Book of Abstract
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Organizing Committee

PLENARY SPEAKER

Id-503

The Future of Safe Batteries

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Abstract: The quest for safer batteries has been ongoing for years, as the benefits of lithium-ion batteries (LiBs) come with inherent risks and hazards that can have significant consequences. Therefore, making significant strides in developing safer battery technologies that prioritize safety while maintaining high performance and energy density is imperative. The first is to explore and implement new materials in LiB, such as new anodes (i.e., silicon-based), new electrolyte additives (lowering flammability) or the use of graphene etc. These materials offer high conductivity and strength, making them ideal for building safe and efficient batteries that can withstand stress and impact. For instance, graphene is a highly conductive and robust material that can enhance the stability and safety of batteries. By adding a layer of graphene to the electrode, researchers can improve battery performance, reduce the risk of thermal runaway reactions, and enhance the overall safety of the battery. Other promising areas of research are solid-state and sodium-ion batteries. The absence of a liquid electrolyte in the former eliminates the risk of thermal runaway reactions, as solid-state electrolytes are non-flammable and can withstand high temperatures without degrading. Solid-state batteries also have the potential to offer higher energy density and longer lifespan than traditional lithium-ion batteries. Sodium-ion batteries have a higher operating temperature range than LiBs and can be discharged to nominal 0 volts (whereas in LiBs, “0” means around 2.9 V). Sodium is a much more abundant and cheaper material than lithium, making it a more sustainable option. Additionally, sodium is less reactive than lithium, reducing the risk of fire and explosion. In addition to technological advancements, developing regulatory frameworks and safety standards for battery technologies is also critical for ensuring the safety of future batteries. As new technologies emerge, regulatory bodies must evaluate and establish safety standards and protocols to evaluate the associated risks and ensure their safe deployment. In conclusion, the future of safe batteries is promising, with researchers and regulatory bodies taking significant steps towards developing batteries that prioritize safety without compromising on performance. Emerging technologies such as solid-state or sodium-ion batteries and innovative materials offer significant potential to enhance the safety and efficiency of batteries. It is important to continue to invest in research that prioritizes safety as we rely more on battery-powered devices in our daily lives and as the development of new battery technologies is critical to power the electric vehicles and renewable energy systems of the future.

Keywords: battery, safety, lithium-ion, energy, standards.

PLENARY SPEAKER

Id-507

Photovoltaic Material Design and Morphology Optimization for High-Performance Organic Solar Cells

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Abstract: Solution-processed organic solar cells (PSCs) have been regarded as very attractive photovoltaic technology due to the unique advantages of low-cost, light-weight, and the capability to be fabricated into the large area flexible devices. Photoactive layer which generally composed of a donor and an acceptor material is the key component determines the power conversion efficiency (PCE) of OSCs. Therefore, rational design of photoactive layer and morphology regulation is essential to develop high-performance OSCs. In this presentation, we will demonstrate the effective strategies to design organic semiconductors and regulate morphological properties of bulk-heterojunction active layer toward highly efficient OSCs.

Firstly, several examples will be discussed to demonstrate the effect of alkylthio side chain in manipulate the physicochemical properties of organic semiconductors to achieve improved photovoltaic performance. Secondly, we will discuss the rational design of organic semiconductors as a third component to build ternary OSCs to realize improved photovoltaic performance. Due to the fact that controlling the self-assembling of organic semiconductors to form well developed nanoscale phase separation in the bulk-heterojunction active layer is critical yet challenging for building high-performance OSCs. Particularly, the similar anisotropic conjugated structures between nonfullerene acceptors and *p*-type organic semiconductor donors raise more complexity on manipulating their aggregation toward appropriate phase separation. In the third part, we will focus on the volatilizable solid additive strategies developed for controlling the aggregation of photovoltaic materials in active layer for high-performance OSCs. The strong crystallinity of solid additive offers the possibility to restrict the over aggregation of fused-ring nonfullerene acceptor in the process of film formation. During the kinetic process of anthracene removal in the blend under thermal annealing, donor can imbed into the remaining space of solid additive in the acceptor matrix to form well-developed nanoscale phase separation with bicontinuous interpenetrating networks. As a result, significantly improved photovoltaic performance can be realized for the OSCs treated with solid additive.

Keywords: organic solar cells, organic photovoltaic materials, power conversion efficiency, morphology.

PLENARY SPEAKER

Id-511

Boiling and Condensation Heat Transfer Enhancement in Nuclear Reactors

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Abstract: Boiling and condensation processes are very widely occurred in nuclear energy systems. Heat transfer enhancement during those processes is one of the key research areas to improve the nuclear reactor performance and safety. It has been verified that various surface parameters, such as surface intrinsic wettability and surface structures, have significant impact on the boiling and condensation heat transfer. Extensive researches have been conducted by different research groups around the world to improve the thermal performances through surface modifications. However, significant amount of efforts are still required to distinguish the impact of individual parameters in order to better understand the underlying mechanism and design more efficient surfaces. In this talk, extensive experiments and multiscale numerical simulations will be presented for various micro/nano coated surfaces in order to identify a better way for boiling and condensation heat transfer enhancement in nuclear reactors.

Keywords: critical heat flux, boiling and condensation, nuclear reactors.

PLENARY SPEAKER

Id-525

Renewable Hydrogen: A Catalyst for Sustainable Energy and Power-to-X Technologies

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Abstract: Hydrogen is a promising secondary energy source, fuel and feedstock alike for decarbonizing the energy, transport, and chemical sector. Identifying and realizing environmentally-friendly hydrogen production pathways is, however, significantly impeded by the need for step-wise transformation of national energy systems.

This contribution discusses the current level of hydrogen production technology development. Process configurations will be discussed with focus on a comparison of steam methane reforming, steam methane reforming with carbon capture and storage, methane pyrolysis and water electrolysis. Hydrogen from these technologies is often associated with the respective colors grey, blue, turquoise, and green.

The critical comparison of these technologies is objectified and quantified by comparative description based on the methodology of life cycle assessment. For this purpose, the environmental impacts of the hydrogen production technologies are analyzed and the most promising solutions with respect to the progressing energy transition identified. Environmental co-benefits and burden shifting resulting from the transition to more climate-friendly hydrogen production technologies are taken into account. The environmental impact of hydrogen production is found to be determined to a large extend by the under- lying supply chains. Promising to be a green technology, hydrogen also emerges as a secondary energy source to address spatial and temporal imbalances between supply and demand as renewable energy sources like wind and solar become more prevalent. The increased utilization of hydrogen in the context of Power-to-X offers new opportunities to harmonize ecology, economy, and social needs, making it a key technology for achieving sustainability goals, including those outlined by the UN (No. 7, 9, 12, 13).

Keywords: hydrogen, technologies, LCA; sustainability, power-to-X, environmental impact.

