ACADEMY OF SCIENCES OF THE REPUBLIC OF UZBEKISTAN
INSTITUTE OF MATERIALS SCIENCE

in collaboration with

TURIN POLYTECHNIC UNIVERSITY IN TASHKENT

PROCEEDINGS
OF THE UZBEK-CHINESE SCIENTIFIC FORUM ON NEW MATERIALS

3-4 May, 2024

Tashkent, Parkent, Republic of Uzbekistan

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INVESTIGATION OF ELECTRICAL PROPERTIES OF GRAPHENE IN-SITU COATING FUNCTIONAL MATERIALS BASED ON DISCHARGE TECHNOLOGY

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(1) Pt nanoparticles were deposited on the surface of reduced graphene oxide by the pre-discharge-electrodeposition method and high temperature reduction method, and they were used as catalysts for electrolytic water precipitation hydrogen reaction. In the prepared composites, reduced graphene oxide and Pt nanoparticles acted as the skeleton and capping layer, respectively. XRD results showed obvious Pt diffraction peaks in the prepared samples, confirming that Pt was successfully capped on reduced graphene oxide. SEM and TEM could observe that Pt nanoparticles were uniformly distributed on the surface of reduced graphene oxide. XPS proved that Pt/RGO-900 Pt exists mainly in metallic state in the composites. Raman spectroscopy proved that the degree of defects of reduced graphene oxide in the composites increased with the increase of calcination temperature. The prepared Pt/RGO-900 samples were applied as electrodes to the electrolytic water hydrogenation reaction catalyst, which showed an overpotential of 25 mV at 10 mA cm^{-2} and a Tafel slope of 31.23 mV dec^{-1}, indicating that Pt/RGO-900 has good HER performance. The excellent HER performance was attributed to the highly dispersed Pt nanoparticles and the reduced graphene oxide carriers synergistically contribute to the fast electron migration in acidic media. The present work provides a new avenue for the development of controllable preparation of hydrogen precipitation catalysts for application in electrolytic water precipitation.

(2) Co nanoparticles were successfully coated on the surface of reduced graphene oxide by pre-discharge-electrodeposition and high-temperature reduction methods, and applied to the electrode materials of supercapacitors. XRD results showed that the prepared samples had obvious Co diffraction peaks, confirming that the Co had been successfully coated on the reduced graphene oxide. SEM and TEM observed that the Co nanoparticles were uniformly distributed on the surface of the reduced graphene oxide. XPS and Raman spectroscopy showed that the Co nanoparticles were uniformly distributed in the surface of the graphene oxide. XPS and Raman spectroscopy demonstrated that Co was loaded on the reduced graphene oxide in metallic state and did not change the structure of reduced graphene oxide. When the calcination temperature is 500 ℃, the specific capacitance of the prepared Co/RGO-500 composite electrode is 1664.62 Fg^{-1} at 0.5 A g^{-1},

and the prepared nanocomposite is an ideal candidate for supercapacitor electrode materials.

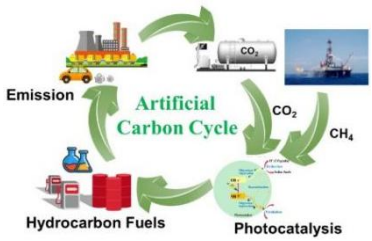
METAL OXIDE-BASED PHOTOCATALYSTS FOR ARTIFICIAL CARBON CYCLE

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Abstract: Imitating photosynthesis in nature, photocatalytic conversion of greenhouse gases (such as CO_2 and CH_4) into high-value hydrocarbon fuels is of great significance from both the scientific and economic points of view. Amidst the development of such a technology, metal oxides have been extensively applied and studied due to their suitable band structure and excellent stability. However, the single metal oxide is confronted with low light utilization efficiency and rapid photogenerated electron-hole recombination, leading to low photocatalytic performance. To overcome these limitations, we have made a great effort in the following fields: (1) the morphology tuning of metal oxides for enhancing the light utilization of photocatalyst; (2) the loading of catalyst on metal oxides for enhancing the photogenerated charge carrier separation; (3) the design of metal oxide-based heterojunction photocatalyst for enhancing the photogenerated charge carrier utilization efficiency. The resultant systems exhibited efficient visible-light photocatalytic performance and improved power conversion efficiency in solar energy, which underpins important solar-energy conversion applications including solar fuel generation and environmental remediation application.



Keywords: *CO_2 conversion • CH_4 conversion • Photocatalysis • Carbon Cycle • Metal Oxides*

REFERENCES

[1] J. Low, B. Dai, T. Tong, C. Jiang, J. Yu, Adv. Mater., 2019, 31, 201802981.
[2] C. Zhang, X. Hao, J. Low* et al., Angew. Chem. Int. Ed., 2024, 136, e202317628.
[3] J. Low, J. Yu, et al., Adv. Mater., 2017, 29, 1601694.
[4] L. Liu, Z. Wang, J. Low* et al. Adv. Mater., 2023, 2300643.
[5] W. Jiang[#], J. Low[#], et al., J. Am. Chem. Soc., 2021, 143, 269–278.
[6] W. Zhang[#], C. Fu[#], J. Low[#], et al., Nat. Comm., 2022, 13, 2806.

POWERPASTE – A PROMISING DEVELOPMENT FOR SAFE AND PORTABLE HYDROGEN STORAGE

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Hydrogen, with its high energy density and clean-burning nature, holds immense potential as a future fuel source. However, its storage remains a significant challenge. Traditional methods like compressed hydrogen gas require high pressures and specialized infrastructure, hindering widespread adoption.

POWERPASTE is a new hydrogen storage substance invented by Fraunhofer IFAM, wich has an exceptionally high specific energy and energy density, as well as many other advantages. When in contact with water, POWERPASTE releases hydrogen gas in a controlled manner in a hydrogen generator. This hydrogen is then converted into electricity using a proton exchange membrane (PEM) fuel cell.

POWERPASTE has a hydrogen storage capacity of about 10 wt.% (i.e., 10 kg of POWERPASTE stores 1 kg of hydrogen). This corresponds to a specific energy of 1.6 kWh/kg and an energy density of 1.9 kWh/liter, which is approximately 10 times the capacity of lithium-ion batteries [1,2]. The advantages of POWERPASTE are following:

Safety: POWERPASTE eliminates the need for high-pressure storage, reducing safety risks.
Convenience: The hydrogen is stored in a solid-state form in a magnesium hydride paste, which is stable and safe to handle. When water is added to the paste in the H_2 generator, it reacts with the magnesium hydride to release hydrogen gas, which is then fed directly into the fuel cell to generate electricity [3].

Future research directions for POWERPASTE include:

Optimizing Hydrogen Capacity: Investigating methods to increase the amount of hydrogen stored within the POWERPASTE formulation.
Refueling Systems: Developing efficient and user-friendly systems for generating hydrogen from POWERPASTE cartridges.
Life Cycle Analysis: Assessing the environmental impact and energy efficiency of POWERPASTE production and use.

The thesis will conclude by summarizing the potential of POWERPASTE as a game-changer for hydrogen storage. While challenges remain, POWERPASTE offers a safer, more portable, and potentially more accessible solution compared to traditional methods. Further research and development efforts can address the limitations and pave the way for widespread adoption of hydrogen as a clean and sustainable fuel source.

REFERENCES

[1] L. Röntzsch, M. Vogt, Powerpaste for off-grid power supply. Technical report – Feb 2019.
[2] M. Tegel, S. Schöne, B. Kieback, L. Röntzsch, Int. J. Hydrogen Energy **42** (4), 2167 (2017).
[3] V.D. Mukku, M. Kania, J. Brinken, *et al.* IFAC-PapersOnLine, **56** (2), 1784 (2023).

METHODS FOR PRODUCING HYDROGEN USING SOLAR ENERGY

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Currently, great success has been achieved in the field of hydrogen production in the USA, China, Japan, and India. For instance, the National Solar Energy Institute, together with the United States Universities, has created systems for producing hydrogen using an electrolyzer. Researchers of the Institute of Materials Science have been conducting research in this area for several years. As a result, hydrogen, oxygen and some other impurities are observed.

Current research presents a method for producing green hydrogen by electrolysis of water using solar energy. The required electrical energy for water electrolysis is obtained from the radiant energy of the Sun using a 10 kW photovoltaic plant. It is assembled from individual photovoltaic panels with a power of 350 W and dimensions of 1x2 m, in an amount of 30 pcs. The photovoltaic plant (or station) consists of 30 modules, each of which is tested during operation using an infrared camera to check the functionality of each element. Comparative characteristics of the current of formation of aqueous solutions of sodium and potassium alkalis in the electrolyzer are given. The work analyzes the influence of the angle of inclination of a solar installation on the efficiency of its operation. A comparative analysis of the accuracy of determining the optimal angles of inclination of a solar installation using various methods was carried out.

Based on data analysis, recommendations were given on the optimal angle of a solar installation for the territory of the Parkent district, where a photovoltaic station with a capacity of 10 kW was installed. The resulting electrical energy is fed into an electrolyzer to produce hydrogen and oxygen from water. In addition, electrolyzers of various designs and different powers from 0.1 kW to 10 kW were developed and created.

REFERENCES

1.M. El-Shafie, S. Kambara, Y. Hayakawa. J. Power and Energy Engineering, **7**, 107 (2019).
2.D. Devaraj, *et al.*, *International Journal of Energy Production and Management*, **5**, 91 (2020).
Green hydrogen cost reduction scaling up electrolysers to meet the 1.5°C climate goal. IRENA. “Green hydrogen cost reduction”. 2020. 106 p.
3.M. Martino, *et al.*, Catalysts **11**, 547 (2021)

EFFECT OF FE AND CU IMPURITY CONCENTRATION ON CRYSTALLINE, OPTOELECTRONIC AND PHOTOCATALYTIC ACTIVITY OF ZNO NANOSTRUCTURES

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Doping proves to be an efficient method in adjusting the optoelectronic characteristics and photocatalytic performance of photocatalysts [1]. Specifically, transition metal doping in ZnO crystal lattice is a well-established method for adjusting its band gap to achieve visible light photocatalytic activity. This study explores the impact of varying Fe and Cu dopant concentrations (0% -10%) on the crystalline structure, optoelectronic characteristics, and photocatalytic performance of hydrothermally synthesized ZnO nanostructures. Fe and Cu were selected as dopants because of their different valence states in contrast to Zn, with Fe serving as the dopant with a higher valence (donor) and Cu as the dopant with a lower valence (acceptor). Density functional theory (DFT) calculations were employed to understand the position and characteristics of specific energy levels within ZnO bandgap caused by the presence of Cu and Fe impurities. The photocatalytic efficiency of both undoped and Fe/Cu doped ZnO nanostructures was assessed by monitoring the degradation of aqueous methylene blue (MB) solution under visible light irradiation.

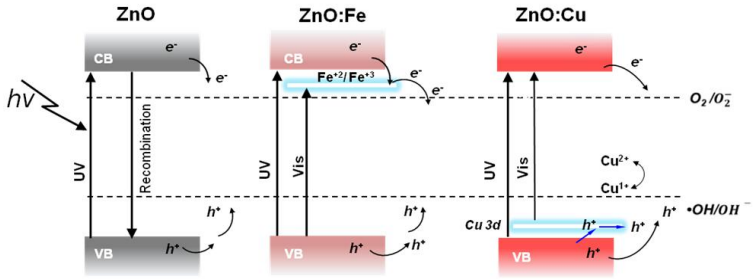


Fig.1. Photocatalytic of the pristine, Fe and Cu doped ZnO nanostructures

The combination of theoretical and experimental findings allowed us to conclude that the introduction of Fe and Cu impurities can enhance the photocatalytic activity of ZnO under visible light through the mechanism shown in the Fig. 1. The enhancement by Fe impurities is attributed to the formation of small donor levels below the conduction band of ZnO that facilitates visible light absorption through the O2p → Fe3d transition and suppresses the recombination of photogenerated charge carriers by capturing electrons from the conduction band. In the case of Cu, the formation of small acceptor levels near the valence band maximum of ZnO facilitates visible light absorption through Cu3d → Zn2p and Cu3d → O2p transitions

and suppresses charge carrier recombination by capturing photoexcited holes. Thus, among the various concentrations of dopant elements, 1% Fe and 3% Cu were found to be favorable, exhibiting the highest photocatalytic activity in the degradation of methylene blue in an aqueous solution, owing to the beneficially modulated electronic structure.

REFERENCES

[1] Q. Wang, K. Domen, Particulate Photocatalysts for Light-Driven Water Splitting: Mechanisms, Challenges, and Design Strategies. Chem. Rev. 2020, 120, 919–985.

ANTI-REFLECTION COATING FOR SOLAR CELLS BASED ON CORDIERITE

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The purpose of this work is the synthesis of materials from the cordierite region on a solar furnace, the study of the phase composition and optical characteristics of the synthesized material, as well as the possibility of using it as an anti-reflection coating material.

The mixture of oxides was melted in a solar furnace with a power of 3 kW at a radiant flux density of at least 800 W/cm^2. 3 compositions were selected with the ratio of components, wt. %: MgO : Al_2O_3 : SiO_2 = 15,07 – 23,86 : 34,34 – 23,27 : 50,59 – 52,87.

To study the optical properties of cordierite using an UVN-71P-3 installation using thermal evaporation, coatings from the synthesized material were applied to silicon and glass plates. The thickness of the samples was controlled by a sample designed for a given design of the evaporator and screen for a fixed substrate.

The reflection and transmission spectra of the coatings were measured on a FO-1 photometer and a Lambda Z-150 spectrophotometer using standard methods. For the spectral region >400 nm, the average transmittance is 82,24 ± 2,02%. The refractive indices of glass 1,53 and cordierite 2,27 ± 0,01 were calculated from the results of optical measurements using the method [1, 2]. It is known that the refractive index of an anti-reflection coating for silicon should be ≥2 in the region of the spectral sensitivity of the solar cell.

Since the FO-1 can measure the reflectance in the spectral region from 367 to 927 nm, a quadratic extrapolation of the reflectance to the limit of the spectral sensitivity of silicon 1100 nm was performed using the formula:

$$R(\lambda) = 1 - 1.37\lambda 0.497\lambda^2 \quad (1)$$

The calculation results using formula (1) agree satisfactorily with the measurement results. Therefore, (1) was used when calculating the short-circuit current density Jsc, which was calculated using the formula:

$$J_{sc} = T_g \int_{400}^{1000} (1 - R(\lambda)) \bullet \lambda \bullet E_s(\lambda) d(\lambda) \qquad (2)$$

λ – wavelength; E_s (λ) – solar radiation flux density (model AM1.5); T_g = 91,5 % – spectral average transmittance of glass. As a result of numerical integration (2), the short-circuit current density was determined to be 38,5 mA/cm^2.

Based on the results obtained, the following conclusions can be drawn:

- cordierite coating is transparent in the solar cell sensitivity range and can be used as an anti-reflection coating;
- the region for which reflection is less than 10 % is quite wide and covers the wavelength range from 450 to 1000 nm;
- the coating has high mechanical strength and good adhesion;
- short circuit current density is 38,5 mA/cm^2.

REFERENCES

1. S.Kh. Suleimanov, M.U. Dzhanklych, V.G. Dyskin, Z.S. Settarova, N.A. Kulagina, *Applied Solar Energy*, 2009, *45* (*4*), 295 – 297.
2. Ю.В. Уханов. Оптические свойства полупроводников. –М.: Наука, 1977.

