The University of Houston's cutting edge showcase of entrepreneurial leadership in materials innovation

INNOVATION AMPLIFIED

Division of Energy and Innovation
UNIVERSITY OF HOUSTON

WELCOME TO INNOVATION AMPLIFIED

Ramanan Krishnamoorti, Ph.D.
Vice President, Energy & Innovation
University of Houston

On behalf of the Division of Energy and Innovation here at the University of Houston, I'm delighted to welcome you to our Tech Innovation Showcase!

As the innovation engine of the Energy Capital of the World, UH is home to some of the brightest, forward-thinking researchers and faculty in the world. What you will see here is just a small sample of some of the promising cutting-edge technology in our Material Sciences portfolio.

The ingenuity that goes on here at UH is poised to change the world and will address society's most pressing challenges. Our mission is to deliver solutions that the world needs, and what it needs is a cultural shift where creativity and innovation accelerates momentum into the future.

This event wouldn't be possible without the efforts of the UH Office of Technology Transfer and Innovation, the UH Division of Research, as well as the efforts of UH Energy. Thank you again for joining us for this occasion, and I welcome you the opportunity to engage with the oustanding faculty, students and researchers responsible for each technology and take consideration in partnering with them.

For more information on licensing or optioning these technologies, please reach out to the Office of Technology Transfer and Innovation contacts below:

Rick James, Director
rfjames@central.uh.edu
713.743.6601

Chanelle Mack, Asst. Director
cnmack@central.uh.edu
713.743.9722

Technology Transfer and Innovation
Division of Energy and Innovation

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

FALL 2023 TECHNOLOGY INNOVATION SHOWCASE ENTRIES

High-capacity Hydrogen Storage Through Molecularly Restructured and Confined Hydrogen Hydrates

Inventors

Rojan Firuznia, PhD Candidate, Advisor: Dr. Hadi Ghasemi

Website for UH PI

https://www.nanothermlab.com/Index.html

Abstract

In the future landscape of sustainable energies and in combating global climate challenges, hydrogen plays a crucial role in both stationary and portable energy systems that currently supply 18% of the total energy demand. High-capacity, safe, and cost-effective hydrogen storage is critical for advancing the hydrogen economy but remains a dauting challenge. A range of advanced material systems including metal hydrides, metal-organic frameworks, and 2D materials have been explored in efforts to achieve high storage capacity, but high operating pressures, low charging/discharging rates, and energy intensive discharging processes have hindered their development and deployment. Here, we report a green material paradigm for high storage capacity with fast charging/discharging and ambient temperature discharging. The material platform is a modified zeolite with rationally tuned pores and modified surface chemistry that exhibits long-term stability and stores hydrogen gas in the form of hydrogen hydrates. The selected pore dimensions enhance the hydrogen solubility through restructuring of water molecules, and the surface chemistry of the material leads to enhanced double donor- acceptor bonds with water molecules for enhanced hydrogen storage capacity. The material enables hydrogen storage in hydrogen hydrate form at 8–10 bar dropping the required storage pressure by two orders of magnitude lower compared to stateof-the-art materials and addresses long-standing hurdles of high operating pressure and slow formation kinetics of hydrogen hydrates providing a promising platform for hydrogen storage.

Fracture-Controlled Surfaces

Inventor

Sina Nazifi Takan Tappeh; Advisor: Dr. Hadi Ghasemi

Website for UH PI

https://www.me.uh.edu/faculty/ghasemi

Abstract

One of the long-standing challenges in minimizing material adhesion to an external object is satisfying both requirements of low adhesion and high mechanical durability. Without high durability, the practicality of these low-adhesion materials remains questionable. Here, we conceptualized, formulated, and demonstrated a new concept called ‘‘fracture-controlled surfaces’’ in which via mechanical and chemical heterogeneity in the material structure, we satisfy both requirements. Through these surfaces, we control the detachment of an external object from a surface through fast crack nucleation and growth at the interface with minimal energy.

The nucleated crack at the interface propagates at the interfacial plane with no side kinking. These surfaces could provide low adhesion to an external object while having several orders of magnitude higher elastic modules compared to state-of-the-art materials. A detailed mathematical model is established that could predict the adhesion of these materials to any external object and rationally guide the innovation of durable low-adhesion surfaces. Fracture-controlled surfaces promise a disruptive platform to address the above challenge and to synthesize highly durable materialswith functionalities including anti-icing, anti-scaling, and anti-fouling.

Multi-Frequency High Electric Field System for MRI Safety Test of Implantable Medical Devices

Inventors

Ji Chen, Jianfeng Zheng, Shuo Song

Website for UH PI

https://www.ece.uh.edu/faculty/chen-ji

Patent ID

UH 2020-073

Abstract

An efficient and improved electric field generator is developed to generate uniform and high strength electric fields at multiple frequencies, designed to be used in the evaluations of radio frequency (RF) related hazards for implantable medical devices (IMDs) under MRI. This system can replace the current RF-coil/ASTM phantom configuration for device testing. It can potentially be included in the standard of ASTM-F2182 for implantable device safety evaluation.

Compared to the ASTM standard test system, the new design has the advantage of low cost, improved stability in measurement, ease of fabrication and operation, and most importantly, integration of both 1.5T and 3T RF heating tests into one single fixture. A short summary is given in the table below.