PLENARY SPEAKER

Id-536

Engineering of Perovskites and ZnO Quantum Dots for Game-changing Improvements in Light Harvesting Devices

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Abstract: Perovskite solar cells (PSCs) are the most emerging area of research among new generation photovoltaic technologies. The power conversion efficiency (PCE) of PSCs has rapidly increased since their first demonstration in 2009 from 3.8% to a current certified value of 25.7% thanks to continuous improvements of synthesis protocols and the understanding of the underlying physics. Both the perovskite absorber layer and electron-transporting layer are the key parameters for improving performance of PSCs. The preparation of metal halide perovskites (MHPs) has commonly relied on solution-based methods. While the solution-based approach is relatively versatile, it faces challenges such as limitations in their compositional engineering or long-term storage. An alternative approach is mechanochemical synthesis by grinding the solid reactants that was pioneered by our group in 2015, which allows the preparation of various phase-pure hybrid lead and lead-free MHP compositions. Moreover, the lack of the solubility limitation in mechanochemical synthesis paved the way for compositional engineering perovskite materials that could not be obtained by wet methods. Strikingly, PSCs fabricated from mechanoperovskites exhibited superior photovoltaic performance compared to conventional devices made using the classical wet-chemical procedure.

ZnO is a promising electron transport layer (ETL) in thin-film photovoltaics. However, the poor chemical compatibility between perovskites and commonly used sol-gel-derived ZnO nanostructures makes challenging fabrication of efficient and stable PSCs. Only recently our group has developed new organometallic approaches to high]-quality ZnO QDs that led to the breakthrough in the field. For example, PSCs based on low-temperature processed ETL composed from processable organic ligand-free ZnO QDs reached a power conversion efficiency (PCE) of 20.05% with no need for the ZnO/perovskite interface passivation, i.e., the state-of-the-art performance among reported non-passivated pure ZnO-based PSCs. In turn, ZnO QDs capped with a zwitterion afforded the device with one of the highest performances (PCE of 21.9%) reported for ZnO-based PSCs, and competitive stability.

Finally, our view on current challenges and future directions in this interdisciplinary area of research will be provided.

Keywords: solar cells, perovskites, zinc oxide, quantum dots, mechanosynthesis.

PLENARY SPEAKER

Id-538

Sustainability of Wind Energy Materials

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Abstract: According to recent global statistics, by 2050 more than 5270 GW of global energy will be produced using wind energy to reduce emissions from fossil fuels and its geopolitical problems. Alos, around 85% of the components (foundation, tower and components in the nacelle) and materials used in the manufacture of wind turbines can be recycled. Whereas other components, especially wind turbine blades, cannot be recycled and are usually disposed of in landfill, which contradicts the concept of sustainability. This type of waste composed of Fiber-reinforced composites (carbon fiber and fiberglass) structure represent the major unrecycled materials, what oblack with sustainability concept. This type of waste is made of fiber-reinforced composite materials (carbon fiber and glass fiber), and it is expected to rise to 43 million tons by 2050. In order to achieve the sustainability of wind energy materials and reduce its environmental risks, this research aims to recover all resin and fibers components of waste wind turbine blades (WTB) using pyrolysis treatment. The experiments were carried out at two different levels to study the basic decomposition properties (fundamental level) and to determine the yield and composition of the pyrolysis products (laboratory level). In the fundamental, the basic pyrolysis characteristic of WTB was studied using TGA-FTIR and GC-MS at different heating rates. While the large experiments were carried out using a 250g lab scale pyrolysis plant. The fundamental results showed that WTB can be completely decomposed up to a temperature of 500 °C and styrene was the main GC compound with activation energy in the range of 159 - 220 kJ/mol. Whereas laboratory experiments have shown that WTB can degrade to only styrene-rich oil (44.5 wt.%) without producing any gaseous product. Also, fibers were extracted as a high purity solid residue after undergoing an oxidation process.

Keywords: wind energy, sustainability, waste wind turbine blades: pyrolysis treatment.

INVITED SPEAKER

Id-498

The Investigation of the Boundries of Liquid Phase

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Abstract: The uncertainty of the boundary of the liquid phase in the P-T diagrams of a pure substance, which were drawn experimentally, theoretically or based on various modeling, is still the most important unsolved problem of physical chemistry. The temperature-dependent boundary gap of the liquid phase is located between the triple point (T_{tp}) and the critical point (T_{cr}) in the P-T phase diagram.
The temperature-dependent boundary range of the liquid phase exists only between these two fundamental points. At the same time, the pressure-dependent boundary range of the liquid phase is between the triple point (P_{tp}) and the critical (P_{cr}) point. However, the critical pressure (P_{cr}) cannot represent a critical situation since $P_1 < P_{cr} < P_2$ takes place in two different pressure ranges in the liquid phase. It is not possible to determine the pressure-dependent boundary range of the liquid phase with a single point (P_{tp}).
Is there a critical point which determines the pressure dependent limit range of the liquid phase? In the phase transition system, the state of the liquid phase due to high pressure has a special status. In this study, the pressure-dependent limit range of the liquid phase was investigated by applying experimental and axiom geometric methods. It is these first experiments that should be regarded as the beginning of the history of critical phenomena.
Keywords: Liquid phase, metastable state, axiogeometric, physical properties, aromatic hydrocarbons.

INVITED SPEAKER

Id-520

Advanced Air-dehumidification Membranes for Energy Efficient Air-Cooling Applications

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Abstract: Space cooling is the most rapidly growing energy consumption in residential and commercial buildings in hot and humid economies. Recently, membrane dehumidification is identified by the US Department of Energy as the top alternative to the conventional vapor compression cooling because of its energy efficiency and eliminating the use of environmentally hazardous hydrofluorocarbons. Nonetheless, viable membrane dehumidification process requires membranes with extremely high-water vapor permeance (WVP), high water/air selectivity, fouling resistance, good durability, and low cost. In this presentation, we discuss our recent research on developing high-performance air-dehumidification membranes based on i) graphene oxide (GO) membranes, ii) polyimide thin film composite membranes and iii) mixed matrix membranes. The correlation between the membrane structure and performance will be discussed. Moreover, the technoeconomic and life cycle analysis of air-cooling based on the optimum air-dehumidification membranes will be presented.

Keywords: Air-cooling, air-dehumidification, graphene oxide membranes; mixed matrix membranes; thin film composite membranes.

Acknowledgment: This research was supported by NPRP grant # NPRP12S-0128190016 from the Qatar National Research Fund (a constituent member of the Qatar Foundation).

INVITED SPEAKER

Id-521

Numerical Prediction of Heat and Mass Transfer Processes in a Bioreactor with Coated Membrane-Based Adsorption Bodies

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Abstract: Bioreactors play a crucial role in groundwater remediation and wastewater treatment, with fixed-bed and floating-bed reactors being commonly used designs. The former employs adsorbents, such as cylindrically shaped activated carbon or coated carrier bodies, to remove pollutants through adsorption or absorption processes, respectively. A novel approach involves coating carrier bodies with a membrane containing doped activated carbon, creating a functionalized layer that combines adsorption and absorption effects.

