**Multiscale Energy Global Frontiers**

**Workshop 2013**



**August 19th to 20th, 2013**

**1Floor, Magnolia**

**Samsung Convention Center**

**Organized by:**

Global Frontier Center for Multiscale Energy Systems

**Supported by:**

Ministry of Science, ICT and Future Planning

Seoul National University

**Welcome Addresss**

Multiscale Energy Global Frontiers Workshop 2013 will be held in Aug 19-20, 2013 at Seoul National University, Korea. The forum is organized by Global Frontier Center for Multiscale Energy Systems.

The nine-year project, named Global Frontier Center for Multiscale Energy Systems, began September 2011. The Korean Ministry of Science, ICT & Future Planning supports us up to 2020 with about 9 million USD annual research budget to pursue fundamental scientific research and develop break-through technology for realizing future Multiscale Energy Systems (future solar and fuel cells), based on multiscale architectures.

The purpose of the forum is to bring frontier scientists in energy its related fields and provide a fruitful encounter platform whereby exchange of ideas and scientific collaborations can be promoted among all participants. The forum consists of two days of series of invited talks by 14 most active frontier scientists from USA, Sweden, Japan, and Korea.

Thank you for participating our workshop and brining your expertise to our gathering. We hope that this workshop will provide a valuable venue for better understanding and sharing the knowledge about Multiscale Energy Systems.

August. 19. 2013.

Mansoo Choi, Ph.D.



Director, Global Frontier Center for Multiscale Energy Systems

Professor, Seoul National University

**Organizing Committee**

* Prof. Mansoo Choi (Organizing Chair, Seoul National University, Korea)
* Prof. Ki Tae Nam (Secretary General, Seoul National University, Korea)
* Prof. Suk Won Cha (Program Chair, Seoul National University, Korea)

**Instruction to Speakers and Session Chair**

* **To the Session Chair**

The Session chair is requested to report their arrival to the staff at the reception desk 15minutes prior to the beginning of each session.

* **To the Speakers**

Please report your arrival to the session chair 5 minutes prior to the beginning of each session

* **Official Language**

Official language for the workshop is English.

* **Equipments for Presentation**

A Projector, a projector screen, a notebook, microphones and laser point will be provided.

* **Presentation time**

Please keep strictly your presentation time. Each speaker will have a maximum of 30minutes for presentation (including discussion).

**Program**

* **August 19 (Mon)**

**(Morning Session)**

|  |  |
| --- | --- |
| 08:50 – 09:20 | Register |
| **09:20 – 09:30** | **Opening remark – Mansoo Choi, Seoul National University, Korea** |
| **Session 1** | **Chair : Ki Tae Nam, Seoul National University, Korea** |
| 09:30 – 10:00 | Han-ill Yoo (Seoul National University, Korea) |
|  | *Open-Circuit-Voltage of a Galvanic Cell, a State Property?* |
| 10:00 – 10:30 | Mitsuru Wakisaka (University of Yamanashi, Japan) |
|  | *Analyses of Fuel Cell Reactions at Pt Single-Crystal Electrodes by Using EC-XPS and STM* |
| 10:30 – 10:50 | Coffee Break |
| **Session 2** | **Chair: Hyunjoo Lee, Yonsei University, Korea** |
| 10:50 – 11:20 | Ji-Won Son (Korea Institute of Science and Technology, Korea) |
|  | *The ultimate low-temperature performance of thin-film and nanostructure-based anode-supported solid oxide fuels cells by means of multi-scale architecture* |
| 11:20 – 11:50 | Ryan O’Hayre (Colorado School of Mines, USA) |
|  | *Materials for Electrochemical Energy Conversion* |
| 11:50 – 13:30 | Lunch  Location : Main building, BF, Crystal |

**(Afternoon Session)**

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| **Session 3** | **Chair: Nam-Gyu Park, Sungkyunkwan University, Korea** | |
| 13:30 – 14:00 | Matthew Beard (National Renewable Energy Laboratory, USA) | |
|  | *Multiple Exciton Generation and carrier dynamics in PbSe QDs, QD films, and QD Solar Cells* | |
| 14:00 – 14:30 | Sang Il Seok (Korea Reseach Institute of Chemical Technology, Korea) | |
|  | *Efficient inorganic-organic hybrid heterojunction solar cells* | |
| 14:30 – 15:00 | So Hee Jeong (Korea Institute of Machinery and Materials, Korea) | |
|  | *Nanocrystal Quantum dots for Photovoltaics: Understanding the Size-dependent Stability* | |
| 15:00 – 15:30 | Coffee Break | |
| **Session 4** | **Chair: Sohee Jeong, Korea Institute of Machinery and Materials, Korea** | |
| 15:30 – 16:00 | Knut Deppert (Lund University, Sweden) | |
|  | *Nanowires for solar cell applications* | |
| 16:00 – 16:30 | Hyunjoo Lee (Yonsei University, Korea) | |
|  | *Atomically Dispersed Platinum with High Activity for Electrocatalytic Reactions* | |
| 16:30 – 17:00 | Hyun Suk Jung (Sungkyunkwan University, Korea) | |
|  | *Atmospheric pressure plasma (APP) assisted fabrication of flexible DSSCs* | |
| 17:00 – 17:30 | Jihun Oh (Korea Advanced Institute of Science and Technology, Korea) | |
|  | *Efficient Nanotextured Silicon Solar Cells Enabled by Control of Photocarrier Recombination* | |
| 18:00 – | Reception | (Invited speakers and committee members ONLY)  Location: Main building, 2F, Marronnier |

