NCCAVS – TFUG Virtual Meeting
https://nccavs-usergroups.avs.org/

Topic: Advances in Energy Storage, Conversion, and Harvesting

Meeting Date: May 19, 2021
Time: 1:30-4:00 p.m. PDT (Time Zone Converter Tool)
Platform: Zoom Webinar

Platinum Sponsor
Nor-Cal Products

Co-Chairs
Mayu Yamamura, Applied Materials
Mayu_Yamamura@amat.com

Michael Oye, UC Santa Cruz
moye@ucsc.edu

Robert Kertayasa,
rolinktech@yahoo.com

MEETING FOCUS
The Thin Films Users Group (TFUG) Meeting on Energy Storage, Conversion, and Harvesting is on **May 19, 2021**. The meeting will provide a forum for researchers, engineers, and practitioners from academia, government, and industry (startups & established companies). TFUG promotes the exchange of opportunities, ideas, friendly relationships and research collaboration.

AGENDA:

1:30 p.m. Welcome and Acknowledgment of Sponsor by TFUG Chair Mayu Yamamura

1:30 p.m. David Kuo, Waha Inc., *Metal Organic Framework for Water Extraction from Air*

2:00 p.m. Mark Huijben, University of Twente, Netherlands, *Tailoring interfaces for superior next-generation batteries*

2:30 p.m. Jeffrey Urban, Lawrence Berkeley National Lab, *Energy storage and thermal harvesting with hybrid materials*

3:00 p.m. James Kaschmitter, SpectraPower, LLC, *An overview of solid-state lithium battery development*

3:30 p.m. Min Hwan Lee, UC Merced, *Atomic/Nano-scale Surface Engineering for Electrochemical Energy Conversions*

BIOS/ABSTRACTS

David Kuo, Waha Inc., *Metal Organic Framework for Water Extraction from Air*

As global warming proceeds, water supply in many regions of the world become less predictable. This manifests itself in the drought experienced in Northern California and many other regions in the world. Though rain water is unreliable, there is plenty of water in the atmosphere, even in the dry regions. In the past few years, atmospheric water harvesting using novel porous materials have been devised. In particular, a class of Metal Organic Framework (MOF) with high water affinity has been developed that exhibits superior capability in atmospheric water production. This innovative material has spurred the development of practical and inexpensive devices that could be deployed in the home, in the office, or in the factory even if MOF based system is located in the desert area.
The amount of water adsorbed (in mass %) in MOF is typically represented as a function of the relative humidity (in %) of the surrounding air in what is referred to as an Adsorption Isotherm. To the first order and for all practical purposes, these curves are insensitive to the temperature. MOF materials exhibit a step-like characteristic, which lets them capture and release water in a very narrow range of humidity. This is in contrast with more conventional materials such as silica gel that exhibit a much more gradual isotherm, or zeolites that only desorb water at extremely low humidity levels. Another advantage of MOF material is that the relative humidity RH_0 where adsorption occurs (adsorption threshold) can be adjusted by changing the molecular characteristics of the material itself. In fact, a continuous range of RH_0 can be obtained by simply mixing various organic or inorganic constituents into multi-variational MOFs of different water affinity. Finally, a large adsorption capacity in mass % is also a requirement for a practical water harvester, and MOF compound do satisfy this constraint.
A typical MOF-based atmospheric water harvesting device usually works in the following processes. The dried MOF is placed in an environment to adsorb water from the environment typically with the assistance of a fan. Once it is saturated with water, the MOF is then desorbed by either heating up the environment or pumping vacuum. Steam generated from desorption is then condensed on a cold plate below its dew point. At Water Harvesting, we have successfully built a device to harvest water from air. With a mere 100g of MOF, it is demonstrated that 4L of water can be produced per day under 20^{o}C and 40% RH environment. The desorption energy is typically 5%-10% higher than the evaporation temperature of the latent heat of water. If energy efficiency is a concern, it is advisable to couple MOF technology with a heat pump system. It is noted that water produced by the MOF device has very high quality which is basically equivalent to distilled water. The ability to produce high quality of water from air in the desert can lend itself to enable Green hydrogen technology, which holds great potential for future energy source.

BIO:
David Kuo currently works for Water Harvesting Inc as a Sr. Vice President of Engineering. He is responsible for Metal Organic Framework based systems development. Prior to join Water Harvesting Inc. in August, 2018, David works as a Sr. Director for advanced product and technology development in Seagate. His team led the highest areal demonstration and developed the highest areal density mobile product in the market. He has years of experience in advanced material, process and equipment development. David holds 109 US and world wide patents. He graduated from UC Berkeley in 1989 with a PhD degree in Mechanical Engineering specialized in thermal science and heat transfer.

Mark Huijben, University of Twente, Netherlands, *Tailoring interfaces for superior next-generation batteries*

The urgency posed by global warming to transform our fossil fuel-dependent society into one based on renewable energy sources, creates grand challenges for enhanced battery technology, especially regarding energy capacity, charging rate, safety, cycle life and material availability. The present showstopper for next generation batteries is the poor reversibility leading to a short battery lifetime. The interfaces between the electrodes and the electrolyte are key to these problems, as this is where the redox chemistry occurs that drives the reversible energy storage. Full reversibility involves fast and reversible electron and ion transfer and transport, as well as chemical and structural transformations. However, parasitic reactions and unfavourable structural rearrangements challenge this reversibility, and are at the origin of poor performance and eventually battery failure. Combatting these degradations requires firstly in-depth understanding of the processes taking place, and secondly it requires materials solutions that prevent these detrimental processes. However, the inherent complexity of the interface morphologies in batteries has hampered studies of the individual interface phenomena.