To assess heat and mass transport processes, we conducted experimental and numerical investigations, aiming to validate the predictive capabilities of our numerical models. A dual- porosity model was integrated into the flow solver TinFlow, efficiently accounting for the mobile and immobile phases in the porous region without dissolving the bed with individual carrier bodies. Additionally, suitable coupling of conservation equations facilitated mapping of adsorptive storage processes for pollutants in the porous layer.

This paper presents and discusses our numerical approach using the dual-porosity method to predict heat and mass transfer processes, providing a valuable comparison to experimental results.

Bioreactors, which can be designed as fixed-bed or floating-bed reactors, are used for groundwater remediation and wastewater treatment. In the case of a fixed-bed reactor, the bed consists of adsorbents, which consist of cylindrically shaped activated carbon or coated carrier bodies. With coated carrier bodies, the adsorption of pollutants takes place on the surface, while with activated carbon, the porosity, i.e. the inner surface, is used for absorption. A new approach for the combination of adsorption and absorption processes consists in coating the carrier body with a membrane with doped activated carbon, which creates a porous, functionalized layer on the carrier body.

To evaluate the heat and mass transport processes, experimental and numerical investigations were carried out with the aim of validating the numerical models for predicting the transport processes. For this purpose, a dual-porosity model was integrated into the flow solver tinFlow, which differentiates between the mobile and immobile phase in the modeling technique of the porous region without the need to dissolve the bed with the individual carrier bodies. At the same time, the adsorptive storage processes of pollutants in the porous layer can be mapped through a suitable coupling of the conservation equations for the mobile and immobile phases.

In this paper we will present and discuss the numerical approach of the dual porosity method for the prediction of heat and mass transfer processes in comparison to experimental results.

Keywords: Computational fluid dynamics, bioreactor, membrane, doted activated coal, adsorption, water remmediation.

INVITED SPEAKERS

Id-541

Engineering Bioinspired Nanocomposites for Next-Generation Batteries

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Abstract: Bioinspired ion conductors have undergone extensive research for energy storage applications beyond traditional lithium-ion technologies. Due to the natural abundance and low toxicity of sulfur, as well as its high theoretical specific energy density (2600 Wh/kg) and specific capacity (1675 mA/g), it has garnered significant attention as a potential alternative for developing battery systems with higher capacity and energy density. These alternative systems aim to replace lithium-ion batteries, which are limited by capacity and energy density in various applications and are subject to safety issues. However, the commercialization of metal sulfur batteries remains challenging due to issues such as polysulfide dissolution and shuttling.

In light of this, we have developed a practical and comprehensive approach for the creation of high-performance metal sulfur batteries, inspired by biological ion transport mechanisms. Our approach utilizes composite ion transport membranes based on Aramid nanofibers (ANF) that do not just prevent dendrite formation but also confine polysulfides on the cathode side. ANF composite battery separators exhibit diverse and opposing properties, including high mechanical strength, high ionic conductivity, and high thermal/chemical stability. These biomimetic separators' highly selective ion sieving properties ensure safe and high-performance batteries.

The production of these biocompatible, flexible, affordable, and high-energy-density batteries is crucial for powering next-generation electronics, such as portable, wearable, and implantable biomedical devices.

Keywords: bioinspired, nanocomposites, structural, zinc, sulfur, batteries.

ORAL PRESENTATION

Id-471

Thermal Behavior of a Green Building with Recycled PET-Sand Bricks in Casablanca, Morocco

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Abstract: The aim of this study was to investigate the thermal behavior of a green building located in Casablanca, Morocco, which has external and internal walls made of recycled bricks manufactured from a mixture of molten plastic PET bottles and sand (2S1P). To compare these bricks with traditional clay ones, we conducted mechanical tests such as compressive strength, flexural strength, and water absorption test, as well as thermophysical tests to determine thermal conductivity and density. the BINAYATE software was used to ensure compliance with the Moroccan Construction Thermal Regulations (RTCM), and then created a model of the house using SketchUp to simulate it on TRNSYS. Different simulations were carried out on TRNSYS to compare the thermal performance of 2S1P with clay bricks, including the temperature evolution, heating and cooling needs, and relative humidity. The results indicate that using a recycled material made from sand and plastic waste can reduce energy consumption while improving thermal comfort.

Keywords: Dynamic thermal simulation, thermal comfort, thermophysical tests, recycled bricks, green building, energy consumption.

ORAL PRESENTATION

Id-497

The Impact of Heat Transfer Fluid Type on Thermal Efficiency of PTC When Direct Radiation is Interrupted

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Abstract: Parabolic trough solar collectors, which focus the solar energy and convert it into usable heat energy, can operate at high efficiency and high temperature. In parabolic trough solar collectors, heat transfer fluid is used to transport the heat. The heat transfer fluid circulates in the receivers, where the sun's rays are collected, carry the heat and transmit it to the end use point through a series of thermal processes. Because of this reason, heat transfer types that are used in parabolic trough solar collectors are very important. In this work, there is no glass around of receiver and also direct radiation is interrupted. In that case there will be heat loss from heat transfer fluid to ambient and this loss is directly related with the convective heat transfer coefficient via with heat transfer fluid thermophysical properties. In this study, the thermal efficiency of three different heat transfer fluids was compared in the case of no sun and no glass. The heat transfer fluids used are Syltherm 800, Therminol VP1 and Hitec XL respectively. In this paper, numerical calculations were made with Ansys/Fluent after validation of numerical model with experimental results which are obtained from literature. In these analyses, fluid motion was solved for turbulent flow under continuous conditions. RNG k-ε turbulence model was used. As a result of the study, it was seen that the heat transfer fluid type has little effect on the receiver performance. The thermal efficiency of synthetic oils such as Therminol VP1 and Syltherm 800 is higher than Hitec XL salt. The maximum thermal efficiency was observed when using Syltherm 800, however, these fluid are relatively expensive. It has been observed that using molten salt results in higher pressure drop and lower thermal efficiency.

Keywords: Heat transfer fluid, thermal efficiency, parabolic trough solar collector, synthetic oil, molten salt.
Acknowledgement: This work was partially funded by the Scientific and Technological Research Council of Türkiye (TÜBİTAK) under project 1001- The Scientific and Technological Research Projects Funding Program. Project number: 122M039.

ORAL PRESENTATION

Id-504

Harnessing Energy from Oceans

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Abstract: The presentation will start by describing the primary energy consumption by fuel types.

The locations of the global deep-water oil and gas reserves will be illustrated and different types of oil and gas exploration and production platforms and their design principles and analysis methods will be discussed.

The presentation will be concluded by describing the offshore renewable energy devices and some recent floating offshore wind turbine installations in Scotland.

Keywords: Oil and gas exploration and production platforms, offshore renewable energy devices.