* **August 20 (Tue)**

**(Morning Session)**

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| **Session 5** | **Chair : Ki Tae Nam, Seoul National University, Korea** |
| 09:30 – 10:00 | Nam-Gyu Park (Sungkyunkwan University, Korea) |
|  | *Organo-Metal Iodide Perovskite as Light Harvester for High Efficiency Mesoscopic Solid-State Solar Cell* |
| 10:00 – 10:30 | Chris Giebink (The Pennsylvania State University, USA) |
|  | *Sustainable Energy Pathways Through Luminescent Manipulation of Sunlight* |
| 10:30 – 11:00 | Myung Mo Sung (Hanyang University, Korea) |
|  | *Vapor-Phase Fabrication of Organic-Inorganic Nanohybrid Thin Films Using Molecular Layer Deposition with Atomic Layer Deposition* |
| 11:00 – 11:10 | **Closing Remark - Mansoo Choi, Seoul National University, Korea** |

**Biography of Invited Speakers**

**Biography of Invited Speakers**

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| **1. Han-Ill Yoo (Seoul National University, Korea)** | | | |
| 서울대_유한일.gif | | | Han-Ill Yoo, Professor at Department of Materials Science and Engineering, Seoul National University, studied for his B.S in Inorganic Materials Engineering (1974) at Seoul National University in Korea, then completed his M.S in Materials Science and Engineering (1976) at Korea Advanced Institute of Science and, his PhD in Ceramics (1984) from Massachusetts Institute of Technology. Since 1985, he has been an academic faculty in the Department of Materials Science and Engineering, Seoul National University. He is a member of editorial boards of several international journals as well as chair of international conferences.  His academic interest is mostly concerned with defect structure and transport properties of predominently nonmetallic, inorganic materials such as diffusion, electrical conduction, thermoelectricity, thermotransport, and electrotransport. On-going research works embrace nonstoichiometry, ionic and electronic partial conductivities, thermoelectric power, chemical diffusion and oxygen permeability, electric field-induced unmixing in various oxides for energy conversion and storage, electro-magnetic, and nuclear fuel applications, respectively. Particularly, the 0 thermopower material and the cross effect between ionic and electronic flows have been discovered in his lab.  He was awarded the Alexander von Humboldt Research Award, Germany in 2004, and elected to Fellow, School of Engineering, The University of Tokyo in 2009.. |
| **2. Mitsuru Wakisaka (University of Yamanashi, Japan)** | | | |
| Mitsuru Wakisaka.jpg | Mitsuru Wakisaka received his BS (1996), MS (1999) and PhD (2002) in Applied Chemistry from Tohoku University in Japan. He has majored in electrochemistry and studied surface structures of platinum-group metals (PGMs) single-crystal electrodes, specifically their surface reconstructions and self-assembly monlayers of small organic molecules on them by using various surface-sensitive techniques, such as scanning tunneling microscopy (STM) and low energy electron diffraction, under his advisor, Prof. Kingo Itaya.  After obtaining his PhD degree, he joined Prof. Andrzej Wieckowski’s group as a post-doc at the University of Illinois at Urbana-Champaign in USA from Apr 2002 to Sep 2003. He has focused on electronic structures of bimetallic electrocatalysts for fuel cells. He has investigated the electronic structures of Ru or Os deposited on Pt single-crystal electrodes with Prof. Choong Kyun Rhee (Chungnam National University, Korea) and Dr. Hoydoo You (Argonne National Laboratory, USA) by using X-ray photoelectron spectroscopy (XPS) and X-ray absorption spectroscopy.  Since Oct 2003, he works at University of Yamanashi in Japan. In 2008, he was appointed as an assistant professor and in 2011 as an associate professor at Fuel Cell Nanomaterials Center, University of Yamanashi. He has been studying fuel-cell related reactions by using STM and XPS under Prof. Masahiro Watanabe (Director of the Fuel Cell Nanomaterials Center) and Prof. Hiroyuki Uchida (Director of the Clean Energy Research Center, University of Yamanashi) in a part of two national projects, “Leading Project” of MEXT and “HiPer-FC Project” of NEDO. He has developed a novel method of quasi in situ XPS, and revealed surface oxidation processes at Pt single crystal electrodes by using the in situ XPS and in situ STM. He has for the first time revealed the structures of CO adlayers on Pt(100) and Pt(110) electrodes.  Mitsuru Wakisaka has obtained several Grant-in-Aids for Scientific Research (KAKENHI) for his own researches. In 2013, he received the Toyama Award in science and technology. He is a member of the Electrochemistry Society of Japan and the Catalysis Society of Japan. | | |
| **3. Ji-Won Son (Korea Institute of Science and Technology, Korea)** | | | |
| 손지원.jpg | | | Ji-Won Son is a principal research scientist at High-temperature Energy Materials Research Center, KIST. She was born in 1971, Seoul, and studied Inorganic Materials Science and Engineering at Seoul National University (SNU), Seoul, Korea. She received BS and MS degrees at SNU. During her master course, she studied the sintering mechanism of oxides used for electronic applications. Afterwards, she entered the graduate school of Stanford University, Dept. of Materials Science and Engineering and received the Ph. D. degree in 2005. Her Ph. D. topic was about oxide thin film materials for optical applications.  Based on her expertise both on oxide bulk materials and thin film materials, she has worked on implementation of thin film and nanostructure materials to high-temperature operating solid oxide fuel cells (SOFCs) since she joined the Solid State Ionics Lab at KIST, 2005. By realizing multi-scale structure at the anode, she successfully achieved both the high performance at lower operating temperatures and the thermomechanical stability of the thin film and nanostructure-base anode-supported SOFCs. She has over 70 scientific papers published, 22 patents granted, and 23 patents applied. |
| **4. Ryan O’Hayre (Colorado School of Mines, USA)** | | | |
| C:\Users\user\Pictures\Ryan O'Hayre.jpg | | | Associate Professor Ryan O’Hayre directs the Advanced Energy Materials Laboratory at the Colorado School of Mines (<http://materials.mines.edu/rc/aeml/index.html>). His laboratory develops new materials and devices to enable alternative energy technologies including fuel cells and solar cells. Prof. O’Hayre is lead author of Fuel Cell Fundamentals, the world’s best-selling textbook on the subject of fuel cell science and technology (translated into both Chinese and Korean) and has published more than 70 peer-reviewed publications in the field as well as several patents and book chapters. He has received several young-investigator research and teaching honors including the Chinese Academy of Sciences Visiting Professorship for Senior International Scientists at the Dalian Institute of Chemical Physics (2012-13), The ASM Bradley Staughton Award, 2011 Kavli Frontiers of Science Fellow, and the 2009 Presidential Early Career Award in Science and Engineering (PECASE), the US’s top honor for early-career scientists and engineers. He collaborates with a number of National Labs and international Universities, including the U.S. National Renewable Energy Laboratory, Oak-Ridge National Laboratory, Risoe-DTU in Denmark, and DICP in China. |
