TiO₂ films before and after annealing. This means that for TiO₂ films before and after annealing at 400 °C, the realization of direct and indirect optical transitions upon absorption of light quanta is equally probable. Optical band gap of the films annealed at 400 °C, determined from the quadratic absorption law, was ~ 3.01 eV, which is typical for TiO₂ films with a rutile structure. This E_g is significantly less than the value obtained using the law with $\gamma = 1/2$, which corresponds to the allowed direct-gap optical transitions.

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Silver nanowires mesh electrode for metal-semiconductor-metal perovskite solar devices.

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Solar cells are one of the most promising clean energy technologies due to their reasonably high energy conversion efficiencies and low carbon footprint. Traditional photovoltaic devices such as Si or thin films solar cells require multi-step fabrication processes that involve costly manufacturing processes, which decreases their competitiveness compared to other types of renewable and energy technologies [1]. Thus, a quest for high-performance PV devices with cost-effective and simple manufacturing has enormous industrial and economic significance.

Here, we report on the progress of our work on fabrication of simple metal-semiconductor-metal (MSM) perovskite solar cells (PSCs), in which the metal electrodes directly contact the perovskite layer to create Schottky junction solar cells.

The photovoltaic properties of MSM PSC will strongly depend on the asymmetry in work function values of two metal contacts which are gold back-contact electrode and silver nanowire (AgNWs) mesh [2, 3]. Modified polyol synthesis was used to produce AgNWs [4]. To achieve homogeneous, uniform and highly-conductive mesh formed by AgNW on the perovskite layer, various fabrication protocols (deposition technique, ambience, solvent, volume, etc.) have been tested. We have developed several protocols for obtaining AgNW mesh electrodes deposited on top of thin perovskite films on glass substrates with the sheet resistances of the AgNW mesh as small as $\sim 2 \text{ K}\Omega/\square$. Further experiments with AgNWs deposition are in progress to enhance the conductivity and, consequently, to fabricate MSM PSC device with desired performance. Four-point probe measurement system and scanning electron microscopy were used to characterize sheet resistance of AgNWs mesh electrodes on perovskite films and analyze their morphology, respectively.

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ZnO-ITO multilayered structure on Si substrate with prospective usage as antireflective covering for solar cells

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ZnO and SnO₂ are some of the most important functional oxides with direct wide band gaps (3.37 and 3.95 eV). They are widely used in electronics as transparent electrodes, materials for optoelectronic devices and solar cells [1]. As is known, nearly 40% of incident light is reflected back in silicon wafers in the 550 nm wavelength region. This causes a significant loss in solar cell efficiency. Capturing of incident light is an essential requirement for high-performance solar cells. Photocurrent in solar cells can be increased by fabricating of antireflective coatings, which are beneficial in transmitting maximum light in such a way that minimal light is reflected from the air–substrate interface. Theoretical modelling of the antireflective thin films, such as ZnO [2], unlocks new options for production of wideband-tunable antireflective coatings that can be applicable in high-performance photovoltaic applications.

This study uses a silicon wafer as the substrate, on which the multilayered structure is formed. This structure includes a 500-nm thick ITO (Indium tin oxide) film, ZnO films with variable thickness and ZnO nanorods of various radii on the top. This kind of coating can enhance solar cell productivity at omnidirectional angles because there is a gradual declination of the refractive index. The multilayered structure were designed and tested using Lumerical FDTD (Finite-difference time-domain) simulations [3], and this reduced it reflectance to <0.5% in the 400-700 nm wavelength range. Optimization results indicate that ZnO nanorods with $r = 35$ nm on a 70-nm ZnO uniform film on the top of ITO thick film has reflectance of 0.0004-0.5% in the visible region. Lumerical FDTD helps and permits the operator to define an appropriate design using different inorganic materials applicable to various supporting substrates and illuminants [3]. This software is a reliable simulation tool that can operate in varying environmental conditions.

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Sensitization of TiO₂ by merocyanine dye in the presence of plasmon nanoparticles

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Currently, an active search and study of non-metal organic luminophores for dye-sensitized solar cells is performed. Merocyanine dyes are characterized by high bipolarity, narrow selective absorption bands, high absorption cross sections (extinctions) and high photochemical stability.

In present work we have studied the effect of Ag nanoparticles (NPs) on the sensitization of a TiO₂ film by merocyanine dye. For this purposes dye was adsorbed onto porous TiO₂ films with the addition of Ag/TiO₂ core-shell nanostructures at a concentration of 0, 0.5, 1, and 2 wt%. These nanostructures consist of a core – Ag nanoparticles (20 nm in diameter) and a TiO₂ shell with a thickness of 4 nm. These TiO₂ films were used both for spectral-luminescence measurements and for DSSC assembling according to a standard technique.

The absorption spectrum of merocyanine is located in the region of 500 – 650 nm with a maximum at 590 nm, the fluorescence band is centered at 630 nm. The measurements showed that the addition of Ag/TiO₂ NPs does not affect on the shape and position of the absorption and fluorescence bands of the dye. In the presence of plasmonic NPs, a 30% increase in the fluorescence intensity of the dye was recorded. The fluorescence lifetime of the dye practically does not change in the presence of Ag/TiO₂ NPs.

The current–voltage characteristics (CVC) of solar cells were measured under the illumination with a Xe lamp with a power of 100 mW/cm². The merocyanine dye has the following photovoltaic parameters: $I_{sc}=0.18$ mA/cm², $V_{oc}=355$ mV, $FF=0.33$, $\eta=0.21\%$. The addition of Ag/TiO₂ NPs doubles the efficiency of the DSSC sensitized with a merocyanine dye and $I_{sc}=0.6$ mA/cm², $V_{oc}=373$ mV, $FF=0.20$, $\eta=0.43\%$. The data on the spectral sensitivity of DSSC show that the addition of Ag/TiO₂ NPs results in the growth in the spectral sensitivity of the solar cell in the absorption band of the dye. At the same time, absorption of plasmonic Ag NPs was recorded in the region of 420 nm. Thus, the combination of the growth of fluorescence and spectral sensitivity of solar cells with Ag/TiO₂ NPs leads to an increase in the efficiency of the generation of charge carriers in a semiconductor sensitized by the investigated merocyanine.

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Effect of copper sulfate concentration in growth solution on photocatalytic properties of ZnO/CuO nanostructures

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Metal oxide semiconductors are the most suitable materials used for photocatalytic processes in industry and the environment (in particular, they are involved in wastewater decontamination processes). Semiconductors are relatively inexpensive, safe for health, chemically stable, and have high photosensitivity [1, 2]. One of the most challenging tasks at present is to improve the photocatalytic activity of photocatalysts for practical applications in the visible range, namely, high energy transfer efficiency, non-toxicity and low cost. The main efforts in the field of photocatalysis are devoted to the modification of existing photocatalysts to increase their photocatalytic characteristics [3]. In this work, semiconductor composites of copper (II) oxide and zinc oxide (ZnO/CuO) were synthesized using a low-cost method.

To study the effect of the concentration of copper sulfate in the growth solution on the photocatalytic properties ZnO/CuO nanocomposites were synthesized by a low-temperature hydrothermal method. The aqueous solution contained copper sulfate, zinc chloride, and sodium hydroxide. A series of samples with different concentrations of copper sulfate (0.7 mmol - 2.0 mmol) was considered.

The results of studying of the synthesized samples by electron microscopy showed that the obtained ZnO/CuO nanocomposites consist of thin filamentary ZnO rods with CuO nanoparticles attached to them. It was noted that an increase in the copper sulfate concentration in the growth solution to 2.0 mmol with the remaining parameters unchanged leads to an insignificant change in morphology: the volume of flocculent structures and the amount of CuO nanoparticles increase.

Samples of the RhB solution for measuring of the optical density spectra were carried out every 30 minutes for 150 minutes. It should be noted, that with the used the same parameters for the ZnO/CuO powders synthesis, an increase in the amount of CuO nanoparticles in ZnO/CuO composites leads to a decrease in their photocatalytic activity which appears to be due to dimming effect at UV exposition.

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Light Management in Perovskite Solar Cell by Incorporation of Carbon Quantum Dots

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Perovskite solar cells (PSCs) with a standard sandwich structure suffer from optical transmission losses due to the substrate and its active layers. Developing strategies for compensating for the losses in light harvesting is of significant importance to achieving a further enhancement in device efficiencies. In this work, the down-conversion effect of carbon quantum dots (CQDs) was employed to convert the UV fraction of the incident light into visible light. For this, thin films of poly(methyl methacrylate) with embedded carbon quantum dots (CQD@PMMA) were deposited on the illumination side of PSCs. Analysis of the device performances before and after application of CQD@PMMA photoactive functional film on PSCs revealed that the devices with the coating showed an improved photocurrent and fill factor, resulting in higher device efficiency. Meanwhile, other effective incorporation approaches of CQD in PSCs will be demonstrated. The underlying mechanism for the enhancement in device performance will be investigated. The obtained results will provide an valuable insight into the community for future light management during PSC fabrication.

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Ag:TiO₂ plasmonic nanocomposite films obtained by RF magnetron co-sputtering

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It is known that TiO₂ is a wide-gap semiconductor, which due to its low cost and photocatalytic properties has found great application in purification of water and organic pollution, as well as solar energy [1]. To expand an application area, various methods of functionalization and alloying of TiO₂ with various metallic and nonmetallic impurities and particles are used. One of these ways is usage of plasmon nanoparticles, like Au and Ag, to increase the absorption region in the visible range [2].

In this work, plasmon nanocomposite films of Ag:TiO₂ were obtained by RF magnetron co-sputtering [3]. It was revealed that the films consist of an amorphous TiO₂ matrix and isolated silver nanoparticles with 3-5 nm diameter. The optical absorption spectra of Ag:TiO₂ nanocomposite films are characterized by local maxima at 465-480 nm corresponding to light scattering plasmon resonance (LSPR). Photoelectrochemical studies of Ag:TiO₂ nanocomposite films in 0.1 M Na₂SO₄ under illumination with 465 nm light showed that silver nanoparticles presence in the matrix increases the photoconductivity. The quantum yield for Ag:TiO₂ composite films increases significantly, while for a pure TiO₂ film this value does not exceed 0.5%.

In addition, work was carried out related to the degradation of the methylene blue dye (MB dye) under the direct action of solar radiation, from which it follows that the presence of silver nanoparticles in the TiO₂ matrix increases the rate of decoloration of the aqueous solution with MB dye.

Thus, the obtained TiO₂:Ag nanocomposite films are a promising material for use in nonlinear optics, electronics, electrooptics, photocatalytic and antireflection coatings and photoconverters, as well as in biomedicine as antibacterial coatings.