ORAL PRESENTATION

Id-505

Different Approaches and Strategies Towards Protonic Conductors with Improved Electrical Conductivity and Chemical Stability

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Abstract: $BaCeO_3$-based compounds represent the group of intermediate-temperature ceramic protonic conductors with a high potential for application in electrochemical devices. Barium cerium oxide crystallizing in perovskite structure exhibits relatively the highest protonic conductivity in this group of conductors. One of the disadvantages of such materials is poor chemical stability in the presence of CO_2 and H_2O vapour which led to the disintegration of material and deterioration of mechanical and electrical properties. Several approaches towards the improvement of electrical properties and chemical stability of $BaCeO_3$ were proposed and described in the literature so far. The formation of aliovalent solid solutions (mostly with Zr), the introduction of non-stoichiometry in cationic sublattice, doping with elements from the lanthanides group or the attempts to modify the grain boundaries by the introduction of additional phase are the most commonly applied strategies.

In this work, the results concerning different approaches towards the formation of $BaCeO_3$ based composites are presented. It was assumed that the introduction of additional phases in the grain boundary area would lead to the improvement of both electrical properties and chemical stability. Different modifier phases and various materials' preparation routines were proposed. The modifier phases (Ba-Ce-Y-Si-P-O system) were prepared by sol-gel method and introduced into the $BaCe_{0.9}Y_{0.1}O_3$ host material using different methods: mechanical homogenization or high-temperature impregnation or by the introduction of modifier sol precursor on the grains surface of the host material. The materials were then compacted in the pellet die and then sintered using two different methods: free-sintering and Spark Plasma Sintering (SPS) at controlled conditions. Obtained materials were characterized and investigated X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) techniques. The electrical properties were determined using Electrochemical Impedance Spectroscopy (EIS) technique as a function of the gas atmosphere and temperature. Based on the analysis of obtained results the influence of chemical composition and preparation method on phase composition, structure, microstructure and the electrical properties of prepared materials was determined and discussed. The improvement of selected properties for some

systems investigated indicates that some of the proposed approaches can be a promising way towards the $BaCeO_3$ based protonic conductors with improved properties.

Keywords: ceramic protonic conductors; electrical conductivity; chemical stability; composites.
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ORAL PRESENTATION

Id-506

Influence of Synthesis Route on Physicochemical and Electrochemical Properties of MnO_2-based Electrode Materials used in Supercapacitors

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Abstract: Improving electrochemical capacitors that can be used in the automotive industry is currently one of the most active research fields. Therefore enhancement of material physical and chemical properties through selective engineering aimed at optimizing functional performance for application use is one of the major topics that scientists should address. It is well known that the microstructure of material can determine the catalytic, sensory, photocatalytic and electrochemical behaviour. Herein we demonstrate the impact of synthesis conditions (pH) on the properties of stable nanostructured MnO_2 and their application as electrode material in supercapacitors. Synthesized samples were characterized by various physicochemical characterization techniques XRD, XPS, SEM, BET surface area analysis. The morphological study of the as-synthesized MnO_2 samples revealed the morphology consisting of nanorods for pH value of 2,5 and cauliflower shape for pH of 3 and 6,5. The XRD study revealed that at low pH a α-MnO_2 is formed whereas an increase of pH during synthesis leads to birnessite phase formation. The electrochemical studies revealed that the birnessite MnO_2 structure exhibits superior electrochemical behaviour when compared to α-MnO_2, when 5% KNO_3 dissolved in dimethyl sulfoxide (DMSO) was used as an electrolyte, and demonstrated higher specific capacitance.

Keywords: MnO2 supercapacitors; hydrothermal synthesis; non-aqueous electrolyte; microstructure.

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ORAL PRESENTATION

Id-527

Socio-Demographic Features and Electricity Consumption Time Series in Main Heating Mode Classification

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Abstract: Cost-efficient integration of variable renewable energy resources requires demand-side flexibility. Home heating system is one of the main determinants of the flexibility potential for individual household. This study analyzes two approaches for heating system classification. We show that features based on hourly electricity consumption time series outperform socio-demographic features as inputs in the main heating classification task. Classification based on socio-demographic features leads to 0.41 precision and 0.43 recall, whereas time series classification methods achieve precision 0.62 precision and 0.64 recall. Since hourly electricity consumption data provides valuable information in heating classification and thus in flexibility potential estimation, the availability of consumption time series data should be considered from the competition policy point of view.

Keywords: Household heating system; supervised learning; smart meter data; time-series classification; socio-demographic features.

Acknowledgement: This research has been funded by Business Finland in project ‘‘Highly Optimized Energy Systems HOPE’’, funding decision 14120/31/2020 and by Academy of Finland in project “Accelerating residential around-the-clock clean electricity consumption through hard and soft policies (ALLTIME), decision 356493.

POSTER PRESENTATION

Id-447

Peri-substituted Dichalcogenides of Nafthalene and Perylene Monoimides

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Abstract: In recent years, much attention has been paid to the design and preparation of new substituted 1,8-naphthalimide architectures and the studies on the properties of materials. Wide possibilities of changing the optical and fluorescence, thermal, electrochemical, electroluminescent, and photoelectrical properties of 1,8-naphthalimide compounds can be materialized by introducing different electron-donating or electron-accepting moieties at the 1,8-naphthalimide core. At the same time, derivatives of substituted 1,8-naphthalimide have found application in other optoelectronic devices, such as organic light emitting diodes, organic solar cells, as well as in memory devices. 1,8-Naphthalimides can have wide energy gaps and low reduction potentials, making them good candidates for use as n-type materials in OLEDs. While many 1,8-naphthalimide derivatives have low luminescent efficiencies at room temperature, due to strong intersystem crossing to their triplet states, 1,8-naphthalimides substituted at the 4 and 5 positions with electron-donating groups can have high fluorescent quantum yields. Tuning of solid-state properties using molecular modification is a key to develop organic functional dyes such as light emitting diodes, solar cells, and memory devices. Herein, we describe the first naphthalene monoimide dithiolato or diselenolate derivatives as well as the preparation of novel NMI-dithiolate and diselenate containing two additional halogen atoms in the ortho positions to the two chalcogens. We also recently reported a facile strategy for synthesis of perylene monoimide dithiolato or diselenolate derivatives.

The new dyes are promising candidates for high-tech applications such as OLEDs, OFET, visualization of cellular organelles, bimodal diagnostic imaging, etc. The synthesis, optical properties and potential applications of several derivatives will be discuses in this poster.

Keywords: 1,8-naphthalimides, peryleneimides, dichalcogenides, functional dyes.

Acknowledgement: Authors are grateful to the Bulgarian National Science Fund project NSF KP 06-N69/1.

