Book of Abstracts

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October 17-23, 2021

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INVITED SPEAKERS

Id-07

Bioelectrochemical Processes for Wastewater Treatment

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Abstract: The treatment of urban and industrial wastewater is usually based on biological processes taking place in living cells The practical application of these redox processes is usually associated with two applications: electricity generation in microbial fuel cells or process enhancement in microbial electrolysis cells. The microbial fuel cell approach has additional advantages because of the direct removal of various pollutants and the avoidance of addition of chemical agents with the associated waste products as it is at the traditional chemical methods. Another option for the bioelectrochemical applications for wastewater treatment is the approach of microbial electrolysis cells. The application of electric field for microbial wastewater treatment might result in different aspects: either in purely electrochemical processes on the electrodes or in different types of bioelectrochemical stimulation of enzyme activity in the living cells. It the present work some practical applications and experimental examples of such bioelectrochemical redox processes stimulated by constant electric field are demonstrated. Those are microbial denitrification, xenobiotic biodegradation as well as removal of chemical oxygen demand for wastewater from pulp and paper processing.

Keywords: Wastewater Treatment, Xenobiotics, Bioelectrochemistry.

INVITED SPEAKERS

Id-17

Giant Transport Anisotropy in a Cubic Thermoelectric Material

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Abstract: A central topic in the development of modern nano- and microtechnology is the recovery of energy via the engineering of heat and charge transport. Type-I clathrates are cubic thermoelectric materials in which guest atoms are weakly bound in a cage-forming network of six tetrakaidecahedra and two dodecahedra per unit cell. The rattling motion of the guest atoms in the cages is responsible for their extremely low lattice thermal conductivity, and the feature is advantageous for a larger thermoelectric figure of merit. This talk will focus on the $Ba_8Au_{6-x}Ge_{40+x}$, a particularly interesting system where the rattling modes of Ba extend to extremely low energy, a situation where the rattling mode-acoustic phonon mode interaction has most drastic effects. Our recent studies have revealed the presence of a giant trasnport anisotropy in high-quality single crystals, in spite of the material‘s cubic crystal structure. This unexpected phenomenon implicates the profound nature of phonon-electron interaction, and also aids the exploration of still-to-be-discovered energy-related materials.

Keywords: Giant transport anisotropy in a cubic thermoelectric material.

INVITED SPEAKERS

Id-18

Enhanced Oil Recovery Methods for Shale Oil extraction from Bazhenov Formation

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Abstract: The Bazhenov Shale formation is a part of the West Siberian Basin; it covers an area of more than a million square kilometers at a depth of 2500–3000 m and has an average thickness of 30–50 m. The Bazhenov deposits are organic rich siliceous oil-prone rocks that possess significant hydrocarbon reserves, most of them are currently classified as shale oil. The Bazhenov formation contains mobile oil in the pore space, which can be extracted by traditional methods of development, hydrocarbons in closed pores, hydraulic fracturing technologies are directed to their extraction, hydrocarbons sorbed by the rock, as well as kerogen, that has a pyrolytic potential for generating synthetic hydrocarbons. The last two types of hydrocarbon deposits are a distinctive feature of the Bazhenov formation and account for ~80% of all resources; therefore, the profitability of oil production directly depends on their involvement in development. Leading Russian oil companies challenge to make oil recovery from Bazhenov formation technologically and economically successful. To create additional permeability and a higher flow rates, multi-stage hydraulic fracturing is usually performed. Even after fracturing oil recovery tends to decrease rapidly due to low stimulated with hydro fracking core volume and extra low permeability of Bazhenov deposits. The next challenge is to involve sorbed and kerogen hydrocarbon resources in development. The enhanced oil recovery (EOR) methods can be applied for this purpose. «Gazpromneft Technological Partnership» Oil Company realizes the project of several EOR methods application of shale oil extraction at pilot oilfield of Bazhenov formation. The project contains the screening and choice of the most perspective technologies, laboratory experiments with the cores and fluids from pilot oilfield, modelling of oil extraction, design and engineering of the pilot site, injection tests, efficiency determination and then pilot field tests. The current stage of the project presents the laboratory researches. Three potentially effective technologies for low-permeable reservoirs are under consideration: hydrocarbon gas injection, surfactant solvent injection and thermal EOR. Injection of associated petroleum gas in the mode of miscible displacement is applicable to recover light oil; injection

of the surfactants water solutions proved its efficiency to separate sorbed hydrocarbons from the rock and change core wettability; heating technologies can be applied to convert solid kerogen into liquid and gaseous hydrocarbons. For the gas EOR application, we explore gas composition, miscible and immiscible displacement modes, displacement stability and economics. For the surfactants, we examine various surfactants and their compositions for thermal and mechanical stability, wettability changes, adsorption, interfacial tension and phase behavior. The thermal EOR method focuses on the hydrothermal effects and hot water influence on kerogen-containing core samples: liquid and gaseous hydrocarbons extraction from kerogen, porosity and permeability increase, optimal temperature and pressure for hydrothermal stimulation. We also determine the effectiveness of each method for specific oilfield conditions and identify which hydrocarbon resources each method is aimed at extracting.

Keywords: Shale oil, Enhanced oil recovery, Unconventional resources, Miscible gas, Surfactant, Hydrothermal extraction.

INVITED SPEAKERS

Id-26

Next Generation Techniques for Ecofriendly-High Efficiency Recovery of Heavy Oil/Bitumen