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Bulk and Interfacial Defect Passivation for High Performance Perovskite Solar Cells

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Nowadays, perovskite materials are considered to be the most promising absorber media for the third generation photovoltaics. Outstanding material properties allowed perovskite solar cells' power conversion efficiency values to exceed 25% in ten years, demonstrating the highest efficiency increase rate among all the available photovoltaic technologies. Despite such progress technology commercialization requires further device performance enhancement. Here, we report a performance increase strategy implying passivation of both bulk and interfacial defect states. To passivate the bulk defects an organic cross linker, 2,2'-(ethylenedioxy)bis(ethylammonium iodide) (GAI), was added into the mixed perovskite absorber layer. Different experimental techniques reveal that optimized amount of GAI, indeed, passivates defect states via cross-linking perovskite grains, while excess amount of cross-linker material deteriorates device performance due to generation of new defects and poor conductivity of the organic additive. The interfacial defects were passivated by interface engineering technique, namely, via application of a composed electron transport layer (ETL) consisting of quantum dot (QD) SnO₂, nanoparticle (NP) SnO₂ and a passivation layers based on PMMA:PCBM. It was demonstrated that a single-layer ETL made of QD SnO₂ or NP SnO₂ causes devices to show I-V hysteresis, while application of a triple-layer ETL effectively suppresses the hysteresis due to the optimization of ETL/perovskite interface. Thus, the cumulative effect of both applied techniques allowed to increase device' power conversion efficiency, almost completely remove hysteresis and improve the solar cell stability.

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Advanced Functional Nanomaterials for Photocatalytic Water Splitting

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Through mimicking Nature, unique assembled nanostructures can be designed and fabricated to improve certain properties of materials and device performance for targeted applications. In this presentation, we discuss the synthesis, and characterization of novel bio-inspired and biomimetic functional nanomaterials, and their properties. At the same time, we discuss how to apply them to investigate fundamental science in photocatalytic water splitting via creating their hierarchical nanostructured materials. In brief, this talk will focus on the following topics: (a) synthesis of bio-inspired functional nanomaterials; (b) fabrication of unique nanoarchitectures to better understand fundamental science; and (c) Applying these unique nanomaterials and nanostructures to resolve the scientific problems in Photocatalytic Water Splitting.

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Synthesis and modification of Gadolinium ferrite nanoparticles for potential application in neutron capture therapy

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For decreasing the mortality from cancer diseases it is crucial to develop effective and low-invasive treatment methods. One of them is appeared to be neutron-capture therapy (NCT). It is based on a neutron capture reaction of isotopes delivered to tumor and thermal neutron flux. In this kind of reaction with ^{10}B or ^{157}Gd (or their combination) resulting particles have high index of linear energy transfer and low path length. That means effective ablation of cells in a short range. But still for NCT to become beneficial two technical problems should be solved: constructing of compact sources of pointed neutron flux and ability to directly deliver NCT agents in appropriate amount [1]. Delivering via magnetic nanocarriers (MNC) is considered to be promising. MNC are injected in-vivo and guided to tumor by external high-gradient magnetic field [2]. For this purpose, modified $\text{Gd}_x\text{Fe}_{3-x}\text{O}_4$ particles were chosen to be MNC. $\text{Gd}_x\text{Fe}_{3-x}\text{O}_4$ nanoparticles were synthesized with a chemical co-precipitation method. Average size of gained particles is 33 ± 9 nm. For excluding the toxicity of Gd, particles were covered by tetraethoxysilane (TEOS). Size of TEOS-covered particle – 83 nm. Then it was functionalized with 3-(trimethoxysilyl) propyl methacrylate (MSPMA) to create double bond for further use in graft polymerization of glycidyl methacrylate that led to branched structure allowing attaching carborane cores with higher concentration. Final size is 95 nm. Gained NPs were characterized by SEM, EDX and FTIR spectroscopy. EDX spectroscopy confirmed the presence of covers. Figure 1 presents SEM scans.

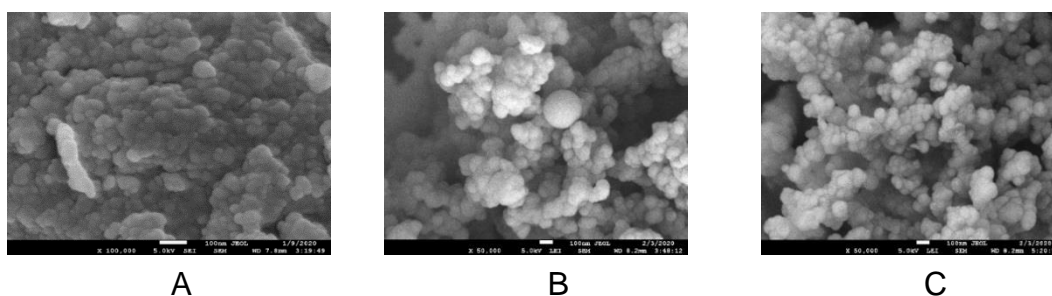


Figure 1. SEM images of A) $\text{Gd}_x\text{Fe}_{3-x}\text{O}_4$ B) $\text{Gd}_x\text{Fe}_{3-x}\text{O}_4\text{-TEOS}$ C) $\text{Gd}_x\text{Fe}_{3-x}\text{O}_4\text{-TEOS-MSPMA}$

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Enhancing of charge transfer efficiency from a perovskite $\text{CH}_3\text{NH}_3\text{PbI}_3$ film in a layer of titanium dioxide in the presence of Ag/SiO₂ nanoparticles.

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Using of localized plasmon resonance (LPR) in metal nanoparticles (NPs) is one of the promising directions for increasing of perovskite solar cells efficiency [1, 2]. Metal NPs coated dielectric shell can be used to exclude the contribution of the NPs to the total electrical conductivity of a perovskite films.

The influence of LPR in the "core-shell" NPs on the process of charge transfer from a perovskite $\text{CH}_3\text{NH}_3\text{PbI}_3$ layer to TiO_2 layer is studied in the work.

Samples with ITO– TiO_2 – $\text{CH}_3\text{NH}_3\text{PbI}_3$ layers structure film were fabricated. Ti-Nanoxide BL/SC (Solaronix) paste were used for fabrication a compact TiO_2 layers. $\text{CH}_3\text{NH}_3\text{PbI}_3$ films synthesized by a one-step method [3]. 0.1 wt% Ag/SiO₂ NPs with respect to the mass of the perovskite was added to a solution of a $\text{CH}_3\text{NH}_3\text{I}\cdot\text{PbI}_2\cdot\text{DMSO}$ adduct in dimethylformamide. The diameter of Ag NPs was 5 nm, and the radius of the dielectric shell (SiO₂) was 2.5 nm.

The addition of NPs to the adduct solution leads to the formation of the perovskite films with a lower optical density than the perovskite without NPs. A decrease in the intensity of the luminescence, and a blue shift in wavelengths of the luminescence intensity maximum is observed for the $\text{CH}_3\text{NH}_3\text{PbI}_3$ films with NPs compared to this parameters for $\text{CH}_3\text{NH}_3\text{PbI}_3$ films without NPs. The luminescence lifetime also decreases for the $\text{CH}_3\text{NH}_3\text{PbI}_3$ with NPs. The intensity maximum of the luminescence kinetics for $\text{CH}_3\text{NH}_3\text{PbI}_3$ with NPs has a time delay (0.05 - 0.1 ns) in comparison with the maximum luminescence intensity of perovskite without NPs. These results indicate an increase in the efficiency of charge transfer from perovskite to TiO_2 in the presence of Ag/SiO₂ NPs.

Acknowledgement

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Free energy of metal ion binding to some functional groups of concrete admixtures in water

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Concrete is the most used man-made materials on earth and has played a fundamental role in shaping our world, ranging from the cities we live in, roads and railways, to the infrastructure to support lower-carbon energy solutions [1]. Compared to other building materials, concrete is inherently a low carbon constructional material. However, as a result of the large volumes of concrete used, the production of Portland cement, the main binder of concrete, contributes 5–8% of annual anthropogenic global CO₂ production [2,3] What can we do to reduce the carbon footprint and to further improve the environmental performance of concrete? Various solutions have been proposed and practiced, such as partial cement replacement by supplementary cementitious materials, development of low-carbon binders, reducing the amount of cementitious material altogether, and enhancement of concrete strength and durability; however, such solutions are often not possible without the development of efficient concrete admixtures, which have now become indispensable ingredients for the production of modern advanced concrete.

There are two main types of concrete admixtures—chemical admixtures and mineral admixtures, both of which can be further grouped into various categories according to their function and chemical constituents. Our work focuses on the development of chemical admixtures, such as superplasticizers, slump-retaining admixtures, rheology modifying agents, and air entraining admixture. While those molecules are designed to sever different functions, most of them contain anionic functional groups and are supposed to act at interfaces [4]. However, the aqueous phase where chemical admixtures are dissolved in contains various metal cations, which may bind to the anionic functional groups of the chemical admixtures and play a profound role in their functions. We believe it is crucial to understand such binding interactions in order to understand the working mechanisms of chemical admixtures and to develop more efficient admixtures. Our current work has focused on calculations of the binding free energies of two different metal cations (Ca²⁺ and K⁺) with several different functional groups of chemical admixtures via two different methods—the quantum density functional theory (DFT) method and classical the force-field-based Metadynamics method. The binding free energies for potassium and calcium cations with different functional groups such as phosphonate, phosphate, carboxylate, sulfonate, sulfate, and alkoxide, as the complexes, have been explored in detail by the two methods.

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Amorphous silicon dioxide as an anode material for li-ion batteries

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In recent decades, progress in Li-ion batteries (LIBs) has grown dramatically. In 2016, about 6.4 billion cells were sold of LIBs and this is equivalent to 90 GWh [1]. even the Nobel Prize in Chemistry in 2019 was awarded to John Goodenough (USA), Stanley Whittingham (Great Britain) and Akira Yoshino (Japan) for the development of lithium-ion batteries. But work on improving the Li-ion batteries is still ongoing.

SiO₂ is one of the most widely used materials on earth. SiO₂ is one of the most widely used materials on earth and is uses in the fields of medicine, cosmetics, agroindustry, electronics [2,3], and has also begun research on the use of SiO₂ as an anode material in lithium-ion batteries [4]. It has a high theoretical capacity (1965 mAh•g⁻¹) [5].

SiO₂ obtained by us is amorphous and the source is rice husk (RH) from Kazakhstan (Kyzylorda region). Material synthesis is divided into two stages. Stage 1 includes washing pre-treatment by HCl and calcination at 600°C (SiO₂-1). Stage 2 includes purification by dissolving in NaOH and extraction pure (SiO₂-2) by adding HCl and washing by distilled water. The use of 1 stage material as an anode material in lithium-ion batteries has shown good stability. Microstructure of SiO₂-1 and SiO₂-2 differs from each other. SiO₂-2 at the beginning showed good stability, but from the 10th cycle, it began to lose capacity.