POSTER PRESENTATION

Id-458

Investigation of Contaminants Present in Industrial Water Utilized for the Cooling of Co-produced Gases

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Abstract: Pyrolysis facilitates waste decomposition while generating valuable by-products, resulting in the formation of gas, liquid, and solid phases. Among the components found in the gas mixture is tar. To purify the pyrolytic gas, water scrubbing technology is employed. However, this approach has a drawback as tar components gradually accumulate in the water. Light heterocyclic aromatic compounds and heavy polyaromatic compounds of tar, which are readily soluble, are particularly susceptible to this accumulation. Although the pyrolytic gas contains high levels of certain light aromatic tar compounds, their presence in the cooling and cleaning water is minimal. Consequently, as the pyrolysis cycles increase, the overall tar content and the proportion of individual tar compounds in the cooling and cleaning water change, with a notable accumulation of the heaviest polyaromatic tar compounds. This accumulation poses challenges for further purification and utilization of the cooling and cleaning water itself.

The cooling water collected from the scrubber was sampled at a pyrolytic gas temperature of 250°C after 5, 10, and 15 pyrolysis cycles. The tar components present in the water were extracted using dichloromethane. The extraction process involved adding 4 mL of dichloromethane to 100 mL of water, shaking it for 30 minutes, and repeating the procedure three times with the same sample to enhance the yield. The extracted compounds were then combined, concentrated using a rotary evaporator, filtered through syringe filters, and injected into GC-MS for analysis.

The concentrations of individual tar compounds in the cooling and cleaning water exhibit different patterns of increase with the number of pyrolysis cycles. For instance, poorly water-soluble light aromatic tar compounds like benzene and naphthalene show only a 1.69- and 1.57-fold increase, respectively, in their concentration in the cooling and cleaning water when the pyrolysis cycles triple. However, readily water-soluble light heterocyclic aromatics tar compounds such as phenol, m-cresol, p-cresol, and 2,3-xylenol demonstrate a 2.54, 2.63, 2.48, and 2.74-fold increase, respectively, in their concentration with a threefold increase in pyrolysis cycles. Similarly, for heavy polyaromatic tar compounds that are poorly soluble in water, the concentration in the cooling and cleaning water increases significantly more compared to light tar compounds. For instance, when the pyrolysis cycles triple, tar compounds like pyrene, chrysene, and coronene show a 2.69, 1.91, and 2.52-fold increase in their concentration in the cooling and cleaning water, respectively.

During contact with the pyrolytic gas, the cooling and cleaning water gradually accumulates readily soluble light heterocyclic aromatics tar compounds and heavy polyaromatic tar compounds. Although the pyrolytic gas contains high levels of certain light aromatic tar compounds, their presence in the cooling and cleaning water is minimal. The process of purifying the pyrolytic gas not only increases the total tar content in the cooling and cleaning water but also alters the ratio of individual tar compounds, particularly with the accumulation of the heaviest polyaromatic tar compounds. These changes present challenges for the subsequent purification and utilization of the cooling and cleaning water.

Keywords: pyrolysis; cooling and cleaning water; extraction; tar; gas chromatography.

POSTER PRESENTATION

Id-459

A Technique for Analyzing and Measuring the Amount of Tar Generated through the Thermal Decomposition of Solid Waste

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Abstract: The environmental problem of disposing of solid waste and their utilization using pyrolysis has gained significant attention in recent years. This approach offers a promising solution to the challenges posed by traditional waste disposal methods, such as landfilling and incineration, which contribute to environmental pollution and resource depletion. By subjecting solid waste to high temperatures in the absence of oxygen, pyrolysis can effectively break down organic matter and recover energy-rich byproducts. The utilization of pyrolysis for solid waste management not only reduces the environmental burden associated with waste disposal but also provides opportunities for resource recovery and the development of a circular economy. However, it is crucial to address technical challenges, optimize process parameters, and ensure proper treatment of the resulting byproducts to maximize the environmental benefits of pyrolysis-based waste utilization.

For conducting research in a practical setting, the selected technology relied on the concept of rapidly heating finely-grained solid waste utilizing a solid heat carrier, such as hot ash, within a rotary drum reactor. This process triggers the thermal decomposition of the solid waste, providing a feasible approach for conducting studies in a real life context. A rotary kiln reactor located in Daugavpils, Latvia was used for the pyrolysis experiments. During the investigation of tar sampling from non-condensable gas produced during solid waste pyrolysis, researchers discovered that the most effective sampling device contained 500 mg of an amino-phase sorbent and 100 mg of activated coconut charcoal. This device was successful in capturing tar and the volatile organic compounds associated with it. The first column used was a 3 mL reservoir, which contained 500 mg of aminopropyl-bonded silica adsorbent with an exchange capacity of 0.6 meq g^{-1}, a particle size of 50 µm, and an average pore size of 60 Å. The second column was a 1 mL reservoir containing 100 mg of activated coconut charcoal with a surface area of 1070 m^2 g^{-1} and a particle size of 20/40 mesh, 420-840 µm.

The method suggested in this research for measuring the concentration of tar compounds requires less sampling time compared to existing methods. This enables faster monitoring of pyrolysis conditions based on tar analysis results in pyrolytic gas. Moreover, unlike other techniques, the proposed method can

measure both heavy tar compounds and light tar compounds like benzene and toluene. There was no significant difference observed in the total amount of tar and its component compounds with the increase in the volume of pyrolytic gas. However, an increase was noted in the quantity of lighter compounds like benzene and toluene that passed through the amino-phase adsorbent and were collected on the activated coconut charcoal as the gas volume increased. As the volume of pyrolytic gas increased, more compounds were detected and identified on the amino-phase adsorbent. It is crucial to consider the concentration of tar in the pyrolytic gas while determining the sampled gas volume and identifying individual tar compounds with low concentrations.

Keywords: SPA method; tar; gas chromatography; solid waste; pyrolysis.

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POSTER PRESENTATION

Id-461

Plasma Gasification of Alternative Fuels using Superheated Water Steam

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Abstract: The annual global increase in energy consumption, coupled with the trend of fossil fuels restriction, has resulted in a need to discover a new, suitable, green energy source. Additionally, since some types of renewable energy sources have inconsistent production, the choice of a suitable energy carrier or energy storage could support the stability of the distribution network. Hydrogen seems to be an excellent solution to this issue for its high calorific value (per unit of weight) and due to the possibility to be compressed under high pressure (approx. 1000 bar). Furthermore, when using it (for combustion or for fuel cells) no by-products are created, as the only product is pure water. Its use for energy production therefore has no harmful consequences for the environment. Also, hydrogen could be easily transported to the desired destination, e.g., in pressure cylinders or within a H_2 infrastructure.

Hydrogen production can be achieved through several methods, most commonly by reforming or electrolysis. However, these methods are not ecological or long-term profitable. Plasma gasification appears to be another suitable method for hydrogen production, because it is used to thermochemically convert various types of alternative fuels into further usable synthetic gas (H_2 and CO). Plasma gasification is a relatively universal technology that can be used to process waste, biomass, and hazardous substances. The organic fraction of the fuel is decomposed into permanent gases using plasma at very high temperatures. The inorganic fraction melts into an inert non-leachable slag. Accordingly, this technology offers a significant environmental advantage, as it processes waste and other substances that could burden the environment while producing the required energy carrier, hydrogen. The combination of waste plasma gasification technology with hydrogen separation processes enables the production of what is commonly referred to as "green energy".