In our group we study thin film 2D model systems, which enables control over the material combination, crystal orientation and elemental termination at the interface to explore its evolution during battery operation. Epitaxial engineering is being used to realize an unique insight into the relation between electrochemistry and structural ordering of such chemically complex interfaces, not obtainable in conventional polycrystalline battery architectures. Furthermore, new interface strategies are being developed, driven by the achieved fundamental understanding, in which advanced coatings are being explored to prevent the formation of ionically resistive or electron-conducting decomposition products, local atomic intermixing, polarization, space charge layers and dendrites at the interfaces between electrodes and liquid or solid electrolytes.

BIO:
I am Associate Professor with ius promovendi and head of the ‘Nanomaterials for Energy Conversion and Storage’ group at the University of Twente, which is part of the MESA+ Institute for Nanotechnology and the Twente Centre for Advanced Battery Technology. My research is focused on the study of novel nanostructured thin films with special structural and advanced functional properties at the incorporated interfaces. My aim is to develop new materials towards improved energy applications, such as next-generation batteries and thermoelectric energy generators.
I started studying interface engineering for oxide electronics during my MSc and PhD (2006) at the University of Twente with a stay at Stanford University (USA). During my postdoc at the University of California, Berkeley (USA), my research was broadened to the field of multiferroic applications with magnetic and electrical interactions at the interfaces. In 2009 I started my research group at the University of Twente as Assistant Professor. At the same time, I became programme director of the strategic research direction 'Nanomaterials for Energy' within the MESA+ Institute for Nanotechnology in order to expand the expertise in nano-related energy research. In these positions, I was successful in obtaining financial support (e.g. EU FP7 projects and personal VENI grant (2010)) in the field of thermoelectrics, photovoltaics and artificial photosynthesis, where high-performance oxide interfaces are crucial. In 2013 I became Associate Professor and shifted the focus to next-generation batteries, for which I received the personal VIDI grant (2014) and several other funded projects (e.g. Perspectief, ECHO). Since 2016 I have a permanent position leading a young and enthusiastic research team in studying innovative nanomaterials for realizing enhanced energy conversion and storage applications. Finally, since 2018 I have also been appointed as guest scientist within the IEK-1 Electrochemical Storage department of Forschungszentrum Jülich (Germany).

Jeffrey Urban, Lawrence Berkeley National Lab, *Energy storage and thermal harvesting with hybrid materials*

Heat, charge, and mass are fundamental energy carrying modes relevant not only to thermoelectrics, but also nearly all dynamic properties of interest in engineering, physics, and modern energy technologies.
The first part of this talk will focus on heat and charge transport in polymeric and hybrid nanomaterials, revealing the physical origins of scaling laws for charge transport in these materials. I will also discuss how understanding these materials from the molecular scale out to the macroscopic domain enables design of new classes of technologies for thermal management, rectification, memristance, and energy harvesting. I will also briefly show how these concepts extend to energy storage more broadly, such as hydrogen storage for fuel cells, and water/energy themes.

BIO:
Dr. Jeff Urban is Director of the Inorganic Nanostructures Facility at the Molecular Foundry at Berkeley Labs. He got his PhD in Physical Chemistry with Prof. Hongkun Park at Harvard studying scaling laws in phase transitions in correlated electron materials and completed postdoctoral training with Prof. Christopher Murray and Prof. Mercouri Kanatzidis at UPenn in thermal and photonics applications of nanocrystal-based devices. His group is highly multidisciplinary and studies heat/charge/mass transport energy storage, water/energy resource management, and catalysis in nanoconfined materials with an emphasis on understanding phenomena at hard/soft interfaces and the impact of nanoscale dimensions on physical behavior.

James Kaschmitter, SpectraPower, LLC, *An overview of solid-state lithium battery development*

BIO:
He has more than 30 years of experience in the battery industry. Jim and his team developed some of the first Li-ion cells in the U.S. and invented the carbon aerogel supercapacitor. They started PolyStor Corporation in 1993 with a grant from President Clinton's TRP program. In 2002 Jim founded UltraCell Corporation to commercialize a unique Reformed Methanol Micro Fuel Cell. UltraCell was acquired by Brentronics and continues to supply these fuel cells to the U.S. military. Jim has a M.S.E.E. degree from Stanford University. Jim founded SpectraPower in 2012.

Min Hwan Lee, UC Merced, *Atomic/Nano-scale Surface Engineering for Electrochemical Energy Conversions*

Since the performance and durability of fuel cells and electrolytes are largely dependent upon the kinetics and stability of oxygen electrocatalysis, a rationale design and development of catalysts for the reaction is very important. We leverage atomic/nano-scale surface engineering of electrodes to enhance their performance and durability. In this talk, I will present selected cases of successful surface engineering mainly enabled by the use of atomic layer deposition (ALD), an emerging low-temperature chemical vapor deposition variant capable of depositing uniform ultrathin overcoat at the atomic scale even on a substrate of extreme geometric complexity.

BIO:
Min Hwan Lee is currently an Associate Professor of Mechanical Engineering at the University of California, Merced. Before joining UC Merced in 2012, he earned his master's and doctoral degree in Mechanical Engineering from Stanford University, and his bachelor's degree from Seoul National University in South Korea. His research centers on small-scale charge transport and electrochemical reactions within and at the interfaces of nanostructured materials that form the basis of electrochemical energy conversion and storage. He is a recipient of NSF CAREER Award in 2018 and featured in the 2020 Emerging Investigators issue of Journal of Materials Chemistry A, a journal by the Royal Society of Chemistry.