SYMPOSIUM ES7

(Photo)electrocatalytic Materials and Integrated Assemblies for Solar Fuels Production—Discovery, Characterization and Performance
April 17 - April 21, 2017

Symposium Organizers
Akihiko Kudo, Tokyo University of Science
Francesca Maria Toma, Lawrence Berkeley National Laboratory
Roel Van de Krol, Helmholtz-Zentrum Berlin
Lianzhou Wang, University of Queensland

Proceedings Statement
All authors are invited to submit articles based on their 2017 MRS Spring Meeting presentations to the journals in the MRS portfolio (www.mrs.org/publications-news). Papers submitted and accepted for publication in MRS Advances (www.mrs.org/mrs-advances) will be available as symposium collections. Visit the MRS/Cambridge University Press Publications Booth #100 in the Exhibit Hall to learn more, including MRS Advances print options available at special rates during the meeting week only.

8:30 AM *ES7.1.01
Artificial Photosynthesis—The Selective CO₂ Reduction Challenge Harry A. Atwater; California Institute of Technology, United States.

9:00 AM ES7.1.02
Optimizing C-C Coupling on Oxide Derived Copper Catalysts for Electrochemical CO₂ Reduction Yanwei Lum; 1, 2 Lawrence Berkeley National Laboratory, United States; 2University of California, Berkeley, United States.

9:15 AM ES7.1.03
Strain Induced Changes in CO₂ Electro-Reduction Pathway at Au-Pd Core-Shell Nanostructures David J. Fermin; University of Bristol, United Kingdom.

9:30 AM ES7.1.04
Surface Science Insights into the Role of the Electrode Surface in Solar-Driven Pyridine-Catalyzed CO₂ Reduction Bruce E. Koel; Princeton University, United States.

9:45 AM ES7.1.05
Investigations of Heterogeneous Processes for CO₂ Reduction Involving Molecular Co-Catalysts Coleman X. Kronawitter; University of California, Davis, United States.

10:00 AM BREAK

11:00 AM ES7.1.06
Solar CO₂ Reduction Coupled with Water Oxidation—Semiconductor/Metal-Complex Hybrid System Takeshi Morikawa; Toyota Central R&D Labs, Japan.

11:10 AM ES7.1.07
High Efficiency Solar-Fuel Devices Chengxiang (CX) Xiang; California Institute of Technology, United States.

11:15 AM ES7.1.08
Highly Efficient Artificial Photosynthesis with Low-Cost Transition Metal Electrocatalysts in Aqueous Solution Huatian Wang; Harvard University, United States.

11:30 AM ES7.1.09
Fabrication of Copper Oxide Photocathode for CO₂ Reduction Guiji Liu; Lawrence Berkeley National Laboratory, United States.

11:45 AM ES7.1.10
Photocatalytic Conversion of CO₂ over Nanostructures into Solar Fuels Yong Zhou; Nanjing University, China.

SESSION ES7.2: Advanced Architectures for Solar Fuels
Session Chairs: Takeshi Morikawa and Bruce Parkinson
Monday Afternoon, April 17, 2017
PCC North, 200 Level, Room 222 BC

1:30 PM *ES7.2.01
Sunlight-Driven Hydrogen Formation by Membrane-Supported Photoelectrochemical Water Splitting Nathan S. Lewis; California Institute of Technology, United States.

2:00 PM ES7.2.02
Nano-Photoelectrochemical Cell Arrays with Spatially Isolated Oxidation and Reduction Channels Mohammad F. Islam; Carnegie Mellon University, United States.

2:15 PM ES7.2.03
Core-Shell Micro-Tube Array for Closing the Artificial Photosynthesis Cycle on a Nanometer Scale Fran Edri; Lawrence Berkeley National Lab, United States.

2:30 PM ES7.2.04
Design of Photonic and Plasmonic Materials for Photocatalytic CO₂ Reduction Ashley Gaulding; Lawrence Berkeley National Lab, United States.

2:45 PM ES7.2.05
Solid-State Architecture for a High-Current, Elevated-Temperature Photoelectrochemical Cell Madhur Boloor; Stanford University, United States.