Acknowledgement

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High Mass-Loading Sulfur-Composite Cathode for Lithium-Sulfur Batteries

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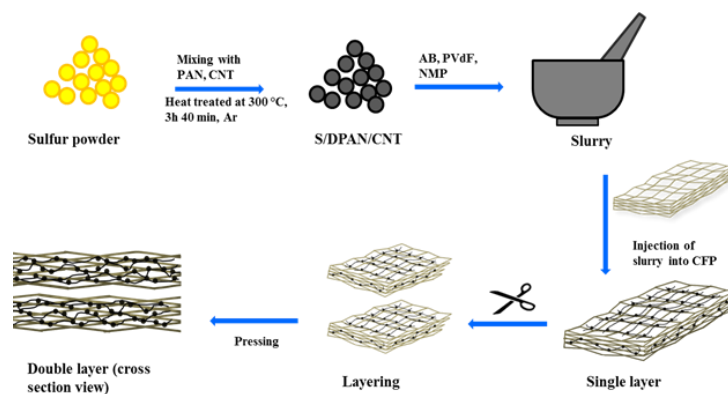


Fig. 1 A schematic representation illustrating the preparation and injection process of sulfur composites into 3D current collector

Lithium-sulfur batteries potentially can be applied in the market of portable devices and storage of electrical energy, due to the cheap and abundant resources and high theoretical discharge capacity of sulfur (1675 mAh g⁻¹). Nevertheless, implementing Li-S batteries face several difficulties based on low electronic conductivity of sulfur and complicated electrochemical reaction. This research is aimed to increase mass loading of sulfur in the composite, which in turn requires improvement in the electrical conductivity. The conductivity of sulfur is improved with the synthesis S/DPAN/CNT composite from polyacrylonitrile (PAN) and carbon nanotubes (CNT), while mass loading is increased with the use of carbon fiber paper as a current collector. Herein we report a simple and efficient preparation way of the sulfur composite cathode with the increased sulfur mass loading and stable electrochemical properties. As a result, mass loading of sulfur was increased up to 5 mg cm⁻² and batteries showed stable electrochemical performance.

Acknowledgements

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Methods of producing a polymer electrolyte on the surface of a 3D structure for lithium-ion batteries

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Three-dimensional microbatteries (3D-MBs) are energy storage devices intended for a large range of microelectronic applications. To date, a large number of various 3D electrodes have been developed (nanotubes, nanopillars and porous foams). However, electrolyte systems for these electrodes have not yet been implemented [1].

Solid polymer electrolytes (SPEs) have several advantages, such as leakage-free, low flammability, flexibility, electrochemical stability, high safety and excellent thermal stability [2], which allows their use in solid 3D batteries. SPEs facilitate the attainment of thin, flexible and adhesive coatings on microscopic surfaces.

Gel or polymer electrolytes into 3D-MBs could be received by soaking a polymer matrix with conventional liquid electrolytes or by electrodeposition polymer layers directly on electrode surfaces [1].

In this research, we compared two methods for producing a polymer electrolyte polymethylmethacrylate (PMMA) on the surface of a 3D structure of Ni foam by drop coating [3] and electropolymerization [4] methods. Ni foam acts as a 3D electrode, because it has an uneven structure. The method of applying a droplet coating was carried out by dropping a solution of PMMA on a Ni foam in a glove box in an argon atmosphere.

The electrochemical deposition of PMMA polymer electrolyte onto Ni foam has been accomplished using a cyclic voltammetry (CV) technique. At the potential 2.6V the formed polymer is anchored firmly to the cathode even in a good solvent for it.

The studies of surface grafting polymers were carried out by microscopic investigation and structural characterization. The obtained PMMA film has a uniform fine structure.

Acknowledgements

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Electrospun 3D structured carbon current collector for Li/S batteries

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Light weight carbon nanofibers (CNF) fabricated by a simple electrospinning method and used as a 3D structured current collector for a sulfur cathode. Along with a light weight, this 3D current collector allowed us to accommodate a higher amount of sulfur composite, which led to a remarkable increase of the electrode capacity from 200 to 500 mAh g⁻¹ of the electrode including the mass of the current collector. Varying the electrospinning solution concentration enabled obtaining carbonized nanofibers of uniform structure and controllable diameter from several hundred nanometers to several micrometers. The electrochemical performance of the cathode deposited on carbonized PAN nanofibers at 800 °C was investigated. An initial specific capacity of 1620 mAh g⁻¹ was achieved with a carbonized PAN nanofiber (cPAN) current collector. It exhibited stable cycling over 100 cycles maintaining a reversible capacity of 1104 mAh g⁻¹ at the 100th cycle, while the same composite on the Al foil delivered only 872 mAh g⁻¹. At the same time, 3D structured CNFs with a highly developed surface have a very low areal density of 0.85 mg cm⁻² (thickness of ~25 μm), which is lower for almost ten times than the commercial Al current collector with the same thickness (7.33 mg cm⁻²).

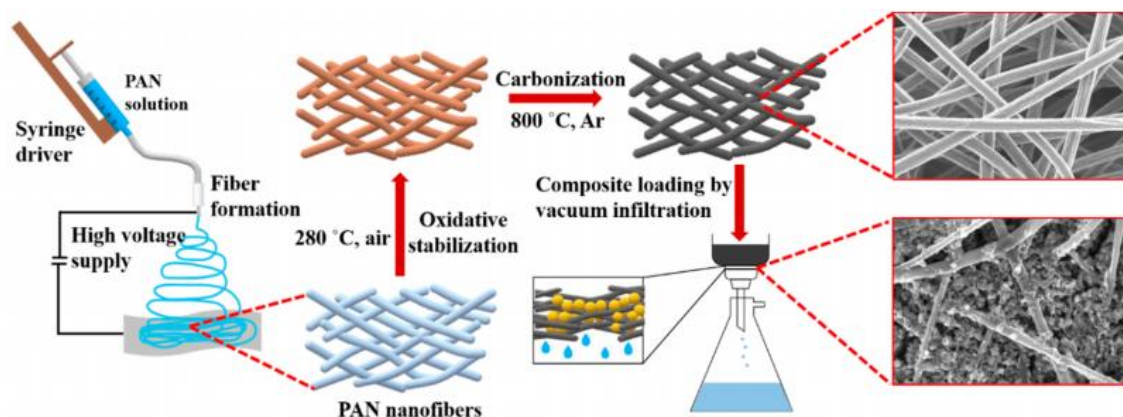


Figure 1. Scheme of carbon nanofiber fabrication and sulfur-based cathode preparation.

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Mechanistic investigation on hybrid Zn/V₂O₅ rechargeable battery using a binary Li⁺/Zn²⁺ aqueous electrolyte

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Low cost, easy processing and environment-friendly aqueous rechargeable zinc batteries have great potential for large-scale energy storage, which justifies they have been receiving extensive attention in recent years. An original concept based on the use of a binary Li⁺/Zn²⁺ aqueous electrolyte is described here in the case of Zn/ V₂O₅ system.

The Zn // Li₂SO₄ – ZnSO₄ // V₂O₅ cell presents, in the narrow 1.6 - 0.8 V voltage range, interesting capacity values about 136-125 mAh g⁻¹ at C/20-C/5 rates respectively. At 1C, a capacity of 80 mAh g⁻¹ is outstandingly stable over more than 300 cycles with a capacity retention of 100 %. A detailed structural study by XRD and Raman spectroscopy allows unravelling the peculiar response of the V₂O₅ layered host lattice. Strong similarities with the well-known structural changes reported in nonaqueous lithiated electrolytes are highlighted, although the emergence of the usual distorted δ-Li V₂O₅ phase is not detected upon discharge to 0.8 V. The pristine host structure is restored and maintained along cycling with mitigated structural changes leading to the high capacity retention. The present electrochemical and structural findings reveal a reaction mechanism mainly based on Li⁺ intercalation, but cointercalation of a few Zn²⁺ ions cannot be completely dismissed. The presence of zinc cations between the oxide layers is thought to relieve the structural stress induced in V₂O₅ under operation, resulting in a limited volume expansion of 4 %.

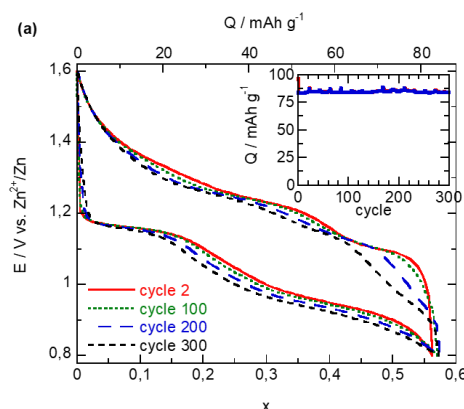


Fig. 1. Cycling performance of V₂O₅ in the Zn/Li₂SO₄-ZnSO₄/V₂O₅ aqueous battery at 1 C in the 1.6 V/0.8 V voltage range.

Acknowledgement

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The performance comparison of $\text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3$ solid electrolyte via various synthesizing methods.

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Development of all-solid-state Li-ion batteries (ASSLBs) has gained significant attention because of its electrochemical, chemical, mechanical, thermal stability and diminished flammability^{1,2}. There are several types of solid electrolytes for ASSLBs such as LISICON-like, argyrodite, garnet, NASICON, Li-nitride, perovskite and Li-halide. Among all types, one of the most stable electrolytes with sufficient ionic conductivity is NASICON, particularly $\text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3$ (LATP03)³.

This research investigates different fabrication methods of LATP03 solid electrolyte such as solid-state, solution chemistry, sol-gel, spray-drying and a molten flux and their structural, morphological and electrochemical characterizations.

Structure of LATP was confirmed by X-Ray Diffraction, and cell parameters were obtained using Rietveld refinement method via GSASII. The morphology of crystals were observed via scanning electron microscopy. The ionic conductivity of materials was determined by electrochemical impedance spectroscopy and it was carried out by applying electron conductive materials on a electrolyte's both sides as blocking electrodes. It was found that the ionic conductivity of LATP03 depends on fabrication methods, grain size, theoretical density of pellets and morphology.

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Metal oxides as additive to suppress dendrite formation on Zn anode of rechargeable aqueous battery

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Recently rechargeable aqueous zinc-ion batteries have attracted interest due to their low cost and high safety advantages; but they still suffer from the problem of dendrite growth on Zn metal anodes that cause early battery destruction [1]. There are various methods for modification of the surface of Zn metal anodes to suppress dendrite formation [2]. Suppression of roughness or dendrite evolution by electroplating may also be achieved with ppm-levels of additives in the plating electrolyte. Several studies reporting the use of additives to control the Zn deposit quality and appearance are noted. Additives in these studies include polyvinyl alcohols, polyamines, carbonyl compounds and surfactants [3].

The role of metal oxides, namely germanium oxide, vanadium oxide, indium oxide and scandium oxide (100 ppm) have been investigated in the electroplating process on the surface of metallic zinc foil disks. The mix of 0.6M ZnCl₂ and 0.1M NH₄Cl in DI water worked as a plating solution. Synthesized Zn-metal oxide anodes characterized by X-ray diffraction and Scanning electron microscopy before and after cycling to study surface morphology, structural changes of anode and to evaluate dendrite growth.

Acknowledgment

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The 8th International Conference on Nanomaterials and Advanced Energy Storage Systems (INESS-2020)

C-SiC and Si-SiC thin film systems as the anodes for LIBs

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The miniaturization of the devices requires the miniaturization of energy storage systems. Lithium-ion batteries can provide the highest energy at smaller size and lighter weight among other energy systems.

The present work reports the study of the development of new types of anodes – carbon film deposited on SiC thin film and Si thin film on SiC produced by chemical vapor deposition (CVD) method. The SiO₂/MgF₂/Al/Ti omics contacts were deposited by magnetron sputtering and annealed at 600 °C and served as the anode current collectors. The studies were accompanied by microscopic investigation and structural characterization. The electrochemical results and characterization details will be detailed at the conference.