| **5. Matthew Beard (National Renewable Energy Laboratory, USA)** | | | |
|  | | | Matthew C. Beard was born in Idaho Falls, ID in 1971. Following a BS in physical chemistry and an MS in thermodynamics from BYU he received a Ph.D. in physical chemistry from Yale University in 2002. While at Yale University he helped pioneer the use of time-resolved THz spectroscopy (TRTS) to study the charge-carrier generation and recombination dynamics in semiconductors and quantum-confined semiconductors. TRTS experiments are particularly useful for studying charge-carriers in quantum-confined semiconductors because it is a non-contact method capable of determining the carrier density and mobility simultaneously and thus can be used on systems where connecting wires could be problematic. Furthermore, TRTS can determine the carrier dynamics with sub-picosecond resolution. Quantum-confined semiconductors are produced in simple chemical reaction baths and have tunable properties depending on the interplay between the chemical regents, temperature, ligands, and solvent. When semiconductors are synthesized with nanoscale dimensions many intrinsic properties, such as melting point and bandgap, become extrinsic. Upon receiving his Ph.D. Dr. Beard received a NRC postdoctoral fellowship at NIST in Gaithersburg MD. At NIST he developed a hyperspectral THz imaging spectrometer and studied the intra-molecular solvation dynamics in simple organic liquids. In 2003, Dr. Beard joined the team lead by Art Nozik at NREL in 2003 to further develop TRTS as a means to investigate the QD-QD electronic coupling in close packed films of QDs. Shortly after arriving at NREL he started studying PbSe QDs as a potential new material a for high efficiency low cost approach to solar energy conversion technologies. The phenomenon of multiple exciton generation (MEG) can potentially increase the theoretical power conversion efficiency by ~ 30% over the single-junction Shockley-Queisser limit. MEG involves the ability to convert one high-energy photon to more than one low energy electron-hole pairs. The phenomenon has attracted much interest in the solar cell and quantum-confined semiconductor communities. In 2010 a new Energy Frontier Research Center, the Center for Advanced Solar Photophysics (CASP) was formed as a joint center between NREL, Los Alamos National Laboratory, University of Californian at Irvine, University of Minnesota, Colorado School of Mines, University of Colorado, and George Mason University. The CASP goal is to explore and exploit the unique advantages of nanostructured materials and solution-based fabrication methods to enable the low-cost, high-efficiency solar cells of tomorrow. In February of 2012 Beard became the co-director of CASP. His interest spans a large range of important physical chemistry problems relating to photoconversion. This includes charge transport in quantum dot arrays and organic semiconductors, charge and energy transfer, and size-dependent phenomena in quantum sized-materials. He is currently investigating carrier generation and charge transport in assemblies of semiconductor nanocrystals and has published over 60 papers in these areas. |
| **6. Sang Il Seok (Korea Research Institute of Chemical Technology, Korea)** | | | |
| 석상일 | Dr./Prof. Sang Il Seok is leading Global Research Laboratory, funded through the National Research Foundation of Korea under the Ministry of Science, ICT & Future, Korea, as Principle Investigator at the Division of Advanced Materials in Korea Research Institute of Chemical Technology (KRICT), Korea. Now he also holds a dual appointment as professor at Department of Energy Science, Sungkyunkwan University (SKKU). He obtained his PhD degree at Department of Inorganic Materials Engineering of Seoul National University, Korea, in 1995. From 1996 to 1997, he experienced a post-doc to investigate defects and transport in Fe-Ti-O Spinel structure in Cornell University, USA, and visiting scholar in University of Surrey, UK, in 2003, and École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, in 2006 respectively. His major research interests were inorganic/organic hybrid materials through sol-gel process for optical amplifier, high dielectrics, corrosion-resistance coatings etc. Since 2006, his research focus is based on the integration of mesoporous architecture/semiconductor nanocrystals (including quantum dots)/polymeric hole conductors for high-performance inorganic-organic hybrid photovoltaics such as photodetectors and solar cells, and novel materials for them. He published over 100 peer-reviewed papers including Nature Photonics, Nano Letters, etc. with awards for his Excellency. | | |
| **7. So Hee Jeong (Korea Institute of Machinery & Materials, Korea)** | | | |
| 2.2 정소희.jpg | Dr. Sohee Jeong is currently Senior Researcher of Nanomechanical Systems Research Division at KIMM, Daejeon, as well as Professor in Department of Nanomechatronics at University of Science and Technology (UST). She obtained B.S. and M.S. degrees in Chemistry from KAIST. She obtained her PhD degree in Chemistry from University of Michigan in Ann Arbor, MI, USA. She joined Dr. Victor Klimov group in Los Alamos National Lab. (LANL), NM, USA while pursuing her doctorate studying surface related photophysical properties of nanocrystal quantum dots. After a postdoctoral research in synthesizing multishell quantum dots for lasing applications at LANL, she started her research career at KIMM located in Daejeon. Her research interests include large-scale synthesis of Nanocrystal Quantum dots (NQDs), charge/energy transfer in NQD/NQD-hybrids arrays, NQD based applications including photovoltaics and light emitting diode. | | |
| **8. Knut Deppert (Lund University, Sweden)** | | | |