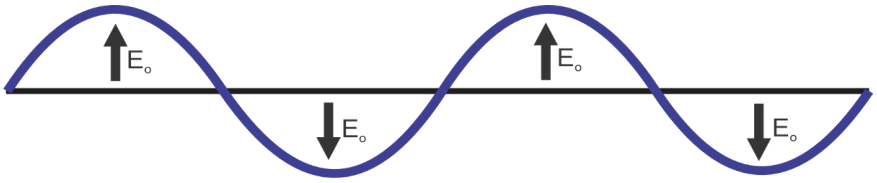
EFFICIENT PHOTOCATALYST FOR HYDROGEN PRODUCTION USING SOLAR ENERGY

R.Kh.Rakhimov, V.P.Ermakov, R.M.Saidov, H.K.Rashidov, M.R.Rakhimov

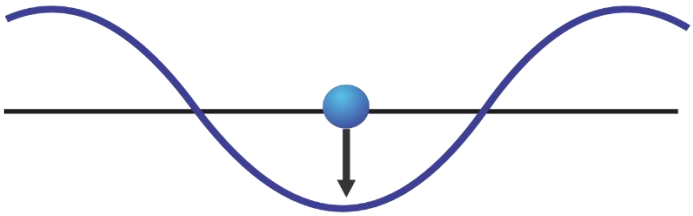
Light is an electromagnetic wave propagating through space. Such a wave consists of electrical and magnetic components.

For the purposes of interaction with matter, consider the electrical component. It is characterized by a time-varying electric field E, the amplitude of which ranges from E_0 to - E_0. It is the value of E_0 that determines the intensity of light.

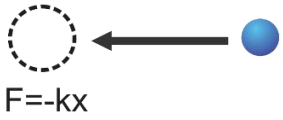
When light passes through a substance, the latter will react to the electric field of the wave. Matter consists of charged particles - electrons, atomic nuclei, and ions.



For each such particle with a charge q, the force F = qE will act. The particles will oscillate under the action of this force around the equilibrium position.



At the same time, there is a returning force that tends to return the particle to the equilibrium position. This force is proportional to the magnitude of the displacement s, with a coefficient of proportionality k.



Mathematically, such a dependence can be described using Taylor series expansion, using only the first term at small offsets.

This model describes the vibrations of atoms and molecules under the influence of light. This is the key to understanding the interaction of light with matter.

$F(x) = k_1x + k_2x + k_3x + k_4x + \ldots + k_nx$

$F(x) = k_1x$, if x is less than 1, then the remaining terms become very small and can be ignored.

To describe the motion of a charged particle under the influence of an electromagnetic wave, it is necessary to consider the combined action of two forces:

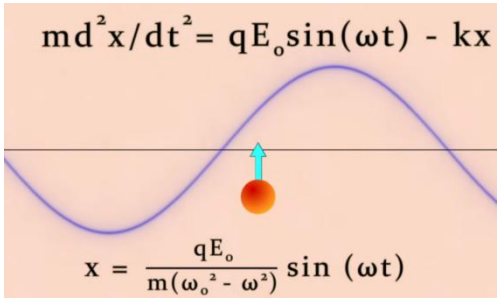
1. The returning force acting against the displacement of the particle from the equilibrium position.

2. The external periodic force F = qE due to the electric field of the electromagnetic wave.

Using Newton's second law, the differential equation of motion can be written:

$md^2x/dt^2 = F_{internal} + F_{external}$

Having solved this equation, we obtain the dependence of the x coordinate on time t.



This is an equation of forced oscillations describing the oscillations of a particle with a frequency of an external force and an amplitude depending on the difference between the natural frequency of oscillations ω0 and the frequency of the external force ω.

At $\omega \approx \omega_0$, resonance occurs when the amplitude tends to infinity. In practice, this means electron transfer, which is an indicator of a chemical reaction. At $\omega \approx \omega_0$, resonance occurs when

the amplitude tends to infinity. In practice, this means going beyond the linear model with small fluctuations.

Under the action of an electric field E of an electromagnetic wave, charged particles in the medium begin to oscillate with a frequency of ω.

This leads to the polarization of the P medium, which in turn determines the dielectric susceptibility:

$P = Np = Nqz$,

where q is the charge of the particle, z is the amplitude of the oscillations.

Using Maxwell's equations, we can write:

$\varepsilon = 1 + \chi = 1 + (4\pi P/E)$

From here we can derive the expression for the phase velocity of the electromagnetic wave:

$v\varphi = c/\sqrt{\varepsilon\mu}$

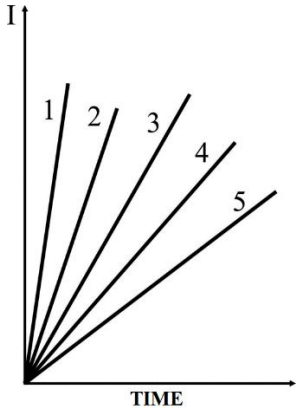
Taking $\mu \approx 1$ for transparent media, we get:

$v\varphi = c/\sqrt{\varepsilon}$

Replacing ε by χ, we obtain the Zelmen formula for the refractive index n:

$n = c/v\varphi = \sqrt{(1 + \chi)}$

Thus, the refractive index and, consequently, the angle of refraction depend on the ratio of ω and ω_0 due to the dependence of χ on the amplitude of vibrations of charged particles in the medium.



Due to the unilateral polarization and "transformation" of the spectrum, PTE surpasses the harmonic oscillations of light in interaction with matter. This is an important new phenomenon that makes it possible to increase the efficiency of using solar energy.

In the case of a pulsed tunneling effect, unipolar polarization allows you to concentrate the full polarization vector. Due to this, a more effective interaction with the object is achieved at the same total intensity. Experiments have shown that with PTE exposure to water vapor, it is possible to reduce the effective photon energy required for decomposition into hydrogen and oxygen by about 3-4 times compared with harmonic oscillations. This is due to unilateral polarization when exposed to pulsed radiation due to PTE. In addition, PTE has the feature that it converts the entire spectrum of light energy into a given quantum pulse energy necessary for a particular process. This determines the maximum efficiency of the selected processes.

Thus, the pulsed tunneling effect makes it possible to use light energy more efficiently, reducing the energy barrier necessary for various processes. This opens up new prospects for the

development of photochemical and photobiological processes.

To fully describe the mechanism of the pulsed tunnel effect, it is necessary to emphasize the following key features:

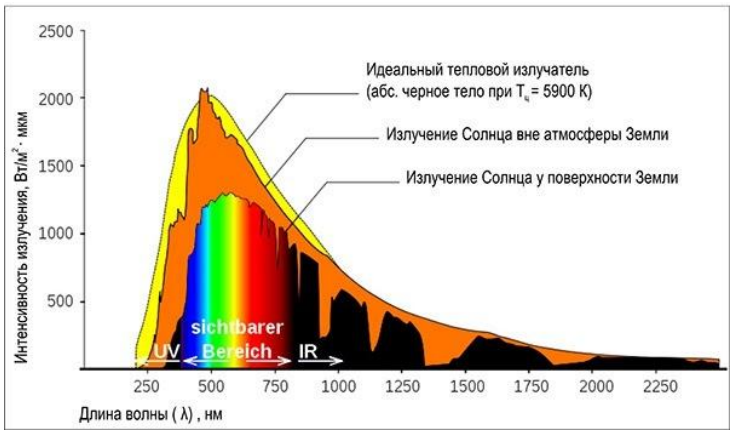
1. PTE provides unidirectional polarization due to the pulsed nature of the impact.

2. In this case, the entire spectrum of incident radiation is converted into a pulse of a given corresponding de Broglie wavelength, optimal for a particular process.

3. Due to this, the effective photon energy is reduced by about 3-4 times compared to harmonic oscillations.

4. It is thanks to the ability to convert the entire spectrum into the desired quantum energy that the maximum efficiency of the process is determined.

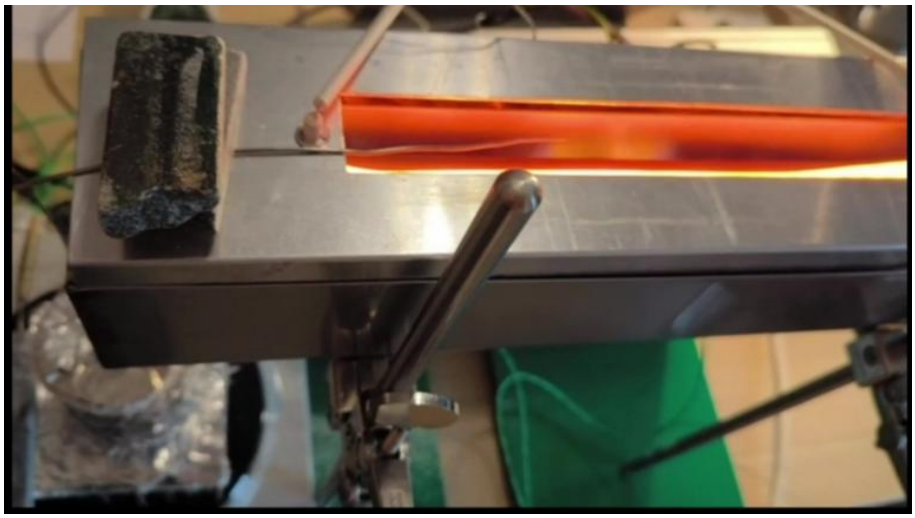
Let's turn to the spectrum of solar radiation. As can be seen from the above data, neither outside the Earth's atmosphere, nor, moreover, after the Earth's atmosphere, there is no quantum energy in the solar spectrum capable of decomposing water vapor into hydrogen and oxygen (12.6 eV). This process can be carried out only by thermolysis or an internal photoelectric effect. Both of these methods are extremely inefficient, and the catalysts used in these processes are unreliable and short-lived.



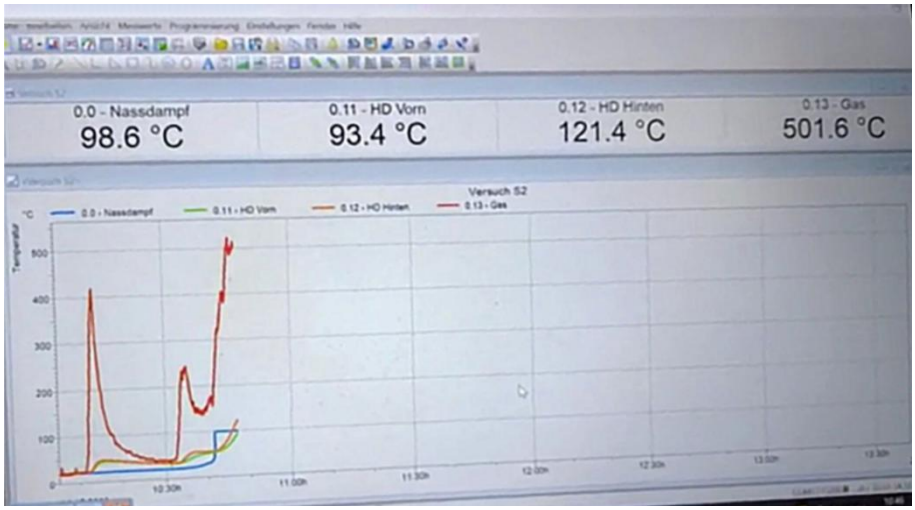
One of the key advantages of the pulse tunneling effect is the ability to fine-tune the rising edge of the pulse in accordance with the energy of the required process. This ensures maximum energy direction and high energy efficiency.

The theoretical energy efficiency of a photocatalyst for hydrogen production based on the effect of pulsed tunneling is 85-95% of the solar energy consumed, which significantly exceeds the efficiency of traditional methods.

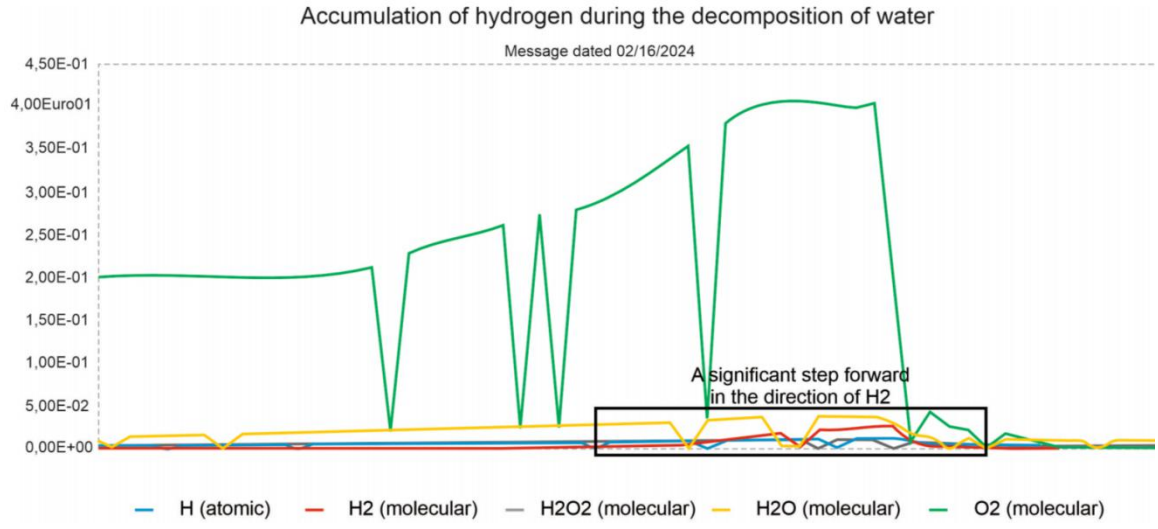
The process of hydrogen synthesis begins at a temperature of 93-98 ° C as a result of decomposition of water vapor.



Generation of hydrogen due to light energy.



Temperature change in the chamber depending on the operating time of the photocatalyst



Originality. The development has no global analogues

Expected efficiency. Currently, the most efficient and durable photocatalyst for the production of hydrogen from solar energy. As follows from the above data, the yield of oxygen, atomic and molecular hydrogen, indicate an efficiency of splitting water vapor of about 85-95%. Tests conducted over 6 months showed that during this period the photocatalyst has not changed its activity and is in its original condition.

REFERENCES

1. Rustam K. Rakhimov, Elena V. Kim., USA Patent “Treatment of materials with infrared radiation", # 5,472,720 from 05/12/1995.
2.Рахимов Р.Х. Возможный механизм импульсного квантового туннельного эффекта фотокатализаторов на основе наноструктурированной функциональной керамики // Computational Nanotechnology. 2023. Т. 10. № 3,С. 26–34. DOI: 10.33693/2313-223X-2023-10-3-26-34. EDN: QZQMCA

NANOTECHNOLOGIES AND NANOMATERIALS BASED ON FUNCTIONAL CERAMICS

R.Kh.Rakhimov, V.P.Ermakov, R.M.Saidov, H.K.Rashidov, M.R.Rakhimov, J.H.Rashidov

A new model of the optical tunneling effect is proposed to explain the unique ability of functional ceramics to convert solar energy into infrared radiation in the form of pulses. The author argues that this model opens up new perspectives in the field of optics and energy, as well as provides a new understanding of the tunnel effect.

The purpose of this work is to analyze the proposed model of the optical pulse tunneling effect and evaluate its significance for the development of nanotechnology and the creation of functional nanomaterials.

The main provisions of the model

According to the model, the incident radiation is absorbed by ceramic particles, which leads to the excitation of vibrations of the crystal lattice - phonons. When a certain density is reached, the phonons switch to a higher energy state and emit infrared photons.

The key role is played by the presence of a radiation pulse rise front, which determines the wavelength of the pulses regardless of the wavelength of the energy carrier. Thus, due to the rise front, energy in the infrared range tunnels through a medium opaque to IR radiation.

This effect allows functional ceramics to generate pulses with preset parameters for resonant interaction with objects. The shape of the pulse is determined by the ratio of functional and transparent ceramics.