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Abstract: Heavy oil and bitumen, characterized by their higher viscosity and density than that of conventional crudes, constitutes more than 70% of the remaining oil reserves around the world with potential for growth in production. In line with this development, GHG emissions associated with the energy-intensive steam-assisted production are expected to increase rapidly. Steam-assisted applications for heavy oil recovery are most commonly applied in the fields to enhance the mobility of heavy oil in the reservoirs. Currently, based on the GHG emissions intensity of nearly 70 kg for every barrel of oil produced via steam injection in Canada (Alberta in particular), the daily amount of GHG emissions averages around 100,000 tons. Therefore, there is an urgent need to research and evaluate alternate techniques to mitigate the environmental footprint of thermal operations. This paper discusses the approaches and methods to minimize steam applications by exploring the next generation in-situ techniques for eco-friendly, optimized heavy oil recovery. New generation in-situ techniques for heavy oil recovery including water (cold production) or steam-based applications with additives such as nano-based smart materials, surface active agents (IFT and wettability changers such as surfactants, alkalis, amines, alcohols, ethers etc.) along with solvent and electromagnetic heating are outlined. Flow and phase behavior of reservoir fluids during the aforementioned in-situ recovery processes at microscale and bench-scale is investigated and theoretical models of enhanced in-situ bitumen recovery technique are presented accordingly using laboratory and field-scale numerical simulation methods. A reduction of 20% to 70% energy or natural gas consumption can be expected using the new generation in-situ techniques (such as “intelligent” nanoparticle based-solvent assisted SAGD). In addition, in the case of Alberta, Canada, the GHG emission has the potential to be annually reduced from 6.7 Mt to 23.5 Mt based on the ongoing bitumen production. The main objective of this research is to decrease GHG emissions and water and natural gas consumption while sustaining a stable (and efficient) recovery of oil, at least, at a comparable level of the currently available conventional in-situ heavy-oil and bitumen recovery technique.

Keywords: Heavy-oil and bitumen, GHG emission, Solvent and chemical injection, Electromagnetic heating.

INVITED SPEAKERS

Id-27

Improving Thermoelectricity of Heusler Compounds: Stucture – Property Relations

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Abstract: Ternary compounds of the form XYZ and X_2YZ form extended families of materials, with a large variety of physical ground states, and as a result, with numerous prospects for technical applications. Here, X and Y are transition metal elements and Z is a main group element. While XYZ systems are called half-Heusler compounds, a full-Heusler compound corresponds to X_2YZ. Both of these families crystallise in a cubic structure with the prototypic LiAlSi-structure ($C1_b$-type) for the former and the Cu_2MnAl-strucutre ($L2_1$-type) for the latter. Heusler systems, however, are prone to a number of anti-site occupations, giving rise to specific modifications of the distinct crystal structure; as a result, the respective electronic structure and the electronic density of states becomes modified as well. Consequently, physical properties changes; an initially non-magnetic material can become magnetic and a simple metal can suffer a metal-to- insulator transition. Such instabilities give rise to an easy tuneability of Heusler-based materials towards desired properties and appropriate applicability. Appropriate tools in this context are substitutions or doping on each lattice site, or specific heat treatments. Preparing such materials as thin films is another path, triggering fundamental changes of the physical behaviour. The present talk aims to focus on these structure – property relations of Heusler compounds by selecting the field of thermoelectricity, which almost ideally combines basic and applied sciences like physics, chemistry or material related subjects. Experimentally observed physical properties will be analysed in terms of density functional theory results, as well as by appropriate phenomenological models in order to trace the mostly structurally driven evolution of physical features. Research supported by the Japanese Science and Technology Agency (JST, project MIRAI).

Keywords: Thermoelectricity, Heusler compound, DFT calculations, Modelling.

INVITED SPEAKERS

Id-28

Energy Storage Properties of NiSalen Type Polymer and Its Composites at Low-Temperature

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Abstract: Nowadays, batteries are widely used in different types of portable electronics and electric vehicles. They retain their electroactivity, both at room temperature and at temperatures up to + 60 ° C. However, at low temperatures, batteries dramatically lose energy as well as power density. One of the important tasks in the development of low-temperature power sources is the choice of the cathode material since the performance of the most contemporary cathode materials drastically decreases under low-temperature conditions. The crystalline structure of oxide-based inorganic cathode materials is disturbed by the transport of lithium at low temperatures, leading to a significant decrease in capacity. This problem can be solved by the replacement of inorganic cathode materials with organic ones. Having a porous structure without a rigid lattice, organic polymers can reversibly adapt to deformation upon intercalation and deintercalation of charge-compensating ions even at low temperatures. Among “soft” energy storage materials, NiSalen-type polymers have already demonstrated their possibility for application as cathode materials of electrochemical power sources or their components such as binder or overcharge protection layer. In this work, polymerized nickel complexes of salen-type ligands in anhydrous acetonitrile-based electrolytes with different electrolyte salts were studied. Electrochemical properties and charge transfer kinetic of different salen-type complexes at low temperature were investigated by cyclic voltammetry, constant rates of redox reactions were calculated from the obtaining experimental data. Mass transfer parameters of the polymer film in the different electrolytes were determined by electrochemical quartz microbalance. Electrochemical impedance spectroscopy was used for establishing charge transfer parameters of the films at low temperatures. Diffusion limitation of the charge transfer at negative temperatures was shown with analysis of the experimental data. For creating a prototype of a power source with a practically significant load of an active material the composite material based on polymer complexes of nickel-salen type and carbon nanotubes were developed. This work was supported by the Foundation for Basic Research, project # 20-03-00746, and using

the equipment of the resource centers "Interdisciplinary Resource Center for Nanotechnology" and "Physical Methods for Surface Research" of the Science Park of St. Petersburg State University.

Keywords: Low temperature battery, Kinetic, Charge transfer, Mass transfer, Conductive polymer.

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INVITED SPEAKERS

Id-37

Bio-assessment of MgB_2

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Abstract: MgB2 is usually prized as the lightest superconductor with practical potential. It has a relatively high critical temperature of about 39 K and a large coherence length (10-30 nm) that allows vortex pinning engineering for control and enhancement of functional properties such as critical current density and irreversibility field. We have also proposed MgB2 for biomedical applications. We explore its biodegradation, antimicrobial and antitumor activities, and cytotoxicity. In this presentation we review our results on bio- assessment of MgB2-based materials as powders, coatings, and bulks. Powders were supplied from different companies and they show very different structural and microstructural features as revealed by complex physical-chemical characterization. The powder type influences the bio-behavior and attempts were made to correlate the specific features with antimicrobial activity. Powders were embedded in biodegradable polymers such as PVP and PLA. The coatings of PVP polymer with MgB2 particles and selected natural plant extracts were also prepared. Cytotoxicity of the coatings was assessed on dermal cells. PLA with additions was demonstrated as an antimicrobial 3D printable material. Spark plasma sintered high density bulks of MgB2, machinable by chipping were obtained by addition of hexagonal BN. These materials show excellent superconducting characteristics for bulk magnet and shielding applications. At the same time they were shown to fully eradicate different bacteria and fungi in planktonic and biofilm states after 48 h. Finally, results of degradation in time of MgB2 bulk samples in water and Dulbecco's Modified Eagle's Medium are addressed by assessing the superconducting properties through magnetic measurements. It is remarkable that although there is a weight loss, the superconducting quality of the remaining sample is not affected. There are no stable intermediate degradation steps, this being convenient in designing controlled release applications and environmental impact

determination. Authors acknowledge UEFISCDI, Romania, grants M-ERA.NET 74/2017 BIOMB and 5PTE/2020 BIOTEHKER.