|  | Knut Deppert, born in 1957, graduated in crystallography from the Humboldt University in Berlin, Germany, where he also obtained his PhD degree in 1986. As post-doc, he worked on growth of crystal structures for optoelectronic devices at the Central Institute of Optics and Spectroscopy, Berlin. In cooperation with Lund University, he developed optical investigation methods for layer growth processes.  In 1994 he turned his interests towards the generation of novel nanostructure materials using aerosol technology. With more than 100 publications in international periodicals and several patents, Knut Deppert has pioneered nanoparticulate materials technology. Particularly should be mentioned the work on size-selected semiconductor nanoparticles, on tailored pattering with nanoparticles, and on the creation of one-dimensional semiconductor structures like nanowires and nanotrees. Currently he is strongly involved in the development of nanowire-based photovoltaics.  Since 1991, he works at Lund University. In 2000, he was appointed Associate Professor and in 2003 he obtained full professorship at Lund University. Currently he serves as the Head of the Physics Department.  Besides advanced research activities, Prof. Deppert is deeply involved in education. He developed a university education program on nanoscience and -technology, Engineering Nanoscience, at Lund University. This five- years program is one of the very few complete curriculums in nanoscience starting at the university entrance level and leading to a Master's degree.  Knut Deppert is adviser to different national and institutional Research Councils and co-founder of two companies In 2003 he received the Aerosologist Award of the Nordic Society for Aerosol Research, in 2008 he was a recipient of the E.ON Research Award and in 2011 of the Pedagogic Prize of Lund University. | | |
| **9. Hyunjoo Lee (Yonsei University, Korea)** | | | |
| 이현주.jpg | | Hyunjoo Lee is an associate professor at Department of Chemical and Biomolecular Engineering, Yonsei University. She received a B.S. (1998) and M.S. (2000) degree in chemical engineering, Seoul National University. Then she moved to California Institute of Technology and received Ph.D. (2005) by the work about zeolite synthesis. She performed post-doctoral research in University of California, Berkeley and Lawrence Berkeley National Laboratory about nanoparticle catalysts. Since she joined Yonsei University, her main research theme is to design nanocatalysts by modulating shape and composition for the application in energy and environment. She has developed various catalysts for fuel cells, biomass conversion, and methane conversion. She has published 55 papers and 11 patents. She received a distinguished lectureship award by the chemical society of Japan in 2010, which is given to distinguished young Asian researcher. | |
| **10. Hyun Suk Jung (Sungkyunkwan University, Korea)** | | | |
| 성대_정현석.jpg | Hyun Suk Jung is an associate professor in school of advanced materials science & engineering at Sungkyunkwan university (SKKU). He received his BS, MS, and PhD degrees in materials science & engineering from Seoul national university (SNU), in 1997, 1999, and 2004, respectively. He joined Los Alamos National Laboratory (LANL) as a director’s postdoctoral fellow in 2005. He had worked for Kookmin University (KMU) since 2006 and joined Sungkyunkwan university in 2011. He published over 100 peer-reviewed papers regarding synthesis of inorganic nanomaterials and dye-sensitized solar cells. He presently researches flexible solar cells and inorganic sensitized solar cells. http://home.skku.edu/~hjung/ | | |
| **11. Jihun Oh (Korea Advanced Institute of Science and Technology, Korea)** | | | |
| KAIST_오지훈.gif | Jihun Oh is an assistant professor in Graduate School of EEWS (Energy, Environment, Water and Sustainability) at KAIST since 2013. He got Ph.D. in Materials Science at Massachusetts Institute of Technology in 2010 and joined National Center for Photovoltaics (NCPV) at National Renewable Energy Laboratory (NREL) as a postdoctoral fellow from 2010 to 2013. As a post-doc, he worked on design and fabrication of Si nanostructures for solar cells and photoelectrochemical water splitting and achieved an 18.2%, a world record, efficient nanostructured black Si solar cell. His research interest at KAIST is to develop a disruptive ultra-high efficiency solar cells and artificial photosynthesis systems by investigating innovative materials, nanostructures and processing. | | |
| **12. Nam-Gyu Park (Sungkyunkwan University, Korea)** | | | |
| 성대_박남규.jpg | Nam-Gyu Park is professor at School of Chemical Engineering and adjunct professor at Department of Energy Sciences, Sungkyunkwan University, where he leads the Group of Next Generation Photovoltaics. He got Ph.D. in Inorganic Chemistry from Seoul National University in 1995. He worked at ICMCB-CNRS, France, and at National Renewable Energy Laboratory, USA, as postdoctoral researchers from 1996 to 1999. He worked as Director of Solar Cell Research Center at Korea Institute of Science and Technology from 2005 to 2009 and as a principal scientist at Electronics and Telecommunications Research Institute from 2000 to 2005 before joining Sungkyunkwan University in 2009. He has been studying on high efficiency dye-sensitized solar cells. He is specialist in design and synthesis of inorganic nanostructured materials as well as photovoltaic solar cell fabrication. He received awards, including Scientist Award of the Month (MEST, Korea), KyungHyang Electricity and Energy Award (KEPCO, Korea), KIST Award of the Year (KIST, Korea) and Dupont Science and Technology Award (Dupont Korea). He published over 140 scientific papers, including Nature Materials, Nature Communications, Nature Scientific Reports, Advanced Materials, ACS Nano, J. Physical Chemistry, together with 35 patent applications and 2 book chapters. His researches are focused on design and synthesis of organo-metal perovskite and quantum dot materials for super high efficiency solar cells. | | |
| **13. Chris Giebink (The Pennsylvania State University, USA)** | | | |
| Chris Giebink.jpg | Dr. Giebink joined Penn State in 2011 following a two year postdoctoral fellowship at Argonne National Laboratory. His research interests highlight the combination of organic and inorganic materials in optoelectronic and photonic devices, with a particular emphasis on applications for solar energy conversion and storage. In addition, his group focuses on fundamental physical questions underlying the behavior of charge carriers, excited states and light-matter interaction in disordered and nanostructured semiconductors. He holds three patents and is a member of the Optical Society of America, the Materials Research Society, and the American Physical Society. | | |
| **14. Myung Mo Sung (Hanyang University, Korea)** | | | |
| 한양대_성명모.jpg | Myung Mo Sung, Professor at Department of Chemistry, Hanyang University, studied for his B.S in Chemistry (1986) at Seoul National University in Korea, then several years of experience of working as a researcher in Korea Research Institute of Chemical Technology. After that, he completed his PhD in Chemistry (1996) from University of Houston. Since 2006, he has been an academic faculty in the department of Chemistry, Hanyang University. His research closely related to Organic-Inorganic Nanohybrid Thin Films: Atomic Layer Deposition, Molecular Layer Deposition and Soft Lithography: Nanotransfer Direct Printing, Single-Crystal Organic Nanowire Arrays. | | |