	MR suites/ASTM	MR RF coil/ASTM	This system
Power requirement	2.0 KW	2.0 KW	<100 W
Space requirement	800 SF	300 SF	50 SF
Cost	1.5T ~ $1.5 millions 3T ~ $2.5 millions	~ $700K (for both 1.5T and 3T)	~ $120K + UH IP licensing

Conversion of Polyolefin Resins and Waste Thermoset Polyurethanes to Thermoset Polyurethanes

Inventors

Ronard Herrera Monegro, Megan L. Robertson, Ramanan Krishnamoorti

Website for UH PI

http://robertsongroup.chee.uh.edu/index.html

Patent ID

2483-14600 (Application No.)

Licensing Status

PROVISIONAL PATENT FILED

Abstract

The upcycling of waste plastics to durable value-added goods with long product lifetimes is an attractive solution to divert future waste from landfills and incineration. Thermoset polyurethanes (PUs) are used in applications as foams, tough elastomers, and films where material use can extend over decades. The application of hydroxyl-functionalized POs as PU materials is highly desired because of their high strength-to-weight ratio, excellent insulation, high thermal stability, impact strength, toughness, and fatigue life. We invent a strategy for transforming PO waste to thermoset PUs. The outstanding innovation here is the control of molecular weight, branching, and functionality of the PO block and understanding the role of these parameters in tuning the mechanical properties of the PUs.

The extent of PO hydroxylation provides facile tunability of the resulting crosslink density of the PU network, which typically controls important thermomechanical properties, thereby providing access to a diverse group of PU materials. Preserving the semicrystallinity of the PO in the PU network is a governing factor in the thermoset PU properties. This interplay between PO semi-crystallinity and PU network architecture can be leveraged to tune theresulting PU properties.

Fast ambient-temperature synthesis of OER catalysts for water Electrolysis/Catalysts for use in renewable energy systems

Inventors

Zhifeng Ren, Luo Yu, Shuo Chen, Zhifeng Ren, Minghui Ning

Website for UH PI

https://www.uh.edu/nsm/physics/people/profiles/zhifeng-ren/

Patent ID

Patent 1: **US 20230220570 A1** (Publication No.)
Patent 2: **2483-14400** (Application No.)

Licensing Status

Pending

Abstract

Patent 1 provides time and energy-efficient synthesis of OER catalysts for water electrolysis. An exemplary synthesis method includes dissolving amounts of $Fe(NO_3)_3 \cdot 9H_2O$ and $Na_2S_2O_3 \cdot 5H_2O$ in deionized water at ambient temperature to form a solution, placing Ni foam into the solution where the Ni foam serves as a substrate and a Ni source for growth of sulfur-doped (Ni,Fe)OOH (S-(Ni,Fe)OOH) catalysts, leaving the Ni foam in the solution at ambient temperature for a duration between one minute and five minutes to provide a treated foam where the S-(Ni,Fe)OOH catalysts grow on the substrate during the duration, and removing the treated foam from the solution after the duration.

Patent 2 provides a universal and one-step activation strategy to quickly convert stainless steel into good HER and OER catalysts. Specifically, high temperature annealing (~1200 °C) was first applied to heat the stainless steel in air. Subsequently, the heated stainless steel was quickly quenched in $Ni(NO_3)_2$ aqueous solution to activate its surface into HER and OER active species.

A Novel Acid- and Base-Free Process for High-Yield Recycling of Spent Lithium-Ion Battery

Inventor

Zhifeng Ren and Shaowei Song

Website for UH PI

https://sites.google.com/nsm.uh.edu/ren/home

Licensing Status

Available

Abstract

The demand of lithium-ion batteries is experiencing rapid growth because of the surging market of electric cars, portable electronics, and renewable energy storage needs. The limited availability of Li, Co, and Ni poses a significant sustainability challenge for the developing of energy storage needs. Meanwhile, the limited lifetime of lithium-ion battery gradually increased the burden of waste management. Therefore, seeking an efficient and environmentally friendly method to recycle lithium and other valuable materials is imperative. Currently, pyrometallurgy and hydrometallurgy are the two primary routes for recycling valuable materials in lithium-ion batteries, but their processes always involve high-temperature treatment and use of a large amount of strong acid or base leaching, which leads to challenging disposal issues. We propose an innovative recycling process for spent lithium-ion batteries without using strong acid-or baseadditives. Our proposed method has demonstrated an impressive lithium extraction efficiency of 99.3%, and 99% for Co, Cu, and Al. The operation is more economical compared with the existing technologies.

Notably, the resulting products, including cobalt sulfate ($CoSO_4 \cdot xH_2O$), lithium sulfate ($Li_2SO_4 \cdot xH_2O$), and cobalt oxide (Co_3O_4), hold the potential to be directly employed in the production of active cathode materials.