To increase the H_2/CO ratio in the produced synthesis gas, it is necessary to adjust the plasma gasification process appropriately. Hence, for our gasification test of municipal waste, water vapor was chosen as the working gas. The test condition and results will be specifically presented in the poster. The objective was to verify and demonstrate the possibility of gasification of municipal waste and to test newly developed plasmatron.

Nowadays, we focus on the advancement of a current model of the plasma torch that will employ superheated steam (or in combination with nitrogen) for operation. This inventive approach will significantly

diminish the impact of water vapor on the temperature reduction of the gasification process, as well as the potential threat of extinguishing the plasma torch. We have already submitted a utility model to safeguard this innovative solution. Utilizing superheated water steam could be integrated into both types of plasmatron (ultra-high frequency as well as electric arc ones). Further information will be available in the poster.

Keywords: Plasma gasification, alternative fuel, hydrogen, superheated water steam.

POSTER PRESENTATION

Id-483

Contribution to the Development of Nanosatellite Pack Battery for PEDAGO-SAT Mission

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Abstract: PEDAGO-SAT is a new kind of Satellite mission proposed by engineers & searchers of the Algerian Space Agency (ASAL) to attract the Algerian universities to participate in the space development. The adopted approach consists on the development of an engineering training Nanosatellite platform, which will be open source academic platform. The preparation of functional and practical tests will be also done. Main Goal through such as project is to open to a students and trainees an era for space exploration and allow them to access various knowledge related to satellite development and tests. In this work, we focus to the development a battery-pack in 4SnP configuration, which will be integrated, tested and qualified in PEDAGO-SAT mission. In PEDAGO-SAT, the need for electrical storage (battery module) is limited to emulating functional tests related to the interaction between equipment of the power subsystem in orbit (battery cycling, charging mode, discharging mode, voltage monitoring, SOC, DOD…etc). The educational Nano-satellite is often connected to a stabilized power source. Consequently, the battery module is not part of its first power supply chain during daily use in the AIT phase and/or in the laboratory-operating phase.

The present work will cover the power budget, mechanical design, the electrical specification of the pack-battery, manufacturing technics, proposed cell welding processes and prototype realization.

Keywords: Educational nanosatellite; PEDAGO-SAT; mechanical design; electrical design; Li-ion battery.

POSTER PRESENTATION

Id-489

Performance Analysis of Ultra-Low Temperature Refrigeration System for BOG Re-liquefaction

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Abstract: Recently, there has been growing global interest in ultra-low temperature refrigeration systems, driven by various applications such as transportation of COVID-19 vaccines, storage of food in low-temperature warehouses, creation of low-temperature environments for semiconductor quality enhancement and a re-liquefaction process of BOG (Boil-Off Gas) in LNG carriers for utilization of eco-friendly fuels. One of refrigeration cycles capable of achieving ultra-low temperatures is cascade Joule-Thomson refrigeration cycle, which utilizes mixed refrigerant on low stage side. This cycle offers sufficient cooling capacity and target temperature while also pursuing simplicity of system. However, there have been only studies focusing on temperature reduction using cascade Joule-Thomson refrigeration cycle, with limited research on its commercialization. Therefore, this paper focused on achieving a commercial ultra-low temperature refrigeration system for BOG re-liquefaction within LNG vessels at an evaporation temperature of -100°C. The study primarily emphasized refrigeration system downsizing and utilized ASPEN HYSYS and MATLAB software for simulation analysis to investigate a change of compressor displacement according to composition ratio of mixed refrigerant. Three kinds of non-flammable refrigerants, R-134a, R-23, R-14 were used for the analysis. A refrigerant of high stage was R-404A, commonly used refrigerant in industrial sites. The results showed that as cooling capacity was equal, with an increase in high boiling point refrigerant ratio, there was a declining and increasing trend in total compressor displacement. As the ratio of middle boiling point refrigerant increases, compressor displacement tends to rise. Low boiling point refrigerant shows similarity to high boiling point refrigerant.

Keywords: BOG re-liquefaction, cascade Joule-Thomson refrigeration cycle, non-flammable mixed refrigerant, refrigeration system downsizing, compressor displacement.

Acknowledgement: This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No.2022R1F1A1071257)

POSTER PRESENTATION

Id-490

Simulation Analysis on Power Consumption Reduction of Cooling System Using Waste Cooling Heat Source from Liquified Air

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Abstract: There is a growing concern for environmental destruction in modern society. Particularly, research is being conducted on utilizing renewable energy for power generation in order to reduce pollutant emissions. However, renewable energy-based power generation has the drawback of being inconsistent due to its dependence on surrounding environmental conditions. To address this drawback and store excessive surplus power generated at specific times, various studies are being conducted on energy storage systems. Among them, there is a growing interest in the use of liquefied air energy storage technology. Liquefied air energy storage has fewer geographical limitations during installation and generates no pollutants compared to other energy storage systems. However, current research on liquefied air energy storage mainly focuses on the efficiency of power generation and storage processes, and there is limited research on using the discharged low-temperature air (waste cooling heat source) for indoor cooling. Therefore, this study conducted an analysis of the performance of a cooling system when utilizing the low-temperature air discharged from the power generator for partial-load operation, in order to derive the energy-saving efficiency. The simulations were conducted using Aspen HYSYS, and for the comparison of power consumption, a vapor compression refrigeration system using R-410a was selected as the reference. The cooling operation was assumed to occur from 9:00 AM to 6:00 PM for the entire day, while the cooling with low-temperature air was assumed to take place from 12:00 PM to 6:00 PM. The key results obtained through simulations are as follows. The energy-saving rate of partial-load operation showed an increasing trend as the outdoor temperature increase. This is because cooling with low-temperature air, which is not affected by outdoor temperature changes, consumes less power compared to cooling with vapor compression refrigeration systems, which consume more power as the outdoor temperature increases. Utilizing cooling heat source from the liquefied air plant has a significantly higher energy-saving rate compared to conventional vapor compression refrigeration system, especially at higher outdoor temperatures, with a maximum energy-saving rate of 94% achieved.

Keywords: Liquified air; renewable energy; energy storage; cooling system; power consumption.