**Abstract**

**Open-Circuit-Voltage of a Galvanic Cell, a State Property?**

H.-I. Yoo

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A galvanic cell involving a mixed ionic electronic conductor compound generates an electromotive force (EMF) or open-circuit voltage (OCV) when subjected to its component chemical potential difference(s) between the two electrodes. This phenomenon serves the very principle of the energy conversion/storage devices, e.g., fuel cells and batteries, and the information conversion/storage devices, e.g., chemical sensors and electrochromics, only to name a few, which are now the subjects of a worldwide research spree.

It is well known that OCV of a galvanic cell involving a binary compound, or a multinary compound with a single kind of mobile ionic species, is a path- and time-independent, state property or completely determined by the chemical potential values at both electrodes. Authors have, thus, conventionally believed that U is still a state property for a galvanic cell involving even a ternary or multinary compound with two or more kinds of mobile ions under multitude chemical potential gradients of those mobile components.

In this contribution, we will show mathematically that this cannot be true in general, and demonstrate experimentally, with a galvanic cell involving a proton conducting oxide subjected to both oxygen and water chemical-potential gradients, that OCV is indeed path- and time-dependent and even history-dependent, and manifests itself along the diffusion paths of the two mobile components H and O under given boundary conditions. Implications of the path- and time-dependencies are discussed.

**Analyses of Fuel Cell Reactions at Pt Single-Crystal Electrodes by Using EC-XPS and STM**

Mitsuru Wakisaka

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The application of Pt-based single-crystals to investigations on fuel cell reactions is to be encouraged for understanding of their reaction mechanisms and catalytically active sites. The surface oxidation states of Pt electrodes are highly essential to understand the electrocatalytic reactions, e.g., oxygen reduction and hydrogen or small organic molecule oxidation, because the oxygen species formed on the electrode surface can act as a reactant, oxidant, spectator or, in some cases, poison. These fuel cell reactions are well known to be structure-sensitive and exhibit different activities among Pt(hkl) electrodes. We have for the first time clarified the structural effects on the surface oxidation processes at the three single-crystal electrodes on the basis of the coverages of each type of oxygen species evaluated by X-ray photoelectron spectroscopy combined with an electrochemical cell (EC-XPS). Furthermore, we have demonstrated the dynamic process of the roughening of the Pt(111) surface during the surface oxidation/reduction cycles by in situ scanning tunneling microscopy (STM). The adsorption of CO molecules on Pt surfaces is also one of the most important topics in fuel cell reactions because Pt anode catalysts are severely poisoned by trace amounts of CO remaining in reformed hydrogen fuel or by CO formed as an intermediate during the methanol oxidation reaction. By using STM, we have for the first time revealed highly ordered structures of CO adlayer formed on Pt(100) and Pt(110) single-crystal surfaces in electrolyte solutions, which strongly depended on the crystal planes and varied with the electrode potential as well as CO partial pressure in the solution. These findings can provide new insights into the structure-sensitive electrocatalytic reactions at Pt electrodes in fuel cells.

**The ultimate low-temperature performance of thin-film and nanostructure-based anode-supported solid oxide fuels cells by means of multi-scale architecture**

Ji-Won Son

High-temperature Energy Materials Research Center

Korea Institute of Science and Technology (KIST), Korea

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Solid oxide fuel cells (SOFCs) are considered as one of the most promising candidates of the next generation power sources due to its high efficiency and fuel flexibility. Nevertheless, the high operating temperature exerted substantial burdens to the SOFC systems; therefore, extensive research efforts have been put to lower the operation temperature of the SOFC. For this reason, thin-film electrolytes and nanostructure electrodes are implemented at an ever increasing rate to decrease the operation temperature of the SOFC via reduction of the physical dimensions of the cell components, while not drastically changing the currently available SOFC materials. Nonetheless, the reliable implementation of thin-film and nanostructure components has been largely unsuccessful due the frail nature of the components themselves and the free-standing cell platform even at the low operating temperature regime (≤ 500 °C) of the SOFC. On the other hand, realization of thin-film electrolytes and nanostructure electrodes over a realistic SOFC platform like a porous anode-support has been extremely difficult, hence only a handful of groups reported successful fabrication of thin-film electrolyte and nanostructure electrode-based anode-supported SOFCs (anode-supported TF-SOFC).