Qudits Employing Nonlinear Dielectrics

Inventor

John H. Miller, Jr

Website for UH PI

https://tcsuh.com/people/prininv/miller_john/

Patent ID

US Pat. Appl. No. 17/981,322

Licensing Status

Currently in the research & development phase

Abstract

Superconducting quantum computers use qubits based on Josephson junctions (JJs). The transmon is the most widely used qubit, and has shown progress in gating, coupling, and readout. It consists of a JJ coupled to a capacitive element (C) in a nonlinear LC resonator. The JJ acts as a nonlinear inductor (L) due to its nonlinear kinetic inductance. Due to anharmonicity, the energy levels have unequal spacing so two states can be selected to represent |o and |1. A transmon-based quantum computer achieved quantum supremacy in Google's Sycamore processor [Arute et al, Nature 574, 505 (2019)]. Such systems, unfortunately, must be cooled to about 15 mK with large, expensive dilution refrigerators. These severe cooling requirements make today's quantum computer look like an old mainframe system and impede wider applicability. The proposed qubit (or qudit for ≥ 2-state) concepts interchange the roles of which element is nonlinear in the LC resonator. The inductive component L can be the material's own kinetic inductance, an element that is superconductive but linear, or a series JJ array. The capacitive component (C) employs a nonlinear dielectric material. Suitable materials include, but are not necessarily limited to, those that form charge and spin density waves (CDWs & SDWs), quantum paraelectrics (QPs), and ferroelectrics. The qubits, and extensions such as qutrits and qudits, are expected to have significant, potentially gamechanging advantages over existing technologies. Large CDW Peierls energy gaps suppress quasiparticle poisoning, a source of decoherence. Converted to temperature, for superconducting aluminum the BCS energy gap is ~4.2 K, vs. Peierls gaps of ~2000 K in some CDWs. One would thus expect comparable quasiparticle poisoning at ~7 K for the proposed device vs. 10-20 mK for existing technologies. Due to coherence among many parallel CDW chains (or phonons for QPs), the proposed qubit is expected to behave as a macroscopically occupied ensemble of many qubits acting in concert. The "quantum" of charge for a fluidic CDW soliton domain wall is 2eN, where N is the (large, ~ 109) number of parallel chains in the crystal. The condensation (macroscopic occupation) of many boson-like entities within the qubit (or qudit) states is expected to significantly increase the operating temperature. Importantly, our qubit concepts will be compatible with existing gating, coupling, readout, and pulsesequence methodologies. This will provide significant advantages for design and scalability as compared to topological quantum computing based on Majorana fermions. Finally, nonlinear dielectric regions can be much thicker than the insulating barriers in JJs, improving ease of manufacturing and uniformity.

All-Solid-State Lithium Secondary Battery And Method of Preparing the Same

Inventors

Yan Yao, Lihong Zhao, Liqun Guo, Benjamin Emley, Chaoshan Wu, Zheng Fan

Website for UH PI

http://yaoyangroup.com/research

Patent ID

2023-066; 2024-006

Licensing Status

Discussion

Abstract

Rechargeable batteries with extended service life have been developed for use in implantable medical devices. Applications in implantable devices demand batteries with high safety standards, reliability, superior energy density, and prolonged cycle life, especially when operating within the human body's temperature range. Traditional liquid-electrolyte batteries pose inherent risks of gas formation and electrolyte leakage, which could have severe consequences for the human body. All-solid-state batteries emerge as a promising solution for implantable applications due to their exceptional safety profile and high energy density. However, forming and maintaining stable solid–solid contact between the lithium anode and solid electrolyte remains a major challenge in all-solid-state batteries. During charging and discharging, dramatic volume change in the Li metal anode leads to void formation, contact loss, and nonuniform deposition at the metal–electrolyte interface, ultimately resulting in cell short-circuiting. To address these challenges, an interlayer is introduced to buffer the volume change, as well as to homogenize the current distribution during cell operation. This approach significantly enhances the reliability and cycle life of solid-state batteries. At the UH, we have pioneered the development of advanced interlayers that enable room-temperature cycling of all-solid-state batteries at high rates. By optimizing interlayer microstructure, we facilitate Li transport in the material, eliminating the need for elevated temperatures as reported in prior studies.Moreover, we have engineered noble-metal-free interlayers that significantly reduce material costs and overall cell weight. As a result, we can manufacture all-solid-state batteries that meet the stringent criteria for implantable applications, boasting high safety (no liquid), reliability (no short-circuiting), superior energy density (456 Wh/L), and extended cycle life (2500 cycles).

Chemo-Thermo-Piezoresistive Highly Sensing Smart Cement with Integrated Real-Time Monitoring System

Inventor

Cumaraswamy Vipulanandan Ph.D., P.E.

Website for UH PI

http://cigmat.cive.uh.edu

Patent ID

10,481,143

Licensing Status

Received

Abstract

For a successful oil well and gas well cementing operations, it is critical to determine the flowing of cement slurry between the casing and formation, depth of the circulation losses and fluid loss, setting of cement in place and performance of the cement after hardening. Recent case studies on cementing failures, including the disaster in the Gulf of Mexico in 2010, have clearly identified some of these issues that resulted in various types of delays in the cementing operations. At present there is no technology available to monitor cementing operations in real time from the time of placement through the borehole service life. Also, there is no reliable method to determine the length of the competent cement supporting the casing. In this innovation well cement was modified (conductive filler < 0.1% of cement)* to have better sensing properties (chemo-thermo-piezoresistive), smart cement*, so that its behavior can be monitored at various stages of construction and during the service life of wells. The critical sensing property for the smart cement has been identified. The smart cement is a bulk sensor with no sensors buried in it. A series of experiments evaluated well cement behavior with and without modifications in order to identify the most reliable sensing properties that can also be relatively easily monitored. Tests were performed on the cement from the time of mixing to hardened state behavior. During the initial setting the electrical resistivity changed with time based on the type and amount of additives used in the cement. A very reliable real-time monitoring system has been developed (brain of the system) to monitor the changes in the bulk smart cement. A new quantification concept has been developed to characterize cement curing based on electrical resistivity changes with curing time. When cement was modified with less than 0.1% of conductive fillers* (special method developed in CIGMAT lab), the piezoresistive behavior of the hardened smart cement was substantially improved without affecting the cement rheological and setting properties. For the smart cement the resistivity change at peak compressive stress was over 1000 times higher than the change in the strain (0.2%). Also low level of contamination of the smart cement could be detected. Also methods are being developed to repair the damaged smart cement (chemo-thermo-piezoresistive) in situ.