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POSTER PRESENTATION

Id-491

CFD Analysis on Heat Exchanger with Inner Fins for Thermal Management of Electricity Bus

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Abstract: As the entire world declares throw out of the combustion engines, it is nowadays common sense that most of major vehicle companies is being developing electric vehicles as the alternative of traditional. Currently, the thermal management system for electric vehicles are separated into the system for the cabin HVAC and the battery thermal control system, which means the two systems work independent. As integrating the two different systems, the reduced net weight and production cost and the easier maintenance are expected. The integrated thermal management system is necessary especially for electric buses, which a lot of passengers takes and continuous operation are required, to prolong driving mileage. Therefore, this research project aims to develop the thermal control system by integrating two separated control systems for the electric buses: the cabin HVAC and the battery thermal control system. The expanded two-phase refrigerant exchanges heat with the coolant in the plate HEX of the integrated system. Also, during the heating mode, the heat wasted from other parts is recovered in the plate HEX. For these reasons, the plate HEX takes an important role in the integrated system, and understanding thermal characteristics of the HEX properly is important for the effective operation of the system. Therefore, the main purpose of this study is to select heat exchangers with high low pressure drop and heat transfer rates through CFD simulations for two different cases (CASE A and B) using k-epsilon turbulence model, which provides a relatively short computational time to analyze complex geometric models. The main results show that althogh the heat transfer rate from the entire surface was relatively 23% higher at CASE B than that of CASE A, the value from the single heat transfer layer was reversal; CASE A showed rather 20.7% higher. That means, decreasing fin pitch dose not contribute to the heat transfer enhancement. It rather results in increased pressure drop due to its complex flow sturctures.

Keywords: Thermal management of electricity bus, inner fin heat exchanger, heat transfer rate, pressure drop.

Acknowledgement: This work was supported by the Technology Innovation Program or Industrial Strategic Technology Development Program- KEIT (202205250002, Development of Technology for

Integrating Temperature Control System Function and Improving Efficiency for Hydrogen Electric Bus) funded By the Ministry of Trade, Industry & Energy(MOTIE, Korea)

POSTER PRESENTATION

Id-513

Thermoelectric Properties of $Bi_2Sr_2Co_2O_y$ Ceramics Doped with $Na_2B_4O_7$ and $Pb(BO_2)_2$

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Abstract: Growing energy consumption and global warming's negative environmental impacts have become a major challenge facing the world today. Thermoelectric materials can generate clean energy by converting low-grade waste heat directly into electrical power. Layered cobaltites possessing conductivity of p-type have a great potential for possible applications in thermoelectric devices due to their environmentally friendliness, high thermal and chemical stability, abundance and low cost of raw materials, etc. For this reason, the cobalt oxides have attracted the extensive interest of various research groups. Nevertheless, due to their relatively low heat-to-electricity conversion efficiency when compared with the traditional ones, the practical use of cobaltites still remains a problem. Introduction of suitable dopants is a useful strategy to enhance the functional properties of thermoelectric materials. In this work, the structural, morphological and thermoelectric properties of $Bi_2Sr_2Co_2O_y$ thermoelectric doped with borax $Na_2B_4O_7$, lead borate $Pb(BO_2)_2$, and co-doped with these borates were studied. Samples of $Bi_2Sr_2Co_2O_y$, $Bi_2Sr_{1.95}[Na_2B_4O_7]_{0.025}Co_2O_y$, $Bi_{1.9}[Pb(BO_2)_2]_{0.1}Sr_{1.95}[Na_2B_4O_7]_{0.025}Co_2O_y$, and $Bi_{1.95}[Na_2B_4O_7]_{0.025}Sr_2Co_2O_y$ were prepared by the conventional solid-state reaction method. The apparent densities ranges from 72% of theoretical value for the reference sample up to 90-91% for the $Na_2B_4O_7$ and $Pb(BO_2)_2$-doped specimens which is positive for optimization the thermoelectric performance of the Bi-Sr-Co-O system. Doping with $Na_2B_4O_7$ and $Pb(BO_2)_2$ leads to the decrease of electrical resistivity. Resistivity values of $Bi_2Sr_{1.95}[Na_2B_4O_7]_{0.025}Co_2O_y$, $Bi_{1.9}[Pb(BO_2)_2]_{0.1}Sr_{1.95}[Na_2B_4O_7]_{0.025}Co_2O_y$, and $Bi_{1.95}[Na_2B_4O_7]_{0.025}Sr_2Co_2O_y$ were found to be 1.3, 1.8, and 2.1 times smaller at 973 K, than for reference $Bi_2Sr_2Co_2O_y$ sample (57 mΩ•cm), respectively. Seebeck coefficient values of prepared compositions raised with temperature increasing and were close to each other up to 773 K (~150μV/K). At higher temperatures Seebeck coefficient values of doped samples are slightly lower than the reference one. Power Factor (PF) values of ceramics increased due to doping from 59 μW/m•K^2 for reference sample to 100 μW/m•K^2 for $Bi_2Sr_{1.95}[Na_2B_4O_7]_{0.025}Co_2O_y$ at 973K. Partial substitution of Sr and Bi sites with borates leads to the increase

of thermal conductivity at 573 K from 0.71 W/m•K for reference sample up to 1.23 W/m•K for dual doped $Bi_{1.9}[Pb(BO_2)_2]_{0.1}Sr_{1.95}[Na_2B_4O_7]_{0.025}Co_2O_y$ composition. Among all the prepared materials, samples with partial substitution of Sr and Bi sites by $Na_2B_4O_7$, the compounds $Bi_2Sr_{1.95}[Na_2B_4O_7]_{0.025}Co_2O_y$ and $Bi_{1.95}[Na_2B_4O_7]_{0.025}Sr_2Co_2O_y$ show the maximum ZT values. ZT for these samples reaches to 0.030-0.033 at 573 K, which is approximately 32 % higher than that of the reference $Bi_2Sr_2Co_2O_y$.

Keywords: Thermoelectricity, $Bi_2Sr_2Co_2O_y$ system, doping, PF, ZT.

Acknowledgement: This work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [grant number AR-22-470/ Borates-containing graphene/ceramic thermoelectric composites — a step toward commercialization]

POSTER PRESENTATION

Id-528

Thermoelectric Performance Enhancement of Sol-Gel Processed $Bi_2Sr_2Co_2O_y$ Cobaltite by $BiBO_3$ Doping

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Abstract: The detrimental environmental effects of global warming continue to be an important challenge to the world today. The development of eco-friendly energy conversion technologies has therefore intensified. Thermoelectric materials directly convert waste heat into electricity through the Seebeck effect. The widespread implementation of thermoelectric generators for producing electrical power from low-grade waste heat is anticipated to benefit from the development of high-performance materials. Conventional intermetallic thermoelectric alloys that are used in current niche applications are composed of heavy, poisonous, and rare elements. The development of new thermoelectrics for potential applications became possible with the finding of thermoelectric cobaltites. These materials have a variety of attractive features, including chemical stability, cost-effectiveness, non-toxicity, etc. Cobaltites' real-world use, however, continues to be an issue owing to their inferior thermoelectric performance compared to conventional intermetallic compounds. The process of doping suitable elements and compounds into layered cobaltites is considered to be a key approach for enhancing thermoelectric performance. In the present study, an attempt has been made to improve the efficiency of a heat-to-electricity conversion in the $Bi_2Sr_2Co_2O_y$ system via doping with bismuth borate — $BiBO_3$. With this aim, samples with nominal compositions of $Bi_{2-x}Sr_2Co_2O_y(BiBO_3)_x$ (x=0, 0.005, 0.015, and 0.025) were prepared through a sol-gel method using $Bi(NO_3)_3 \cdot 5H_2O$, $SrCO_3$, $Co(NO_3)_2 \cdot 6H_2O$, and $BiBO_3$ commercial powders as starting materials. The structural, microstructural, electrical, and thermal transport properties were measured, and the thermoelectric performance of prepared materials (power factor — PF, and figure of merit — ZT) was evaluated. Lightly doped (x=0.005) sample has the lowest electrical resistivity among studied materials which is 13 % lower at 973 K compared to reference one. The resistivity increases with further increasing $BiBO_3$-doping level. The apparent density of reference sample is equal to 89 % of theoretical value. Sample with the lowest $BiBO_3$ content, x=0.005, possesses a slightly reduced density (87 %). Doping with higher $BiBO_3$ concentrations leads to the significant decrease of density to around 73 % of theoretical value. The Seebeck