In the current presentation, it will be shown that just how the successful realization of anode-supported TF-SOFC is possible by means of multi-scale architecture. A multi-layer, thin electrolyte can be reliably constructed over an anode support of which the microstructure scale changes from m to nm; and a nanostructure composite cathode with a gradually changing microstructure is built over the thin electrolyte. This multi-scale architecture of the TF-SOFC not only enables to reliably implement thin-film electrolytes and nanostructure electrodes to SOFCs, thus to achieve the critical low-temperature performance of the SOFC; but also secures the thermo-mechanical stability of TF-SOFC and therefore elongates the lifetime. The ultimate level of the low-temperature performance and significantly improved thermo-mechanical stability of the multi-scale architecture anode-supported TF-SOFC will be presented.

**Materials for Electrochemical Energy Conversion**

Ryan O’Hayre

Metallurgical and Materials Engineering

Colorado School of Mines, USA

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Electrochemistry is central to many current and emerging energy conversion technologies including batteries, fuel cells, photoelectrochemical systems, and membrane reactors. Recent research in the Advanced Energy Materials Laboratory at the Colorado School of Mines (Golden, Colorado, USA) is focused on developing new design paradigms and new physical insights into the materials that are used in a variety of these electrochemical energy conversion technologies. In this presentation, a number of our ongoing research efforts will be discussed, including the development of nitrogen-functionalized carbon support structures for direct methanol fuel cell catalysis, ceramic-based membrane structures for gas separation and membrane reactor applications, nanoionic composite materials which may provide enhanced ionic transport capabilities, and redox-active oxides for solar-thermal production of hydrogen from water.

**Multiple Exciton Generation and carrier dynamics in PbSe QDs, QD films, and QD Solar Cells**

Matthew C. Beard

Center for Advanced Solar Photophysics

National Renewable Energy Laboratory, Golden, CO, USA

Matt.Beard@nrel.gov

Nanomaterials are a flexible material platform that has great promise for providing new ways to approach solar energy conversion. The synthesis, investigation, and utilization of these novel nanostructures lie at the interface between chemistry, physics, materials science and engineering. Semiconductor nanostructures, where at least one dimension is small enough to produce quantum confinement effects, provide new pathways for controlling energy flow and therefore have the potential to increase the efficiency of the primary photo conversion step. One such avenue is the process of multiple exciton generation (MEG) where absorption of high-energy photons can lead to the production of multiple electron-hole pairs which can contribute to an enhanced photocurrent in solar cells. We studied the size-dependent MEG in QDs consisting of either PbSe, PbS, or a PbSxSe1-x alloy for various sizes with corresponding bandgaps ranging from 0.6 to 1 eV. For each sample we determine the MEG efficiency, , defined in terms of the electron-hole pair creation energy ( such that . In previous reports, we found that is about 2x greater in PbSe QDs compared to bulk PbSe. In this study, we find for both PbS and PbSxSe1-x alloyed QDs that decreases lineally with increasing QD diameter. When the QD radius is normalized to a material-dependent characteristic radius, defined as the radius at which the Coulomb and confinement energies are equivalent, PbSe, PbS, and PbSxSe1-x exhibit similar MEG behavior. Our results confirm that MEG increases with quantum confinement, and shed light on the interplay between a size-dependent MEG rate vs. hot exciton cooling. Finally, I will discuss ongoing work in Si QD samples that may have the potential to achieve very high MEG efficiencies as well as strategies for incorporating both the Pb chalcogenide and Si QDs into prototype solar cells.

**Efficient inorganic-organic hybrid heterojunction solar cells**

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Solar energy is one of the renewable sources, which are clean and inexhaustible. Among the solar energy technologies, inorganic-organic hybrid photovoltaic devices have received much attention because they have potential advantages, such as high-efficiency, low-cost, and relatively high-stability compared with conventional organic photovoltaic cells. Furthermore, Inorganic-organic hybrid architectures provides innovative routes for next-generation solar cells as they can combine advantages of semiconductor nanocrystals or inorganic-organic hybrid materials as light harvester and conducting polymers as hole transport materials. In this talk, we will demonstrate highly efficient solar cells using nanostructured architecture and PbS, Sb2S3, Sb2Se3, and chemically managed inorganic/organic hybrid materials as light harvesters. Some of these cells exceed 14 % in a power conversion efficiency of under air-mass 1.5 global (AM 1.5G) illumination mW cm–2 intensity. These results lead to fabricate more efficient and cost-effective inorganic-organic hybrid solar cells for future practical applications with excellent perspectives.

**Nanocrystal Quantum dots for Photovoltaics: Understanding the Size-dependent Stability**

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A noticeable photoconversion efficiency of nanocrystal quantum dot solar cells has been achieved very recently, more than 7 % (Ip et al., Nature Nanotechnology 2012). Understanding and controlling the carrier transport in quantum dot solids (QDS) is crucial for further improvement in efficiency. Here, based on the microscopic understanding of the surface properties of nanocrystal quantum dots, we created an assembled quantum dot structures with enhanced conductivity. Further, a few fundamental aspects of efficient nanocrystal quantum dots-based photovoltaics including size-dependent stability will be discussed.