Keywords: MgB2, Antimicrobial, Cytoxicity, Powder, Coating, Bulk.

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INVITED SPEAKERS

Id-53

Combined Transient Heat and Mass Transfer Modeling of Solar Powered Food Dryers

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Abstract: Solar food drying is a process of moisture removal from food items through a coupled heat and mass transfer process using solar radiation as energy source. As the shelf life of dried food items drasticallyincreases, food drying using solar energy both tackles the problems of climate change and food depletion. Over the last years, the use of solar energy for food drying applications is becoming more popular due to rapid depletion of natural fuel resources, rising fossil fuel costs and climate change. Asthe drying process is a complex multi-physics, multi-scale problem, it is hard to design an optimal dryergeometry and/or to predict optimal settings of operational parameters using experiments alone. An attractive tool to model the physical processes in solar dryers is Computational Fluid Dynamics (CFD).The use of CFD for studying airflow velocity, temperature and humidity distributions inside solar food dryers has been demonstrated in several research works, for which an overview is given by Getahun et al. [1]. With CFD, time consuming and costly experiments can be avoided and hence it is a powerful tool in the design process. However, most of the works focus on the prediction of steady state velocity,temperature and moisture distributions within the dryer and there exists only a limited number of researches on transient heat transfer modelling [2]. Moreover, most of the models available in today's literature neglect the food to be dried or model it as a porous medium as the main focus is often on thedetermination of the solar collector efficiency. To overcome this gap in literature, a combined transientheat and mass transfer model of a solar dryer is developed and experimentally validated in this research. The detailed model includes fluid flow and heat/mass transfer. The velocity field inside the solar drying chamber is obtained from CFD and is experimentally validated using Particle Image Velocimetry (PIV). To the best of our knowledge, a detailed PIV study on the flow field in solar dryers has not been done before. In addition, the heat transfer in the solar dryer is validated by thermal measurements performed under controlled laboratory conditions using an artificial sun. The spatial andtemporal distribution of temperature at various locations inside the solar dryer is recorded and used forvalidation of

the model. Moreover, the drying kinetics and efficiencies are also been investigated at various locations with distinct measurements of weight loss of the food items. It was shown that the model can capture the involved physics of the drying process and is hence a good tool to help in the design, optimisation, and performance evaluation of solar food dryers.

Keywords: Solar drying; Computational fluid dynamics; Heat and mass Transfer modeling.

INVITED SPEAKERS

Id-58

Pd- and Ti-based Metallic Glasses: Electrochemical Hydrogen Activity and Corrosion Properties

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Abstract: Among the state-of-the-art metallic alloys, metallic glass (MG) is a potential candidate for hydrogen storage and production due to its grain-free amorphous structure, increasing the number of interaction sites. Our recent publications on Pd-Si-based MG nanofilms by structural (aberration-corrected high-resolution transmission electron microscopy, X-ray diffraction), electrochemical (chronoamperometry, cyclic voltammetry, electrochemical impedance spectroscopy), composition (X-ray photoelectron spectroscopy, energy dispersive X-ray) and morphologic (scanning electron microscopy, atomic force microscopy) techniques have brought insight for the hydrogen storage and electrocatalytic activity of these multicomponent alloy systems. The hydrogen to Palladium ratio of Pd-Si-Cu MG was found to be 1.56 (c.f. 0.61 in polycrystalline Pd + Si/SiO_2 of the same film thickness) [1, 2]. It has been shown that the maximum total hydrogen charge stored in Pd-Si-Au MG nanofilm is equal to that in polycrystalline Pd films with 1 μm thickness [1]. Regarding electrocatalytic activity, Pd-Cu-Si MG-based hybrid structure has a Tafel slope of 109 mV/dec, less than half of the crystalline PdNF electrode of similar thickness. This hybrid assembly also shows the highest overpotential at 10 mA/cm^2, indicating a better electrocatalytic activity [2, 3]. The second part will be about the nanoporous Pd-Si-based MG for hydrogen storage/sensing and electrocatalytic activity [4]. The third part is devoted to

developing fully biocompatible Ti-based MG compositions with no toxic and precious group elements but with high metalloid content. Our preliminary results show that the fully amorphous ribbons confirmed by X-ray synchrotron radiation have very much lower passive current densities compared to Ti-6Al-4V alloy in 0.9 wt.% NaCl solution at 37 °C corroborating their biocompatibility.

Keywords: Hydrogen storage, Electrocatalysis, Corrosion behavior, Metallic glass, Palladium, Titanium.

INVITED SPEAKERS

Id-298

Assessing the Evolution of the Romanian Renewable Energy Market

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Abstract: This paper analyzes the evolution of the renewable energy market in Romania. Attracted by a generous support scheme, foreign and domestic investors flocked to the market. As a consequence, the sector witnessed a remarkable progress, especially in the wind power category. Romania approached fast the national target set by the European Union concerning the share of the country's energy consumption from renewable sources. However, frequent changes in the support scheme and in the regulations issued by public authorities led to chaos. The aim of the paper is to emphasize the characteristics and development of the renewable energy market in Romania, to investigate the support measures implemented as well as their effects, and to critically assess the impact of the legal changes on the producers involved in the renewable energy sector. By means of an exploratory study and several interviews with executives of renewable energy companies, the main challenges confronted by producers and the shortcomings of policy-making are highlighted. The revision of the support scheme and the string of legal changes adopted since 2013 were found to be the main determinants for the falling revenues and the declining financial performance of renewable energy producers. Subsequently, some recommendations for improved policy-making so as to re-establish the trust of investors and to foster the future development of the sector are suggested.

Keywords: Renewable energy, Energy policy, Electricity, Support scheme, Green certificates.