Model analysis

The proposed model as a whole consistently explains the process of converting light, including solar energy, by functional ceramics into infrared pulses.

The key link is the mechanism of accumulation and transition of phonons to a higher energy state, which leads to the generation of photons. The assumption of the role of the pulse rise front explains the ability of ceramics to interact with objects regardless of the wavelength of

the carrier.

The model is based on the wave properties of radiation and the vibrational nature of ceramics, which gives it a physical validity. In addition, it is supported by numerous experiments.

Significance for nanotechnology

The proposed model is important for the development of nanotechnology and the creation of new functional materials:

1. It reveals the mechanism of the unique properties of functional ceramics, which will allow purposefully synthesizing materials with specified characteristics.

2. This model provides an incentive for the development of new applications in optics, energy and other fields.

3. The model can be extended to other types of functional nanomaterials.

4. The effect of optical tunneling is proposed, which deserves further study.

Thus, this work stimulates further research in the field of nanotechnology based on functional ceramics and nanomaterials.

In conclusion, we note that the paper proposes a new model of the optical tunneling effect, which allows us to explain the unique properties of functional ceramics. The model has a physical validity and stimulates the development of nanotechnology. The work opens up prospects for applied research in the field of optics, energy and other fields.

Here are some promising areas of research and application of functional ceramics:

1. Medicine and biotechnology. The use of the properties of functional ceramics for photodynamic therapy, including oncological diseases, stimulation of tissue regeneration, synthesis of drugs.

2. Agriculture. Development of effective methods for stimulating the growth of crops, pest control and plant diseases using pulsed infrared radiation.

3. Purification of water and air. The study of the possibility of functional ceramics to activate the processes of disinfection, decomposition of toxic compounds.

4. Solar energy. Creation of efficient solar panels and panels based on functional ceramics.

5. Materials science. The study of the effect of pulsed radiation on the properties of various materials, for example, increasing strength.

6. Food industry. Development of methods for safe food processing and storage.

7. Archaeology. Using the capabilities of functional ceramics for non-destructive authentication and dating of cultural values.

8. Mining industry. The use of pulsed IR radiation to increase the speed and selectivity of mining.

9. Metallurgy. The use of point effects at the energy barrier level to optimize the processes of melting, welding, separation of metals and alloys.

10. Energy. Development of energy conversion systems with maximum efficiency by fine-tuning pulse parameters to the threshold characteristics of processes.

11. Sterilization. The use of functional ceramics for fast and effective disinfection of premises, equipment, and products.

12. Hydrogen energy. Creation of highly efficient photocatalytic systems for hydrogen production under the influence of pulsed radiation.

13. High-performance drying and polymerization of materials with minimal energy

consumption by fine-tuning the parameters of pulsed IR radiation.

14. Development of desert territories by creating composite films that prevent moisture evaporation and icing under the influence of radiation. This will allow you to do without expensive greenhouses.

15. Cultivation of microalgae in seawater and fresh water for the production of fuel, feed additives with simultaneous wastewater treatment. Such a system helps to capture carbon dioxide.

16. Restoration of the Aral Sea zone and similar arid areas through the use of pulsed infrared radiation to intensify irrigation and agriculture.

17. Creation of integrated systems, for example, based on coal-fired power plants, where the captured carbon dioxide is directed to the cultivation of microalgae.

18. Investigation of the possibility of producing ammonia under the action of photocatalytic systems based on functional ceramics for efficient hydrogen storage.

The use of pulsed radiation with fine-tuning of pulse parameters can be applied not only for heating, but also for cooling objects. This is a really interesting idea worth exploring.

A few points about this:

• A mechanism similar to laser cooling is possible, when the temperature of the object decreases when photons are absorbed.

• The pulsed nature of the radiation allows you to smoothly adjust the wavelength of the "absorbed" particle by tilting the pulse front.

• This gives additional degrees of freedom to fine-tune the cooling process.

• The advantages of a pulse over a sine wave can be realized.

Thus, the concept of ITE cooling looks promising and requires practical verification.

The idea of using pulsed radiation in combination with electric and magnetic fields for deep cooling seems really promising.

A few points:

• Pulse action allows you to fine-tune the interaction at the desired energy levels.

• This will give a unidirectional effect without oscillation, as with a sine wave.

• EM fields can focus and direct radiation for more efficient cooling.

• Coordinated impact of different factors will increase the effect.

• Prospects for cooling to the nanokelvin range.

This approach deserves detailed theoretical consideration and experimental verification. This is indeed a very promising area of research.

And this is not a complete list of possibilities for applying the ITE principle based on functional ceramics.

REFERENCES

1. Rustam K. Rakhimov, Elena V. Kim., USA Patent “Treatment of materials with infrared radiation", # 5,472,720 from 05/12/1995.

2. Рахимов Р.Х. Возможный механизм импульсного квантового туннельного эффекта фотокатализаторов на основе наноструктурированной функциональной керамики // Computational Nanotechnology. 2023. Т. 10. № 3,С. 26–34. DOI: 10.33693/2313-223X-2023-10-3-26-34. EDN: QZQMCA

ABOUT THE NEED TO ENSURE THE ACCURACY OF MEASURING THE TEMPERATURE CHARACTERISTICS OF THE SOLAR CONCENTRATOR

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As is known, high-temperature heating with concentrated solar radiation has a number of advantages, for example, the absence of contamination of synthesized materials, inertia-free heating, the ability to control the heating and cooling rate, a wide range of solar radiation, etc. So, we can say that a concentrated solar energy is an important component in the arsenal of methods for synthesizing materials with a set of specified properties [1, 2].

One of the problems in using concentrated solar radiation from a Big Solar Furnace (BSP) is the difficulty of measuring the exact temperature in the focal plane of the concentrator, on the surface of the synthesized material or crucible where the material itself is located, as well as the material itself.

Due to the limited technical capabilities of measuring high temperatures (more than 2000 °C), for "calibration" of a solar furnace, it is often necessary to use refractory materials with a known melting point or aluminum oxide (T = 2044 ° C).

Thus, by observing the process of their melting, it is determined which temperature is in focus. As a result, the error in determining the temperature of the effect of concentrated solar energy on the material is large. Experiments on measuring the temperature of concentrated solar energy were carried out on a small solar furnace (SMF) with a concentrator diameter of 2 m.

The concentration coefficient of solar radiation in such furnaces depends on the opening angle of the concentrator and reaches up to 10,000 times. The technical characteristics of the SMF allow it to conduct fundamental and applied research on the synthesis and heat treatment of high-temperature oxide materials.

The temperature at the focus was first time measured with an Explorer 7000 infrared pyrometer with a measuring range of 200-2200 ^{O}C, with an optical resolution of 80:1. The pyrometer is equipped with a special laser pointer to facilitate temperature measurements. The device is conveniently connected to a computer, where you can store and process pyrometer readings.

A charge made of aluminum oxide was installed on the focus. The pyrometer showed a melt temperature of 2047 °C, which corresponds to the temperature of its melt. Thus, it has been established that the infrared pyrometer provides an accurate determination of the temperature of the material melted at the focus of the solar concentrator, within the specified measurement limit. The next task is to install several pyrometers connected to a computer and measure the temperature from different points of the material: on the surface, on the backside and the melt.

REFERENCES

1. Flamant G, Ferriere A, Laplaze D, Monty C. Solar Processing of Materials: Opportunities and New Frontiers. SolarEnergy, vol. 66, issue 2, pp. 117-132. (1999).

2. Рахимов Р.Х. Синтез функциональной керамики на БСП и разработки на ее основе. Журнал Computational nanotechnology. 2015, №3, стр.11-25. https://cyberleninka.ru.

ANTI-REFLECTION COATING BASED ON ALUMINOSILICATES TO INCREASE THE EFFICIENCY OF SILICON SOLAR CELLS

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An important part of the development of high-efficiency silicon solar cells is the use of anti-reflection coatings (ARC) [1, 2].

The goal of this work is to develop ARCs based on aluminosilicates synthesized in a solar furnace, which have the necessary spectral and optical properties to increase the efficiency of silicon solar cells.

We have developed a single-layer ARC based on mullite $3A1_2O_3 \cdot 2SiO_2$, synthesized in a solar furnace at a concentration of charge components, wt. %: $A1_2O_3 : SiO_2 = 75 : 25$ [3, 4].

ARC based on mullite has high transparency and has an integral reflection in the region of maximum sensitivity of a silicon solar cell of R = 2,2 – 3,9 %, which is much lower than for industrially used ARC based on Si_3N_4.

ARCs based on mullite with thicknesses ranging from 40 to 85 nm were deposited on silicon solar cells with an efficiency of 12,9 % to investigate the increase in their efficiency. Measurements of current-voltage characteristics (CV) of silicon solar cells were measured using an automated complex that includes a source meter Keithley 2420 solar radiation spectrum simulator. Coatings up to 50 nm thick did not increase the efficiency of solar cells. Due to the deposition of ARCs with a thickness of 80 – 85 nm, an increase in efficiency is observed on average to 6 %, while the efficiency of a silicon solar cell increases up to 20,98 %.

The measurements show that the open circuit voltage U_{oc} and the maximum voltage U_m have remained virtually unchanged. On silicon solar cells without ARCs, U_{oc} = 0,547 V, U_m = 0,395 V, on silicon solar cells with ARCs based on mullite, U_{oc} = 0,573 V, U_m = 0,44 V. The short-circuit current density and the maximum current density increased from J_{sc} = 52,15 up to J_{sc} = 72,52 mA/cm^2, from J_m = 43,88 up to J_m = 64,41 mA/cm^2. It follows that an increase in the efficiency of silicon solar cells on average up to 6 % is due to the application of ARCs based on mullite.

REFERENCES

1.M.M. Колтун. Оптика и метрология солнечных элементов. –М.: Наука. 1985, 279 с.
2. N. Shanmugam, R. Pugazhendhi, R. M. Elavarasan, P. Kasiviswanathan, N. Das, *Energies*, 2020, *13* (*10*), 2631.
3. S.Kh. Suleimanov, M.U. Dzhanklych, V.G. Dyskin, Z.S. Settarova, N.A. Kulagina, *Applied*

Solar Energy, 2009, *45* (*4*), 295 – 297.

4. S.X. Suleymanov, V.F. Gremenok, V.V. Khoroshko, V.A. Ivanov, V.G. Dyskin, M.U. Djanklich, N.A. Kulagina, *Journal of applied spectroscopy*, 2020, *87* (*4*), 720 – 723.

ADSORPTION OF WATER ON TRANSITIONAL METAL SURFACES

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The energy sector seeks efficient, eco-friendly hydrogen production methods. Water electrolysis, generating hydrogen through electricity application to water, is key. However, efficient catalysts are needed to accelerate reactions at low temperatures. Studying atomic-level reaction mechanisms elucidates catalyst-water interactions for efficient hydrogen release. First principles calculations analyze metal atom reactivity [1-2]. These insights aid in identifying promising catalyst candidates, considering energy and kinetic properties, enabling predictive reactivity assessment and optimized design.

In this work, the interaction of a water molecule "on atop" of the low-index (100) and (110) planes of Pt, Ni, Co and Pd was studied within the framework of density functional theory (DFT) using the Quantum Espresso (QE) software package. Surfaces were modeled as 2 × 2 × 2 unit cell slabs with two atomic layers containing 16 atoms. PBE-based PAW potentials were used for all calculations. It should be noted that, the M-O distance can vary depending on the type of dispersion correction method. The d-band centers were determined from spin-polarized DFT calculations employing the Hammer-Nørskov model [3]. The adsorption energies of water monomers on indicated surfaces are summarized in Table 1.

Table 1. Adsorption energies (E_{ads}), optimized distances ($d_{M–O}$), and d-band centers (εd) for water adsorption on (100) and (110) surfaces of 3d, 4d, and 5d transition metals. The two d-band centers for the majority and minority spins are respectively εd↑ and εd↓.

Surface	εd↑ (eV)	εd↓ (eV)	E_{ads} (eV)	$d_{M–O}$ (Å)	$d_{O–H}$ (Å)
H_2O@Pt (100)	-2.13240	-1.95551	-0.06294	2.90	0.9743
H_2O@Pt (110)	-2.53102	-2.53076	-0.04426	3.14	
H_2O@Ni (100)	-1.89824	-1.09193	-0.09531	2.47	
H_2O@Ni (110)	-1.90194	-1.15874	-0.25425	2.16	
H_2O@Pd (100)	-1.78733	-1.52301	-0.1918	2.34	
H_2O@Pd (110)	-1.98333	-1.61618	-0.09543	2.73	
H_2O@Co (100)	-2.46706	-0.77631	-0.21444	2.25	

H_2O@Co (110)	-2.30758	0.65074	-0.32168	2.17	

The study clarified how metal properties, surface plane orientation, and adsorption position affect adsorption characteristics, particularly adsorption energy. Additionally, the shift of d-band centers was calculated. The geometry of water monomer "on atop" of the metal is important, and for H_2O adsorption at these surfaces, E_{ads} value range from about -0.06 eV on Pt(100) to -0.21 eV on Co(100), where increasing stability order is Pt(100)<Ni(100)<Pd(100)<Co(100). In the case of (110) surface, E_{ads} value range from about -0.04 eV on Pt(110) to -0.32 eV on Co(110), where increasing stability order is Pt(110)<Pd(110)<Ni(110)<Co(110).

REFERENCES

1. Ohwaki T., Kamegai K., Yamashita K. Bull. Chem. Soc. Jpn. **2001.** V. 74. №. 6. P. 1021-1029.
2. Ungerer M.J. et al. J. Phys. Chem. C. **2019.** V. 123. №. 45. P. 27465-27476.
3. Cao A., Nørskov J.K. ACS Catal. **2023.** V. 13, P. 3456–3462.

OPTICAL CHARACTERISTICS of COATINGS BASED on ZnO DOPED with Al_2O_3 and Dy_2O_3

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The creation of a technology for deposition of transparent conductive thin films by thermal evaporation in a vacuum at low temperatures is promising for industrial production. To do this, it is necessary to create appropriate materials, which include ceramic composites.

The main direction of research is the development of a technology for producing ceramic composites based on ZnO doped with Al_2O_3 and rare earth metal oxides (for example, Dy_2O_3) in a solar furnace.

The composite material was prepared at a component ratio of wt. %: ZnO : Al_2O_3 : Dy_2O_3 = 96 – 97 : 3 – 1 : 1 – 2. Coatings were applied to glass substrates from samples of a mechanical mixture of oxides and from material synthesized in a solar furnace using the method of vacuum thermal evaporation.

Transmission spectra of coated glass plates were measured on a Lambda 150 EZ spectrophotometer. After evaporating, the coatings have low transmittance values about 50 – 60 %. Since the concentration of the components is insignificant, and the annealing temperature was several times lower than the formation temperature of corundum or spinel, a possible explanation for the low transmittance of the films is either multiple scattering of radiation on the

roughness of the film surface, and/or the formation of a cermet film of Zn + ZnO or Al + ZnO . To increase the transmittance, the coatings were annealed at T = 400°C, as a result of which the transmittance increased to 82 – 85 %, which may be due to the restructuring of the films. With complete evaporation of a sample weighing 100 mg, the possible thickness of the continuous coating is ~89 nm.

To check the assumption about the formation of cermet, it is necessary to find the volumetric concentration of the components and the film thickness. To solve this problem, an algorithm was developed and a computer program was written. In the program, the variable variables were the concentration of components and film thickness. The optical constants of cermet were calculated using the formula of D. Bruggeman. Objective function – the difference between the experimental T_e and theoretical T_c transmittance coefficients

$$\sum_{i=1}^{N} \left(T_{e,i} - T_{c,i}\right)^2 \quad \min$$

N – number of experimental points. The computer program verification results demonstrate good agreement between the calculation results and the experiment. The correlation value was ~2%.
It has been established that when deposited in a vacuum, films of doped ZnO sublimate in the same way as pure ZnO. To obtain high optical characteristics, evaporation must be carried out for as short a time as possible, because during the application process, the stoichiometry is disrupted. The optimal substrate temperature and deposition modes for obtaining conductive transparent films must be determined experimentally at higher temperatures T > 400 °C.