Rapid Detection and Quantification of Surface & Bulk Corrosion & Erosion in Metals & Non-Metallic Materials with Integrated Monitoring System

Inventor

Cumaraswamy Vipulanandan Ph.D., P.E.

Website for UH PI

http://cigmat.cive.uh.edu

Patent ID

10,690,586

Licensing Status

Received

Abstract

Corrosion of metals and non-metallic materials is one of the oldest problem that has ever challenged the industrial world. The estimated losses due to corrosion problems are in the billions of dollars per year in the US alone. Corrosion is the gradual physiochemical-thermo-mechanical destruction of materials by the action of the environment and applied loading conditions. Corrosion of the material will result in degrading many other material properties. At present there is no realtime technology available to rapidly detect corrosion in a non-destructive way in situ from very small to very large area of the material in the laboratory to the field.

In this innovation, critical monitoring property of the material (metals, non-metals and interfaces) has been identified. This is a nondestructive contact method of detecting the corrosion and the level of corrosion can be quantified real-time. The method can be used in the laboratory and in the field. The innovative contact method can be used on steel, other metals, plastics and interfaces. The method will quantify the corrosion based on bulk properties and contact properties. A series of experiment have been performed on small (laboratory samples) and large (beams, columns) samples to demonstrate the concept. (LCR Meter: Inductance (L), Capacitance (C), Resistance (R)).

Inventions for Zeolite Catalysts Optimization

Inventors

R. Jain, H. Dai, Y. Shen, M. Kumar, M.T. Conato, M.D. Oleksiak

Website for UH PI

https://rimergroup.com/

Abstract

The ultrasmall channels and cages of zeolites have been widely used as shape-selective heterogeneous catalysts for numerous applications in the energy and chemicals industries. A common objective of zeolite crystal engineering is to overcome the inherent mass transport limitations of these nanoporous materials. Here we present four inventions that utilize facile synthesis protocols todramatically enhance the performance of zeolite catalysts for a variety of reactions. Invention 1 is a novel approach to introduce small nanosized protrusions on the exterior surfaces of a catalyst, referred to as “fins”, which have been demonstrated for multiple zeolite structures, including commercial materials. These crystalline features transform larger particles into pseudo-nanoparticles where their catalytic activity, lifetime, and selectivity are markedly improved over their conventional counterparts. Invention 2 is a cost-effective technique to produce hierarchical ZSM-5 zeolites with architecture comprised of pillared nanosheets. This approach is an organic-free synthesis that generates pillared zeolites in much higher product yield and with a substantially higher density of acid sites than approaches reported in literature. We have demonstrated that these materials greatly outperform conventional ZSM-5 in both gas and liquid phase reactions. Invention 3 is a synthetic approach that uses two organic structuredirecting agents to cooperatively promote the crystallization of mordenite (a commercial zeolite) with ultrathin dimensions.

The use of cooperative structure-directing agents has been used by our group to tailor the properties of zeolites, such as the creation of silica-zoned materials with enhanced mass transport properties. Invention 4 is a new approach to generate zeolite FAU (faujasite) with the highest silicon content for an organic-free synthesis. Achieving high Si/Al ratios for this commercial catalyst is a major objective for improving its hydrothermal stability. Collectively, the inventions presented here offer facile, commercially-feasible routes to alter existing processes for zeolite production in ways that will produce superior products.

Apparatus and Methods for Medical Applications of Laser-driven Microfluid Pumps

Inventors

Wei-Kan Chu, Jiming Bao, Di Chen, Shuai Yue and Tian Tong

Website for UH PI

https://www.uh.edu/nsm/physics/people/profiles/wei-kan-chu/

Abstract

In the year 2020, we invented a laser streaming process using optical fibers. This device, integrating a quartz fiber implanted with gold nanoparticles, leverages laser energy to generate ultrasound waves for propelling fluids. The unique aspect is it has no moving parts, controlled solely by laser beams. We started a company named Quantum Med (QM). QM licensed the IP from the University of Houston and applied to the NSF, obtaining funding from the NSF SBIR program. During the first year of the grant, we constructed prototypes and conducted experiments, proving the concept of liquid handling and mixing. We plan to extend our invention to drug delivery and gene therapy applications. In this poster presentation, we will showcase preliminary ongoing experimental activities with potential applications. The objective of this presentation is to attract more support or collaborators to advance our NSF SBIR project into its second year phase and eventually move QM towards an IPO stage four years from now

Catalysts for Microwave Reforming of Hydrocarbons

Inventors

Xiaonan Shan, Jiefu Chen

Website for UH PI

https://shanlab.ece.uh.edu/ https://modal.ece.uh.edu/

Patent ID

63/443,924

Licensing Status

Provisional patent submitted, and full patent application approved

Abstract

1)The proposed method provides an efficienty wave to convert the methane to hydrogen using microwave heating. Especially, it can be used for methane pyrolysis which will generate hydrogen without any carbon emission. The method will efficiently and selectively convert the microwave energy to heat onthe catalysts for high efficient methane conversion to hydrogen.