INVITED SPEAKERS

Id-300

A Novel Two Stage Pyrolysis/Splitted Product Gasification (PSPG) System for Biomass Conversion

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Abstract: Thermo-catalytic cracking processes such as pyrolysis and gasification have a great potential to convert lignocellulosic biomass to useful chemicals and energy. Although much attention has been devoted to gasification in recent years, there are still a number of challenges to full commercialization of biomass gasification. Heterogeneity of raw materials, gas tar content and reduced efficiency are the main technical challenges. In this study, a biomass gasification unit consisting of a pyrolysis stage and a splitted product gasification stage (PSPG) was investigated considering: increase of gas lower heating value (LHV), reduction of gas tar content (GTC), increase of cold gas efficiency (CGE) and carbon conversion efficiency (CCE). The samples of waste biomass have been subjected of experimental study. Two types of natural clay were used as catalyst in the secondary catalytic reactor. The temperature in the pyrolysis reactor and secondary catalytic reactor was 550 ^{o}C. and 800 ^{o}C . Gas composition and tar content of gas was observed under different process conditions. Air split ratio between secondary catalytic and char gasifying reactors had a significant effect on the biomass gasification system performance. Tar content in syngas is significantly affected by the air split ratio; splitting air between secondary catalytic reactor and char gasification reactor reduced the tar content in syngas. Increased air flow in secondary catalytic reactor led to the reduction of coke formation inside the reactor. For equivalence ratios ER from 0.05 to 0.22 and air split ratio from 0 to 1, the values of LHV/GTC varied between 0.83 and 2.01. The optimal air split ratio was 0.325 when the highest LHV/GTC value of 2.01 was recorded. The produced gas consist of CO (23-27 mol.%), H_2 (4-9 mol%), CH_4 (4-10 mol.%), CO_2 (10-17 mol.%) and N_2 (39-54 mol.%). The lower heating value of syngas was 7.34 MJ.Nm^{-3}. The liquid yield was 5.21 g.kg^{-1}. Liquid condensate consisted of a water fraction (92%) and an organic fraction (8%). GC-MS analysis of water fraction shown that beside water, acetic acid, phenolic components and Levoglucosan are the main components of this fraction. Organic fraction content phenols, Polycyclic aromatic hydrocarbons, oxygenated heterocyclic hydrocarbons and others. Catalytic

effect of both natural catalysts has been confirmed experimentally and both catalysts were capable of methane decomposition and gas tar reduction. The studied multistage pyrolysis/gasification approach has high potential to reduce all mentioned problems to a minimum level. However, global optimization of process conditions required more experimental research. This work was supported by the project APVV-15-0148 provided by the Slovak Research and Development Agency

Keywords: biomass, gasification, pyrolysis, two stage, multistage

REGULAR SESSIONS

Id-49

Differentiating Technical and Non-Technical Losses in Electricity Distribution System

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Abstract: This work has been initiated for creating a method to differentiate technical losses from non-technical losses in electrical distribution systems. Total loss in the electricity distribution system can be calculated by subtracting total distributed power from total power billed to the consumers. The total loss of electricity can be categorized into two topics; technical losses and non-technical losses. Technical losses are caused by losses on the conductors and hardware that distributes the power to the consumers. On the other hand, non-technical losses mostly caused by faults in the system or illegal use of the electricity. In this this work technical losses, which is caused by different parts of the distribution system, has been formulated. The formulas which we use to calculate the technical losses are almost 1% accurate in theory, however since the load is assumed to be static while making the calculations, these results must be confirmed with practical test. In order to confirm the calculations, three different areas have been chosen from the distribution area of our company to test the formulas. A number of parameters have been determined to be collected from the distribution system. Two of these areas have been modified with modems which uses RS-485 communication method to gather all the relevant data from the system. The last area has been modified with Power Line Communication (PLC) system to gather the information periodically. After the relevant data have been collected over a period of time, the calculations have been made with real world data. It has been observed that if the consumer is farther away from the distribution center, then the loss gets higher. The technical loss from three test areas are calculated and observed as 4%, 1% and 0.5% respectively. These differences are caused from the distribution system type differences such as underground and above ground, and the total distance of the consumers to the distribution center. When we compare calculated loss and real loss, it has been observed that our calculations are relatively close to real world. Thus, in the result of this work, formulations for technical losses are established and confirmed with real world applications which enables us to separate the technical and non-technical losses in electricity distribution system.

Keywords: Electricity distribution systems, Electricity loss, Electricity distribution efficiency, Illegal electricity detection.

REGULAR SESSIONS

Id-56

Forecasting Wind Energy Density Distribution in the Baltic States Based on NEWA Atlas

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Abstract: Most recent energy generation and consumption forecasts for the time horizon after 2030 indicate that the Baltic States will not be able to ensure uninterrupted operations of their electricity systems, as the power plant capacity in the Baltic region taken together with the import capacity will nolonger be sufficient to cover the peak demand. At the same time, the rapid development of the wind energy technology has led to the emergence of wind turbines with a rated power up to 5.8 MW, adapted to low wind conditions. In these conditions, typical for Latvia's eastern regions, one of the solutions is the development of new regional industrial clusters based on modern wind turbines. In line with the European Green Deal policy initiatives, the excess energy could be routed towards the production of green hydrogen. The purpose of this study is to show the prospects of using modern methods of modelling the distributionof wind energy density at the heights up of 500 m in combination with new energy storage technologies to solve the problem of energy shortages and accelerate the development of the national economy, which can lead to a significant increase in social and economic activity in the Baltic region. The authors present the results obtained using a model of wind resource forecasting developed in the course of ERA-NET+ NEWA project, in which 30 partners from 8 European countries took part. The mesoscale modelling covers the entire EU plus Turkey and 100 km offshore as well as the complete North and Baltic Seas. The WRF model was used in a NEWA consortium developed configuration, with a 3 km grid spacing and simulation period covering 30 years (1989-2018). The framework of NEWA atlas can be used to estimate the values of wind energy density for the specified heights level of interest. The study presents the results of the analysis in the form of maps of wind energy density distribution at the heights of 100, 150 and 200 m. The maps distinctly feature the regions with the highest estimated value of the wind energy flux density.This makes it possible to identify the most advantageous locations for wind farms and the optimal

heights of wind turbine masts. The emphasis is made on finding areas with low population density that are remote from existing economic and industrial centers. The construction of wind parks in such social and environmental conditions would make it possible to use wind energy resources and make these regions more attractive for local manufacturers, while the surplus energy could be used to produce green hydrogen. Furthermore, the authors consider the possibility of using the method of liquid compression of hydrogen for its storage at high pressure as a part of proposed infrastructure. This technical solution can be used at fueling stations for hydrogen powered vehicles. Thus, the results of the study can be useful for the governmental authorities that develop social and economic policies for Latvian municipalities.