THE POTENTIAL OF FILM-CERAMIC COMPOSITE FOR GREENHOUSES AND HOTHOUSES MADE FROM FINITE WASTE OF MF AGMK

R.Kh. Rakhimov, V.V. Pankov, V.P. Ermakov, Kh.K. Rashidov, P. John.

Аннотация. Разработан пленочно-керамический композит на основе полиэтилена и функциональной пленки, синтезированной на большой солнечной печи, который представляет из себя трехслойную полиэтиленовую пленку, верхний слой которой содержит добавки, преобразующие УФ-излучение в излучение видимого диапазона. Средний слой повышает механическую прочность. Нижний слой содержит набор функциональной керамики, генерирующей инфракрасные импульсы с заданными параметрами.
Annotation. A film-ceramic composite based on polyethylene and a functional film synthesized in a large solar furnace has been developed, which is a three-layer polyethylene film, the upper layer of which contains additives that convert UV radiation into visible radiation. The middle layer increases mechanical strength. The bottom layer contains a set of functional ceramics that generate infrared pulses with specified parameters.

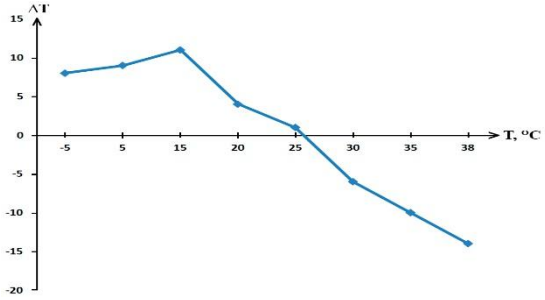


Fig. 1. Temperature difference ΔT in chambers made of pure polyethylene film and a three-layer composite depending on the ambient temperature T.T =T1–T2, where T1 is the temperature under a conventional film, T2 is the temperature under a

film–ceramic composite.

The mechanism of thermoregulation of the film. Ceramics convert solar energy into pulsed radiation with a given wavelength:

9.7-10 microns, which corresponds to a temperature of 17-22oC. This happens at any ambient temperature. In other words, in the heat, the film cools, and in the cool it increases the temperature in greenhouses. From one high-energy photon, 20 or more photons with such quantum energy are formed. In addition, the pulsed radiation generated by the composite penetrates to a depth of more than 1 meter, warming the soil, which subsequently serves as a source of phonons, which are partially converted into photons, and partially maintain the temperature of the soil and plant roots. A kind of thermal accumulator is being created.

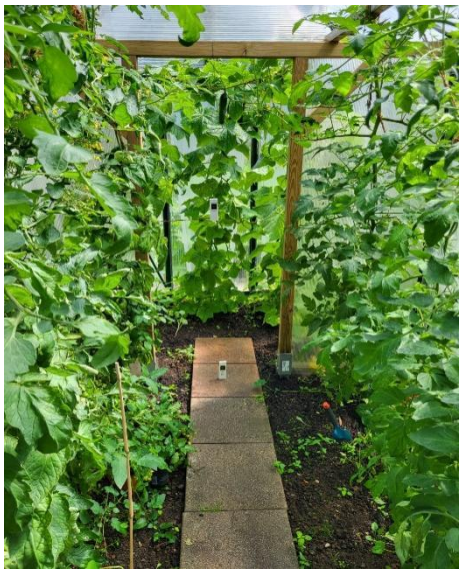


Fig.2. Location of temperature sensors in the greenhouse. The sensors are located at different heights to monitor the temperature gradient.



Fig. 3. Temperature in greenhouses made of composite and ordinary polyethylene:

1. Outer – blue; 2. Time – white; 3. Composite, lower sensor – orange; 4. Composite, sensor in the center – yellow; 5. Ordinary film.

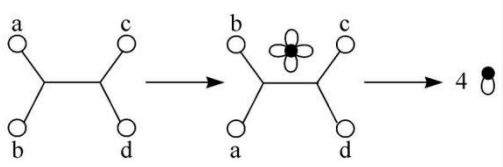
Как следует из приведенных данных, температура отличается более, чем на 10 градусов.

As follows from the above data, the temperature differs by more than 10 degrees**.**

2. 620-680 nanometers, which is the necessary radiation for photosynthesis. When the illumination is below a certain threshold, photosynthesis does not occur. If this radiation

is pulsed, then the radiation density in the pulse significantly exceeds the required threshold for photosynthesis, even at dusk. The fact is that photosynthesis has both light reactions – photon absorption, and dark reactions – the use of this photon by the plant. The first stage lasts 50 times shorter than the second. Therefore, the efficiency of photosynthesis cannot be higher than 2%. The pulsed nature of the generated FC radiation provides the necessary energy density even in low light conditions.

Radiation of 660 nm activates phytochrome, which controls the activity of enzymes and, accordingly, the growth and development of plants. Due to the conformational change, phytochrome opens the active centers of enzymes and their activity increases 36,000 times.



3. **3,2-3.6 microns.** The polyethylene film is not transparent in this range. This radiation is trapped inside the greenhouse, which not only ensures that the temperature is maintained in the cold, but also prevents vaporization, since the temperature on the film does not allow the moisture condensation process to take place. It is characteristic that due to the uniformity of temperature, evaporation in greenhouses with composite is 4-6 times lower than under a conventional film.



Обычная пленка Композит

Fig. 4. The development of plants in greenhouses made of ordinary polyethylene and composite.

The absence of evaporation (mechanism) in the greenhouse and what it gives. 1. Since the quantum energy of most of the radiation generated by the composite corresponds to a temperature of 17-22 degrees C, evaporation decreases sharply. 2. The ceramic layer gives powerful pulsed radiation, which dramatically reduces condensation on the composite. 3. There is no large temperature gradient in height inside the greenhouse.

Areas of application. The development of deserts, turning it into an oasis. Providing comfortable indoor and outdoor conditions by stabilizing the temperature and reducing moisture evaporation.

The absence of a characteristic odor in greenhouses when using a composite. The composite provides so-called low-temperature sterilization. The principle of operation is as follows. The

pulses generated by functional ceramics are selected with such parameters that they suppress the process of copying DNA and RNA of pathogenic microflora, therefore, their reproduction.

Conclusions. Temperature optimization, activation of phytochrome, pulsed generation of high-density red light even in low light, allows plants to absorb photons in low ambient light, sudden fluctuations in external temperature, as well as due to the fact that the composite provides good soil heating and moisture retention up to 6 times longer than when using conventional polyethylene, disinfection and all this leads to high yields - +30-50% and low fuel consumption (reduced by at least 40-60%), high quality and low cost of final products. The main raw material for the production of functional ceramics is the final waste of the AGMK copper ore plant, which has accumulated several billion tons.

REFERENCES

1. Рахимов Р.Х., Ермаков В.П., Рахимов М.Р., Юлдашев Н.Х., Исмаилов К., Хатамов С.О. Особенности синтеза функциональной керамики с комплексом заданных свойств радиационным методом. Часть 3. Computational nanotechnology, 2016, выпуск №2, с. 66–76.
2.Рахимов Р.Х., Ермаков В.П., Рахимов М.Р. Синтез материалов радиационным методом и их применение. Applied Solar Energy, том 58, №1, 2022, 165-171

PERSPECTIVES OF APPLYING FILM-CERAMIC PHOTOCATALYSTS FOR MICROALGAE CULTIVATION

R.Kh. Rakhimov, V.P. Ermakov, T.S. Saidvaliev

There are many types of microalgae that can grow in seawater and freshwater, containing high levels of lipids. The lipids found in microalgae are used for the production of biofuels, cosmetics, pharmaceuticals, and other products. This article focuses on evaluating the optimal conditions for cultivating such microalgae, taking into account their individual spectral sensitivity and maximum utilization of solar light. This will enable the creation of film-ceramic composites that provide the highest biomass growth with minimal water and time consumption.

Certain conditions are required for industrial-scale microalgae cultivation.

• Firstly, microalgae require light for photosynthesis, so they need to be provided with an adequate amount of light.

• Secondly, microalgae need water and nutrients such as nitrogen, phosphorus, and potassium.

• Thirdly, the ambient temperature and pH should be controllable and suitable for the specific type of microalgae.

• Fourthly, cultivating microalgae on an industrial scale requires specialized equipment such as bioreactors and monitoring systems.

• Finally, drying is also required.

An ideal production system for cultivating algae is not focused solely on producing a single product. It utilizes the benefits of ecosystem services that algae can provide and extracts multiple products from the same biomass. This has both economic and environmental

advantages.

Currently, there are three different production methods:

• Open pond systems,

• Photobioreactors, and

• Fermenters.

Each technology has its advantages and disadvantages, and the decision on which one to choose should depend on the end product, types of microalgae, and production costs.

In addition to water availability and solar radiation, important factors to consider are labor and energy costs, as they are key factors in production expenses. Freshwater algae can be used for wastewater treatment or in areas with an excess of freshwater. On the other hand, fermentation is easily scalable, inexpensive, and interesting for "converting" organic carbon compounds into biomass rich in compounds such as omega-3 or antioxidants. In addition, CO2 from fermentation can be used to increase the productivity of photobioreactors.

Open pond systems are generally cheaper in construction and operation, so for large-scale, low-cost biomass production, closed photobioreactors are usually considered unsuitable. Closed bioreactors or fermenters are ideal for growing high-quality starter cultures used for inoculating open pond bioreactors. Additionally, when producing valuable products, closed photobioreactors are usually preferred as they are more reliable and less susceptible to pests compared to open pond systems. However, their use requires more energy for gas exchange to avoid oxidative stress.

To help reduce the production costs of large volumes of low-value products derived from algae, simultaneous production of high-value products from the same biomass is the most environmentally beneficial approach. As by-products of oil or protein extraction, algae can yield pigments and bioactive compounds. The key in this extraction method is to utilize chemical substances that will not have a negative impact on the environment.

Overall, an ideal production system for cultivating algae should be flexible and adaptive, taking into account various factors such as the end product, types of microalgae, and production costs. It should harness the benefits of the ecosystem provided by algae and extract multiple products from the same biomass to improve economic efficiency and reduce environmental impact. Cultivating microalgae on non-arable land is ideal for land-based cultivation.

Cultivating microalgae holds promise for the production of biofuels, food, and cosmetic products. However, existing methods have low efficiency. The use of film-ceramic photocatalysts is proposed to address this. They enable the efficient transformation and direction of solar energy to stimulate microalgae growth.

Key parameters for such composites include:

- 600-680 nm radiation for photosynthesis
- 500-560 nm for phytoplankton growth
- 660 nm for activating growth enzymes
- 3.2-3.6 μm for heat preservation during nighttime
- 9.7-10 μm for temperature stabilization

Tests have been conducted on these composites, demonstrating reduced moisture evaporation and increased plant growth rates compared to polyethylene.

One promising target is Chlorella. It is proposed to create a photocatalyst with an optimal spectrum for its cultivation in desert conditions and the Aral Sea region. This will enable land

development and environmental improvement.

Overall, the development of these technologies will yield significant economic and environmental benefits for different regions.

REFERENCES

1. Rustam K. Rakhimov, Elena V. Kim., USA Patent “Treatment of materials with infrared radiation", # 5,472,720 from 05/12/1995.

2. Рахимов Р.Х., Ермаков В.П., Саидвалиев Т.С. Перспективы применения пленочно-керамических фотокатализаторов для выращивания микроводорослей // Computational Nanotechnology. 2023. Т. 10. № 2. С. 60–69. DOI: 10.33693/2313-223X-2023-10-2-60-69. EDN: BTHXIR

3. Рахимов Р.Х. Возможный механизм импульсного квантового туннельного эффекта фотокатализаторов на основе наноструктурированной функциональной керамики // Computational Nanotechnology. 2023. Т. 10. № 3,С. 26–34. DOI: 10.33693/2313-223X-2023-10-3-26-34. EDN: QZQMCA

FILM-CERAMIC COMPOSITE FOR GREENHOUSES

R.Kh. Rakhimov, Kh.K. Rashidov, V.P. Ermakov, Zh.K. Rashidov, T.S. Saidvaliev

The film-ceramic composite converts solar energy into radiation with peaks at 0.62-0.68 μm, which is essential for photosynthesis; 3.2-3.6 μm, a range in which polyethylene film is opaque, providing temperature retention during nighttime or cloudy weather; and far-infrared radiation with a peak at 9.7-10.0 μm for maintaining optimal temperature. This is achieved by utilizing functional ceramics (0.3% by mass) to convert a single high-energy photon in the ultraviolet and visible range into 10-20 photons with energies corresponding to temperatures of 17-26°C. This occurs at any external temperature. Consequently, the film cools in hot weather and increases temperature in cooler conditions. The transition temperature is approximately 25°C.

Field trials have demonstrated that the proposed method reduces gas consumption in greenhouses and similar structures by 60%-100% compared to conventional films, while increasing crop yields by 50%-100%. Moisture evaporation is reduced by a factor of 4-6.

The mechanism of film temperature regulation involves the main ceramic component continuously converting solar energy into pulsed radiation with a quantum temperature of 17-22 degrees, regardless of the external temperature. Thus, the film cools in hot weather and increases temperature in cooler conditions. From a single high-energy photon, 20 or more photons are generated with the required quantum energy. Furthermore, the pulsed radiation generated by the composite penetrates over 1 meter in depth, heating the soil. The soil subsequently serves as a source of phonons that partially convert into photons and partially maintain the temperature of the soil and plant roots. Additionally, the ceramics emit radiation at other wavelengths to activate necessary plant growth and development processes. Fuel consumption is reduced by 60%-100%.

The film does not fog up due to the small temperature gradient within the greenhouse and the constant energy emission from the lower ceramic layer, preventing moisture condensation on the

film.
Moisture evaporation is reduced by a factor of 4-6. 1. Since the quantum energy of the converted composite corresponds to temperatures of 17-22°C, evaporation is significantly reduced. 2. The ceramic layer has a higher temperature, preventing condensation on the film. 3. There is a uniform temperature distribution vertically inside the greenhouse, eliminating the dew point.
Apart from greenhouses, the composite can find other applications. It allows for the transformation of deserts into oases, providing comfortable conditions in indoor and outdoor spaces by stabilizing temperature and reducing moisture evaporation.
Why is there no characteristic odor in greenhouses when using the composite material?
The composite material provides what is known as low-temperature sterilization. The principle of operation is as follows: the pulses generated by the functional ceramics are designed in such a way that they suppress the process of DNA and RNA replication in pathogenic microflora, thereby inhibiting their reproduction.
What is the mechanism behind improved photosynthesis? When the illumination falls below a certain threshold, depending on the type of agricultural crops, photosynthesis does not occur. The process of photosynthesis involves the absorption of a light photon over a period of time, and it takes approximately 50 units of time to assimilate and process that quantum. By delivering this radiation in pulses, the radiation density in each pulse significantly exceeds the threshold even during twilight, ensuring normal photosynthesis.
Why do plants grow rapidly and become resistant to diseases when using the composite material?
In all types of seeds, there is a phytochrome that actively regulates the activity of enzymes, thus affecting the growth and development of plants. It can transition from one conformational state to another under the influence of light with a wavelength of 660 nanometers (activating enzymes) and 730 nanometers (suppressing enzyme activity). Considering that 660 nm corresponds to the part of the spectrum responsible for photosynthesis, and the composite material generates this energy in a pulsed mode, the phytochrome is activated.
What explains the high crop yield when using the composite material? The optimization of temperature, activation of phytochrome, pulsed generation of high-density red light even under weak illumination allows plants to absorb photons under low external light conditions and sharp fluctuations in external temperature. Additionally, the composite material provides good soil warming and moisture retention up to 6 times longer than regular polyethylene, suppresses pathogens, and improves pollination (bees are attracted to the composite material).
Why is the temperature maintained during the nighttime? This is because the composite material includes functional ceramics that generate radiation with wavelengths of 3.2-3.6 μm. Polyethylene is not transparent in this range. Additionally, the soil acts as a thermal accumulator.
As an example, we present the results of field trials for regular polyethylene film (ZB0), as well as films containing 0.1% functional ceramics (ZB1 and ZB2). The graph shows the temperature dependence for different films.