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Hierarchical Defective Fe_{3-x}C@C Hollow Microsphere Impulses Fast and Long-lasting Lithium-Sulfur Batteries

Yongguang Zhang^{1*}, Jiayi Wang¹, Xin Wang^{2**}

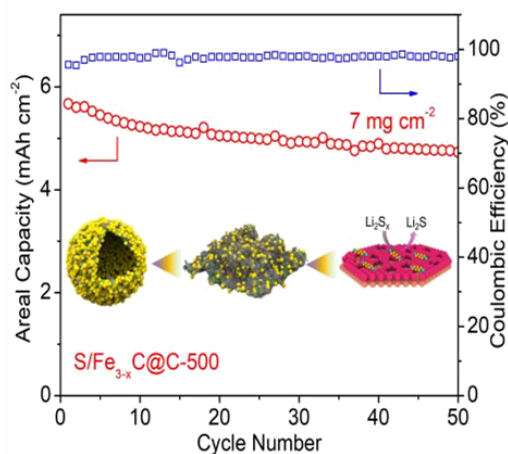
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Lithium-sulfur (Li-S) batteries present one of the most promising energy storage systems owing to their high energy density and low cost. However, the practicalization of Li-S batteries is still hindered by several technical issues mainly represented by the notorious polysulfide shuttling and sluggish sulfur conversion kinetics. In this work, we developed the unique hierarchical Fe_{3-x}C@C hollow microsphere as advanced sulfur immobilizer and promoter to realize high-efficiency Li-S batteries. The porous hollow architecture not only accommodates the volume variation upon the lithiation-delithiation processes, but also exposes vast active interfaces for facilitated sulfur redox reactions. Meanwhile, the mesoporous carbon coating establishes a highly conductive network for fast electron transportation. More importantly, the defective Fe_{3-x}C nanosized subunits impose strong LiPS adsorption and catalyzation, rendering a fast and durable sulfur electrochemistry. Attributed to these structural superiorities, the obtained sulfur electrodes exhibit excellent electrochemical performance, i.e., high areal capacity of 5.6 mAh cm⁻², rate capability up to 5 C, and stable cycling over 1000 cycles with a low capacity fading rate of 0.04 % per cycle at 1 C, demonstrating a great promise in the development of practical Li-S batteries.





Fabrication and characterization of electrospun PVAM/TEOS based gel polymer electrolyte for Lithium-ion batteries

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Gel polymer electrolytes (GPEs) are promising components in lithium ion batteries (LIBs) because of leak proof, longer shelf life and safety. GPE consists of a porous polymer host and liquid electrolyte saturated within and combine the advantages of both the liquid and solid components [1].

In this study, a GPE based on poly(vinyl alcohol)/maleited PVA/tetraethyl orthosilicate (PVA/PVA-MA/TEOS) polymer fibers were prepared in different weight ratios. Crosslinked nanofibrous polymer membrane for GPE was fabricated by UV-electrospinning method. Dual crosslink polymer membranes were obtained after heat treatment of as-prepared polymer nanofibers, due to the condensation of hydrolyzed TEOS. The morphology of the electrospun membranes was studied using scanning electron microscopy. Thermal properties of the membranes were investigated using thermal gravimetric analysis. The membrane has good porosity exhibits high uptake when activated with the liquid electrolyte of lithium salt in a mixture of organic solvents and also shows high liquid retention properties. Electrochemical impedance spectroscopy and linear sweep voltammetry was used to determine the conductivity and electrochemical stability of prepared GPEs. Electrochemical performance of the polymer gel electrolyte is evaluated in Li/polymer electrolyte/LiFePO₄ coin cell.

Acknowledgements

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Adsorption arsenite from aqueous solutions by Cu/CuO loaded composite track-etched membranes

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Nanoscale structures of copper and its oxides are widely used in heterogeneous catalysis and demonstrate improved properties compared to bulk analogues [1]. Previously, we demonstrated the high potential of composite track-etched membranes with copper microtubules (MTs) as effective catalysts for p-nitrophenol hydrogenation and the Mannich reaction [2]. In addition, efficient sorption of ions of heavy metals, such as As, Pb, Cd, Ni, etc. is a promising application of CuO NPs [3].

The composites with the internal pore diameter of 280 nm and the copper microtubules wall thickness of 75 nm were obtained by chemical template synthesis in nano-channels of track-etched PET membranes. Upon the analysis of the data on the phase composition and degree of crystallinity of microtubules before and after annealing, it was found that the complete conversion of copper to copper(II) oxide is possible only at temperatures of 140 °C and higher, and 100% tenorite phase is formed after 10 hours of annealing at 140°C. The composites annealed at 140 °C were also tested in terms of their arsenic (III) ions sorption capacities in the flow mode. For the unannealed sample, the effect of flow-rate on sorption activity was studied and the optimal value of 10 mL/min was established. It was shown that the sorption capacity of composite membranes increases by 48.7% compared to the initial sample at 10 h of annealing and then decreases by 24% with an increase in the annealing time (24 h). Successfully combining mechanical strength, the possibility of repeated use, low cost and ease of production, such Cu/CuO/PET membrane composites can be considered as promising materials for sorption of arsenic ions from aqueous solutions.

Acknowledgement

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Analysis of the dependence of the structural parameters of membranes based on NOA and anode current on the parameters of the production process

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Among the porous membranes, PAOA-based membranes, formed by the method of electrochemical anodizing of aluminum foil, are of the greatest interest. Membranes obtained by electrochemical anodization are highly ordered structures with parallel vertical pores [1]. The unique porous structure, the parameters (diameter, length and distance between adjacent pores) of which can be varied during the synthesis process allows the use of films of porous aluminum oxide as inorganic membranes, templating material for the synthesis of nanowires or nanotubes with a controlled diameter and high geometric anisotropy, as well as 2D photonic crystals and biosensors [2,3].

Aluminum foil (99.999%) with a thickness of 0.5 mm was used as the starting material for the synthesis of films of porous aluminum oxide. Oxide layer formed on the foil surface was removed by electrochemical polishing of aluminum in a mixture of 40g CrO₃ + 210 ml H₃PO₄ (concentrated acid) + 45 ml H₂O at a temperature of 80°C. The membranes based on porous alumina were obtained by a two-stage anodizing process in 0.4 M oxalic acid at a temperature of 4–19 °C.

With an increase in the magnitude of the voltage, the thickness of the porous film, which grows in the same time, increases; the growth rate of the film grows sublinearly. With increasing voltage value, the initial value of the anode current also increases. The anode current in the anodization process gradually decreases, which, as already noted, indicates the beginning of pore formation and further stabilization of the anode current occurs when the pores grow deep into the oxide film. According to the data obtained on the dependence of the anode current on the time of the anodization process, it can be concluded that the maximum current value at room temperature is higher than at low temperature, and this can be traced for all voltage values.

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The effect of chemical activating agents on the morphology and structure of bio-derived activated carbon

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Recently, activated carbon (AC) has attracted more and more attention since it exhibits various properties, including operated pore size and morphology, strong mechanical and physico-chemical stability, good absorption capacity and crucially important, large surface area. This makes it an ideal material for use in energy storage, metal recovery, air purification, medical wastewater treatment, water purification, gas storage, and removal of caffeine.

In this study, ACs were fabricated by single-stage carbonization and activation of a carbon precursor with four different chemical activating agents such as potassium hydroxide (KOH), zinc chloride (ZnCl₂), phosphoric acid (H₃PO₄) and sulfuric acid (H₂SO₄), respectively. Agar-agar was used as a bio-derived carbon precursor due to its high carbon content and the lack of any traces of heavy metals. The effect of the activating agents and the weight ratio of activating reagents / precursor as well as the nature of the precursor have been examined and discussed. The morphological and textural properties of ACs were investigated using an electron scanning microscope (SEM), X-ray diffraction (XRD), Raman and FTIR techniques.

Key words: activated carbon, agar-agar, activating reagents.

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Study of the lithium-ion battery at low temperatures

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Nowadays, LIBs are one of the most demanded power sources due to their portability, high power and energy density. The performance of LIBs depends on ambient temperature, especially, at low temperatures. According to [1] kinetic reactions rate slows down at low working temperatures, due to physical and chemical electrolyte properties changes, such as viscosity and conductivity etc. The main function of the electrolyte is to transport lithium ions between the electrodes, which slows down due to a decrease in electrical conductivity at a low operating temperature of LIBs. Furthermore, the solid electrolyte interphase (SEI) morphology, components, and formation mechanism have significant impact on the performance of LIB. Therefore, the wide service temperature range and required properties of the electrolyte can be achieved by changing the combination and ratio of solvents, salts and additives.

In present work, two types of lithium-ion cells (CR2032, MTI Corp.) were assembled in Ar-filled glovebox (LABmaster Pro, MBRAUN, <0.1 ppm H₂O and O₂). The first one was a reference and another one was with electrolyte additive. 1 M LiPF₆ (LPF) in ethylene carbonate (EC)/dimethyl carbonate (DMC)/ethyl methyl carbonate (EMC) (1:1:1, by volume) was used as an electrolyte. The modified electrolyte was prepared by adding 3 wt. % acetonitrile (AN) to the above LPF-based electrolyte. Cathode slurry was prepared by mixing LiFePO₄ (LFP), acetylene black (AB), and poly(vinylidene fluoride) (PVDF) at a weight ratio of 80:15:5 in N-methyl-pyrrolidone (NMP) solvent, lithium metal was used as an opposite and reference electrode. The electrochemical performance of the cells with and without AN additive was investigated at room and low (- 30 °C) temperature. All electrochemical cycling test results as well as synthesis routes and characterization details will be presented at the conference.

Acknowledgement

This research was supported by the research grants № AP08052231 “Development of solid-state electrolytes with high ionic conductivity for the next generation of lithium-ion batteries”, №AP05133519 “Development of 3-dimensional thin film silicon based anode materials for next generation lithium-ion microbatteries” from the Ministry of Education and Science of the Republic of Kazakhstan for 2018-2020 and №SOE2019001 “Development of 3D solid state thin film materials for durable and safe Li-ion microbatteries” from NU for 2019-2021.

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Study of a solid-state electrolyte for lithium-ion battery

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Currently, lithium-ion batteries have been used in many products, such as consumer electronics, electric/hybrid electric vehicles, stationary energy storage systems etc. One of the significant parts of the battery is an electrolyte. However, traditional lithium-ion batteries have critical safety issues because of use of highly flammable organic liquid electrolytes. Liquid-state batteries have low thermal stability and low flame point so that it is easy to cause fire accidents and explosion if they are improperly used. The formation of dendrites in the lithium-ion battery could lead to a short circuit of the battery and further explosion. The possible solution in terms of safety is to use solid-state batteries that contains the solid electrolytes.

The aim of the study is to find the most optimal synthesis method for solid electrolytes. $\text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3$ (LATP) revealed the highest ionic conductivity of $7 \times 10^{-4} \text{ Scm}^{-1}$ at 25 °C, which is comparable to other high Li-ion conducting materials. LATP solid electrolytes can be prepared by different techniques, one of these is a molten flux. The molten flux method showed high pure LATP material in comparison with another ones and it used as a method for further doping of LATP electrolyte. The characterization details as well as synthesis procedures will be presented at the conference.