2) Microwave heating has been used to heat up the catalyst for methane conversion to hydrogen. However, the efficiency of microwave adsorption is highly depended on the geometry and material properties of the catalyst structure.

3) The proposed method is based on the design and optimize the catalyst structure's geometry and material compositions to increase the microwave adsorption efficiency, and the conversion efficiency to transfer the microwave energy to heat.

4) High efficient

5) Different geometry and materials will have different adsorption efficiency for the microwave, control and design both geometry and materials structure will allow us control and improve the overall energy conversion rate.

6) In addition, we can control the temperature distribution on the catalyst structure by controlling the geometry and especially the materials.

Stretchable Fabric Based Electrode-Polymer Electrolyte Battery

Inventors

Haleh Ardebili, Bahar Moradi

Website for UH PI

https://www.me.uh.edu/faculty/ardebili

Patent ID

20200136101

Licensing Status

Not Licensed

Abstract

A flexible and stretchable fabric-based electrode-polymer electrolyte battery described herein comprises at least one electrochemical cell. The electrochemical cell comprises a first stretchable electrode having a first active material coupled with a first stretchable fabric current collector, a second stretchable electrode having a second active material coupled with a second stretchable fabric current collector, a stretchable separator configured between the first and second electrodes, and at least one stretchable encapsulant material, wherein the stretchable material encapsulates the electrochemical cell and is capable of reversible bending, twisting, folding and stretching.

Advanced polymer electrolyte membranes for energy conversion & green-H_2 production large scale manufacturing protocol

Inventor

Anima Bose

Website for UH PI

https://dot.egr.uh.edu/departments/et/people/faculty/bose-anima

Patent ID

US 2483-141000

Abstract

Fuel cells are a clean and efficient power generation device, and they are of many kinds. Among them, Polymer Electrolyte Membranes Fuel Cell (PEMFC) can provide power for a wide range of applications and is an especially good candidate for transportation. The polymer electrolyte membrane (PEM) is one of the key components of PEM based fuel cell, electrolyzer, flow battery, and also used in separation processes. NafionTM is still holding the state-of-the-art (SoA) PEM membrane for 50 years plus [1], but water flooding and radical attack causes untimely degradation of NafionTM membrane in electrochemical device operation. On the other hand, other inherent problems are mechanical stability and unstable ion (Proton, H+) conductivity that affects performance and stability of PEMFC [2]. This invention herein, named as NafionTM-Plus, not only resolved the 50 years inherent issues of NationTM, but also brought a solution for reducing the reactant crossover [3] [4]. In addition, NafionTM-Plus offers stable proton conductivity at elevated temperatures above 80 oC. In brief, the mechanical stability and chemical stability of NafionTMPlus are improved by 70% and 50% respectively compared to the SoA NafionTM membrane. Unstable power delivery due to uncontrolled swelling are corrected through this invention.

For example, NafionTMPlus offers peak power 1800 mW cm-2 compared to 1000 mW cm-2 generated by SoA NafionTM , and demonstrated 40% higher durability. The membrane also showed better performance in water electrolysis setup (2.25 V at 0.625 A cm-2 at room temperature).

CSense

Inventors

Summer Dalgamouni, Driss Benhaddou & Stanko Brankovic

Website for UH PI

https://ecnfg.ece.uh.edu/

Patent ID

2024-016

Licensing Status

Pending

Abstract

CSense is an innovative and highly sensitive sensor designed to deliver real-time, in-line measurements of chlorine levels in water and water-based environments. This Intellectual Property encompasses the development of cutting-edge sensor technology utilizing gold-coated Fiber Bragg Grating (FBG) fibers and electrocapillarity phenomenon to create a highly sensitive sensor. This sensor offers a vital sensing for ensuring water safety and quality across a range of applications, including medical devices and industrial processes. Through the utilization of FBG sensing technology, CSense not only provides precise and continuous chlorine level monitoring but also concurrently captures essential data on temperature and pressure as well. Key Features and Components: Gold-Coated Fiber Bragg Grating (FBG) Sensors: CSense harnesses the unique properties of goldcoated FBG sensors, which exhibit remarkable sensitivity to changes in strain levels around the FBG area. Gold Coating: The utilization of gold's electrocapillarity i.e. sensitivity to chlorine adsorption enhances the sensor's response accuracy to chlorine concentration making the adsorption process reversable and exceptionally effective in detecting even minor fluctuations in chlorine concentration. Multi-Parameter Data Acquisition: Beyond chlorine measurement, CSense captures real-time data on temperature and pressure within the water supply. This comprehensive data suite enables the early detection of chemical contamination events. Applications: CSense's versatility extends its utility across various domains:Medical Devices: In healthcare settings, CSense ensures the water used in medical equipment meets rigorous quality standards. Continuous monitoring guarantees patient safety during medical procedures.Industrial Processes: Industries, such as pharmaceutical manufacturing, food production, and semiconductor fabrication, benefit from CSense's precision water quality control, enhancing product quality and process efficiency. Environmental Monitoring: CSense plays a vital role in environmental protection by promptly detecting water contamination events, safeguarding ecosystems, and public health. Municipal Water Treatment: Municipalities integrate CSense into water treatment facilities to optimize disinfection processes and adhere to regulatory standards.