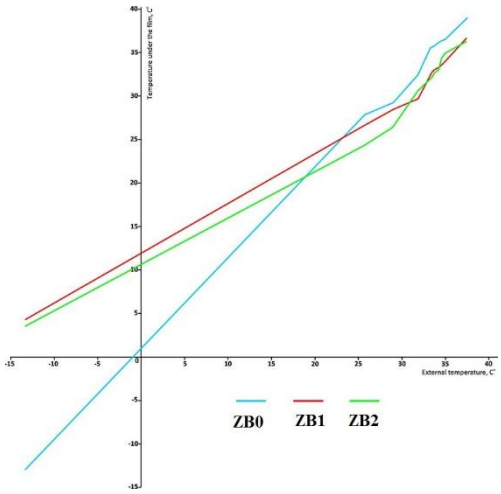
The development of plants under the composite ZB1.



The development of plants under a conventional ZB0 film



The development of plants under the composite Zb2



Conclusions:

The use of the composite material offers the following advantages:

It reduces fuel consumption by at least 40-60% (in reality, we have not used heating at all, and acceptable temperatures have been maintained throughout the year).

Cooling occurs during hot weather.

Crop yield increases by 30-50% (in actual trials conducted in three greenhouses measuring 60x10 meters each, tomato yield increased by more than 2 times); water consumption is reduced by 4-6 times.

Condensation does not form, which can turn into ice or droplets that fall on plants and harm them.

Disinfection of premises is ensured, and unpleasant odors from the activity of pathogenic microorganisms are eliminated.

Plant diseases are not observed for the same reason.

Notably, bees choose greenhouses with the composite material, which ensures good pollination of plants and, consequently, high yields.

In comparative trials conducted in the Parkent region, where there is a high level of UV radiation, regular polyethylene film had to be replaced 6 times from February to December 2021 due to UV degradation, while the composite material remains in excellent condition.

Considering that Uzbekistan consists of 70% desert areas, one of the main applications of the composite material is seen in transforming these lands into oases and restoring the Aral Sea region.

REFERENCES

1. Рахимов Р.Х. Возможный механизм импульсного квантового туннельного эффекта фотокатализаторов на основе наноструктурированной функциональной керамики // Computational Nanotechnology. 2023. Т. 10. № 3. С. 26–34. DOI: 10.33693/2313-223X-2023-10-3-26-34. EDN: QZQMCA
2. Рахимов Р.Х., Ермаков В.П. Перспективы солнечной энергетики: роль современных гелиотехнологий в производстве водорода // Computational Nanotechnology. 2023. Т. 10. № 3. С. 11–25. DOI: 10.33693/2313-223X- 2023-10-3-11-25. EDN: NQBORL
3. Рахимов Р.Х., Ермаков В.П., Саидвалиев Т.С. Перспективы применения пленочно-керамических фотокатализаторов для выращивания микроводорослей // Computational Nanotechnology. 2023. Т. 10. № 2. С. 60–69. DOI: 10.33693/2313-223X-2023-10-2-60-69. EDN: BTHXIR

STUDY OF THE EFFECTIVENESS OF FUNCTIONAL CERAMICS ADDITIVES OBTAINED BY VARIOUS METHODS ON THE PROPERTIES OF WELDING ELECTRODES

R.M.Saidov, R.H.Rakhimov

In this work, a comparative analysis of the effectiveness of photocatalysts of nanostructured functional ceramics (PNFC) brand “ZKXM” [1], obtained under the influence of concentrated solar radiation on the Large Solar Furnace, and brand “ZB-1”, manufactured using the method of synthesis of FNFC according to the technology with subsequent activation by pulsed radiation [2] generated by functional ceramics, on the welding and technological properties of welding electrodes of the MP-3 brand. The welding-technological properties of welding electrodes were determined according to the methods described in [3].

Comparative results of the formation of welded welds with the addition of photocatalysts of the “ZKXM” and “ZB-1” brands from 1% to 8% into the coating charge of a welding electrode of the MP-3 brand showed that welds with high-quality formation without external defects are achieved when surfacing with electrodes with additives of both stamps up to 1%. When welding with electrodes containing more than 1% PNFC, deterioration in the quality of formation of deposited beads is observed in both cases.

According to the results obtained, with a PNFC content of up to 1%, the breaking length of the arc “L_{bla}” increases when welding with an electrode both with the additive of the ZKXM brand and with the additive of the ZB-1 brand. A further increase in the amount of additive in the composition of the PNFC coating of both brands worsens the stability of arc combustion, characterized by a decrease in the arc breaking length.

The influence of PNFC additives on the size of the visor at the end of the electrode “h_k”

showed that the addition of photocatalyst brand “ZKXM” up to 2% reduces the size of the visor, and its further increase increases its value. The addition of photocatalyst brand “ZB-1” to the coating reduces the “h_k” indicator to 25% when the content of the “ZB-1” additive is up to 8%.

As shown by the results of studies of the influence of “ZKXM” additives in the electrode coating, the melting coefficient “α_p” increases the value over the entire studied range with a maximum value with the addition of “ZKXM” up to 8%. On the contrary, welding electrodes with additives PNFC brand “ZB-1” slightly reduce this indicator. The influence of PNFC additives on the deposition coefficient “$\alpha_н$” of welding electrodes has similar correlations and dependencies as for the melting coefficient “α_p”.

In accordance with the data obtained, the most effective effect on losses due to waste and spattering is observed when adding photocatalyst “ZB-1” brand to the composition of electrode coatings, which allows reducing this indicator throughout the entire range of its content. The maximum reduction (by 44.5%) of this indicator is observed when the content of PNFC “ZB-1” is 1%. A slight decrease in the loss coefficient due to waste and spattering “ψ” is also observed when adding up to 1% photocatalyst “ZKXM” brand to the coating. A further increase in this additive leads to an increase in losses of the welding electrode during the welding process.

REFERENCES

[1] Rustam K. Rakhimov, Elena V. Kim., USA Patent “Radiation emitting ceramic materials and devices containing same”, # 5,350,927 from 27/09/1994.
[2] Rustam K. Rakhimov, Elena V. Kim., USA Patent “Treatment of materials with infrared radiation”, # 5,472,720 from 05/12/1995.
[3] R.M. Saidov, R.H. Rakhimov, B.D. Yusupov, M.K. Kholdorov, A new method of drying and calcining welding electrodes using functional ceramic emitters. Computational Nanotechnology, 2020, 1, 44-52.

STUDY OF THE INFLUENCE OF ADDITIVES OF NANOSTRUCTURED FUNCTIONAL CERAMICS TO THE WELDING ELECTRODES COATINGS ON THEIR PROPERTIES

R.M.Saidov, R.H.Rakhimov, S.M.Abduraimov, Kamel Tuileb

The objective of this study was to investigate the impact of nanostructured functional ceramics photocatalysts (PNFC) called ZB-2 [1], which were synthesized using a pulsed radiation activation method and the influence of small additives of this PNFC in the coating composition of the welding electrode MR-3 on their welding and technological properties.

The ZB-2 photocatalyst consisted of a powder mixture primarily composed of chromium oxide (44.7%), along with iron oxides (28%), silicon dioxide (17%), calcium oxide (5.5%), aluminum oxide (2.5%), magnesium oxide (2%), and copper oxide (0.3%). The particle size distribution ranged from 2 to 10 microns, with a minimum fraction of 5 microns constituting at least 50%.

Studies of the influence of photocatalyst additives of the “ZB-2” brand in an amount from 1% to 8% on the welding and technological properties of the MP-3 welding electrode were

carried out on such properties as the stability of the arc of the welding electrode “L_{bla}”, the formation of a deposited point “$ø_{dp}$” .”, the size of the visor or cover at the end of the electrode “hк” and the coefficients of melting “αp”, surfacing “αн”, losses due to waste and spattering “ψ”. The specified welding-technological properties of welding electrodes were determined according to the method described in [2, 3].

In accordance with the research data obtained, an increase in the breaking arc length "Lрдд" of the MP-3 welding electrode was revealed when adding "ZB-2" to the coating charge in an amount of up to 2%. With additions of more than 2%, the breaking arc length decreases.

The additive “ZB-2” has the same effect on the diameter of the deposited point “$ø_{dp}$” welding electrode MP-3. When its content in the coating is up to 2%, the diameter of the deposited point increases, and a further increase in the additive content reduces this indicator.

A decrease in the height of the visor at the end of the electrode “h_k” was revealed when the content of the “ZB-2” additive was up to 1%, and a further increase in the “ZB-2” content above 1% leads to an increase in “h_k”.

As research results have shown, the influence of “ZB-2” additives in the welding electrode coating has a strong correlation with the melting coefficient “α_p” and a weak correlation with the deposition coefficient “$\alpha_н$”, as well as a very strong correlation with the loss coefficient for waste and spattering “ψ”. At the same time, with increasing addition of PNFK, the value of the melting coefficient “α_p” decreases, and the value of the deposition coefficient “$\alpha_н$” increases. In this regard, the loss coefficient due to waste and splashing “ψ” drops sharply to 53% when the additive content in the coating mass is up to 8%.

REFERENCES

[1] Rustam K. Rakhimov, Elena V. Kim., USA Patent “Treatment of materials with infrared radiation", # 5,472,720 from 05/12/1995.

[2] R.M. Saidov, R.H. Rakhimov, B.D. Yusupov, M.K. Kholdorov, A new method of drying and calcining welding electrodes using functional ceramic emitters. Computational Nanotechnology, 2020, 1, 44-52.

[3] T.R. Litvinova, S.K. Elsukov, I.S. Antipov, M.P. Korolev, D.V. Pleytkin, O.V. Bessonov, I.V. Egorov, Study of welding and technological properties of coated electrodes for welding low-alloy high-strength steels. International Research Journal, 2017,5, Part 3, 71-75.

OPTICAL-ENERGY CHARACTERISTICS AND HEATING TEMPERATURES IN SMALL SINGLE-MIRROR SOLAR OVENS

Sh.I. Klychev, S.A. Bakhramov, O.R. Parpiev, M.S. Paizullakhanov, L.S. Suvonova D.E. Kadyrgulov

Abstract. The possibilities of using small single-mirror solar furnaces (SMSF) based on floodlight mirrors in high-temperature materials science have been studied. The optical-energy characteristics of the small solar furnace (SMSF) (average concentrations and fluxes in the focal

plane) were determined. It is shown that SMSF, like Uranium optical furnaces, can be used both at the stage of research and development of the technology for their production at the Large Solar Furnace. The dynamics of heating temperatures of raw materials at the focus of the SMSF was determined.

Keywords. Photometric theory of the radiation field, optical concentration of direct solar radiation, non-stationary heating.

The issues of developing methods for calculating nonstationary temperatures of bodies, taking into account their own radiation, are currently one of the most relevant in thermal engineering [1-3]. The purpose of this work is to determine the heating temperatures of materials in the focal plane of a searchlight mirror, depending on its optical and energy characteristics. Concentration at some point of the receiver

$$C_r = \frac{E_r}{R_z * E_c} \quad (1)$$

where E_r is the density of the concentrated flux at the point (elementary site dS) of the receiver, W/m^2; R_z is the mirror reflection coefficient of the mirror; Ec is the density of direct incident solar radiation, W/m^2. Average concentration C_{av}

$$C_{av} = \frac{F_s}{S} \quad (2)$$

where Fs, [W] is the flux of concentrated solar radiation at the site S,[m^2]. The streams Fs and F_K are equal

$$F_s = \sum E_r * dS \qquad F_K = R_z * E_c * S_M \quad (3)$$

where S_M is the area of the hub's midsection or the area of its projection onto a plane perpendicular to the incident sunlight. A Delphi language program has been developed to calculate concentrations and fluxes in the focal zone of the SSF paraboloid concentrator.

It was found that at an average concentration of 5000, the yield at almost equilibrium temperatures does not exceed 2c. It can also be noted that to obtain high heating temperatures of the order of 3000 K, average concentrations of more than 10000 are required. In general, small single-mirror solar furnaces for direct tracking of the Sun with paraboloid searchlight mirrors can provide sufficiently high heating temperatures up to 3500K. In this case, the flow reflected from the concentrator can be up to 50%. Concentrations of more than 10,000 are required to obtain heating temperatures up to 3000K. To ensure effective melting of the material, it is desirable to place the lower edge of the tablet in "focus", and during the melting process move the tablet towards the mirror.

REFERENCES

1. G.V. Kuznetsov, M.A. Sheremet. Differential methods for solving thermal conductivity problems. A study guide. Tomsk: TPU Publishing House, 2007. – 172 p .

2. A.N. Tokareva, V.N. Litvinov, S.V. Panchenko, M.S. Demchenko. Solving problems of non-stationary thermal conductivity in multilayer structures by the finite difference method. Methodological guidelines. 2021. – 22 p.

3. Leontiev A.I. Theory of heat and mass transfer. Moscow, “Higher School", 1979, 495 p.

THE TITLE OF THE PROJECT IS 'RADIATION-BASED METHOD USING FUNCTIONAL CERAMICS FOR THE PREPARATION OF METAL CATALYSTS ON DIFFERENT SUPPORT MATRICES

R.Kh. Rakhimov, Kh.K. Rashidov, V.P. Ermakov, Zh.Kh. Rashidov, R.M. Saidov

There are two main methods for synthesising nanoparticles on different carrier matrices. The first method involves impregnating salt solutions into a porous carrier, followed by calcination and reduction if metallic particles are desired. The second approach is based on the radiation reduction of metal salts in aqueous solutions impregnated in the carrier matrix.

Our development aims to minimize radiation in metal salt catalysts when used in aqueous solutions on aluminium oxide.

Nanotechnology involves the study of systems and processes that occur at the nanoscale, which can lead to the discovery of new effects and interaction mechanisms, as well as the development of new methods for synthesising nanocomposite materials. In modern chemistry, obtaining metal catalysts is crucial for processing petroleum products, coal industry products, fuel cells, and other applications.

The radiation method facilitates the production of metal alloy nanoparticles in various matrices and enables adjustment of the redox potential, through composition and size, to optimize catalysis of a specific redox reaction (where $E0(D+/D) < E0(Mn+/Mn) < E0(A/A-)$). This document outlines various properties of palladium catalysts on an aluminum oxide carrier, prepared using three different methods:

A) Radiation reduction in the presence of isopropyl alcohol;

B) Reduction by isopropyl alcohol (without irradiation), and

C) Calcination in air at 450°C.

According to the results, platinum nanoparticles obtained by the radiation method (A) exhibited the highest dispersibility (42%), while the chemical reduction method (B) showed the lowest dispersibility. The study examined three different methods for reducing radiation, namely: Furthermore, the catalyst obtained by the radiation method demonstrated the longest retention time of carbon monoxide. It could be argued that this particular catalyst exhibits a higher degree of selectivity in hydrogenating propylene when compared to methylacetylene, and it is worth noting that it also boasts a longer service life.