3:00 PM BREAK

SESSION ES7.3: Novel Concepts
Session Chairs: Nathan Lewis and Lianzhou Wang
Monday Afternoon, April 17, 2017
PCC North, 200 Level, Room 222 BC

3:30 PM ES7.3.01
Photoelectrochemical Tandem Configuration for Solar Water Splitting Exceeding 7% Using Photon Recycling Jong Hyeok Park; Yonsei University, Korea (the Republic of).

3:45 PM *ES7.3.02
Photoelectrochemical Solar Energy Storage—Hydrogen Production vs Direct CO₂ Reduction and Photoredox Flow Batteries Bruce A. Parkinson; University of Wyoming, United States.

SESSION ES7.4: Advanced Characterization and Operando Studies
Session Chairs: Rainer Eichberger and Dunwei Wang
Tuesday Morning, April 18, 2017
PCC North, 200 Level, Room 222 BC

10:30 AM *ES7.4.01
In Situ and Operando Characterization of CO₂ Reduction Reaction Catalysts Using Soft and Hard X-Ray Spectroscopy Junko Yano; 1, 2 Lawrence Berkeley National Lab, United States; 1Lawrence Berkeley National Lab, United States.
2:45 PM ES7.4.02
Corrosion Behavior of p-GaNp, Thin Films for Photoelectrochemical Water Splitting Studied by Ambient Pressure X-Ray Photoelectron Spectroscopy
Monika Blum; University of Nevada, Las Vegas, United States.

11:45 AM ES7.4.03
X-Ray Characterization of Solar Fuels Catalysts under Operation Walter Drisdell; Lawrence Berkeley National Laboratory, United States.

3:45 PM ES7.5.04
Soft X-Ray Spectroscopic Investigation of the CdS/Cu(In,Ga)S2 Interface in Thin Films for Photoelectrochemical Water Splitting
James C. Carter; University of Nevada, Las Vegas, United States.

11:45 AM ES7.5.05
Characterization of BiVO4 Powders and Thin Films by Electron Microscopy
Hector A. Calderon; Instituto Politecnico Nacional - ESFM, Mexico.

SESSION ES7.5: Understanding Interfaces
Session Chairs: Lianzhou Wang and Junko Yano
Tuesday Afternoon, April 18, 2017
PCC North, 200 Level, Room 222 BC

1:30 PM *ES7.5.01
Charge Transfer Processes in Catalyzed Semiconductor Photoelectrodes
Shannon W. Boettcher; University of Oregon, United States.

2:00 PM *ES7.5.02
Probing Energetics and Kinetics at the Interface of the Photoelectrode and Water Danwei Wang; Boston College, United States.

2:30 PM ES7.5.03
Direct Observation of Photoelectrochemical Water Oxidation Intermediates on α-Fe2O3 Electrode Surfaces Employing Operando ATR-IR Spectroscopy
Omid Zandi; University of Texas at Austin, United States.

2:45 PM ES7.5.04
Amorphous Molybdenum Sulphide—Surface Water Dependent Properties, Humidity Sensing and Electrolyte Free Water Splitting
Torben Daeneke; RMIT University, Australia.

3:00 PM BREAK

SESSION ES7.6: Protection Layers
Session Chairs: Shannon Boettcher and Lianzhou Wang
Tuesday Afternoon, April 18, 2017
PCC North, 200 Level, Room 222 BC

3:30 PM ES7.6.01
Atomic Layer Deposited Transition Metal Oxide-Titania Alloys as Corrosion Resistant Schottky Contacts for Silicon Photoanodes
Olivia Hendrick; Stanford University, United States.

3:45 PM ES7.6.02
Controlling the “Leakiness” of TiO2 Protection Layers
Anke C. Brommeberg; Helmholtz-Zentrum Berlin für Materialien und Energie, Germany.

4:00 PM ES7.6.03
Charge Transfer Characterization on Atomic Layer Deposited TiO2 Protective and Conductive Layers for Photoelectrochemical Solar Fuels
Carles Ros Figueras; IREC, Catalonia Institute for Energy Research, Spain.