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Preparation of a Piezoelectric PVDF Sensor via Electrospinning

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Due to growth in robotics and automation in recent years, tactile sensors, which are designed to detect various information by physical contact, have gained much importance in the development of biomedicine, social assistance and industry. Piezoelectric tactile sensors fabricated from polyvinylidene difluoride (PVDF) are used for sensing vibrations because of their high sensitivity, mechanical flexibility, multi-technology compatibility, stability, and cheaper cost [1]. Generally, piezoelectric materials produce an electrical charge on the surface when stress is applied. Among the polymorphs of PVDF, only the β -phase exhibits piezoelectric properties. As electrospinning involves both mechanical stretching and poling, which facilitate the formation of β -phase, it is the most suitable method to increase the voltage output from a PVDF film [2-3]. In this study, we prepared an electrospun samples from 10-20 wt.% PVDF dissolved in different volume ratios of DMF/acetone and DMF/THF. The suitable solvent and wt.% of PVDF to obtain uniform and high β -phase content fibers were studied.

The analysis of the introduced design of the sensor as two layers of the electrode in between of PVDF was performed using COMSOL Multiphysics software. The simulation study helps to optimize the development of sensors and allow their adjustments by comparing the analytical results of different changes of the output signal, eigenfrequency, vibration amplitude and applied pressure to the film.

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Synthesis of 4,7-dibromo-9H-carbazole and its N-alkylation under Microwave Activation Conditions in a Flow-type Microwave Reactor

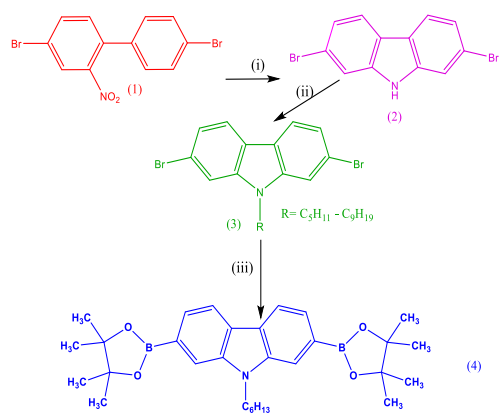
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The study is devoted to one of the most popular and expensive building blocks synthesis design (4) in a microwave flow reactor, which are used in the Photovoltaic Polymers synthesis. Replacing the bath-type reactor, in which we studied this reaction before, [1,2] with a flow-type reactor opens up the possibility for industrial production (4) under microwave activation conditions.



The use of a microwave flow reactor allowed to avoid a reducing of the microwave synthesis efficiency by increasing the amount of reagents and obtaining a bigger amount of product (2), (3), (4).

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Etching the surface of aluminum foil using high-frequency plasma to produce a nanoporous aluminum oxide membrane

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In recent years, the trend of creating and improving sensitive sensors has taken an important place in the field of medicine, environmental monitoring and research of biomolecular interactions. In addition, these nanoporous aluminum oxide films are actively studied in the fields of nanoelectronics, microbiology, and nuclear physics [1].

In this research work, a porous aluminum oxide membrane with pre-treatment of the aluminum coating with plasma was developed for the first time. The process of processing the aluminum film with plasma in a high-frequency discharge, in a vacuum environment, and as a result, the surface oxide layer was destroyed and a surface roughness was formed. During the experiment, a vacuum medium with a Vup-5 device was adopted, a plasma with a pink tinge of 0.6-0.7 Pa was formed between the two electrodes, argon gas was obtained as the main gas, and room temperature was used as the temperature parameter. In order to determine the differences that occur on the surface of the film, the power size was obtained to such a different extent. And the processing time for all films is the same value $t=15$ minutes. The process of electrochemical anodizing into an aluminum film with this surface treated with plasma was also carried out. As the electrolyte, orthophosphor was obtained, the chemical reaction took place at room temperature 19°C , voltage $U=80$ V, $t=30$ min. The process of electrochemical anodizing was a step-by-step process.

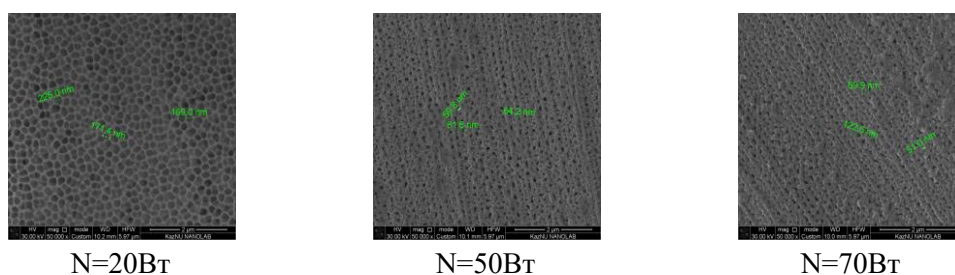


Fig.1. SEM images of nanoporous aluminum oxide membranes

In the experiment in vacuum environment, in a high-frequency discharge plasma treated surface layer of the aluminum film, based on the electrochemical anodization received nanoporous aluminium oxide. In the course of the study, it was noted that the change in parameters, in particular, differs from the surface roughness due to the different power values of 20 W 50 W and 70 W (Fig. 1).

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Surface morphology analysis of copper films produced by anodizing process

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Currently, copper oxide films are of interest to researchers due to their environmental friendliness, rich resources and low cost. Copper oxide is a p-type semiconductor with a narrow band (1.9 eV-2.2 eV). This material is characterized by the possibility of effective application in sensors [1], hydrogen production [2], energy conversion [3], for the creation of supercapacitors [4], semiconductor catalysis [5], biosensorics [6]. The anodizing process allows you to obtain porous materials based on metal oxides. As with aluminum and titanium oxides, the anodizing process can produce a porous material based on copper oxide. Anodizing is a low-temperature, versatile, economical and simple method. In addition, anodizing allows to change the morphology and size of the copper oxide nanostructure to some extent [7].

In the course of practical work, a copper plate with a size of several microns was used as the initial material. The process of single-stage anodizing was performed at a temperature of 4°C for 90 seconds in an electrolyte of an acidic environment. As a result, the morphology of copper films was studied using Ntegra Therma (NT - MDT) atomic force microscopy. AFM shows that the surface morphology depends on various chemical bonds on the surface of copper.

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Prospects of application of iron-containing carbon-paste electrode in electrochemical analysis

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The literature analysis devoted to the number of electrochemical sensors developed for metal ions is growing. This is due to the modification of already known classical electronic systems, or the use of new materials in the production of solid-phase, membrane, gas electrodes. One of these systems is a carbon-paste electrode, which belongs to the group of heterogeneous carbon electrodes. The ability to select an electrode-active substance for a specific research task is the main advantage of these electrochemical sensors. For example, an active electrode material was synthesized a polymer metal complex of lead(II) to determine lead ions in a solution [1]. The application of expensive reagents such as ethylene glycol dimethacrylate is the one of the disadvantages of them. Therefore, the purpose of the work was the identifying possibility of application an environmentally friendly natural material for modifying the carbon-paste electrode and determining iron ions in aqueous solutions. The active electrode material (iron-containing carbonized wool) was characterised by modern physical and chemical methods (scanning electron microscope (SEM), Fourier Transform Infrared Spectroscopy (FT-IR), thermal analysis (TG-DTA)).

The analytical characteristics of the iron(III)-containing electrode were also determined in the direct potentiometry mode: $1.00 \cdot 10^{-4}$ mol/l was taken, $9.20 \cdot 10^{-5}$ mol/l was found ($n = 5$, $P=0.95$, $S_x=4.74 \cdot 10^{-6}$), relative error of the determination 8% and during potentiometric titration with a solution of ethylenediaminetetraacetic acid in the presence of sulfuric acid (0.001 mol/l): $\Delta E= 4.4$ mV, $1.0 \cdot 10^{-3}$ mol/l was taken, $0.95 \cdot 10^{-3}$ mol/l was found, $S_r=1.92 \cdot 10^{-5}$, $n=5$, $P=0.95$, the relative error of the determination 0.2 %. Therefore the amount of iron (II) in aqueous solutions can be determined potentiometrically with a modified carbon-paste electrode.

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Photocell modernization

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In our modern world, where science is developing rapidly, it is difficult to determine a specific area of science, which is more promising than the rest. One of the promising areas of science is research aimed at obtaining cheap energy. In the near future, all world reserves of combustible fuel will end: coal, oil, etc., so it remains to develop and study renewable energy sources, such as wind energy, hydropower, solar energy, bioenergy, geothermal energy and, of course, nuclear power. Out of competition, of course, is nuclear power. Despite this, I propose to consider the issue of solar energy. There are minuses and pluses of solar energy. In this article, I propose ways to solve them.

The possibilities of using solar energy are limited by a very low energy density, as well as its fluctuations in time, which leads to a huge area of solar radiation collectors and a large material consumption of energy production. For example, in the winter season or at night.

A photoelectric effect is the emission of electrons by a substance under the influence of light. The photoelectric effect occurs under the influence of electromagnetic radiation, and electromagnetic radiation is not only photons. Cosmic rays can become a new source for the operation of the solar cell, since they have tremendous energy. A solar cell operating under the influence of cosmic rays will work around the clock, regardless of the seasons. But the main problem is the question of how we will do it.

It is known that the flux and energy of cosmic rays are colossal, from several eV to 10^{20} eV. It is also known that particles passing through the so-called scintillators give a flash, and our idea is to use these flashes for the operation of the photocell. This technique has not yet been studied and is not being studied by all. In the near future, people will learn this technique and we can use solar panels around the clock. The future is for high energy physics.

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Thickness-Dependent Raman and Photoluminescence Spectra of 2D Indium Selenide

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Recently, III–VI group layered two-dimensional (2D) semiconductors, such as GaS, GaSe, InSe, have considered as promising potential materials for next-generation optoelectronic devices, due to their variable bandgap, high electron mobility, wide photoluminescence (PL) response and ohmic contact [1-3].

In this work, samples of layered indium selenide were synthesized by fusing the corresponding stoichiometric compositions in a vacuum and then thinned down to a nanometer thickness using micromechanical exfoliation. Obtained thin flakes of InSe were placed on SiO₂/Si substrates and studied using atomic-force microscopy and Raman spectroscopy. It was found out that the decrease of the thickness down to 4 nm leads to the rise of an additional peak at ~200 cm⁻¹ in Raman spectrum, which is explained by mechanical stress or by the stronger light absorption of thinner InSe flakes.

Photoluminescence studies were performed using Raman spectrometer and 473 nm excitation laser. There was revealed a strong dependence of the intensity of PL peak at 510 nm (2.43 eV) on the thickness of the InSe flake. However, single- and bi-layered samples demonstrate neither Raman nor PL signal, possibly due to the fast oxidation without protective coating.