Keywords: NEWA Atlas, Wind Resource Modelling, Maps of Wind Energy Density, Economic Policies,Hydrogen.

REGULAR SESSIONS

Id-65

Development and Implementation of a Smart SCADA System for Hybrid PV-Wind Installation

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Abstract: SCADA systems plays an important role in any smart control and monitoring system. They are widely used to control renewable energy applications and constitute a decision support tool for better energy management. The present paper deals with the design, the development and the implementation of a smart SCADA system. The proposed system consists of a set of sensors for measuring both meteorological and electrical parameters SCADA system, object of the present work consists of a controller module, an interface, and a weather unit. For that, Arduino Nano and ESP32 microcontrollers, were considered. In addition, weather variables, wind/photovoltaic power, and stored energy were displayed on a locally generated dashboard and the ThingSpeak cloud platform.

Keywords: Data Acquisition System, IOT, Smart Control, ESP32, Real Time Control.

REGULAR SESSIONS

Id-67

Biomass based Carbon Materials for Fuel Cells

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Abstract: The use of renewable energy sources (solar, wind and water) in electricity generation is still not enough to meet humanity's growing energy demand. That is why the documents of the World Economic and Energy Forums emphasize the importance and need for the use of renewable energy sources, such as fuel cells. Mobile, renewable energy sources are essential for both portable electronics (mobile phones, laptops, tablets, etc.) and vehicles. Research and development of fuel cell technologies, as well as the improvement of their properties, are widely studied all over the world. The main problem is the high price of fuel cells, where the main source of costs is the platinum required in the catalyst. Technologies that use biomass as a raw material for the production, transformation and storage of electrical energy are attracting scientific interest worldwide. Preparation of tailored carbon materials from biomass and its waste resources by a simple and up-scalable method still is a challenge. From all available biomass waste resources, more than 47 million tons of wood residues is available across the EU each year. At the same time developers of new innovative wood biorefinery processes meet the problems with obtained by-product valorisation. For example, in thermochemical conversion technologies char and liquid wastes are produced as by-products and can use only as fuel, while in sugar platform technologies, using acids or ferments for hydrolysis, lignin as a by-product has been obtained, which has been characterized as a low added value product and the size of its further utilization market is far from what is need. The properties of the solid, liquid and combined precursor have the crucial influence on the nanoporus carbon structure. In this study two pretreatment methods of various precursors, traditional carbonisation and hydrothermal treatment, were compared for the synthesis of the nitrogen doped activated carbons. Carbons porosity, structure and composition are studied as well as their application as cathodes for oxygen reduction in fuel cells. The ORR activity of the nonoporous carbon materials was comparable with commercial 20% Pt/C catalyst. Electrocatalytic properties of the synthesized nitrogen doped wood-derived carbon catalysts may be associated with the highly developed surface area, micro- and mesoporous ratio and balance, high percentage of pyridinic nitrogen

and lack of stacking defects of graphene layers. Despite many efforts by researchers to improve the productivity, efficiency and durability of fuel cell technology, the large-scale commercial use of metals, especially platinum group-free catalysts, is problematic. Therefore, the task is still to develop a cheap, platinum-free catalyst for fuel cells with similar or higher electrochemical activity and stability. The study was supported by project Nr. lzp-2020/2-0019 New biomass origin materials hybrid carbon composites for energy storage (BiComp).
Keywords: Biomass, Activated carbons, Porous structure, Fuel Cells.

REGULAR SESSIONS

Id-299

High Performance Mg and Mg-Li/Na-Ion Hybrid Batteries through Defect Engineering of Metal Oxide Electrodes

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Abstract: Rechargeable batteries are extensively used for electronic devices, power grids and electric vehicles applications. However, energy/power limitations, safety issues and high-cost of current generation lithium-ion batteries are limiting their real-world applications. Mg-batteries recently emerged as a promising post-lithium technology due to the abundance (2.3% of earth's crust, ~10^4 fold > Li), inexpensive nature (~$2/Kg, 10 fold < Li) high volumetric capacities (3833mAh/cm^3), dendrite-free redox reactions and environmental benign nature of Mg-metal. Despite of these advantages, its commercialization is hindered by the sluggish diffusion of Mg^{2+} ions into the cathode. Bivalent Mg-ion experience a much stronger electrostatic repulsion from the charge clouds of the host electrode. This results in the limited specific capacity, rate performance and cycling stability of Mg-based batteries. Mg-Li and Mg-Na hybrid batteries have been proposed with the hope to overcome the drawbacks of conventional Mg-batteries while maintaining superior cost-effectiveness and safety credentials. However, direct implementation of several Li and Na-ion compatible electrodes are restricted in the hybrid systems due their incompatibility with Mg-ions. Although several metal oxide electrodes are demonstrated for Li and Na-ion storage, their application in Mg-Li hybrid batteries are limited due to the above-mentioned sluggish Mg^{2+} diffusion. Herein we present high rate/ ultra-long life Mg and Mg-Li/Na-ion hybrid batteries through defect engineering of metal oxide electrodes. Crystal defects such as oxygen vacancies and grain boundaries are engineered in TiO_2 based electrodes to significantly enhance the electrochemical performances. Fast kinetics of the diffusion independent pseudocapacitive Mg/Li/Na-ion diffusion also minimizes structural changes and provides electrode robustness. Morphological and microstructural uniqueness of the defect engineered TiO_2 electrodes made it an excellent candidates for high rate and ultralong life Mg and Mg-Li/Na-ion hybrid batteries. The demonstrated approach for efficient pseudocapacitive Mg/Li/Na-ion intercalation enhanced by crystal defects can be further exploited in the development of other high performance electrodes for advanced Mg and Mg-Li/Na-ion hybrid batteries.

Keywords: Batteries, Nanomaterials.