4:15 PM ES7.6.04
Enhanced Photoelectrochemical Efficiency and Stability Using A Conformal TiO2 Film on a Black Silicon Photoanode
Yanhao Yu; University of Wisconsin-Madison, United States.

4:30 PM ES7.6.05
Passivating Silicon Photocathodes by Solution-Deposited Ni-Fe Layered Double Hydroxide for Efficient H2 Evolution in Alkaline Media
Jihong Zhao; Stanford University, United States.

SESSION ES7.7: Poster Session
Tuesday Afternoon, April 18, 2017
8:00 PM - 10:00 PM
Sheraton, Third Level, Phoenix Ballroom

ES7.7.01
Phase Transition-Induced Band Edge Engineering of BiVO4 to Split Pure Water under Visible Light
Wen Jun Ye; Massachusetts Institute of Technology, United States.

ES7.7.02
CuO Based Photostable Photoanodes by the Au Passivation for High-Efficiency Photoelectrochemical Applications
Hee Jun Kim; UNIST, Korea (the Republic of).

ES7.7.03
Photoelectrochemical Hydrogen Production by Water Splitting over Dual-Functionally Modified Oxide—P-Type N-Doped Ta2O5 Photocathode Active under Visible Light Irradiation
Tomoko M. Suzuki; Toyota Central R&D Labs Inc, Japan.

ES7.7.04
Enhanced Visible Light Photocatalytic Water Reduction of a g-C3N4/SrTaO4 Heterojunction
Shiba P. Adhikari1, 2; Wake Forest University, United States; 2Centre for Energy Studies, United States.

ES7.7.05
Interface Engineering of Colloidal CdS± Thin Film Photocathodes for Solar-Driven Hydrogen Evolution
Hui Li; Wake Forest University, United States.

ES7.7.06
Unique Role of Metal Oxide 2D Nanosheet in Optimizing Catalyst Performance of Graphene for Oxygen Reduction Reaction
Xiaoyan Jin; Ewha Womans University, Korea (the Republic of).

ES7.7.07
Direct Fabrication of BaNbO4N Crystals on Niobium Substrates for Visible-Light-Responsive Photoanode by Flux Coating under Ammonia Flow
Sayaka Suzuki; Shinshu University, Japan.

SESSION ES7.8: Oxygen Evolution Catalysts
Session Chairs: Artur Braun and Francesca Maria Toma
Wednesday Morning, April 19, 2017
PCC North, 200 Level, Room 222 BC

9:00 AM ES7.8.01
The Reaction Mechanism with Free Energy Barriers at Constant Potentials for the Oxygen Evolution Reaction at the IrO2 (110) Surface
Yuan Ping; University of California, Santa Cruz, United States.

9:15 AM ES7.8.02
Electronic Structure of Manganese Based Oxides under OER
Katarzyna Skorupska1, 2; Max-Planck-Institut für Chemische Energiekonversion, Germany; 2Max-Planck-Institut für Chemische Energiekonversion, Germany.

9:30 AM ES7.8.03
Elucidating the Role of the Mn Oxidation State in Thin Film MnOx Oxygen Evolution Catalysts
Paul Plate; Helmholtz-Zentrum Berlin, Germany.

9:45 AM ES7.8.04
Development of Solar Fuels Photoanodes through Combinatorial Integration of Ni-La-Co-Ce and Ni-Fe-Co-Ce Oxide Catalysts on BiVO4
Aniketa Shinde; California Institute of Technology, United States.

10:00 AM BREAK
SESSION ES7.9: III-V Semiconductors
Session Chairs: Roel Van de Krol and Lydia Wong
Wednesday Morning, April 19, 2017
PCC North, 200 Level, Room 222 BC

10:30 AM *ES7.9.01
Recent Advances in III-V Multijunction Semiconductor Photo-
Electrochemical Water Splitting Todd G. Deutsch; National Renewable
Energy Laboratory, United States.