Acknowledgement

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Semiconductor film CuBi₂O₄, modified Pt

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Various methods for modifying the surface of semiconductors with platinum nanoparticles are presented in the literature: electrochemical and photoelectrochemical deposition, electrophoretic deposition, photoreduction, chemical deposition, vacuum deposition, atomic layer deposition. At the same time, chemical deposition of Pt, which does not require expensive vacuum and electrochemical equipment, seems to be the least energy-intensive and labor-intensive method. This method consists in applying a solution of H₂PtCl₆ to the surface of a semiconductor film and subsequent thermal decomposition of this compound to platinum metal at temperatures above 400°C.

The chemical deposition method of platinum nanoparticles on the surface of semiconductor CuBi₂O₄ electrodes by dip-coating from an aqueous solution of 5 mmol/L H₂PtCl₆ followed by annealing at 450°C is shown. The platinum content in the modified CuBi₂O₄ film was determined by scanning electron microscopy. It was found that during dip-coating of platinum, the obtained Pt nanoparticles are globules 50–200 nm in size. The deposition of Pt on the surface of CuBi₂O₄ electrodes leads to an increase in the photocurrent density by 20% (0.3M NaOH solution). Modification of CuBi₂O₄ electrodes with Pt nanoparticles leads to a decrease in the degradation of the photocurrent from 25% to 3% after 300 s of photopolarization measurements.

High values of the quantum efficiency of the photocurrent, reaching 70%, and photoelectrochemical stability make it possible to consider CuBi₂O₄ electrodes modified with Pt nanoparticles as a promising system for use in photoelectrochemical solar cells and photoelectrochemical decomposition of water.

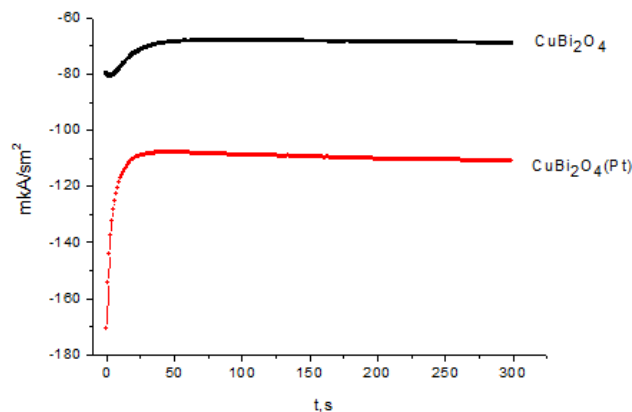


Figure 1 – Dependences of the photocurrent density on time

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Solar cell research at an altitude of 3340 meters above sea level

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Providing electricity to consumers in the mountainous regions is one of the urgent problems of power engineers. Laying and maintenance of power lines is expensive because of the difficult terrain and climatic conditions. Providing a heating system for heating boilers, requires the acquisition and delivery of large quantities of combustible material. The heating season in the highlands lasts up to nine months. Considering all the costs of electricity consumption and heating, it becomes necessary to conduct research and evaluate the economic efficiency of using solar power plants, focused on providing electricity to consumers in mountain regions.

In order to create a scientific basis for solving innovative problems in solar energy at the Tien Shan high-mountain cosmic ray scientific station (TSHSS), located at an altitude of 3340 meters above sea level, initiative work is underway to create a solar power station (SPS), assess its effectiveness, safety, environmental friendliness and reliability in work.

At the moment, a solar power station has been created at an altitude of 3340 meters above sea level. A comparative analysis of the results of generating electricity from the same type of solar power plants located at altitudes of 800 and 3340 meters above sea level was carried out. It is shown that the amount of electricity generated by a solar power plant at an altitude of 3340 is 20 percent more than at an altitude of 800 meters.

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Enhanced gas sensing properties of IZO thin films using SILAR

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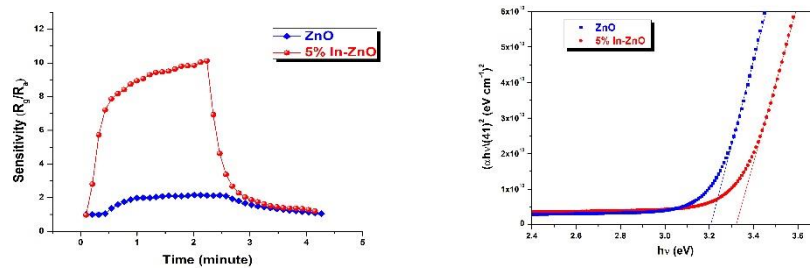
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In the last decades, resistive gas sensors based on semiconductor oxides have been the topic of interest for a long time due to their high sensitivity to both oxidizing and reducing gases. These sensors meet the main market requirements such as low cost, small size, and easy maintenance.

Currently, much attention has been attracted to finding an effective method to improve the nanomaterials' sensing ability and selectivity. Sensor devices based on semiconductor oxide like ZnO are important sensing material for detection of hazardous gases [1]. ZnO is the most extensively applied as a gas sensing material, since it has remarkable characteristics necessary for an ideal metal oxide gas sensor such as wide band-gap energy ($E_g=3.37$ eV) and high binding energy ($E_e=60$ meV) [2]. Several approaches have been applied to improve gas sensing performance, for instance, morphological changes by doping metal. Especially, indium (In) significantly influences the electrical, chemical, structural, and gas sensing properties of ZnO.

In the present work, the effect of In doping on the various properties of ZnO was investigated. The pure ZnO and indium doped ZnO thin films have been synthesized by the SILAR method. The obtained results clearly demonstrated a significant improvement in gas sensitivity by incorporating In into the ZnO.



Acknowledgements

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Effect of Ag impurity on the optical properties of GST225 thin films

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Intensive research is currently underway to develop materials for the optical recording of information based on a glass-crystal phase transition. Promising materials for this direction are thin films of chalcogenide semiconductors based on the Ge-Sb-Te system. To improve the parameters of recording and rewriting information, the speed of the phase transition, the number of write-erase cycles used the impurity modification with metals such as Ag, In and Bi. It was found that Ag atoms act as nucleation centers that can reduce the activation energy of crystallization and increase the crystallization rate of the film, thereby erasing the PCRAM erasure rate [1].

The report presents the results of the influence of silver impurity and size effect on the optical properties of Ge₂Sb₂Te₅ (GST225) films.

Nanosized films GST225 modified by Ag were obtained by ion-plasma RF magnetron sputtering of a combined target from GST225 and Ag in an Ar atmosphere. The used power of the RF generator was selected in such a way as to produce GST225 films with an amorphous structure. Crystallization was performed by thermal annealing at 300°C. The films' thickness range ~50-150 nm and was determined on the Quanta 3D 200i SEM. The concentration of silver impurities in the films was 5.0 and 9.7 at. %.

The optical properties of studied films deposited on glass substrates were investigated using Shimadzu UV2000. It was found that the spectral dependences of the transmission coefficients $T(\lambda)$, absorption $\alpha(h\nu)$, and the optical band gap E_g depend both on the concentration of Ag in the films and on their thickness. It was found that for amorphous and crystalline GST225<Ag> films in the range of the studied Ag impurity concentrations and their thicknesses, the quadratic law of light absorption is observed, which indicates the realization of indirect allowed optical transitions. Modification of amorphous and crystalline GST225 films with silver impurities leads to a substantial decrease in the optical band gap. At a fixed concentration of Ag impurity in GST225<Ag> films in the amorphous and crystalline state, with a decrease in their thickness to 50 nm, a significant decrease in E_g is also observed.

Thus, the modification of GST225 films with an Ag impurity leads to significant changes in their structure and optical properties.

Acknowledgement

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**Effective penetration depth of optical radiation
in nanoscaled modified Ge₂Sb₂Te₅<Ag> films**

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Thin films of Ge-Sb-Te (GST) chalcogenide semiconductor materials and, in particular, Ge₂Sb₂Te₅ composition, are used for creation of optical information carrier on the basis of a “glass-crystal” reversed phase transition. To improve information recording parameters, GST compositions are modified with an admixture of metal. In this case, the impurity must be isovalent and isomorphous with one of the components of the matrix. For the Ge₂Sb₂Te₅ composition, one of these impurities is silver.

The report presents the results of study of the optical properties of nanoscale amorphous and crystalline Ge₂Sb₂Te₅ films modified with Ag, and spectral dependence of the effective depth of penetration of optical radiation into these materials $d_{eff}(\lambda)$ are also presented.

Amorphous Ge₂Sb₂Te₅ films modified with silver (a-Ge₂Sb₂Te₅<Ag>) were obtained by ion-plasma RF (13.56 MHz) magnetron sputtering of a combined target from a polycrystalline of Ge₂Sb₂Te₅ and Ag. The film thickness l was ~ 100 nm, and the silver impurity concentration in the films was reached 5 at.%. Crystallization of the amorphous films was carried out by thermal heating. The phase state of the film structure was monitored using Raman spectroscopy.

The optical properties of the films (transmission spectra $T(\lambda)$ and reflection $R(\lambda)$ of light) were recorded on a Shimadzu UV2000 spectrophotometer in the range from 300 to 1100 nm. The spectral characteristics of light absorption $\alpha(\lambda)$ of the films were calculated from the expression $\alpha(\lambda) = -1/l \cdot \{\ln[T(\lambda)/(1-R(\lambda)^2)]\}$. The effective penetration depth $d_{eff}(\lambda)$ of the optical radiation for the films was determined from the relation $d_{eff}(\lambda) = 1/\alpha(\lambda)$. Analysis of the spectral dependences $d_{eff}(\lambda)$ for amorphous and crystalline Ge₂Sb₂Te₅<Ag>films showed that the effective depth of light penetration decreases significantly with increasing impurity concentration. In c-Ge₂Sb₂Te₅<Ag>crystalline films, it is much smaller than in amorphous a-Ge₂Sb₂Te₅<Ag> films.

The obtained results are important for creating optical information carriers based on nanoscaled Ge₂Sb₂Te₅<Ag>films using radiation from lasers with different wavelength.

Acknowledgement

This research was funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan (Grant No. AP05133499).



The Green Method for Recycling Polylactic Acid Made Products under Ultrasonication Conditions

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As polylactic acid products are produced, the number of PLA products that have fallen out of use and require recycling or re-use is expected to increase. It was found that the use of ultrasonic exposure allows to dissolve PLA and products based on it 5-10 times faster in various solvents at room temperature, which allows 100% regeneration of PLA and other useful components much faster than in the previously described convective methods.



The developed method fully complies with the principles of the "green chemistry" concept and is highly effective.

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New composite material for both biodegradable electronics and soft biomedical electronics

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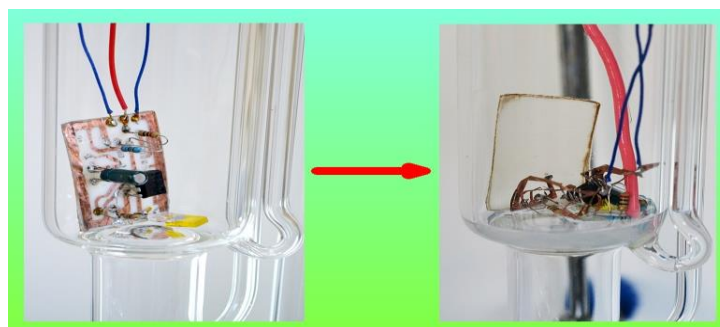
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The study of biodegradable polymers is in the focus of scientific interest, which is due to their increasingly diverse applications. Biodegradable polymers are widely used in the manufacture of packaging materials, cases for various products. In addition, they are used for various fields of medicine - from biodegradable prostheses to soft biomedical electronics [1-3].