POSTER SESSIONS

Id-19

Assessment of PV Modules Soiling and Proposition of Innovative Low Cost Cleaning Techniques

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Abstract: This paper summarizes some results obtained from the studies we are performing on the impact of soiling on PV panels and the development of innovative low cost cleaning techniques. We start by presenting an experimental simulation of the effects of soiling on solar PV glass using a test bench that we have performed at home laboratory. The first tests conducted on this bench have been validated by other experimental studies performed in outdoor conditions. From the results obtained it has been concluded that the test bench developed has approached the mechanism of the deposition of soiling phenomenon. After, an experimental approach to evaluate the soiling rate via the performance ratio using solar front-glass has been detailed. The aim of this study is to present a simple and low cost soiling measurement protocol for PV modules. A comprehensive study of exposed solar glass samples according to two different exposition angles 0° and 45° has been also conducted. The study has included a close comparison of soiling distribution and optical transmittance of the samples. This was analyzed by presentation of the loss trend due to soiling and which has marked 2.25% during two months of dry period. In the last part of the work, an innovative and very low cost cleaning technique for dynamic photovoltaic panels on solar bi-axial tracker produced by Helioslite was developed and implemented. This relevant and competitive technique doesn't need any energy supply because it works using only the force of gravity. The cleaning tests were carried out and validated using an optimal design of the cleaning system prototype of the real bi-axial tracker that has been developed locally. The results of the tests have been taken into consideration to realize the cleaning technique in real dimensions and normal operating conditions.

Keywords: Soiling, PV Panels, Indoor simulation, Performance ratio, Transmittance.

POSTER SESSIONS

Id-29

3ω thermal conductivity measurements on type-I clathrate nanowires

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Abstract: With the European Union recently signing the Green Deal, in which its members promise to become completely climate neutral until 2050, sustainable energy sources are more important than ever. Thermoelectric materials play an intriguing role here, since they cannot only be used to convert waste heat into electricity, but also for regulating temperature in a climate-friendly way. Their conversion efficiency is given by the dimensionless thermoelectric figure of merit $ZT = S2 \cdot \sigma \cdot T/\kappa$, with S being the Seebeck coefficient, T the absolute temperature, and σ and κ the electrical and thermal conductivity, respectively. Finding a good thermoelectric material with high values of S and σ, but a low κ, is not an easy task, since these quantities are connected, but there are several material classes with promising properties. Among them are the so-called clathrates, which form in cage-like structures that encapsulate heavy guest atoms. The rattling of these guest atoms disrupts the heat carrying phonons, thus leading to a remarkably low lattice-phonon conductivity, while keeping a high electrical conductivity. Recently it was discovered that the acoustic phonon modes and the rattling modes of such systems can hybridize in a way that resembles the Kondo effect. This phononic Kondo effect leads to a universal scaling of phonon thermal conductivity with the product of sound velocity vs and lowest-lying Einstein temperature ΘE. Due to this relation it should be possible to reduce the thermal conductivity even further by cutting off long-wavelength phonons propagating with vs. We attempt to do this by nanostructuring characterized bulk single crystals using a focused ion beam (FIB) and measuring the thermal conductivity at temperatures between 300 and 80 K, where an influence of crystal defects can be neglected. To avoid measurement uncertainties at such high temperatures, we implement a 3ω technique, in which the suspended nanowire itself acts both as a heater and a thermometer, making it one of the most precise methods available. With this, we plan to trace the complex relationship between the size and the thermal conductivity of type-I clathrates.

Keywords: Thermoelectrics, Clathrates, Nanowires, Thermal Conductivity.

POSTER SESSIONS

Id-30

Gold-Nickel Catalysts Supported on Titanium for Borohydride Oxidation Designed by Femtosecond Laser Structuring and Chemical Modification

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Abstract: The use of femtosecond (fs) lasers in material processing grew substantially in the last two decades. It is motivated by unparalleled control of processing parameters enabled by such a light source. Among other fields, surface structuring benefited greatly from the usage of fs lasers. In this study, the gold-nickel (AuNi) catalyst coated microstructured titanium (Ti) electrodes with enhanced surface roughness were prepared as catalysts for the electro-oxidation of sodium borohydride. A modified "Laser Nanofactory" (Femtika Ltd.) setup was used to develop model Ti electrodes. Processing was carried out using 1030 nm wavelength (fundamental harmonic of Yb:KGW laser), 500 fs pulse duration, and 600 kHz repetition rate. Distinct Ti surface structures were produced and used as a substrate for the deposition of AuNi catalyst using an electroless Ni plating, followed by galvanic displacement of Ni by Au nanoparticles. The morphology, structure, and composition of the prepared AuNi/Ti catalysts were characterized by scanning electron microscopy (SEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and inductively coupled optical emission spectroscopy (ICP-OES). The electrochemical activity of catalysts in the borohydride oxidation reaction was evaluated using cyclic voltammetry and chronoamperometry approaches. It was found that the laser-induced surface structuring yields a substantial enhancement in the electrochemical activity of AuNi catalyst.

Keywords: Gold, Nickel, Femtosecond laser structuring, Borohydride oxidation.

POSTER SESSIONS

Id-31

Conversion of Black Liquor to Highly Active Nitrogen-Doped Carbon for Oxygen Reduction Electrocatalysts

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Abstract: Nowadays, great attention focuses on converting biomass to useful metal-free doped carbon materials for energy applications, such as fuel cells and batteries. In this study, the conversion of kraft pulping residue, black liquor, to nitrogen-doped carbon (NC-BL) for highly efficient oxygen reduction reaction (ORR) electrocatalysts is presented. The NC-BL catalyst was prepared from black liquor through a two-step process, including chemical activation with NaOH at high temperature and doping with nitrogen using dicyandiamide (DCDA). This catalyst had a high specific surface area of 2481 m^2 g^{-1}. The nitrogen-doped carbon had a high nitrogen content of 4.33 at%. Most of the nitrogen was in the pyridinic-N (66.58 at%) and graphitic-N forms (33.42 at%), widely recognized as the ORR-active species. The NC-BL catalyst displays excellent electro-catalytic activity towards the ORR with an onset potential of 1.0 V vs. reversible hydrogen electrode (RHE) in alkaline media (1 M KOH). The rotating ring disc experiment showed a four-electron pathway (n = 3.6). Our present results demonstrated that kraft pulping residue, such as black liquor, can be employed as a promising carbon precursor for the low-cost and efficient non-precious metal electrocatalysts toward ORR. This study was financially supported by the Lithuanian-Latvian-Taiwanese Tripartite Cooperation Program under the project “Innovate Catalysis for Sustainable Energy (ICatSE)” (P-LTT-21-4, LV-LT-TW/2021/2, MOST 110-2221-E-006-165-MY3) and Postdoc project 1.1.1.2/VIAA/4/20/596 “Nitrogen and phosphorus-containing biomass based activated carbons for fuel cells and supercapacitors”.