11:00 AM ES7.9.02
Solar-to-Hydrogen Efficiency—Shining Light on Photoelectrochemical
Device Performance James L. Young; National Renewable Energy Laboratory,
United States.

11:15 AM ES7.9.03
Photoelectrodes for Characterizing Defects and Photoelectrochemical
Activity Yuuki Imaizaki; University of Tokyo, Japan.

11:30 AM ES7.9.04
GaN-Based Nanopillars for Solar Water Splitting Siva Karuturi; Australia
National University, Australia.

11:45 AM ES7.9.05
Self-Oriented Sb$_2$Se$_3$ Nanoneedle Arrays on a Conductive Substrate for
Photoelectrochemical Water Splitting Prepared by Simple Spin-Coating
Method Woosuk Yang; Yonsei University, Korea (the Republic of).

SESSION ES7.10: Understanding and Improving Hematite
Session Chairs: Giulia Galli and Akiihiko Kudo
Wednesday Afternoon, April 19, 2017
PCC North, 200 Level, Room 222 BC

1:30 PM *ES7.10.01
Intermediates in PEC Water Oxidation—How They Come and How They
Go Artur Braun; Empa, Switzerland.

2:00 PM *ES7.10.02
Strategies to Improve the Performance of Semiconductor Photoelectrodes
for Photoelectrochemical Water Splitting Lydie Wong; Nanyang
Technological University, Singapore.

2:30 PM BREAK

SESSION ES7.11: Theory and Modeling
Session Chairs: Todd Deutsch and Roel Van de Krol
Wednesday Afternoon, April 19, 2017
PCC North, 200 Level, Room 222 BC

3:30 PM *ES7.11.01
Optimizing Solar Interfaces from First Principles—In Search for
Descriptors Giulia Galli; University of Chicago, United States.

4:00 PM ES7.11.02
Modelling the Electrochemical Interface—Applications to CO$_2$
Reduction Michal Badich; Stanford, SLAC, United States.

4:15 PM ES7.11.03
Understanding CO$_2$ Reduction on Transition Metals Karen Chan; SLAC
National Accelerator Laboratory, United States.

4:30 PM *ES7.11.04
Catalysis on Nanoparticle Derived Aerogels Alexander Eychmueller; TU
Dresden, Germany.

SESSION ES7.12: Towards Practical Systems
Session Chairs: Katherine Ayers, Miguel Modestino, Francesca Maria Tomi
and Roel Van de Krol
Thursday Morning, April 20, 2017
PCC North, 200 Level, Room 222 BC

8:30 AM *ES7.12.01
An Integrated Inorganic-Biological Hybrid System for a Complete
Artificial Photosynthesis Daniel G. Nocera; Harvard University, United States.

9:00 AM *ES7.12.02
Electrochemical Carbon Dioxide Reduction as an Alternative Source of
Fuels and Chemicals Sichao Ma; Opus 12, United States.

9:30 AM ES7.12.03
A Monolithic and Scalable Device Based on Adapted Silicon HIT
Photovoltaic Structures Enabling Bias-Free CO$_2$ Conversion to
Syngas Felix Urbain; IREC, Catalonia Institute for Energy Research, Spain.

9:45 AM ES7.12.04
Design, Analysis and Optimization of High Voltage Photovoltaic
Electrolysis System for Solar Fuel Production from CO$_2$ Gorri M.
Sriramagiri$^1$ $^2$; 1University of Delaware, United States; 2Institute of Energy
Conversion, United States.

10:00 AM BREAK

10:30 AM *ES7.12.05
Working Together to Enable Gigawatt Scale Renewable Hydrogen
Production—Solar Fuels and Large Scale Electrolysis Katherine Ayers;
Proton OnSite, United States.

11:00 AM ES7.12.06
User-on-Demand Power Supply System Operation Using the Concept
of High Performance Solar to Hydrogen Conversion Device Masakazu
Sugiyama; The University of Tokyo, Japan.

11:15 AM ES7.12.07
A Durable and Efficient Solar Hydrogen Generator Karl A. Walczak;
Lawrence Berkeley National Laboratory, United States.