**Nanowires for solar cell applications**

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Semiconductor nanowires are a new class of building blocks for electronics [[1](#_ENREF_1)], photonics [[2](#_ENREF_2)], photovoltaics [[3](#_ENREF_3)], life sciences [[4](#_ENREF_4)], and fundamental physics studies [[5](#_ENREF_5)]. These structures have typically a diameter of 2 to 100 nm and a length of several micrometers. The growth of the nanowires is often mediated by metallic seed particles [[6](#_ENREF_6)]. For the growth, the nanoparticles are deposited prior growth onto a suitable semiconductor substrate. After initiation of the growth process the nanoparticles define the position and the diameter of the nanowires.

Here, we will describe the growth of III-V semiconductor nanowires assisted by a metal seed and discuss the growth mechanism involved. We will describe the possible architectures of axial and radial heterostructures and describe and discuss their morphological properties and the possibilities of doping will be discussed. The focus is on epitaxial III–V semiconductor nanowire structures, with the two materials GaP and InP used as typical examples of structures with cubic (zincblende) and hexagonal (wurtzite) crystal structures. We will present efforts to use the self-assembly of one-dimensional nanostructures in order to create novel devices and we will focus here on applications for solar cell devices. Finally, a way of creation of nanowires without the supply of substrates will be presented [[7](#_ENREF_7)].

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**Atomically Dispersed Platinum with High Activity for Electrocatalytic Reactions**

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Heterogeneous catalysts have been widely applied in modern chemical industry. In spite of their practical importance, fundamental understanding and rational design of the heterogeneous catalysts has been impeded because the structure of the catalyst is often hard to control. We are trying to understand the chemical reactions occurred at the surface of nanoparticle catalysts and design the catalysts to have better performance of higher activity, selectivity, and stability. Controlling the interaction between catalytic metal components and support materials can enhance the activity and stability while minimizing the amount of precious metal catalysts. We found that the mode of Pt deposition on Au with different surface structure (e.g. Au(100) vs. Au(111)) is distinct resulting in different activity. The amount of deposited Pt on Au(111) surface was controlled and atomically dispersed Pt catalyst was prepared. This catalyst presented unprecedentedly high activity for electrocatalytic formic acid oxidation whereas the same catalyst showed no activity for electrocatalytic methanol oxidation.

**Atmospheric pressure plasma (APP) assisted fabrication of flexible DSSCs**

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A key challenge to the industrial application of nanotechnology is the development of fabrication processes for functional devices based on nanomaterials which can be scaled up for mass production. In this report, we disclose the results of non-thermal radio-frequency (rf) atmospheric pressure plasma (APP) based deposition of TiO2 nanoparticles onto a flexible substrate for the fabrication of dye-sensitized solar cells (DSSCs). Operating at 190 oC without a vacuum enclosure, the APP method can avoid thermal damage and vacuum compatibility restrictions and utilize roll-to-roll processing over a large area. The analysis of the TiO2 deposition properties demonstrates superior film properties can be obtained by the non-thermal APP method when compared with the thermal sintering process operating at 450 oC. The crystallinity of the anatase TiO2 nanoparticles is significantly improved without thermal agglomeration, while the surface defects such as Ti3+ ions are eliminated, thus providing efficient charge collecting properties for solar cells. Finally, we successfully fabricated a flexible DSSC with energy conversion efficiency of 4.2% using a transparent plastic substrate (Figure 1). This work demonstrates the potential of non-thermal APP technology in the area of device-level, nano-enabled materials manufacturing.

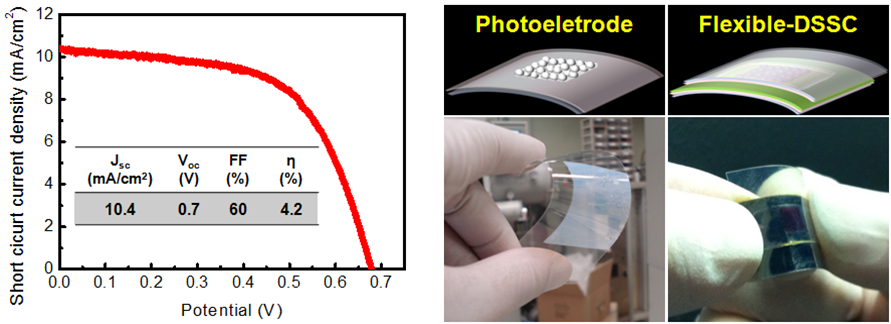


Figure 1. Flexible photoelectrode and DSSC fabricated by APP process. a, I-V characteristic of flexible DSSC under 1 sun illumination (AM 1.5G). b, schematic illustrations and real photo images of flexible TiO2 photoelectrode and DSSC based on ITO/PEN substrate.

Efficient Nanotextured Silicon Solar Cells Enabled by Control of Photocarrier Recombination

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Nanostructuring a semiconductor is a promising way to fabricate highly-efficient and low-cost solar cells, because of excellent optical properties of the nanostructure. Here, I’ll present our recent result of an 18.2% efficient nanotextured Si solar cell, made with a low-cost wet etch that replaces more expensive anti-reflection (AR) coatings. Our nanotextured silicon is fabricated by metal-assisted etching and forms a density-graded layer that provides broadband AR properties (R < 4%) for the photons above the Si bandgap. However, a solar cell with a high surface area nanostructure often shows a poor performance due to enhanced photocarrier recombination at the nanostructure. To design an efficient nanotextured Si solar cell, we investigate recombination mechanisms in high surface area Si solar cells. Through identification and control of these recombination, we demonstrate a world-record, 18.2%, efficient nanotextured Si solar cell.