Keywords: Black liquor, Nitrogen-Doped carbon, Oxygen reduction.

POSTER SESSIONS

Id-33

Synthesis and Characterization of 3D NiCu Foams on Ti Surface for Borohydride Oxidation

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Abstract: This study is related to the intensively developing research in the field of fuel cells and nanomaterials. It is devoted to searching for new effective materials, which can be used to develop and design direct alkaline fuel cells. The precious metal (gold, platinum, ruthenium, and its other alloys) catalysts are very promising; however, such catalysts are costly and their use is not cheap. This study presents the preparation, characterization, and investigation of 3D metal NiCu nanostructured catalysts on titanium surface (NiCu/Ti) synthesized by electroplating. NiCu foams were electroplated on the Ti surface from a bath containing 1 M HCl, 1.5 M H_2SO_4, 0.5 M $NiSO_4$, and 0.01 M $CuSO_4$. The electrochemical deposition was carried out at the current density of 1.5 Acm^{-2} for a different time. The morphology and composition of the catalysts have been examined using scanning electron microscopy, energy-dispersive X-ray spectroscopy, X-ray diffraction, and inductively coupled plasma optical emission spectroscopy. The electrocatalytic properties of the prepared NiCu/Ti catalysts for sodium borohydride oxidation was investigated by recording cyclic voltammograms in a 1 M NaOH solution containing 0.05 M $NaBH_4$ at a potential scan rate of 10 mV s^{-1} in the potential range from -1.2 up to 0.6 V vs. $Ag/AgCl/KCl_{sat}$ at a temperature of 25 ºC. This project has received funding from European Social Fund (project No 09.3.3-LMT-K-712-19-0138) under a grant agreement with the Research Council of Lithuania (LMTLT).

Keywords: Catalysts, Anode materials, Borohydride, Alkaline fuel cells.

POSTER SESSIONS

Id-38

Manganese Nanoparticles Doped Graphitic Carbon Nitride Electrocatalyst for Oxygen Reduction

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Abstract: Nowadays, great attention focuses on developing effective catalysts based on earth-abundant elements for energy applications, such as fuel cells and batteries. Herein we present the preparation of Mn nanoparticles doped graphitic carbon nitride (g-C_3N_4) for efficient oxygen reduction reaction (ORR). The Transmission Electron Microscopy (TEM), X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS) were employed for characterization of the prepared catalysts, whereas the electrocatalytic activity of Mn-g-C_3N_4 towards ORR was investigated using the rotating disk electrode technique. The g-C_3N_4 was prepared by annealing melamine at 520 ^oC for 2 h. The obtained g-C_3N_4 had a high nitrogen content of 67.92 at.%. The Mn nanoparticles were obtained using microwave synthesis. The mixture of g-C_3N_4 and Mn nanoparticles was used to investigate ORR in 0.1 M KOH solution at different rotating rates. Compared to the metal-free g-C_3N_4, the immobilization of Mn nanoparticles enhances the electrocatalytic activity and the selectivity towards the 4e- reduction reaction of O_2 to H_2O. Our present results demonstrated that Mn nanoparticles doped graphitic carbon nitride could be employed as a promising catalyst for the low-cost and efficient non-precious metal electrocatalysts towards ORR. This project has received funding from European Social Fund (project No. 09.3.3-LMT-K-712-23-0188) under a grant agreement with the Research Council of Lithuania (LMTLT).

Keywords: Manganese, Graphitic carbon nitride, Oxygen reduction.

POSTER SESSIONS

Id-40

Gold Nanoparticles Modified 3D Copper-Nickel Metallic Foams for the Electrooxidation of Sodium Borohydride

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Abstract: At the moment, it is vital to look for new efficient fuel cell catalysts from the industry's point of view. It is well known that the electrooxidation of sodium borohydride ($NaBH_4$) is effectively catalyzed by precious metal catalysts, such as gold, platinum, etc. However, precious metal catalysts are very expensive, so an alternative is being sought. This study presents the fabrication of low-cost and efficient catalysts with a foam-like structure with 3D porous architecture. 3D copper-nickel Cu-Ni metallic foams have been deposited onto titanium (CuNiFMs/Ti) via galvanostatic deposition from electrolytes contained 0.5 M Ni^{2+} and 0.01-0.02 M Cu^{2+} ions. Additionally, the prepared CuNiFMs/Ti have been modified with small quantities of gold nanoparticles (AuNPs) by their immersion into a 1 mM $HAuCl_4$ solution at 25 ºC for 1 min. The surface and structure of the 3D CuNiFMs/Ti and AuNPs-CuNiFMs/Ti were analyzed using scanning electron microscopy (SEM), X-ray diffraction (XRD), and inductively coupled plasma optical emission spectroscopy (ICP-OES), while their electrochemical performance in a 0.05 M $NaBH_4$ and 1 M NaOH solution was evaluated using cyclic voltammetry. The prepared 3D CuNiFMs and AuNPs-CuNiFMs have been found to show good electrochemical stability in alkaline $NaBH_4$ solution. In addition, modification of CuNiFMs by AuNPs increases the electrocatalytic activity for the electrooxidation of $NaBH_4$ compared to pure CuNiFMs. The high performance of AuNPs-CuNiFMs makes it an attractive anode material for $NaBH_4$ electrooxidation in an alkaline medium.

Keywords: Anode materials, Catalysts, Fuel cells, Borohydride.