New Liner Technology for Repurposing NG Pipelines for Hydrogen Transport

Inventors

Nafiseh Amiri, Ishtiaq Rabbi and Stanko Brankovic

Website for UH PI

www.ecnfg.ece.uh.edu

Licensing Status

IN PROGRESS

Abstract

Hydrogen can ingress into structural materials and lead to detrimental effects due to hydrogen embrittlement and stress corrosion cracking. It introduces a big risk in the transportation and storage of hydrogen, as it can gradually diffuse into the pipelines and storage containers, reducing the strength of steel, and resulting in serious consequences. Therefore, finding a convenient way to reduce hydrogen embrittlement of materials is of great importance. To provide protection from hydrogen permeation synthesis and deposition of hydrogen permeation barriers on the surface facing high concentrations/pressures of hydrogen-containing environment is developed. Many existing coatings require extreme conditions for their synthesis which make their application impractical.

Our invention is based on the design and characterization of hydrogen permeation barrier (HPB) coatings on high carbon steel (construction material) with minimum investments and alterations of the existing structures. We have successfully developed room temperature chemical deposition for high-quality Cu-based HPB films on high-carbon steel material which shows more than 200 times permeation reduction factor. Because of the simple synthesis method and the fact that our method is electroless deposition and room-temperature procedure, this Cu-coatings can be an unrivaled candidate in protecting and repurposing existing natural gas (NG) pipelines.

Polyolefin Recycling with Cellulose Nanocrystals

Inventors

Megan L. Robertson, Ibrahim Kamara, Ramanan Krishnamoorti, Alamgir Karim

Website for UH PI

http://robertsongroup.chee.uh.edu/index.html

Patent ID

63/530,809

Licensing Status

Provisional patent filed

Abstract

Reuse and recycling of polyolefin (PO) waste is low due the presence of multiple components and downgrade of properties after recycling. Mechanical recycling of PO waste is proving to be limited due to technological, scientifical and economical challenges. Hence, a new commercial approach targeted to recycle wide variety of PO waste would significantly improve recycling landscape. Our invention provides strategy for upcycling and/or recycling PO through reinforcement and property modification. The innovative approach involves functionalizing cellulose nanocrystals (CNCs) with polymer chains and addition to PO waste to enables polyolefin recycling and circularity.

Since CNCs are not compatible with PO, we modified the CNCs by grafting PO to the CNCs using melt extrusion to create a universal compatibilizer and adding to PO waste. The effectiveness of functionalized CNCs as property modifiers and compatibilizers for PO waste was validated by reduction in average particle size of the domain and increase in tensile strength and elongation at break. This technology can be leveraged to recycle mixed PO waste into high value goods while maintaining and/or enhancing physical properties of the mixed PO waste.

Methods and systems for fabricating High-quality Superconducting Tapes

Inventors

Goran Majkic and Venkat Selvamanickam

Website for UH PI

https://selva.me.uh.edu/ https://www.me.uh.edu/faculty/majkic
https://www.me.uh.edu/research/laboratories-facilities/gm-2d-xrd-facility

Patent ID

9,892,827; 11,417,444; 11,410,797

Licensing Status

Licensed (SuperPower, Inc.)

Abstract

An MOCVD system fabricates high quality superconductor tapes with variable thicknesses. The MOCVD system can include a gas flow chamber between two parallel channels in a housing. A substrate tape is heated and then passed through the MOCVD housing such that the gas flow is perpendicular to the tape's surface. Precursors are injected into the gas flow for deposition on the substrate tape. In this way, superconductor tapes can be fabricated with variable thicknesses, uniform precursor deposition, and high critical current densities.

Quality Control of High Performance Superconductor Tapes

Inventors

Goran Majkic and Venkat Selvamanickam

Website for UH PI

https://selva.me.uh.edu/ https://www.me.uh.edu/faculty/majkic
https://www.me.uh.edu/research/laboratories-facilities/gm-2d-xrd-facility

Patent ID

11,393,970

Licensing Status

Currently implemented as external service to 2G-HTS superconductor manufacturers

Abstract

A superconductor tape and method for manufacturing, measuring, monitoring, and controlling same are disclosed. Embodiments are directed to a superconductor tape which includes a superconductor film overlying a buffer layer which overlies a substrate. In one embodiment, the superconductor film is defined as having a c-axis lattice constant higher than 11.74 Angstroms. In another embodiment, the superconductor film comprises $BaMO_3$, where M=Zr, Sn, Ta, Nb, Hf, or Ce, and which has a (101) peak of $BaMO_3$ elongated along an axis that is between 60° to 90° from an axis of the (001) peaks of the superconductor film. These and other embodiments achieve well-aligned nanocolumnar defects and thus a high lift factor, which can result in superior critical current performance of the tape in, for example, high magnetic fields.