coefficient of the reference sample at 973 K (190 μV/K) is approximately 3-10 % higher than the $BiBO_3$-doped compositions. Doped sample with x=0.005 shows the marked enhancement of PF values at temperature range 293-773 K. At 973 K reference and low $BiBO_3$-doped (x=0.005) samples exhibit almost the same PF around 14-15 $mW/K^2 \cdot m$. These values exceed some of the best results for the $Bi_2Sr_2Co_2O_y$ system that have been reported in the literature. The $Bi_2Sr_2Co_2O_y$ thermoelectric exhibits a markedly reduced thermal conductivity upon doping with $BiBO_3$, which indicates that phonon transport has been suppressed, leading to a decrease in lattice thermal conductivity. Since all $BiBO_3$-substituted compositions possess substantially reduced thermal conductivity, doped $Bi_2Sr_2Co_2O_y$ compositions exhibit higher ZT values than the reference sample. The ZT for doped samples is 38% higher than that of the reference specimen, reaching 0.055 at 573 K.

Keywords: Thermoelectricity; $Bi_2Sr_2Co_2O_y$ system; sol-gel synthesis; doping; thermoelectric performance.

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POSTER PRESENTATION

Id-530

Measurement of Instantaneous Wall Stress Distributions in Turbulent Wall Flows using nm Flexible Mirror Embedded in Micro-wells

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Abstract: The ability to measure shear-stress and pressure measurement simultaneously carries a significant interest for various fluidic dynamic monitoring, slip detection, drag management, measurement of friction, and other diagnostics applications. Various techniques have been proposed to evaluate the distribution of wall pressure and sheer stresses under flow. Studies have been performed in this area using piezoelectric, piezoresistive, and piezo-capacitive sensors but the outcomes are under expectation. At present, the employed methods measuring the instantaneous shear and pressure are not free of limitations and difficult to perform. Shortcomings include (i) low spatial and temporal resolutions (ii) intrusive readout methods, (iii) lack of robust and novel concepts, and (iv) limited range of frequency responses. Based by our recent success in synthesizing a wrinkle-free nm thin metallic film encased in polymers (i.e., flexible mirror), we are developing a technique capable of simultaneous measurement of pressure and shear stress distributions non-invasively at high spatial resolutions. To perform this task, we fabricated an array of deformable mirrors embedded in polymer in microwells with their top surfaces open to flows. Each μWell encases a flexible nanostrain sensor (flexible mirror) fabricated through an in-situ layer-by-layer deposition process. The novel innovation is the nm-thick wrinkle-free Al thin film in polymer that acts as a microscale flexible mirror. Once exposed to flow, the nm-scale 3D deformations within each □Well (pixel), is obtained by digital holographic microscopic interferometry. Using interfacial jamming by nanoparticles, we have successfully fabricated miniaturized polymer encased flexible mirrors and microscopic interferometry. Initial assessment shows the sensitivity of ~4Pa and response frequency of 170 kHz. Additional validations are ongoing using our benchtop shear facility.

Keywords: Pressure sensor, shear sensor, turbulent flow, flexible mirror, interferometry.

POSTER PRESENTATION

Id-535

The Non-isothermal Nanofluid Flow in a Lid-driven Square Cavity with an Obstacle: An Irreversibility Analysis

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Abstract: In the literature, many papers have examined the convection of a Buongiorno's nanofluid in a cavity or in a channel with an embedded cavity. For instance, this regard, the forced convection heat transfer of a nanofluid in a channel has been widely investigated, while the mixed convection of a nanofluid (with various types of nanoparticles) in an open cavity has been pointed out by Mehrez et al. The single phase model for the description of the nanofluid has been employed. Recently, the analysis of vortex formation in the case of laminar flow of a nanofluid fluid, flowing in a duct with an embedded cavity has been studied, while a wide review concerning cavities is discussed.

In this context, the motivation in the current work is that flow of nanofluid in a cavity has been extensively discussed in the past by many authors, but very few attentions has been paid to the presence of an obstacle inside the cavity.

The present article investigates the laminar mixed convection of a nanofluid confined in a square cavity, in presence of a vertical rectangular obstacle, that acts also as vortex promoter. The nanofluid is modelled according to Buongiorno's theory. The governing equations are written in a dimensionless form and numerically solved, by a finit element method, in order to determine the velocity, temperature, nanoparticle concentration and entropy generation distributions. The effect of the governing parameters, namely the Reynolds number, the Grashof number, the Lewis number, the Brownian diffusion coefficient, the thermophoretic coefficient, the buoyancy ratio and the thermal radiation parameter are investigated separately. Analyses are performed on the impact of Brownian diffusion and thermophoresis, which represent the average mobility of the nanoparticles due to temperature gradients, temperature, and concentration. Brownian diffusion still operates toward transferring nanoparticles downstream into the hot wall. However, thermophoresis prevents such migration when fluid from the cold wall shifts toward the hot wall. These opposing forces ultimately result in the formation of local accumulations of nanoparticles at the front and the establishment of local stable zones inside the flow. It is possible to see the primary and secondary vortex flows that recirculate because of this in the form of streamline patterns. Graphical drawings investigate the assisting and opposing influences of the dually moving lid; its control over the

small and high Reynolds number-driven flow regimes; and isothermal, isoconcentration, and entropy generation.
As results, for increasing values of the Reynolds number a massive vortex begins to form near the rectangular obstruction. This central giant vortex pushes the reverse flow vortex, which lessens the reverse flow effect. On the other hand, large values of Re make the cavity a better heat conductor, and the entropy generation increases. The nanoparticle concentration decreases with rising thermophoresis constraint NT and Brownian motion constraint NB. The parameters NT and NB have inverse relation with the concentration profile. The effect of NT is negligible on the average Nusselt number, in agreement with the literature. On the contrary, NB displays a noticeable effect on the mass transfer rate when the particle size is small, i.e. for small values of NT. Concerning the effect on the heat transfer, due to thermophoresis tiny nanoparticles move towards the colder region from the hotter region, again in accordance with the literature.
Keywords: Nanofluid; cavity with obstacle; Buongiorno's model; entropy generation; finite element method.

9th International Congress on Energy Efficiency and Energy Related Materials (ENEFM 2023)

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