**Organo-Metal Iodide Perovskite as Light Harvester for High Efficiency Mesoscopic Solid-State Solar Cell**

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Highly efficient perovskite CH3NH3PbI3-sensitized mesoscopic solid-state solar cells will be presented in this talk. CH3NH3PbI3 sensitizer was directly deposited on mesoporous TiO2 film or nanorod using a spin coating. The perovskite sensitizer adsorbed TiO2 layer was in contact with solid hole transporting material. A PCE of 9.7% was achieved when the CH3NH3PbI3-sensitized submicometer TiO2 film was contacted with spiro-MeOTAD hole transport material, along with excellent long-term stability. Hole transfer was confirmed from femto-seconf laser dynamics. Besides light harvesting ability, CH3NH3PbI3 exhibited charge accumulation behavior, which was found for the first time from impedance study. Two-step coating technology led to higher efficiency than one-step procedure. The highest performance of 14% was achieved using a two-step method.

**Sustainable Energy Pathways Through Luminescent Manipulation of Sunlight**

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Sunlight is a diffuse energy resource and thus all methods of solar energy conversion and use by society share one feature in common – concentration. Manipulating sunlight directly offers many prospects for a sustainable energy future, for example by reducing the cost of solar cells through optical concentration, routing natural daylight into buildings through optical fiber, or tailoring the distribution of light in an algae culture to improve biofuel productivity. Luminescent manipulation of sunlight affords a general opportunity to address all of these applications in a potentially inexpensive and scalable fashion.

Whereas passive geometric optical concentrators are invariably bound by the sine limit, luminescent solar concentrators (LSCs) operate by absorbing and re-emitting sunlight, and can in principle achieve high concentration ratio (>100x) without tracking the Sun. We are exploring opportunities to improve LSC performance and diversify their application by photonically controlling the luminescent etendúe. Leveraging highly directional luminescence together with a generalized nonimaging optical framework, we demonstrate routes to both increase concentration ratio for photovoltaics and alternatively to optimize the distribution of light within closed photobioreactors for enhanced algal biofuel productivity. Our approach, which is based on the use of macroscopic freeform waveguides, leads to the formation of optical pseudo-potentials that act like in-plane graded index variations, channeling the flow of light and localizing it at particular points to dramatically boost concentration ratio.

**Vapor-Phase Fabrication of Organic-Inorganic Nanohybrid Thin Films Using Molecular Layer Deposition with Atomic Layer Deposition**

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We report a vapor phase deposition method of high quality organic thin films, called molecular layer deposition (MLD). MLD is a gas phase process analogous to ALD and also relies on sequential saturated surface reactions which result in the formation of a self-assembled monolayer in each sequence. In the MLD method, the high quality organic thin films can be quickly formed with monolayer precision under ALD conditions (temperature, pressure, etc). The MLD method can be combined with ALD to take advantages of the possibility of obtaining organic–inorganic hybrid thin films. The advantages of the MLD technique combined with ALD include accurate control of film thickness, large-scale uniformity, excellent conformality, good reproducibility, multilayer processing capability, sharp interfaces, and excellent film qualities at relatively low temperatures. Additionally, a vast library of materials is accessible by ALD methods, ranging from single elements to compound semiconductors to oxides, nitrides, and sulfides. Therefore, the MLD method with ALD is an ideal fabrication technique for various organic-inorganic nanohybrid superlattices.

**Guide of HFH 1.**

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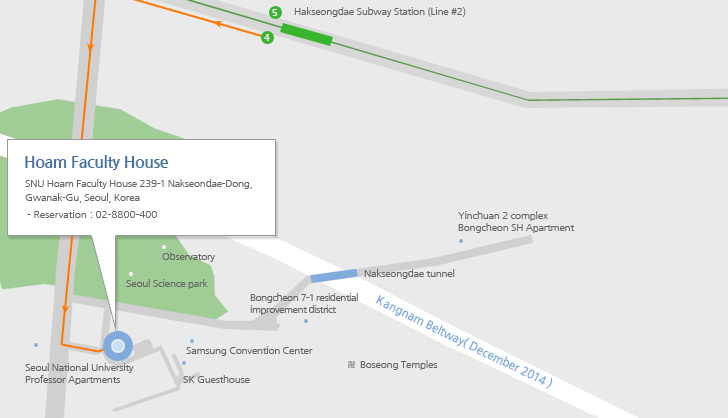
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**Guide of HFH 2.**

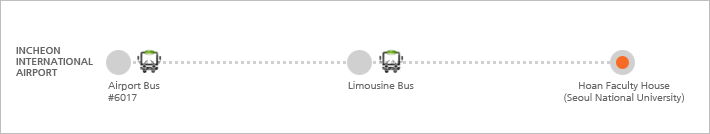
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TEL: 02-8800-400 (<http://www.hoam.ac.kr/eng/>)



**▶ Way #1 From Incheon airport to Hoam**



1. Take the "#6017 Airport limousine bus" at the GATE 6B or 13B. (Check the Bus time table)

2. Get off at the last stop "Hoam Faculty House

**▶ Way #2 From Kimpo airport to Hoam**

1. Take the "#6003 Airport limousine bus" at the Bus terminal #6. The bus will depart every 20minutes. The bus fare is 4,000 won by cash.

2. Get off at the main gate of Seoul National University. Take a taxi or a shuttle from the main gate of Seoul National University

- Shuttle service is available upon reservation only.

- Running hour of shuttle: 08:00~19:00 (Monday to Friday).

- Please contact at 82-2-880-0311 for reservation

**▶ Way #3 By Taxi**

1. Take a taxi from Incheon/Kimpo airport to Hoam Faculty House (HFH).

2. The fare could be changeable upon traffic situation. Please contact us at +82-2-880-0311 or front@hoam.ac.kr for reservation.