Materials and Methods for Iodine Capture

Inventors

O.S. Miljanic; A. Robles

Website for UH PI

www.miljanicgroup.com

Patent ID

18/216,181, filed on June 29, 2023. UHID# 2023-027

Licensing Status

NOT LICENSED

Abstract

New organic materials for the capture of iodine from a variety of sources have been developed. Small organic molecules based on cyclotetrabenzil hydrazones are capable of capturing elemental iodine, as well as triiodide and iodate forms, from aqueous and organic solutions, vapor, and aqueous-organic interfaces. This last feature is particularly important in maintaining the integrity of the so-called nuclear paint, used to coat the insides of nuclear reactors and waste containment vessels. By preventing radioactive iodine from reaching this paint, its degradation and the formation of radioactive and carcinogenic organic iodides can both be prevented.

Cyclotetrabenzil Compounds for Electrochemical Lithium-Ion Storage

Inventors

O.S. Miljanic; Y. Yao; S. Jalife; J. I. Wu; A. Robles

Website for UH PI

http://www.miljanicgroup.com/

Patent ID

18/216,410, filed on June 29, 2023. UHID# 2023-051

Licensing Status

NOT LICENSED

Abstract

New organic materials for lithium-ion batteries have been developed. Organic electrode materials circumvent the need for inorganic cobalt- and phosphate-based electrodes, which are problematic because of their low abundance and unsustainable mining practices. Our team has developed new compounds for electrochemical lithium ion storage using small organic molecules known as cyclotetrabenzils, which were pioneered by the PI's group. These compounds are characterized by eight redox active groups per molecule which can be reversibly oxidized and reduced. The best performing of these electrode materials shows an electrochemical capacity of 279 mAh g–1, 65% capacity retention after 135 cycles, and low solubility on account of the hindered rotation around the compound's C2–C6 axis.

Crack-Free Ultrawide-Bandgap Group-III-Nitride Semiconductor Films Deposited on Silicon Substrate

Inventors

Jae-Hyun Ryou, Mina Moradnia, Sara Pouladi, Muhammad Aqib

Website for UH PI

http://ryouteam.me.uh.edu/default.html

Patent ID

UHID 2023-054 / 63532595 (Provisional patent application)

Licensing Status

NONE

Abstract

Disclosed are new methods for the epitaxial growth and deposition of crack-free single-crystalline group-III-nitride (III-N) semiconductor films including AlN and AlGaN on Si substrates to address the current technical challenges in high-quality ultrawide-bandgap semiconductor materials and devices. In this invention disclosure, we introduce several schemes of (1) epitaxial metallic interlayers and (2) superlattice structure consisting of alternating AlN and metal layers between Si (111) substrate and III-N thin film to reduce the in-plane tensile strain or to change the strain to in-plane compressive strain in the film. (3) We also introduce a new route of epitaxial lift-off using water for a film transfer process. This approach offers a new opportunity to overcome the technical challenges of III-N devices for electronic, photonic, energy, and sensing applications with improved performance characteristics and functionalities while reducing manufacturing costs.

Skin-attachable Sensor System and Method for Tracking Eye Movement and Position

Inventors

Jae-Hyun Ryou, Nam-In Kim

Website for UH PI

http://ryouteam.me.uh.edu/default.htm

Patent ID

UHID 2021-054 / US 63/213,048, PCT/US2022/034279

Licensing Status

NONE

Abstract

We disclose a method to continuously track the movement of eyeballs in all the possible directions, including lateral, vertical, diagonal, and rotational movements, using a compact arrayed sensor network that can be attached on the temple area of the face. Disclosure are principles of sensing, fabrication methods, and unique applications of highly sensitive and biocompatible flexible piezoelectric eyemovement sensors using group III-nitride (III-N) thin films with single-crystalline structure. We claim several details in this invention disclosure. First, the III-N TFs, including aluminum nitride (AlN), gallium nitride (GaN), indium nitride (InN), and their alloys, are used for sensing an element of the eye movement sensors. Second, the sensors can be comfortably attached on the temple area of a face to detect the various movements of eyeballs. Third, detailed eye-related motions are monitored by the sensor network. Fourth, measurement results of the sensor can be used (1) to evaluate the eye and brain fatigue, (2) as an indicator for the diagnosis of several brain-related diseases, and (3) compact eye tracking in personal electronic systems including virtual reality and augmented reality.

Systems & Methods for Wireless Transmission of Power in Deep Subsurface Monitoring

Inventors

Jiefu Chen, Xiaonan Shan, Miao Pan, Yong Wei

Website for UH PI

https://modal.ece.uh.edu/ https://shanlab.ece.uh.edu/

Patent ID

WO2021102270A1

Licensing Status

Full patent submitted

Abstract

A reliable and cost-effective wireless telemetry system using the electromagnetic waves for the realtime subsurface monitoring (e.g. CO2 sequestration) is developed. An array of toroidal transceivers are deployed winding around the highly conductive casing string for wireless data transfer between surface and deep subsurface, and energized casing technique is utilized to charge

the toroidal transceivers and subsurface sensors. This novel wireless telemetry system will help to maintain well integrity and reduce potential leakage by eliminating the needs for perforated casing or an umbilical in the cement annulus since no direct path of fluid (e.g. oil and gas, underground water, CO2) leakage is induced by this wireless system. This approach has two elements. First, develop a reliable and cost-effective wireless telemetry system for real-time data transmission of meaningful measurements from deep subsurface to surface, and from the surface to deep subsurface. Second, develop a wireless power transfer system tocharge the downhole antennas and subsurface sensors using energized casing. This system can also be used to operate downhole well equipment including sensing, control, and telemetry devices.