A new method for the production of Printed Circuit Boards (PCBs) based on polylactic acid and natural silk is proposed in this paper. The originality of our proposed method is to replace the currently used environmentally hazardous polymer binders with biodegradable polymers based on Polylactic acid and its copolymers. Experimental data have shown that the obtained rigid laminate for the production of PCB has a number of practically useful characteristics: it is relatively resistant to environmental factors; has good properties: durability, lightness, low electrical conductivity, good adhesion to both hydrophilic and hydrophobic materials, can be made from renewable sources and can be completely recycled into low-molecular-weight natural substances or reused.



Also, the proposed material biodegrades into environmentally natural substances. This approach has great potential for practical industrial applications, especially in the light of the “green chemistry” and “circular economy” concepts. Besides, the described materials are a promising base for creating new composite materials for both biodegradable electronics and soft biomedical electronics.

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The 8th International Conference on Nanomaterials and Advanced Energy Storage Systems (INESS-2020)

Synthesis of nitrogen-doped zinc oxide nanostructures and their application in antibacterial activity against *e.coli*, *lactis*, *aerogenes*, *s.marcescens*

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The nanoparticles made of zinc oxide are well known because of their broader applications in various optoelectronic devices. The current work was dedicated to the synthesis, characterization, antibacterial testing and statistical assessment of the N-doped zinc oxide nanostructures (N-doped ZnO-NStr). The nanostructures were prepared via a hydrothermal treatment of zinc nitrate and ethylenediamine at 200°C for 3 h. The bacterial activity of synthesized N-doped zinc oxide nanostructures were tested on four different bacterial species: E.coli, Lactis, Aerogenes, S.marcescens at the range of concentration of the N-doped ZnO-NStr (0.078-0.78 mg/ml), estimated by UV-visible spectrophotometry. The bacteria were prepared with LB broth at the ratio 1:500000. The assessment of the results revealed that the low concentration (0.078-0.15 mg/ml) of the N-doped ZnO-NStr enhances the bacteria growth and the high concentration (0.78 mg/ml) of the nanoparticles reduces the population of bacteria. The N-doped zinc oxide nanostructures were well characterized by fluorescence spectroscopy, atomic force microscopy, Fourier transform infrared spectroscopy. Statistical assessment was also conducted for the bacterial pathogens with synthesized nanoparticles.



Green Method of Preparation for Phenol Formaldehyde Foams under Microwave Irradiation

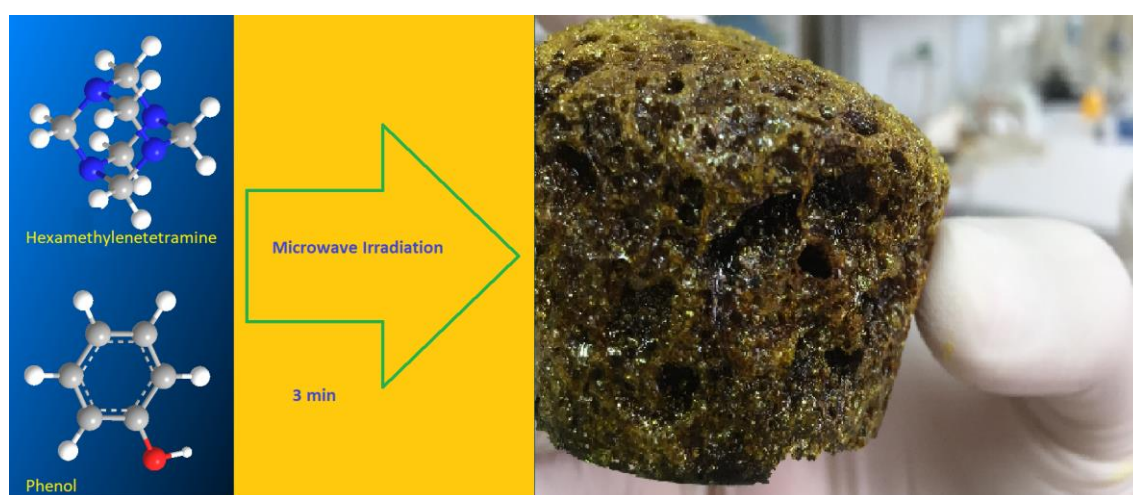
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The production of phenol-formaldehyde foams under classical conditions is a long and labour-consuming process. Phenol-formaldehyde foams containing various fillers can be synthesized within 3-5 minutes under microwave activation. Currently this is the fastest and most energy-efficient way to produce the material.



The use of a microwave reactor allowed to synthesize phenol-formaldehyde foams without any fillers within 3-5 minutes, as well as to include copper, zinc, cobalt, lanthanum and other metals' phthalocyanines into the material in order to give it catalytic properties.

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Polymer Physics and Modeling of Polycarboxylate-based Superplasticizers

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The tendency of developing urban areas brought a great demand for building materials in the last few decades. The innovation of new chemical admixtures has an increment in industry improving the rheology and early strength of cement-based material [1,2]. The use of modified polycarboxylate-based (PCE) superplasticizers in ready-mix or precast concrete cuts off required energy for construction decreasing the curing temperature and cost of building material. Moreover, the addition of superplasticizers results in a significant reduction to the annual worldwide CO₂ emissions. Therefore, a continuous development of the PCE superplasticizers would be benign for us all if one considered the big picture of reducing the consumption of natural resources and energy.

The research is a computational study, and our objective is to explore the polymer physics of PCE superplasticizers in aqueous solution and at liquid/solid interfaces using both the all-atom Molecular Dynamics (aaMD) and the Coarse-grained Molecular Dynamics Simulation (CGMD) simulation methods. More specifically, we are going to study (i) the interactions between PCE fragments and the various ions in a cement pore solution and how ions distribute around those PCE fragments; (ii) interactions of C-S-H surfaces with ions and calculations of the surface zeta potential [3]; and (iii) interactions between PCE fragments and C-S-H surfaces in the presence of ions using the aaMD simulation method. The aaMD method has a spatial resolution on the scale of a single atom, which is a great advantage when studying the physics of interfaces. However, it is rather computationally demanding to simulate polymers using the all-atom model, and that's why we choose to work with PCE fragments instead of the entire macromolecule. The downside is that this choice may limit us from studying the polymer physics of PCE polymers [4].

In order to simulate the actual PCE polymers used in industry, we apply the CGMD simulation method by first developing coarse-grained models for PCE polymers in aqueous solution and then apply the same polymer model to study their conformational and adsorption properties at liquid/solid interfaces. We are particularly interested in exploring the physics of PCE polymers, which are comb-shaped copolymers with negatively charged backbones and neutral side chains, in the vicinity of a negatively charged surface with the presence of multi-valent cations [5].

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**Sputtering of alkali metals into a gas medium upon excitation by products
of nuclear reaction ${}^6\text{Li}(n,\alpha){}^3\text{H}$**

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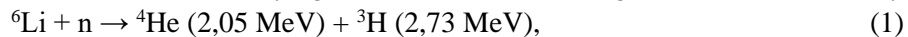
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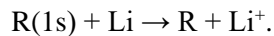
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Uranium fission fragments, as well as products of ${}^3\text{He}(n,p){}^3\text{H}$ and ${}^{10}\text{B}(n,\alpha){}^7\text{Li}$ nuclear reactions were used in the nuclear reactor for gas ionization and excitation [1, 2]. The use of a nuclear reaction with lithium-6 with thermal neutrons was studied to a less extent, before our works [3, 4]. The large mean free path of tritium nuclei in lithium (130 μm) and gaseous media (35 cm in atmospheric pressure helium) makes it possible to excite large volumes of gases and provide a larger amount of power nested in the gas in comparison with reaction products with ${}^{10}\text{B}$. Several modification of irradiation devices with a lithium cell for reactor experiments were constructed. At studying luminescence of noble gases with excitation by nuclear reaction products:



it was found, that at a temperature of the lithium layer of ~ 500 K, lines of lithium, as well as impurities of sodium and potassium in lithium appear in the spectrum [4, 5]. The vapor density significantly exceeding density of saturated lithium vapor during ordinary thermal heating of lithium is generated by the α -particles and tritium nuclei released from the lithium layer, as well as when the opposite wall is bombarded [5]. It was noted that the population of the lithium atom levels almost has no any effect on the population of 2p-levels of a noble gas atoms. The main channel leading to the population of lithium levels, apparently, is the Penning process (R is a noble gas atom):



Excitation of sputtered lithium atoms occurs as a result of further plasma-chemical reactions in a gas.

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Results of thermal stability tests of the IGR reactor HEU fuel

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The use of highly enriched uranium-graphite fuel (HEU fuel) in research reactors is of great concern to the world community due to the danger of nuclear material proliferation suitable for nuclear weapons fabrication. In this regard, large-scale work is currently being carried out at the IAE NNC RK related to the conversion of two unique research reactors IVG.1M and IGR, which should be subjected to a procedure with a decrease in fuel enrichment from 90% to 19.75% U-235 (LEU fuel).

Individual solutions for the nuclear fuel design of batch reactors pose high requirements for the designers of a new low-enriched fuel.

Before the IGR reactor is converted to LEU fuel, it is required a series of tests, one of which is the high temperature stability of fuel under cyclic process of heating-cooling conditions.

This paper describes the experimental procedure and thermocyclic test results of a HEU fuel sample. The results of thermocyclic tests of a HEU fuel sample will be a reference when comparing with the results of thermocyclic tests of HEU fuel samples. Therefore, the main criteria for the suitability of using LEU fuel in the IGR reactor will be mass loss of the sample during thermal cycling, which should not exceed the values obtained during the test data with HEU fuel.

The tests have been carried out at the TiGrA experimental complex, created on the basis of the TGA/DSC 3+ thermogravimetric analyzer and ThermoStar mass spectrometric gas analysis system. As a result of testing the HEU fuel sample, 100 heating-cooling cycles were carried out in the temperature range from 150°C to 1100 °C with a heating rate of 100 °C/min and cooling rate of 50 °C/min. In this case, the change in the sample mass and the gas phase composition above the sample were recorded.

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ZnO-CoO Nanopowders for Asymmetric Supercapacitors

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Zn_{1-x}Co_xO nanopowders were obtained by chemical bath deposition followed by thermal annealing. The structure and morphology of the samples were studied by X-ray diffraction analysis and scanning electron microscopy. Raman spectra were studied at room temperature using a Solver Spectrum (NT-MDT) spectrometer with laser excitation at 473 nm. Depending on the synthesis conditions, nanopowders with an average size of 1-2 nm were obtained.