The application of radiation technology allows for the production of not only nanoscale metals on oxide carriers but also oxide carriers with an enormous specific surface area. This ultimately significantly increases the catalytic activity of the product. There are no analogues to this approach in the manufacture of catalysts. This has been confirmed by a patent for the invention and a series of articles [1-4].

Advantages of radiation method for the preparation of nanoscale metal catalysts on various carriers.

1. One-stage synthesis - the substance obtained after irradiation can be immediately used as a catalyst without preliminary calcination, reduction, etc.

2. Absence of additional reducing agents, which allows obtaining more pure catalytic

systems.

3. Possibility to obtain smaller nanoparticles in comparison with the reduction method, since the size of the formed metal nanoparticles depends on the dose rate.

4. Unlike macroscopic-sized particles, nanoparticles of many metals have catalytic properties similar to platinum group metals, and their application is more promising due to their greater prevalence in nature and lower cost.

REFERENCES

1. IAP patent 04844. Composition for the production of films for solar dryers.

2. Rakhimov R.H., Pankov V.V., Ermakov V.P., Rashidov J.H., Rakhimov M.R., Rashidov H.K. Investigation of the properties of functional ceramics synthesized by the modified carbonate method // Computational Nanotechnology. 2023. T. 10. № 3. C. 130–143. DOI:10.33693/2313-223X-2023-10-3-130-143. EDN: SZDYRZ

3. R.KH. Rakhimov, H.K. Rashidov, M. Ernazarov. Physical methods of influence at enrichment of technogenic and ore raw materials. International Conference "Fundamental and Applied Problems of Modern Physics", October 19-21, 2023. 49-51

4. R.H. Rakhimov, H.K.Rashidov, J.H.Rashidov. Effects of pulsed infrared radiation based on functional ceramics on magnetic properties of iron-containing minerals. International Conference "Fundamental and Applied Problems of Modern Physics", October 19-21, 2023. 235-237

CARBON NANOSTRUCTURES FOR BIOMEDICAL APPLICATIONS

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Cancer chemotherapeutics (such as Paclitaxel) fail to treat Non-small cell lung cancer (NSCLC), due to limitations such as multidrug resistance, dose limiting toxicities, tumor relapse, off-target side effects and their inability to silence the overexpressed oncogenes. In NSCLC, overexpressed antiapoptotic survivin gene is responsible for promoting NSCLC survival. CD133, a transmembrane glycoprotein, is reported to be overexpressed in NSCLC, it is therefore, can be exploited for site specific drug cargo delivery by using CD133 monoclonal antibody (mAbs) Further, CD133 blockade with mAbs can also help in decreasing NSCLC chemoresistance, carcinogenesis, survival, metastasis and tumor growth.

In 2021-2023, the Uzbek-Indian joint project No. UZB-Ind-2021-77 "CD133 mAbs surface modified carbon nanotubes loaded with Survivin siRNA and Paclitaxel for the treatment of non-small cell lung cancer" [1-3] was executed in the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan.

In the present paper, an effort has been made, therefore, to develop CD133 mAb surface

modified carbon nanotubes loaded with survivin siRNA and Paclitaxel (PTX) (CD133-SWCNT-Survivin-PTX) to achieve site specifically deliver of multiple drug cargoes to effectively treat NSCLC.

The developed formulation is expected to provide the following advantages over the existing treatment:

Able to carry multiple drug cargoes consisting of antiapoptotic Bcl-2 gene siRNA, and chemotherapeutic agent.
Can achieve site specific delivery of multiple drug cargoes to NSCLC through CD133 mAb directed against CD133 receptors present on NSCLCs
Can reduce dose limiting and off-target side effects of Paclitaxel

REFERENCES

1.Ammu VVV Ravi Kiran, Garikapati Kusuma Kumari, Praveen T Krishnamurthy, Renat R Khaydarov Tumor microenvironment and nanotherapeutics: intruding the tumor fort. Biomater. Sci., 2021,9, 7667-7704

2.Ammu R.K., Kumari G.K., Praveen T. K., Khaydarov R.R. et al. Methods for enhancing dispersibility of carbon nanotubes, in "Emerging Applications of Carbon Nanotubes in Drug and Gene Delivery", 2023, Editor: Prashant Kesharwani, Woodhead Publishing, Elsevier, pp. 95-118

3.Ammu R.K., Kumari G.K., Praveen T. K., Khaydarov R.R. et al., Gene cargo delivery aspects of carbon nanotubes, in "Emerging Applications of Carbon Nanotubes in Drug and Gene Delivery", 2023, , Elsevier, pp. 157-174

THE OXIDATION OF 2-VALENT IRON IN SULPHURIC ACID SOLUTIONS CAN BE ACHIEVED THROUGH PULSED INFRARED RADIATION TREATMENT USING FUNCTIONAL CERAMICS, WITHOUT THE NEED FOR ADDITIONAL REAGENTS

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Many hydrometallurgical processes use sulphuric acid as a leaching agent and trivalent iron sulphate as an oxidising agent to extract valuable components from ores. It is worth noting that during leaching, the oxidising agent is consumed and changes to the divalent state. To compensate for the loss of oxidant, the treated solution must either consume more oxidant, increasing the cost of the process, or be regenerated.

Various methods are used for regeneration purposes, but all of them involve costs for chemical reagents or contaminate the productive solution with extraneous impurities. For regeneration of oxidant in recycle solutions it is necessary to provide effective oxidation of divalent iron ions. Of the various modern methods of oxidising of the $^{Fe2+}$ ions in sulphuric acid solutions, the best known are:

- use of strong oxidising agents (pyrolusite, chlorates, etc.);

- use of hydrogen peroxide;

- use of molecular technical oxygen, or air oxygen.

One of the most promising for use for the specified purposes are radiation-chemical methods of influence on the treated substance by means of radiation treatment of technological solutions with pulsed infrared radiation. The main advantages of radiation-chemical technology (RCT):

- high productivity when working in continuous round-the-clock mode;

- possibility to carry out treatment at relatively low temperatures, i.e. without expenses for forced heating of irradiated material;

- no need to use chemical reagents and catalysts, which determine the ecological purity of RCT.

A new technological direction has been developed in radiation-chemical technologies for influencing technological solutions through radiation treatment. This principle of action is based on the interaction of pulsed infrared radiation with a thin film of flowing water, and it appears to be unique in its approach. The water treatment method described here is characterised by a higher amount of specific energy transferred to the water, which has a targeted effect on exciting the rotational and vibrational degrees of freedom of water molecules. This excitation occurs through asymmetric and symmetric deformation oscillations, rotations, and elastic dissipation of recoil energy. Changes in impulse parameters result in changes to the properties of the water.

It is confirmed by the patent for the invention and a number of articles [1-4].

One of the most important requirements for modern hydrometallurgical technology of ore raw material processing is environmental cleanliness. Industrial production nowadays should be not only resource- and energy-saving, but also practically waste-free, the latter condition makes it necessary to obligatory neutralisation of toxic waste, organisation of closed water circulation, recycling and regeneration of reagents. The application of our technology makes it possible to simplify and intensify the technological process, increase the extraction of the target component, reduce the consumption of reagents, i.e. reduce the cost of production, increase the level of environmental friendliness of production and, thus, pay back with excessive financial costs for radiation treatment with pulsed infrared radiation.

REFERENCES

1. IAP patent 04844. Composition for the production of films for solar dryers.

2. Rakhimov R.H., Pankov V.V., Ermakov V.P., Rashidov J.H., Rakhimov M.R., Rashidov H.K. Investigation of the properties of functional ceramics synthesized by the modified carbonate method // Computational Nanotechnology. 2023. T. 10. № 3. C. 130–143. DOI:10.33693/2313-223X-2023-10-3-130-143. EDN: SZDYRZ

3.R.KH. Rakhimov, H.K. Rashidov, M. Ernazarov. Physical methods of influence at enrichment of technogenic and ore raw materials. International Conference "Fundamental and Applied Problems of Modern Physics", October 19-21, 2023. 49-51

4.R.H. Rakhimov, H.K.Rashidov, J.H.Rashidov. Effects of pulsed infrared radiation based on functional ceramics on magnetic properties of iron-containing minerals. International Conference "Fundamental and Applied Problems of Modern Physics", October 19-21, 2023. 235-237

ENHANCING HYDROGEN CATALYST PERFORMANCE THROUGH BARRIER LAYER REMOVAL IN ANODIZED ALUMINUM OXIDE TEMPLATES

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ABSTRACT

Anodized Aluminum Oxide (AAO) has emerged as a versatile template for diverse nanoscale applications, including its promising role as a platform for hydrogen catalysts. However, the presence of a barrier layer, an inherent byproduct of the anodization process, poses a significant obstacle to the efficient performance of AAO templates in hydrogen evolution reactions (HER). This study delves into the critical aspect of barrier layer removal from AAO templates to unlock their full potential as efficient hydrogen catalysts.

Various methods for barrier layer removal are investigated in detail, encompassing chemical etching, electrochemical techniques, and laser ablation. Chemical etching offers a selective dissolution of aluminum oxide using either acidic or alkaline solutions, leaving behind a porous structure devoid of the barrier layer. Electrochemical methods leverage an applied electric field to facilitate controlled removal of the barrier layer, while laser ablation provides precise removal through high-energy laser pulses.

The profound impact of barrier layer removal on hydrogen catalyst performance is elucidated, primarily through enhancements in mass transport and reductions in overpotentials. Experimental findings underscore the effectiveness of chemical etching, as evidenced by scanning electron microscopy (SEM) micrographs revealing clean hexagonal cell boundaries following treatment with 10 wt% H3PO4 for 45 minutes.

This research emphasizes the pivotal role of barrier layer removal in optimizing AAO templates for hydrogen catalyst applications. The improvements in mass transport and overpotential reduction achieved through this process hold substantial promise for enhancing catalytic activity. As the field of sustainable hydrogen production continues to advance, AAO templates represent a compelling avenue for the design and optimization of efficient hydrogen evolution catalysts.

Keywords: AAO template, hydrogen catalyst, barrier layer removal, hydrogen evolution reaction, nanoscale fabrication.

REFERENCES

1. Zhang, J., et al. (2018). "Tunable Surface-Plasmon-Resonance-Enhanced Light Emission

from Anodized Aluminum Oxide Nanowire Array by Controlled Hole-Filling." ACS Applied Materials & Interfaces, 10(8), 7062-7071.

2. Li, J., et al. (2021). "Highly Ordered Porous Anodic Aluminum Oxide Membranes for Nanofluidic Applications." Small, 17(3), 2003457.

3. Yu, H., et al. (2022). "Anodized Aluminum Oxide (AAO) Membrane with Interconnected Macropores and Nanopores for Enhanced Water Treatment." Chemical Engineering Journal, 427, 131526.

THEORETICAL STUDY OF HYDROGEN PRODUCTION BY TRI-REFORMING OF METHANE

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Currently, about 96% of hydrogen is produced from fossil fuels, especially natural gases. Chemicals synthesized from fossils are usually produced through syngas, which is produced by steam reforming of methane. Other reforming reactions of hydrogen production from methane are dry reforming of methane with CO_2, dual reforming of methane in a mixture of CO_2 and H_2O, and tri-reforming of methane in a mixture of CO_2, H_2O and O_2 [1]. The main problems with steam reforming of methane to produce hydrogen are the formation of solid carbon (coke) and CO_2, since solid carbon causes catalyst deactivation and CO_2 is an undesirable reaction product. The problem of catalyst deactivation is also relevant for dry reforming of methane. The formation of solid carbon during dry reforming of methane can be avoided by tri-reforming reaction, that is, by adding oxidizing agents, namely H_2O and O_2, to a mixture of methane and CO_2. These combined reforming processes can generate hydrogen and syngas with different H_2/CO ratios through manipulation of the reactant composition. In addition, tri-reforming prevents the energy-intensive process of retaining CO_2 gas in the exhaust gas during combustion of fossil fuels. Despite intensive experimental and theoretical study of reforming reactions of methane, until now the mechanisms of deactivation and sintering of catalysts during methane conversion, have not been well understood.

The purpose of this work is a theoretical study of the reaction mechanism of tri-reforming of methane into hydrogen and syngas, and possibility of experimental implementation of the tri reforming reaction at high temperatures using a Solar Furnace. The kinetics of the reaction of tri reforming of methane into hydrogen and synthetic gas with addition of oxidants can be studied within the framework of electronic approaches of catalysis [2,3]. The electronic theory allows to analyze the reaction rate as a function of the Fermi level of the catalyst with respect to the antibonding states of intermediates and establish the optimal Fermi level of the catalyst and optimal temperature to maximize the reaction rate and avoid undesirable steps of coke formation.

REFERENCES

1.C. Song, W. Pan, Catal. Today 98, 463 (2004)
2.Wolkenstein, T. The electron theory of catalysis on semiconductors. Advances in Catalysis; Elsevier, 1960; pp 189−264.
3.Hammer, B.; Nørskov, J. K. Theoretical surface science and catalysis: calculations and concepts. Advances in catalysis; Elsevier, 2000; pp 71−129

GROWTH OF A NEW SUBSTITUTIONAL SOLID SOLUTION $(ZNSE)_{1-X-Y}(SI_2)_X(GAP)_Y$ ON GAP SUBSTRATES AND ITS LUMINESCENT PROPERTIES

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This paper presents the results of a study of liquid-phase epitaxy of the substitutional $(ZnSe)_{1-x-y}(Si_2)_x(GaP)_y$ solid solution (SS), as well as the luminescent properties of n-GaP – n+-$(ZnSe)_{1-x-y}(Si_2)_x(GaP)_y$ structures. SS had been grown on GaP (111) substrates from the limited volume of Sn solution-melt (Sn+Si+GaP+ZnSe) in a hydrogen atmosphere. The thickness of the solution was 1 mm, the cooling rate of 1 degree/minute and the crystallization onset temperature of 880 °C, the grown films had been a perfect single-crystal structure with a (111) orientation, as well as n-type conductivity. The entire surface of the substrate was covered with an epitaxial film with tight adhesion and a thickness of 30 μm; the surface of the film was smooth.

The results of X-ray diffraction microanalysis of the surface and of the cleavage showed that in the transition region located between the substrate and the epitaxial film, there is the thin transition buffer layer enriched with Si, with the molar concentration of up to 99 at. %, and in the epitaxial layer the distribution of the components ZnSe, Si and GaP is more or less uniform in depth. On the film surface, the molar content of Ga was 3.7 at.%, P – 5.3 at.%, Se – 42.2 at.%, Zn – 45.8 at.% and Si 3.0 at.%, which corresponds to the formation of substitutional solution $(ZnSe)_{0.88}(Si_2)_{0.03}(GaP)_{0.09}$.

The surface relief of SS film was studied using a scanning atomic force microscope (AFM). Analysis of the AFM results showed that wells with a height of ~2.5 and a width of ~25–46 nm are formed in the near-surface region of the film. The basic component in the near-surface region of the $(ZnSe)_{0.88}(Si_2)_{0.03}(GaP)_{0.09}$ SS is wide-gap ZnSe. Apparently, such nano-sized wells are formed by Si and GaP phases, the band gap of which is smaller than that of ZnSe. Such wells form quantum wells that create a local electrostatic field with a strength of 10^7-10^9 V/cm at a distance of up to 150 nm.

A study of the electroluminescence of the isotope heterojunction n-GaP–n^+-$(ZnSe)_{1-x-y}(Si_2)_x(GaP)_y$ ($0 \le x \le 0.03$, $0 \le y \le 0.09$) showed that when a reverse bias is applied to the structure, starting from V = 8.5 V, a red glow is visually observed. However, with increasing voltage, the spectral composition of the glow changes, and yellow radiation appears against the background of red light. At voltages V > 11.5 V, yellow light predominated. We have previously shown that in the photoluminescence spectrum of the solid solution under study at 5

K, against the background of a wide spectrum, clearly pronounced emission peaks are observed at photon energies of 1.67 and 2.21 eV [1], caused by the energy levels of the atoms of the Si_2 and GaP molecules, respectively, located in the forbidden zone of the SS. The observed red and yellow glow of the structure is apparently due to electronic transitions involving the energy levels of the atoms of Si_2 and GaP molecules.