POSTER SESSIONS

Id-47

Implications of Next Generation Memory Materials for Green Data Centers

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Abstract: Recently, next generation memory materials (NGMM) such as STT-MRAM (spin transfer torque magnetic RAM) and PC-RAM (phase change RAM) have been commercialized. For example, Intelintroduced OptaneTM, which is a kind of 3D Xpoint memory. Samsung also commercialized eMRAM and plans to expand its applications to server systems. As NGMMs are non-volatile as well as byte-addressable, they have both memory and storage characteristics. It is prospected that the excessive idle power caused bythe refresh operations of DRAM will disappear if we adopt NGMM as the main memoryof computer systems. This will contribute to advancing a new paradigm of energy-efficient green data centers. Also, if NGMM is adopted as a front-end storage layer, it will accelerate slow HDD and even flash-based SSDs. However, as the detailed characteristics of NGMM vary, the exact performance implications need to be investigated. In this paper, we quantifythe operation characteristics and performance implications of NGMM, and suggest how to adopt them in green data centers. Specifically, we focus on two NGMMs, PC-RAM and STT-MRAM. PC-RAM stores data by utilizing a material called GST, in which two phases can be set by controlling heating time and temperature. As each phase provides different resistance when the electric current is passed, data can be differentiated. While detecting the resistive value is fast, changing the phase takes longer, and thus writing is slower than reading. On the other hand, STT-MRAM utilizes the magnetic properties of a material whose orientation can be controlled and detected by using electrical signals. Specifically, STT-MRAM has two ferromagnetic layers that are varied by the relative magnetization directions. Although the latencies for reading and writing are almost the same in STT-MRAM, the amount of current required for writing is significantly larger than that for reading. Thus, for energy-efficiency, the memory layer with STT-MRAM should be carefully designed to minimize writing. This paper explores the challenges and implications of using NGMM instead of DRAM and HDD with a broad range of experiments for future green data centers. Our experimental results show that even with fast NGMM storage, the performance improvement is

not large for reading data as current I/O mechanisms do a good job in hiding the slow performance of HDD. To assess the potential benefit of NGMM, we make use of various configurations and perform experiments to quantify the effects of the existing mechanisms optimized for DRAM and HDD. Our preliminary findings with these experiments can be summarized as follows. The effectiveness of buffer caching is limited in NGMM, and in some cases, direct I/O performs better than using buffer cache. Synchronous writes do not affect the performance of NGMM, which gives room for improving the reliability of storage by shortening the flush frequency. Unlike HDD, NGMM is more sensitive to the I/O size than the I/O frequency, and thus reducing I/O traffic is important. We anticipate that our findings will provide directions for designing future green data centers in presence of NGMM.

Keywords: Next Generation Memory Material, Green Data Center, STT-MRAM (Spin Transfer Torque magnetic RAM), PC-RAM (Phase-Change Random Access Memory), DRAM.

POSTER SESSIONS

Id-63

Band gap Modified Metal oxide Nanomaterials for Visible Light Absorption

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Abstract: Visible light absorbing nanomaterials are of great importance for the applications such as remediation of environmental pollution and solar energy conversion. In this scenario, TiO_2 nanomaterial based photocatalysts has been attracted considerable research attention for their diverse optical, electrical and ecofriendly properties. But their wide band gap limits them from visible light mediated outdoor applications. In the current study, visible light absorbing TiO_2 nanomaterials have been synthesized through a simple sol gel technique. Visible light absorption was achieved by performing a band gap modification/reduction using Mn as dopant. Optimum concentration of Mn for the maximum visible light absorption was noted. The structural, electronic and optical properties of the synthesized nanomaterials were characterized by XRD, DSC, FTIR, UV vis and Diffused reflectance Spectroscopy. The materials synthesized at 500°C were shown to have anatase phase and a possesses a high degree of crystallinity. A significant red shift in the absorption of TiO_2 was observed in the DRS as a result of Mn doping and thus it is expected to be highly promising for visible light activated applications in future.

Keywords: Photocatalyst, TiO_2, Doping, Visible Light Etc.

ALL SUBMISSIONS & TOPICS

Topic	Submission
Novel and Efficient Technologies for Energy Production	65 - Development and Implementation of a Smart SCADA System for Hybrid Pv-Wind Installation
Solar Energy	53 - Combined Transient Heat and Mass Transfer Modeling of Solar Powered Food Dryers
Biofuels and Bioenergy	300 - a Novel Two Stage Pyrolysis/Splitted Product Gasification (PSPG) System for Biomass Conversion
Petroleum	18 - Enhanced Oil Recovery Methods for Shale Oil Extraction from Bazhenov Formation
	26 - Next Generation Techniques for Ecofriendly-High Efficiency Recovery of Heavy Oil/Bitumen
Efficient Consumption of Energy	49 - Differentiating Technical and Non-Technical Losses in Electricity Distribution Systems
Energy Efficient Products	47 - Implications of Next Generation Memory Materials for Green Data Centers
Bio-Assessment and Toxicology	37 - Bio-Assessment of Mgb2
Water Pollution and Treatment	7 - Bioelectrochemical Processes for Wastewater Treatment
Assessment and Management on Energy and Material	56 - Forecasting Wind Energy Density Distribution in The Baltic States Based on Newa Atlas
Energy Policies Andenergy Policies and Regulation	298 - Assessing the Evolution of The Romanian Renewable Energy Market
Materials for Renewable and Sustainable Energy	58 - Pd- and Ti-Based Metallic Glasses: Electrochemical Hydrogen Activity and Corrosion Properties
Thermoelectrics	17 - Giant Transport Anisotropy in a Cubic Thermoelectric Material
	27 - Improving Thermoelectricity of Heusler Compounds: Stucture – Property Relations
	29 - 3ω Thermal Conductivity Measurements on Type-I Clathrate Nanowires

Batteries	28 - Energy Storage Properties of Nisalen Type Polymer and Its Composites At Low-Temperature
	299 - High Performance Mg and Mg-Li/Na-Ion Hybrid Batteries Through Defect Engineering of Metal Oxide Electrodes
Supercapacitors	24 - Morphology-dependent Electrochemical Energy Storage Performance of MnO2 Nanostructures
Fuel cells	30 - Gold-Nickel Catalysts Supported on Titanium for Borohydride Oxidation Designed by Femtosecond Laser Structuring and Chemical Modification 31 - Conversion of Black Liquor to Highly Active Nitrogen-Doped Carbon for Oxygen Reduction Electrocatalysts 33 - Synthesis and characterization of 3D NiCu foams on Ti surface for borohydride oxidation 38 - Manganese Nanoparticles Doped Graphitic Carbon Nitride Electrocatalyst for Oxygen Reduction 40 - Gold Nanoparticles Modified 3D Copper-Nickel Metallic Foams for the Electrooxidation of Sodium Borohydride 67 - Biomass based Carbon Materials for Fuel Cells
Photovoltaics and so	19 - Assessment of PV Modules Soiling and Proposition of Innovative Low Cost Cleaning Techniques
Solar-driven reactio	63 - Band gap Modified Metal oxide Nanomaterials for Visible Light Absorption