It was shown that while chemical precipitation from a solution of zinc nitrate allows to obtain zinc oxide, and chemical precipitation from a solution of cobalt nitrate results in cobalt hydroxocarbonate, the presence of zinc and cobalt in equal molar concentrations inhibits the growth of both zinc oxide and cobalt hydroxocarbonate. The growth mechanism in the case of equal molar concentrations of zinc and cobalt in the growth solution changes dramatically. The resulting material is transformed by annealing in air into ZnCo₂O₄ oxide. However, it can be easily transformed by annealing at 350 °C in hydrogen atmosphere into a ZnO-CoO solid solution having a ZnO-type hexagonal lattice. The obtained fine powder of ZnO-CoO solid solution has an average crystallite size of 1-2 nm, depending on the conditions of preparation, and optical absorption spectra indicate the presence of doubly charged cobalt Co²⁺, which is in a tetrahedral environment. XRD and Raman results show that a single-phase Zn_{0.5}Co_{0.5}O solid solution is obtained, which consists of a hexagonal phase of the ZnO type. Electrodes from the obtained material showed a high specific capacity.

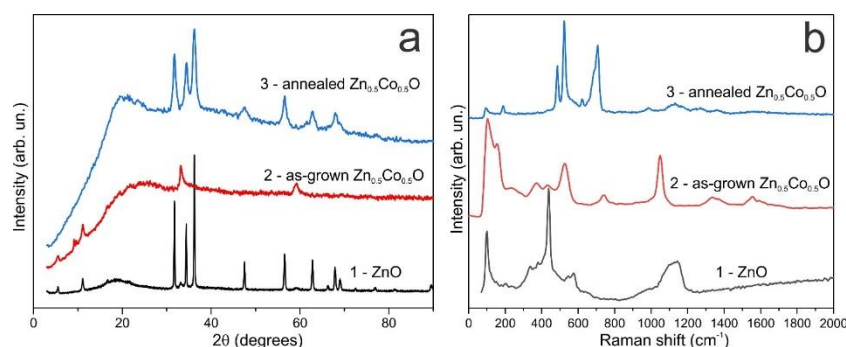


Figure 1. XRD patterns (a) and Raman spectra (b) of the samples: 1 - ZnO, 2 - Zn_{0.5}Co_{0.5}O immediately after synthesis, and 3 - Zn_{0.5}Co_{0.5}O after annealing in a hydrogen atmosphere at 350 °C/3 hours.

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Conformal coating of LTO/PAN for high performance Si nano-composite anodes

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Silicon is a potentially promising anode material for the next-generation energy storage devices owing to advantages as low cost, low toxicity and high specific capacity. However, there are several disadvantages of the silicon that shorten the life time of the battery such as instability of SEI layer, low electrical conductivity and volume change [1]. Huge volume expansion (>300%) during the lithiation/delithiation processes, which results in the pulverization of Si particles and fast capacity loss of the anode material, is considered as a major problem [2]. To be implemented commercially Si nanoparticles should exhibit high-power and low volume change. So far, there have been no credible Si-based materials reported satisfying all of these requirements [3]. Here, we report modified Si nanoparticles co-coated with $\text{Li}_4\text{Ti}_5\text{O}_{12}$ and cyclized polyacrylonitrile targeted to enhance the conductivity and tolerance to volume change. The synergistic effect from both coating provide the Si electrode with good conductivity and better performance. Synthesized Si/LTO/cPAN composites were characterized by X-ray diffraction (XRD) and Scanning electron microscopy (SEM) to identify the structure and morphology of composites.

Key words: coating, Si nanoparticles, Si/LTO/PAN composite.

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Hydrothermal Low-cost Synthesis of ZnO-GO Nanocomposites

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One of the best known multifunctional semiconductor oxide materials is zinc oxide (ZnO). The wide band gap, high binding energy of exciton, radiation resistance, and high chemical stability make it a promising material for sensors [1], LEDs, solar cells, piezoelectric devices, transistors, etc. Recent studies have shown that composite materials based on ZnO and graphene oxide (GO) can have optical and electrical properties superior to those of ZnO [2].

This work is devoted to the development of the synthesis of photocatalytically active composites based on ZnO and graphene oxide by simple, low-cost effective methods. Graphene oxide was obtained by the Hammers method and then added to a solution for hydrothermal synthesis of zinc oxide. To form zinc oxide nanoparticles, a solution of sodium hydroxide NaOH at room temperature was added dropwise to a glass beaker with a solution of zinc acetate $(\text{CH}_3\text{COO})_2\text{Zn}\times 2\text{H}_2\text{O}$, after which the entire solution was thoroughly mixed on a magnetic stirrer for another 15 minutes. The resulting precipitate was washed with distilled water, separated by centrifugation, and then dried in an oven at 125°C for 12 hours. The morphology, structural properties, and photocatalytic activity of the synthesized ZnO-GO samples were studied. Measurement of the photocatalytic activity of the obtained samples was carried out in relation to the degradation of Rhodamine-B (RhB) dye. It was noted that an increase in the GO concentration in the ZnO growth solution makes it possible to obtain more photocatalytically active ZnO – GO composites. Figure 1 shows the morphology of the ZnO-GO powder, containing 0.005 wt% GO, and the change in the optical density spectra of an aqueous solution of RhB in its presence.

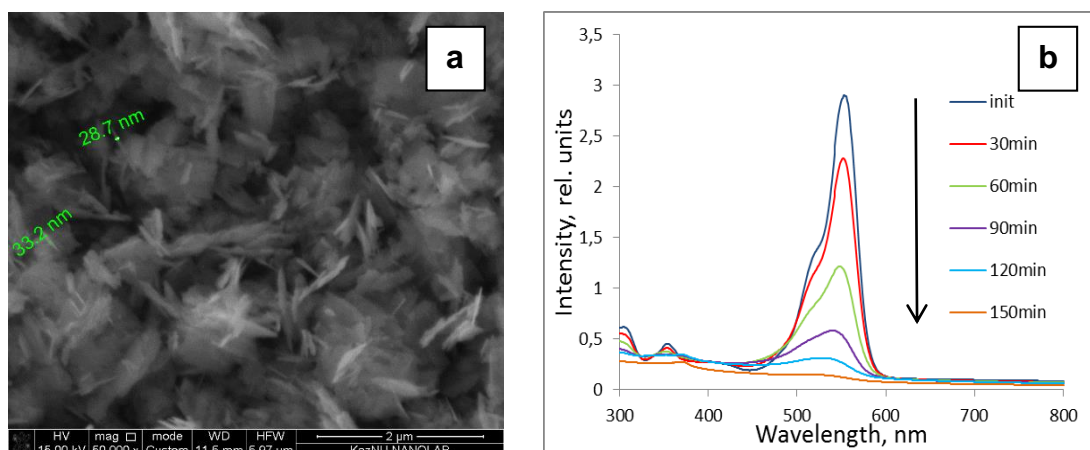


Figure 1 – ZnO-GO sample; a - morphology, b - change in the optical density spectra of an aqueous solution of RhB

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Composite PAAM-based hydrogel electrolyte for hybrid aqueous (Zn-Li-ion) battery

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Hybrid aqueous rechargeable batteries are very attractive alternative to conventional rechargeable lithium ion batteries for stationary application because of production and usage safety, reduced production cost and environmental friendliness. Previously aqueous rechargeable batteries with Zn/LiCl-ZnCl₂/LiFePO₄ system with liquid electrolyte has been reported [1]. The system performed a high rate capability up to 60 C with the average operation voltage 1.2 V and cycling performance with a capacity retention of 80 % over 400 cycles at 6 C.

However, there are several drawbacks including water decomposition and zinc dendrite formation hindering the commercialization [1]. The present study aimed to develop a PAAM-based hydrogel electrolyte with inclusion of montmorillonite and halloysite clay nanoparticles for hybrid aqueous rechargeable zinc/lithium ion batteries to overcome above mentioned problems. Polyacrylamide hydrogel was chosen because of its high ionic conductivity, high water content and simple fabrication method in which cross-linking degree, thickness, etc. were optimized. Inclusion of clay could improve mechanical stability of hydrogel electrolyte, prevent water decomposition and dendrite formation.

All tests performed in Zn/LiFePO₄ cell operating in an optimized LiCl/ZnCl₂ aqueous electrolyte based hydrogel.

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Silicon solar cells textured using gold of induced etching

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As is known, a layer with a dielectric coating remains the standard of a photoelectric converter and many research groups are studying various alternative methods to achieve an antireflection effect in silicon for photovoltaic and other optoelectronic applications [1]. Some of these methods include electrochemical etching [2], sol-gel deposition [3], magnetron sputtering of metal oxide films [4], and anisotropic etching [5].

Ready-made structures with a p-n junction were used as the initial substrate, the specific resistivity of the n⁺ layer was 0.008-0.01 Ohm·cm and the total plate thickness was 300 μm. Then, the front side of the sample is chemically activated in a solution of 0.4 mM, HAuCl₄ for 3-5 s, after which it is thoroughly washed in deionized water.

The output parameters of solar cells were determined from the characteristics. In particular, open circuit voltage $U_{oc} = 610$ mV, short-circuit current $I_{sc} = 32$ mA / cm², duty cycle $\xi = 0.77$, light emission power $P_{max} = 100$ mWt /cm², efficiency is ~ 15.03%.

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Wireless power transmission technology

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The technology of wireless power transmission is truly revolutionary for the current society, because it is already beginning to be widely used today. Although the first large-scale experiments were conducted by Nikola Tesla just over a hundred years ago, this technology has only now moved to a more global level. And we can say with confidence that in the near future it will become one of the fundamental ones in the process of direct development. Nowadays, wireless transmission of energy is widely considered in electronics area. For instant, if we want to charge kitchen equipment, the easiest way to do this is to use inductors. The principle here is very simple. 2 coils are taken and placed close to each other. One of them is powered. The other plays the role of a receiver.

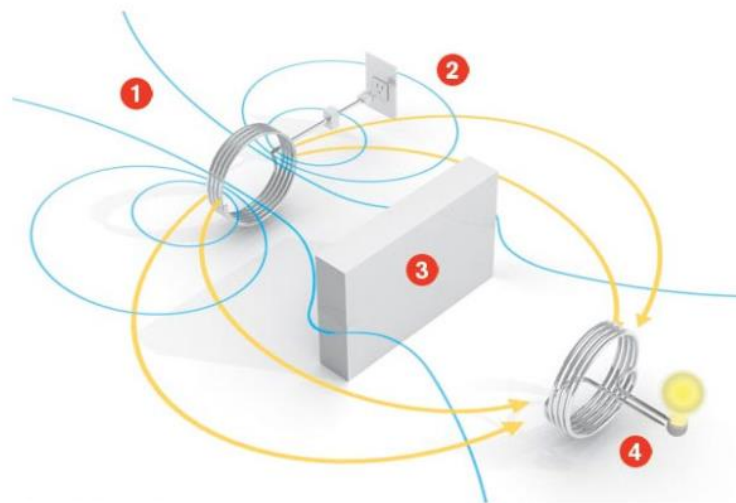


Fig. 1. Resonant coil connected to the socket (1); power socket (2); obstacle (3); resonant coil connected to a light bulb (4)

When the current in the power supply is adjusted or changed, the magnetic flux on the second coil also automatically changes. As the laws of physics say, an EMF will arise and it will directly depend on the rate of change of this flow.

It would seem that everything is simple. But the flaws spoil the whole rainbow picture. There are three cons like: low power, short distance, low efficiency. These main disadvantages are the questions that scientists want to solve.

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