Thus, single-crystalline substitutional SS $(ZnSe)_{1-x-y}(Si_2)_x(GaP)_y$ ($0 \leq x \leq 0.03$, $0 \leq y \leq 0.09$) were grown on GaP (111) substrates by liquid-phase epitaxy from a tin solution-melt, with attractive photovoltaic properties. Such SS can be used to develop photodiode structures with integral light without a phosphor, as well as for structures with a radiation wavelength controlled by an external electric field in the visible region of the radiation spectrum.

REFERENCES

1.Saidov AS, Usmonov Sn. N., Rakhmonov U. Kh, Kurmantayev AN & Bahtybayev AN Multicomponent Solid Solutions $(ZnSe)_{1-x-y}(Si_2)_x(GaP)_y$. Journal of Materials Science Research 2012. Vol. 1, No. 2. pp. 150-156. doi:10.5539/jmsr.v1n2p150

MAGNETIC PROPERTIES OF FERRITE $Ni_{1-x}[Ca_3(PO_4)_2]_xFe_2O_4$

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The creation of new materials based on calcium phosphate ($Ca_3(PO_4)_2$) has undergone major changes in recent decades due to technological progress and the development of computational methods [1-2].

In the present work, NiCa of different chemical compositions $Ni_{1-x}[Ca_3(PO_4)_2]_x Fe_2O_4$ with x=0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 are prepared for ferrite synthesis in a solar furnace. The aim of this study is to confirm that different compositions can affect the magnetic properties so that information on the best composition can be obtained for the fabrication of NiCa ferrite magnets by solar technology methods [3].

Solar technologies, in contrast to traditional technologies, are characterized by high heating rate, allow to obtain fine homogeneous material of high chemical purity. At the same time, in ferrite materials the ferritization process takes place simultaneously. In this work we have studied samples of ferrite synthesized from the melt on the solar furnace of stoichiometric mixture of NiCaFe of different chemical composition. The stoichiometric amounts of raw materials, calculated in mole percentages, were first mixed and wet milled in a ball mill with corundum balls for 8 hours. Based on the finished mixture, specimen rods of 5 mm diameter and 140 mm length were molded (50kN) and placed on the focal plane of a solar furnace and melted under concentrated solar radiation. Castings were cooled in the first case by pouring into water, at which the cooling rate was of the order of 1000 deg/sec. The material retains its properties with rapid cooling of the molten sample. Then, the material is pulverized to a size of 45 microns. One

part of the components is mixed with PVA, in the MS100 machine at a pressure of 50 kN, a tablet shape with a diameter of 20 mm is obtained. Finally, the samples were sintered at a temperature of 1150-1350 °C for 3 hours [4].

The chemical composition of $Ni_{1-x}[Ca_3(PO_4)_2]_xFe_2O_4$ ferrite was investigated by varying the composition with x=0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7. It is found that the composition, has a strong influence on the magnitude of magnetic properties Ms, Mr, R and Hc Maximum magnetic properties were obtained at x=0.3, Ms=39.4652 erg/g, Mr=31.1568 erg/g, R=0.79 and Hc=0.3040 kA/m. The dependence of saturation magnetization and residual magnetization increases at x=0.1, 0.2 and 0.3 and then decreases at x=0.4, 0.5 and 0.6.

REFERENCES

[1] J.G. Lee, H.M. Lee, C.S. Kim, Y.J. Oh, J. Magn. Magn. Mater. 177 (1998) 900.

[2] M. Rajedran, R.C. Pullar, et al., J. Magn. Magn. Mater. 232 (2001) 71–83.)

[3] M.S. Paizullakhanov, Zh Z Shermatov, EZ Nodirmatov, OT Rajamatov, FN Ernazarov, MT Sulaimanov, Sh Nurmatov, Nikolai N Cherenda, Synthesis of materials by concentrated solar radiation, Journal of High Temperature Material Processes: An International Quarterly of High-Technology Plasma Processes, 2021, 25(2).

[4] IG Atabaev, Sh A Faiziev, M Paizullakhanov, Zh Z Shermatov, O Razhamatov, High-strength glass-ceramic materials synthesized in a large solar furnace, Journal of Applied Solar Energy, 2015.07, 51, 202-205.

INTERACTION OF INTENSE IONIZING RADIATION OF A WIDE ENERGY SPECTRUM WITH HIERARCHICAL STRUCTURES

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The concept of “complexity” is considered in relation to radiation processes in condensed matter. It has been shown that the combination of properties such as nanosize, fractality, small dimension, chirality and hierarchy, combined with high nonequilibrium created by high-intensity and energy-broadband radiation, creates conditions for the manifestation of unusual, “emergent” radiation effects such as radiation synergetics, large dose reduction threshold radiation effects, etc. The presented examples of radiation effects in living and non-living systems (Metals, dielectrics, semiconductors, superionics and fracton structures containing simultaneously 1D, 2D and 3D elements) are interpreted within the framework of the concept of “complexity”.

The main provisions of the concept of complexity that we have developed and the examples given (as well as many others) allow us to outline the main conditions for the

implementation of three paradigms (self-organization, dynamic chaos and self-organized criticality). Note that in the case of a combination of characteristic structural properties, new effects manifest themselves more strongly, i.e. Reducing the size to nano sharply enhances the manifestation of new properties. It is extremely important that the combination of radiation properties: high intensity and wide energy spectrum makes the implementation of radiation effects noticeable even within elementary cells. It is precisely this kind of radiation situation that is naturally realized under irradiation conditions in the Large Solar Oven and synchrotron. It is significant that over many years of using BSP, such new properties of the material have been revealed many times.

We believe that emergent properties can be most correctly and more fully studied on the basis of new theoretical approaches, one of which is radiation complexity. More detailed information on the most important provisions of these theses can be found in the literature sources below [1 – 4].

REFERENCES

1.Oksengendler B.L., Turaeva N.N., Maksimov S.E. et all. // Horizons in World Physics. N.Y.: Nova Science Publishers. V. 298. 2019. P. 1.

2.B. L. Oksengendler, S. E. Maksimov, N. N. Turaeva,and F. G. Djurabekova, Nucl. Instrum. Methods Phys. Res., Sect. B **326**, 45 (2014).

3.Oksengendler B.L., Turaeva N.N., Maksimov S.E. // J. Experim. Theor. Phys. 2010. V. 111. No 3. P. 415. https://doi.org/10.1134/S1063776110090104

4. Oksengendler B.L., Turaeva N.N., Karpova O. et all. // Perovskite Solar Cells: Properties, Application and Efficiency. Chapter 2. NY: Nova Science Publishers, 2019. P. 77.

ROOM TEMPERATURE FACILE SYNTHESES OF LEAD CsPbBr3 PEROVSKITES

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Recently, all-inorganic perovskite materials have attracted much attention for their high carrier mobility, high radiation recombination efficiency, high color purity, and tunable bandgap, which are considered promising materials for next-generation light-emitting devices (LED) [1].

In 2009, perovskite solar cells were reported for the first time demonstrating that perovskite semiconductor has potential applications in optoelectronic devices. Now power conversion efficiency of the perovskite solar cell has increased to 25.2% in the last years [2].

For $CsPbX_3$ (X = Cl, Br, I) QDs, the most commonly used methods are the hot-injection method, room temperature antisolvent method, and ion exchange methods. The hot injection method allows to synthesize high-performance perovskite nanomaterials. The original concept of ligand assisted reprecipitation (LARP) was proposed by Schmide et al. [3]. Taking Yang et al.'s used a different approach and by dissolving CsBr in deionized water and $PbBr_2$ in DMF.

$CsPbBr_3$ The synthesis of quantum dots of perovskite materials was carried out as follows:

CsBr and $PbBr_2$ salts were measured in the appropriate mass in the mol ratio of 1:1. Dimethylsulfoxide (DMSO) was used as a solvent. 0.1M solutions of CsBr and $PbBr_2$ in DMSO were stirred on a magnetic stirrer at room temperature for 12 h. Then these precursors were mixed in 1 ml in one container. As ligands, 0.1 ml of oleinamine (OAm) and 0.2 ml of oleic acid (OA) were added to the CsBr + $PbBr_2$ solution. During the synthesis, the salts were completely dissolved in the solvents and no precipitation was observed. 0.1 ml of the obtained perovskite ($CsPbBr_3$) solution was taken and mixed with 6 ml of toluene solution in a magnetic stirrer. As a result, a bright green (0.000416M) $CsPbBr_3$ perovskite quantum dot was formed. This experiment was carried out utilizing the LARP method.

The spectra of the solutions of bright perovskite ($CsPbBr_3$) quantum dots were measured using a spectrophotometer (UV-2600i, Shimadzu, Japan) and a spectrofluorimeter (RF-6000, Shimadzu, Japan).

It can be seen that the absorption maximum of the synthesized $CsPbBr_3$ perovskite is equal around 518 nm. That is, it was determined by spectrum analysis that this quantum dot shows a spectrum in the green area.

Adding octylammonium bromide ($C_8H_{20}BrN$) as a ligand in addition to oleic acid and oleic amine in the synthesis of $MAPbBr_3$ perovskite, using toluene and chloroform as an antisolvent allows us to determine the spectrum of the solution of this perovskite quantum dot in the bright blue region.

Synthesis of bright green $CsPbBr_3$ perovskite quantum dots was carried out at room temperature. The obtained perovskite compounds were spectrally analyzed and the formation of bright green dots was observed in these compounds.

REFERENCES

1.Xu, J., Zhang, H., Wu, C., and Dai, J. (2020a). Stable $CsPbX_3@SiO_2$ Perovskite Quantum Dots for White-Light Emitting Diodes. J. Nanoelectron. Optoelectron.15 (5), 599–606. doi:10.1166/jno.2020.2824

2.Roy, P., Kumar Sinha, N., Tiwari, S., and Khare, A. (2020). A Review on Perovskite Solar Cells: Evolution of Architecture, Fabrication Techniques,Commercialization Issues and Status. Solar Energy 198, 665–688. doi:10.1016/j.solener.2020.01.080

3.L.C. Schmidt, A. Pertegas, S. Gonzalez-Carrero, O.Malinkiewicz, S. Agouram et al., Nontemplate synthesis of $CH_3NH_3PbBr_3$ perovskite nanoparticles. J. Am. Chem. Soc.**136**, 850–853 (2014). https:// doi. org/ 10. 1021/ ja410 9209

PHOTOVOLTAIC CHARACTERISTICS OF THIN-FILM SOLAR CELLS BASED ON $SB_2(S_X,SE_{1-X})_3$ SOLID SOLUTION FILMS

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Researchers are currently focusing on the utilization of chalcogenide binary compounds such as Sb_2Se_3, Sb_2S_3, and their solid solutions $Sb_2(S_x,Se_{1-x})_3$ (with the chemical formula Sb_2X_3) as absorbing layers for solar cells [1,2]. These materials possess physical properties such as p-type conductivity, band gap (Eg = 1.1 (1.8 eV)), high absorption coefficient (> 105 cm^{-1} in the visible region), low melting points (Sb_2Se_3-612°C, Sb_2S_3-550°C), and high partial vapor pressure that closely resemble those of $Cu(In,Ga)(Se,S)_2$ [3]. Moreover, the constituent elements of these materials are abundantly available in nature, cost-effective, and exhibit stability under external conditions, along with low toxicity. This enables the production of environmentally friendly and efficient solar modules, paving the way for their widespread industrial-scale manufacturing.

Solar cells based on $Sb_2(S_x,Se_{1-x})_3$ solid solution films were formed on glass substrates coated with a molybdenum layer.

Dark and light current-voltage characteristics of solar cells based on $Sb_2(S_x,Se_{1-x})_3$ solid solution films were measured using a solar simulator UHE-NL-250 and the values of photovoltaic parameters were calculated: short-circuit current density, open-circuit voltage, filling factor light current-voltage characteristic (FF) and efficiency (η).

Analysis of experimental data on thin-film solar cells has shown that the composition of the base layer of solar cells significantly affects their photovoltaic characteristics. In this case, the enrichment of the base layer of solar cells with selenium leads to an improvement in the spectral characteristics, and the enrichment with sulfur leads to a deterioration in the spectral characteristics.

The results of the light current-voltage characteristics and spectral characteristics of solar cells of various compositions of the base layer $Sb_2(S_x,Se_{1-x})_3$ showed that solar cells with the composition S/(S+Se=0.6) achieved the highest efficiency. Photoelectric parameters have the following values: U_{XX}=523 mV; I_{SC} =27.2 mA/cm^2; FF= 46.7% and η=6.47%.

The quantum efficiency of $Sb_2(S_x,Se_{1-x})_3$ cells was also measured with six different x values (0; 0.6; 0.7; 0.8; 0.9 and 1) by monitoring the S/(S+Se) element ratios in the vapor phase during the growth process. To improve accuracy, all samples were measured simultaneously throughout the day, controlling the light spot area to be smaller than that of the elements themselves. Similar to the JV curves, $Sb_2(S_x,Se_{1-x})_3$ (x=0.6) exhibits higher quantum efficiency with a peak value approaching 90% in the range of 450 nm÷650 nm. Lower FE values at shorter wavelengths are caused by parasitic absorption in the buffer layer

REFERENCES

1.Xiaomin Wang, Rongfeng Tang, Chunyan Wu, Development of antimony sulfide–selenide $Sb_2(S, Se)_3$ -based solar cells. Journal of Energy Chemistry 27 (2018) 713–721.

2.M.M. Nicolás-Marín, J.R. González-Castillo, O. Vigil-Galán, Maykel Coure, The state of the art of $Sb_2(S,Se)_3$ thin film solar cells: current progress and future prospect. Journal of Physics D: Applied Physics 55 (2022) 303001.

3.Abdurashid Mavlonov, Takhir Razykov, Fazal Raziq, et al., A review of Sb_2Se_3 photovoltaic absorber materials and thin-film solar cells. Solar Energy Volume 201, 1 May 2020, Pages 227-246.

PREPARATION OF NANOCOMPOSITE FILMS FROM HYBRID CdSe/CdS QUANTUM DOTS

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The growing interest in quantum dots is due to the fact that they are superior to traditional phosphors in terms of photostability, have a narrow and intense size-dependent luminescence, and absorb light in a wide region [1]. Quantum dots are attractive for use as light emitting devices, solar cells, and luminescent labels [2,3].

For practical applications, quantum dots are often embedded in polymer matrices, thus creating nanocomposite materials. In this case, not only the properties of polymers and quantum dots are combined, but also in composites, the polymer is able to additionally increase the luminescence efficiency of nanoparticles and protect them when interacting with the environment [4].

The emission and excitation spectra were recorded on a Cary Eclipse (Varian) spectrofluorimeter. The study of the optical properties of mixtures of QDs (constant concentration) and PVCL in toluene showed that an increase in PVCL concentration (radiation maximum at 370 nm) leads to a decrease in the QD radiation intensity (maximum at 520 nm) (Fig. 1a). It can be seen from the excitation spectra (Fig. 1b) that the greatest quenching of luminescence is observed at wavelengths corresponding to the absorption maxima of the polymer – 297, 333, and 345 nm.

