Topical Symposia
Room Pacific F-G - Session TS2-TuA

Sustainable Surface Solutions, Materials, Processes and Applications

Moderators: Justin Cheney, Oerlikon Balzers Coating, USA, **Prof. Fan-Bean Wu**, National United University, Taiwan

1:40pm **TS2-TuA-1 Application of High Entropy Spinel Oxides on Photodetector**, ***Jyun-Yi Li,*** *K. Kuo,* National Cheng Kung University (NCKU), Taiwan*; T. Nguyen,* National Cheng Kung University (NCKU), Taiwan, Viet Nam*; P. Hsiao, C. Chen, J. Ting,* National Cheng Kung University (NCKU), Taiwan

Photodetector as a widely use application in daily life, such as environmental monitoring, biological /chemical analysis, and communication, is often to be constricted to work in the certain wavelength due to the materials inside. Recently, a new concept of high entropy oxides (HEO) has been proposed, which is consisted of more than five metals with concentration of each metal in range of 5-35% and having a calculated configurational entropy ΔS ≥1.5R. Although there have been many studies on high entropy oxides, few of them have focused on photodetectors. Herein, we synthesized a series of high entropy spinel oxides with hydrothermal method and apply on photodetector. The crystal structure of materials were confirmed using X-ray diffraction (XRD). The morphology was characterized with scanning election microscope (SEM). Besides, the material were also characterized using inductively coupled plasma (ICP), X-ray photoelectron spectroscopy (XPS), transmission electron microscope (TEM), …. .The optical performance of HEO photodetector were evaluated by UV-VIS-NIR, responsivity(R), external quantum efficiency (EQE), detectivity (D), rise time and decay time.

Keywords: high entropy oxide(HEO), spinel,photodetector, responsivity, EQE, detectivity

2:00pm **TS2-TuA-2 Euro 7/VII – Challenges for Surface Solutions in ICEVs and EVs**, *J. Vetter,* Oerlikon Balzers Coating Germany GmbH, Germany*;* ***Justin Cheney,*** Oerlikon Balzers Coating, USA*; J. Becker,* JB, Germany*; M. Esselbach,* Oerlikon Surface Solutions AG, Liechtenstein

The upcoming Euro 7 standards are aimed to further reduce pollutant emissions from vehicles and improve air quality. Euro 7 is valid not only for passenger car but also for heavy-duty vehicles. The proposed standard will influence the development of internal combustion engine vehicles (ICEVs) and electric vehicles (EVs) alike.

After all the drivetrain of ICEVs and EVs is quite similar and the requirements with respect to improved long-life performance and reduced particle emission may be even more challenging with EVs. Surface solutions are ready to work as an enabler to reach the goals. E. g. coatings allow a longer lifetime of drive train components which otherwise suffer from the higher torque of an electric motor.

Besides the well-known tribological coatings for engines and drive-train other coatings are of interest. Examples are coatings which allow to measure stress, pressure, or temperature, insulating coatings or conducting coatings for connectors of batteries.

Coatings for hydrogen applications will be discussed. Hydrogen applications can be found in fuel cells, the periphery of fuel cells, but also in hydrogen ICEs.

Whatever coating solution may come up, the requirements of a circular economy need to be an integral part of a system.

2:20pm **TS2-TuA-3 Surface Technology as a Key Technology for New Energy Systems**, ***Yashar Musayev,*** *L. Dobrenizki,* Siemens Energy Global GmbH & Co. KG, Germany **INVITED**

Siemens Energy is one of the world's leading energy technology companies. The company works with its customers and partners on energy systems for the future, thus supporting the transition to a more sustainable world. With its portfolio of products, solutions and services, Siemens Energy covers almost the entire energy value chain – from power generation and transmission to storage. The portfolio includes conventional and renewable energy technology, such as gas and steam turbines, hybrid power plants operated with hydrogen, and power generators and transformers. More than 50 percent of the portfolio has already been decarbonized. An estimated one-sixth of the electricity generated worldwide is based on technologies from Siemens Energy.

Using renewable electrical energy like wind or solar power for "green electrons" from the power sector to decarbonize energy across all sectors unlocks enormous environmental and business benefits. Through Power-to-X technologies, sectors beyond power generation will benefit from renewable power and become increasingly green over the total chain from production to application.

Siemens Energy will provide optimum solutions in order to contribute to the realization of a carbon-neutral society in countries and regions around the world by utilizing our hydrogen related technologies, business and global network. The joint vision of the two companies is to advance the technology to produce green hydrogen from innovative PEM (Proton Exchange Membrane, Fig.1) water electrolysis using renewable energy systems. PEM water electrolysis (Fig.2) enables the production of high-purity green hydrogen. The resulting green hydrogen can not only be used for large-scale power generation and other electric power applications, but also for sector coupling such as heat, transport, and industrial applications.

An PEM-electrolysis cell consists of a MEA (Membrane Electrode Assembly; Catalyst Coated Membrane) as well as porous structures (gas diffusion layer & fleece) on both sides for the distribution of product gases. The cells are separated in the segment by bipolar plates. The PEM-systems have been further developed regarding efficiency, service life and cost-effectiveness. The key performance indicators (KPIs) of an electrolysis stack can be derived from the current-voltage and voltage-time curves.