Simultaneous CO_2 Capture, Mineralization, & Lithium & Other Metal Extraction from Brine

Inventors

Mim Rahimi, Xiaonan Shan

Website for UH PI

https://teamrahimi.com/ https://shanlab.ece.uh.edu/

Patent ID

63/346,187

Licensing Status

Full patent submitted

Abstract

1) The proposed process will simultaneously remove carbon dioxide (CO_2) from the atmosphere and extract lithium (Li) and other metals from brine.

2) The brine could be any salt containing solution, including: produced water from oil industry, sea water, or salt water from lakes;

3) During this process, we will also provide H_2, Cl_2 and fresh water.

4) The benefit of this technique:
- CO_2 capture
- Critical minerals extraction for battery (including Li);
- Fresh water generation;
- Hydrogen production;
- Other useful resources generation: metal salts, and Cl_2.
- We will use renewable energy.

FACULTY/PRINICIPAL INVESTIGATORS

- Alamgir Karim
  akarim3@central.uh.edu
- Anima Bose
  abbose@central.uh.edu
- Haleh Ardebili
  hardebil@central.uh.edu
- Jiming Bao
  jbao@central.uh.edu
- Goran Majkic
  gsmajkic@central.uh.edu
- Hadi Ghasemi
  hghasemi@central.uh.edu
- Jae-Hyun Ryou
  jryou@central.uh.edu
- Jeffrey Rimer
  jrimer@central.uh.edu
- Ji Chen
  jchen23@central.uh.edu
- John Miller
  phys5k@central.uh.edu
- Megan Robertson
  mlrobert@central.uh.edu
- Mim Rahimi
  mrahimi@central.uh.edu
- Ognjen Miljanic
  omiljani@central.uh.edu
- Venkat Selvamanickam
  vselvama@central.uh.edu
- Stanko R. Brankovic
  srbranko@central.uh.edu
- Cumaraswamy Vipulanandan
  cvipulan@central.uh.edu
- Xiaonan Shan
  xshan@central.uh.edu
- Yan Yao
  yyao4@central.uh.edu
- Zhifeng Ren
  zren2@central.uh.edu

UH Technology Bridge

WHAT WE OFFER:

STATE OF THE ART WET LABS
Equipped with fume hoods, RO water and sinks, shelving, emergency power, chemical and flammable cabinets, eye wash, safety showers and lab benches.

GRANT WRITING SUPPORT
Assistance with Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs.

ONSITE ADVISOR ACCESS
Representing the University of Houston Small Business Development Center.

OFFICE HOURS
Offering pro-bono legal office hours from partnering firms

INNOVATION CENTER
Access to conference rooms, event spaces and co-working spaces for startups and established companies.

NETWORKING OPPORTUNITIES
Connect with fellow entrepreneurs at the faculty and student levels for ideation.

MENTORSHIP
Unmatched access to UH faculty and one-one-one mentorship opportunities.

RESOURCES
Whether programming or educational-related, tenants have unparalleled support from UH Technology Bridge.

FREE BEVERAGES
Complimentary coffee and tea on hand.

24/7 ACCESS
No matter the day or time, tenants have access to the grounds.

Need assistance with your startup venture? UH Technology Bridge can support you on your entrepreneurial journey!
Scan the QR code to learn more or email us at:

ottitb@central.uh.edu

UH Technology Bridge Bldg. 4 | 5000 Gulf Freeway | Houston, TX

LEADING INNOVATION

2023 NAI Senior Members at UH: Shishir Shah, Triantafillos Mountziaris, James Briggs & Gomika Udugamasooriya

WHO WE ARE

At the University of Houston, we spur innovation by encouraging the very spark of an idea to the transfer of knowledge and technology. The UH ecosystem powers the innovation engine that the Energy Capital of the World runs on, and by fostering a strong entrepreneurial environment that supports new innovation and startup ventures through incubator and accelerator programs and resources, our excellence has earned UH the distinction of being an Innovation and Economic Prosperity University.

UH's Office of Technology Transfer and Innovation is industry's gateway to innovation.

2022 NAI Fellow Hao Huang, Distinguished Adjunct Professor at the Cullen College of Engineering

WHAT WE DO

- **Nation's #1 Entrepreneurship Program**
- **Ranked in Top 100 Global Universities for Patents seven years running**
- **Home to 50+ startup companies**
- **Three UH-affiliated Student Teams competed at DOE's EnergyTechUP National Pitch Competition**
- **350 Student Businesses Started**
- **Nearly 150 UH faculty members recognized for receiving major grants or patents in FY 20 and 21.**
- **An annual average of more than $60 million in licensing income in FY19, FY20 and FY21**

UH AND THE NAI

- **35 total members**
- **17 NAI Fellows**
- **18 Senior Members**

/uhenergy
@uhenergy
@uhoustonenergy

Division of Energy and Innovation
UNIVERSITY OF HOUSTON

AFFLIATIONS, PARTNERS AND ORGANIZATIONS

TEXE
THE ENERGY COALITION UNIVERSITY OF HOUSTON
UH Technology Bridge

JOIN THE CONVERSATION

@uhenergy

@uhoustonenergy

UH Energy

uh.edu/uh-energy

Division of Energy and Innovation

UNIVERSITY OF **HOUSTON**