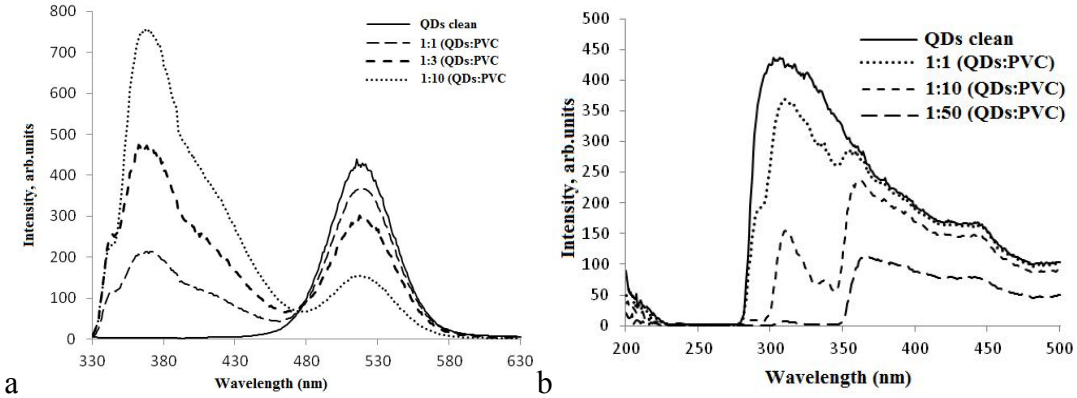


Fig. 1. Emission spectra λ_{ex} = 311 nm (a) and excitation λ_{radi} = 520 nm (b) of a mixture of quantum dots (QDs) and poly(N-vinylcarbazole) (PVC) in toluene

In composite films, polymer molecules and nanoparticles are located close to each other, as a result of which nonradiative energy transfer from the polymer to quantum dots and an increase in their luminescence intensity become possible.

REFERENCES

1. Chaudhuri R.G., Paria S. Core/shell nanoparticles: classes, properties, synthesis mechanisms, characterization, and applications [Text] //Chem. Rev. – 2012. – T. 112. – N. 4. – C. 2373-433.

2. Vashchenko A.A. et al. Electroluminescence of CdSe/CdS quantum dots and the transfer of the exciton excitation energy in an organic light-emitting diode //JETP letters. – 2012. – T. 96. – C. 113-117.

3. Striccoli M. Nanocrystal-Based Polymer Composites as Novel Functional Materials [Text]/M. Striccoli M.L.Curri, R.Comparelli // Lecture Notes in Nanoscale Sci. and Tech. – 2009. – V. 5. – P. 173-192.

4. Ishankulov A.F. Khalilov K.F., Shamilov R.R., Galyametdinov Y.G., Mukhamadiev N.K.. Size-optical characteristics of CdSe/ZnS quantum dots modified by thiol stabilizers //Journal of Sol-Gel Science and Technology. – 2023. – C. 1-6.

SOLAR TECHNOLOGIES DEVELOPED AT THE LARGE SOLAR FURNACE IN PARKENT

E.B.Eshonkulov, S.H.Bobokulov, D.Erkinov, K-Z.Gulamova

The vital requirement for energy saving determines the need to search for opportunities to use renewable energy sources: water, wind, sun. The development of solar energy is one of the priorities of the Republic of Uzbekistan. The use of the Large Solar Furnace for the production and research of new materials combines the solution of two pressing problems. The first is energy saving in the field of high-temperature technologies. The second is obtaining new materials. The basis for the development of solar technologies is the analysis of fundamental data on the nature of the formation of the target compound - congruent melting, eutectic or peritectic reaction, etc. The nature of the formation of the target compound determines the fundamentals of the technological process. In the case of congruent melting, the technology provides for the melting of the initial components at a given cooling (hardening) rate of the melt, which makes it possible to control the dimensional parameters of the crystallites. To obtain a eutectic material, melting is carried out while simultaneously removing the melt from the heating zone, which promotes the directional crystallization of crystallites of the phases forming the eutectic. The cooling mode of the melt determines the mutual orientation of the crystallites and allows, during sharp quenching of the melt, to stabilize the amorphous phase. The implementation of peritectic interaction between the crystalline and amorphous phases requires long-term exposure while maintaining a flat crystallization front. The developed solar technologies have made it possible to obtain isostructural, isostoichiometric series of materials based on ZrO_2, HfO_2, Al_2O_3, TiO_2-R_2O_3 (R=La-Lu,Y,Sc), BSCCO. The obtained materials are presented in Fig. 1a, b. The study of the properties of materials synthesized by solar technologies has made it possible to create ceramics and thin films for special metallurgy, gyroscopes, superconducting sensors for medicine and solar batteries, etc.



a) Al_2TiO_5 b) ZrO_2-MgO

Figure 1. Alumina titanate (Tialit) (a); ZrO_2 stabilized (b)

SYNTHESIS, PROPERTIES AND APPLICATION FUNCTIONAL POLYMERS

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Functional polymers provide innovative ideas, concepts, and achievements in the science and technology of polymers with functional groups that impart unique chemical reactivity or physical, chemical, structural, biological, and pharmacological functionality [1]. Functional polymers are gaining popularity in both academia and industry. They are macromolecules with unique features and applications. A functional polymer contains functional groups that can permit further reaction and provide unique properties. The ability of functional polymers to form self-assemblies or supramolecular structures is a further incentive. Within the past few decades, functional polymer materials have appeared as one of the most expanding areas in polymer chemistry, owing to the extensive adoption of living and controlled polymerization strategies. Functional polymers are applied in many fields, such as drug-delivery, tissue engineering, medical devices, food packaging, sensors, actuators, optoelectronics, organic light emitting diodes, thin film transistors, batteries, waste water treatment, antifouling, etc [2].

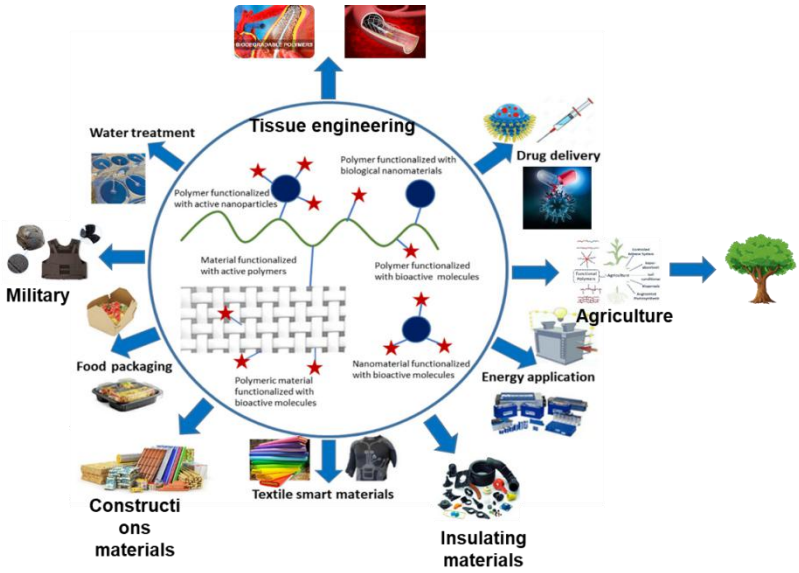


Fig. 1. Application functional polymers

Each application requires customized properties in the polymer, including their chemical compositions, structure, particle size, and morphology.

The advent of modern macromolecular synthesis tools, such as living radical polymerizations, various "click" chemistry strategies, coupling reactions, hydrothermal, solvothermal, and sonochemical synthesis, were simultaneously employed for the synthesis of various functional polymers for various applications. Recently, the utility of functional polymers based on nanomaterials has been quite diverse, involving many potential applications, and has been proposed for their use in various applications.

REFERENCES

[1] Anamika Ghosh, Veeturi Srinivas, Ramaprabhu Sundara. Comprehensive structural and magnetic properties of iron oxide nanoparticles synthesized through chemical routes. Journal of Alloys and Compounds. 818, 2020, 152931. https://doi.org/10.1016/j.jallcom.2019.152931

[2] Jesús Roberto, Vargas-Ortiz, Carmen Gonzalez, Karen Esquivel. Magnetic Iron Nanoparticles: Synthesis, Surface Enhancements, and Biological Challenges. Processes 2022, 10 (11), 2282; https://doi.org/10.3390/pr10112282

SOL-GEL SYNTHESIS AND TEXTURAL PROPERTIES OF $Li_{1.33}Mg_XMn_{(1.67-X)}O_4$ ($0 \leq X < 0.8$) OXIDES

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Samarkand State University named after Sharof Rashidov

Today, the demand for lithium in the world market is growing rapidly, and the natural mineral lithium resources are decreasing significantly. However, the cost per unit of energy is still much higher than conventional systems with batteries. Cost reduction can be achieved by

replacing the expensive cathode material with cheaper materials. For this, it is preferable to use Li-Mn-O oxide compounds with a spinel structure.

The sol-gel method is a convenient method for the synthesis of $Li_{1.33}Mn_{1.67}O_4$ spinels. It is important to control optimal conditions for sol-gel synthesis: Li/Mn ratio, pH, concentration of metal salts, precursors, transition processes of hydrogel, etc. [1].

However, a significant reduction of manganese was found in acid extraction of lithium during the adsorption process [2]. A very effective way to increase stability is to synthesize the spinel phase $Li_{1.33}Mg_xMn_{(1.67-x)}O_4$ replaced by manganese by modifying it with divalent or trivalent ions (M = Mg, Co, Ni, Fe, Ti, Zn, Cr, etc.) [3].

The purpose of this work is to synthesize $Li_{1.33}Mg_xMn_{(1.67-x)}O_4$ ($0 \le x < 0.8$) spinels using the sol-gel method and study the effect of modification with Mg^{2+} ions on their textural properties.

For the synthesis, aqueous solutions of $LiNO_3$, $Mn(NO_3)_2$ and $Mg(NO_3)_2$ were used as precursors, which were mixed in a certain ratio to obtain oxides containing $Li_{1.33}Mg_xMn_{(1.67-x)}O_4$ ($0 \le x < 0.8$). Then a weighed portion of citric acid was added in the amount of 2 mol per 0.05 mol (Mn^{2+}+Mg^{2+}).

The resulting solution was evaporated at 80 °C until a thick gel was formed, and then dried at 100 °C for 8 h. The resulting powder was then calcined in air at 800 °C in a laboratory furnace.

The adsorption and textural properties of adsorbents were studied using the nitrogen adsorption-desorption method in the ASAP 2020 porosity and surface analyzer.

Nitrogen adsorption-desorption isotherms of all samples have capillary-condensation hysteresis loops and belong to type IV according to the IUPAC classification, exhibiting characteristics characteristic of mesoporous bodies. The isotherms of the studied oxides are complicated by a hysteresis loop of the H3 type, which indicates the presence of cracks.

The introduction of Mg^{2+} ions at $x \ge 0.4$ does not change the pore diameter values. The largest pore volume (0.073 cm3/g) and average pore size (21.2 nm) are characteristic of the sample at x = 0.8, in which $Li_{0.5}Mg_{0.5}O_{1.5}$ and $Mn_{1.5}Mg_{0.5}O_{2.5}$ oxides there are mixtures. At the same time, in the range $0.1 \le x \le 0.4$, there is a 1.7-2.1 times increase in the specific surface area and 1.8 times in the pore volume. An increase in the content of Mg^{2+} ions by x = 0.8 leads to a significant increase in the average pore size up to 21.2 nm.

Kinetic experiments showed that the adsorption process followed the pseudo-second-order model, and nitrogen adsorption of Li^+ can be observed by the intraparticle diffusion model.

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REFERENCES

1.Liyan Tian, Wei Ma∗, Mei Han. Adsorption behavior of Li^+ onto nano-lithium ion sieve from hybrid magnesium/lithium manganese oxide. Chemical Yengineering Journal 156 (2010) 134–140..

2.G.M. Song, Z.M. Xu, Y.J. Wang, Y. Zhou, Synthesis and electrochemical character-ization of LiMn2−xAlxO4 powders prepared by mechanical alloying and rotary heating, Electrochem. Commun. 5 (2003) 907–912.

3.S.T. Myung, S. Komaba, N. Kumagai, Enhanced structural stability and cyclability of Al-doped,

J. Electrochem. Soc. 148 (2001) A482–A489.

ENHANCING THE ELECTRONIC STRUCTURE OF CU-DOPED TIO_2 BASED ON DFT CALCULATIONS

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Titanium dioxide (TiO2) is a prominent semiconductor material with versatile applications in various fields. To optimize its performance for specific applications, such as photocatalysis and photovoltaics, precise control over its electronic band structure is essential. In this work, we investigate the enhancement of the electronic band structure of TiO2 through doping with a Copper (Cu) atom using density functional theory (DFT). The methodology involves several key steps. Firstly, we perform geometry optimization runs to obtain the relaxed atomic structures of pure TiO2 and Cu-doped TiO2 systems. The generalized gradient approximation with the Perdew-Burke-Ernzerhof (GGA+PBE) functional is employed for these calculations. The convergence tests ensure the accuracy of the results, with an energy cutoff parameter of 450 eV chosen for sufficient convergence. The Brillouin zone is sampled using a 9x9x14 k-point mesh, considering the tetragonal symmetry of the system.

Subsequently, we calculate the electronic band structure and density of states (DOS) for both the pure and doped systems. The Hubbard potential, implemented as the LDA+U method with a parameter of 8.0 eV for the d-states of the Ti atom, is utilized to accurately describe the electronic interactions within the material. Notably, the spin-polarization case is excluded from our study.

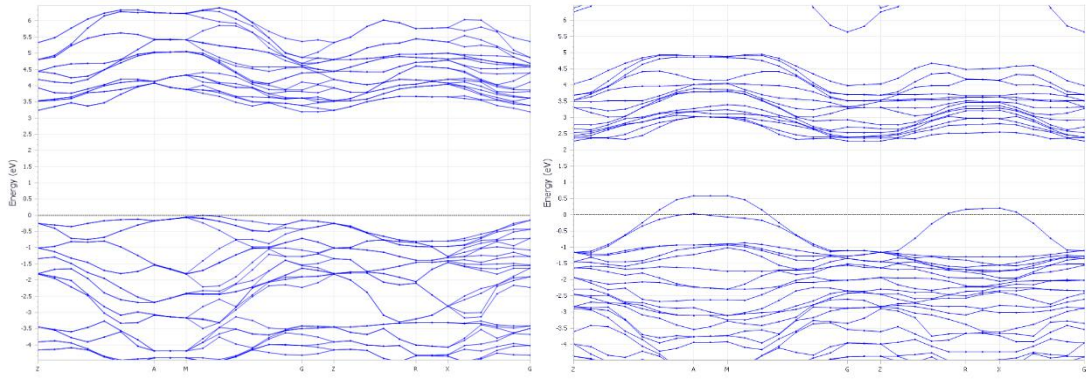


Fig 1. Band structure of pure TiO2 and Cu-doped TiO2

The results reveal significant modifications in the electronic properties of TiO2 upon Cu doping. Specifically, the band gap of pure TiO2 is determined to be 3.183 eV, while the introduction of Cu dopants leads to a reduction in the band gap to 2.81 eV. Additionally, the analysis of the density of states highlights the contribution of the dopant's d-states to the upper edge of the valence band, further elucidating the impact of Cu doping on the electronic structure of TiO2.

REFERENCES

1.Anisimov, Vladimir I., et al. "First-principles calculations of the electronic structure and spectra of strongly correlated systems: the LDA+ U method." Journal of Physics: Condensed Matter 9.4 (1997): 767.

2.Vanderbilt, David. "Soft self-consistent pseudopotentials in a generalized eigenvalue formalism." Physical Review B 41.11 (1990): 7892.

3.He, Rong, et al. "Electronic structure of the intrinsic and extrinsic defects in anatase TiO2." Physical Review B 69.17 (2004): 174418.



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