4:00pm **TS2-TuA-8 Progress on Piezoelectrocatalysis for Hydrogen Production and Environmental Science**, ***Jyh-Ming Wu,*** National Tsing Hua University, Taiwan **INVITED**

Continual technological advancements have substantially improved peoples' quality of life; however, excessive energy consumption and improper waste management have caused tremendous environmental disruption. Unrestricted fossil fuel exploitation contributes to greenhouse gas emissions, precipitating climate change, and the discharge of large amounts of industrial wastewater has deteriorated natural ecologies and contributed to severe health problems. Solutions involving the remediation of water pollutants, water splitting, and clean energy alternatives have been widely investigated. Specifically, electrocatalytic and photocatalytic water splitting are potentially promising strategies for hydrogen gas production and polluted dye decomposition.

This talk will report how 2D transition metal dichalcogenides can be used for piezocatalyts for highly efficient wastewater treatment and hydrogen production without applied light irradiation. Furthermore, we will report that a new generation of piezocatalyts — A self-powered photoelectrochemical microsystem comprising quartz prism microrods assembled with TiO_2 nanoparticles or MoS_2 nanosheets developed and demonstrates a marked catalytic effect on organic dye degradation and hydrogen evolution through a piezopotential sensitized catalytic activity. The induced piezopotential not only tilted the band structure to accelerate the separation of photoexcited carriers but also restrained their recombination, contributing to a more efficacious catalytic reaction. A self-poweredelectrochemical microsystem realizes the remarkable coupling effect of piezocatalysis and photocatalysis on different applications, introducing a potential material and strategy to environmental science and renewable energy fields.

References:

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3. M.-C. Lin, S.-N. Lai, K. T. Le, and J. M. Wu*, Nano Energy, 91. 106640, 2016.

4:40pm **TS2-TuA-10 Visible Light Activated Photocatalytic Coatings by Reactive Magnetron Sputtering for Environmental Applications**, ***Peter Kelly,*** John Dalton Building, Chester Street, UK*; M. Ratova, J. Redfern,* Manchester Metropolitan University, U.K.

Photocatalytic coatings and materials have many potential applications, such as removal of organic pollutants in water and air supplies, antimicrobial and anti-viral surfaces, self-cleaning glass and building materials and the production of hydrogen via water splitting. However, the most widely known photocatalytic material, titanium dioxide in the anatase form, is limited by its low quantum efficiency and wide band gap (3.2 eV), which means it requires UV light for activation. Band gap narrowing can be

achieved by doping the anatase, but this can increase the recombination of the holes and electrons produced by exposure to ultra band gap radiation and lead to an overall reduction in activity.

We report the development of a series of bismuth oxide and bismuth oxide-based coatings with band gaps in the 2.4 to 2.6 eV range and, consequently, significant visible light activity. The coatings were produced by reactive magnetron sputtering and have been deposited onto planar substrates and also particulates including PC500, P25 and 2mm diameter glass beads to demonstrate the flexibility of the deposition process and to allow a wide range of applications to be explored. Coating types investigated include bismuth oxide, bismuth tungstate and bismuth molybdate. The coatings were analysed using SEM, EDX, XRD, XPS, and UV–vis spectroscopy. The photocatalytic properties have been determined by dye degradation tests under visible light irradiation and an acetone degradation test. The antimicrobial efficiency of the coatings was tested via inactivation of E. coli.

It was found that the performance of bismuth oxide for both dye degradation and bacterial inactivation experiments under visible light was superior to that observed for either bismuth tungstate, bismuth molybdate or titanium dioxide coatings also produced for comparison purposes. Additional tests have been carried out against cyanobacteria and free-floating genomic DNA to demonstrate the water treatment potential of the bismuth oxide coatings. Further trials have demonstrated the capability of selected coatings to breakdown microplastics in water.

5:00pm **TS2-TuA-11 A Covalent Organic Framework-Based Ionic Diode Membrane for Ultrahigh Blue Energy Generation***, **Yu-Chun Su**, L. Yeh,* National Taiwan University of Science and Technology, Taiwan

Blue energy has recently attracted significant attention due to the growing energy demand and increasing awareness on environmental protection. Electric eels can convert ionic concentration gradients into a high-efficiency electric power when facing enemies via sub-2 nm biological transmembrane channels, which can exhibit high ion selectivity and strong diode-like ion rectification property. Inspired by this, a heterogeneous ionic diode membrane, composed of an ultrathin (~110 nm) two-dimensional covalent-organic framework (COF) membrane with well-oriented sub-2 nm ion transport channels and a highly ordered alumina nanochannel membrane (ANM), is reported for highly efficient blue energy harvesting. Higher ionic flux can be obtained due to well-ordered ion transport channels which achieves lower membrane resistance. Moreover, as verified by our experimental and simulation results, the heterostructured COF/ANM membrane is capable of strong ionic diode behavior due to asymmetric charges and pore sizes in two aligned COF (1.1 nm) and ANM (100 nm) channels that can enhance current density. Thus, an unprecedented power density of up to 27.8 W/m^2 is achieved by mixing the artificial salt-lake water and river water. This study will open new avenues of using the rectified ion channel-mimetic nanofluidic membrane as a new platform towards the exploration and development of an ultrahigh osmotic power generator.

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