11:30 AM ES7.12.08
Developing Microfluidic Air-Based Solar-Hydrogen Generators Miguel A.
Modestino; New York University, United States.

11:45 AM ES7.12.09
Tandem Cell Approach for Artificial Photosynthesis Gurudayal Gurudayal;
Lawrence Berkeley National Laboratory, United States.
3:30 PM *ES7.14.01
Improvement of Water Oxidation Ability of Oxynitrides Aiming at Application to Photoanodes Hideki Kato; Tohoku University, Japan.

3:00 PM BREAK

SESSION ES7.14: Nitride and Oxynitride Absorbers
Session Chairs: Akihiko Kudo and Ian Sharp
Thursday Afternoon, April 20, 2017
PCC North, 200 Level, Room 222 BC

4:00 PM ES7.14.02
Fabrication of TaN Crystal Layers on Tantalum Substrate Using NaCl-Na2CO3 Flux Evaporation and Their Photoelectrochemical Properties Minori Yana; Shinsyu University, Japan.

4:15 PM ES7.14.03
Enhanced Water-Splitting Performance of Granular Oxynitride Photoanode Films through Improving Inter-Particle Charge Transport Zhaosheng Li; Nanjing University, China.

5:00 PM ES7.14.04
Growth of P-Type CdSxSe1-x:Cu Absorber Layer for Overall Water Splitting in PEC Cells Zi Ye; The Chinese University of Hong Kong, Hong Kong.

6:00 PM ES7.14.05
Feasible and Non-Expensive Photocathodes Based on Kesterites for Water Splitting Carles Ros Figueras; IREC, Catalonia Institute for Energy Research, Spain.

11:45 AM ES7.16.02
Photoelectrochemical and Solid-State Properties of Wide Bandgap Copper Chalcopyrites for Renewable Hydrogen Generation Nicolas Gaillard; University of Hawaii, United States.

10:30 AM *ES7.16.01
Surface-Modified Chalcogenide Thin Films as Efficient Photocathodes for Water Reduction Shigeru Ikeda; Konan University, Japan.

11:00 AM ES7.16.03
Cd-Doped CZTS Photocathode for Enhanced Photoelectrochemical Water Splitting Ying Fan Tay; Nanyang Technological University, Singapore.

3:00 PM BREAK

SESSION ES7.15: 2D Materials
Session Chairs: Gang Liu and Kazuhiro Takanabe
Friday Morning, April 21, 2017
PCC North, 200 Level, Room 222 B

8:30 AM *ES7.15.01
Direct Observation of Single-Atom Photocatalytic Reaction Centers for Hydrogen Production Using Two-Dimensional Oxide Nanosheet Shintaro Ida; Kyushu University, Japan.

9:00 AM *ES7.15.02
2D Inorganic Nanosheets for Solar Fuel Production Seong-Ju Hwang; Ewha Womans University, Korea (the Republic of).

9:30 AM ES7.15.03
Two-Dimensional g-C3N4/Ca4Nb3TaO10 for Efficient Visible Light Photocatalytic Hydrogen Evolution Supphasin Thaweesak; Nanomaterials Centre, School of Chemical Engineering and AIBN, The University of Queensland, Australia.

9:45 AM ES7.15.04
Efficient Photoelectrochemical Hydrogen Production Using Wafer-Scale, Defect-Engineered Transition Metal Disulfide Thin Film Catalysts Ki-Chang Kwon; Seoul National University, Korea (the Republic of).

10:00 AM BREAK

SESSION ES7.16: Chalcogenide Photoelectrodes
Session Chairs: Seong-Ju Hwang and Shintaro Ida
Friday Morning, April 21, 2017
PCC North, 200 Level, Room 222 B

10:30 AM *ES7.16.01
Surface-Modified Chalcogenide Thin Films as Efficient Photocathodes for Water Reduction Shigeru Ikeda; Konan University, Japan.

11:00 AM ES7.16.02
Photoelectrochemical and Solid-State Properties of Wide Bandgap Copper Chalcopyrites for Renewable Hydrogen Generation Nicolas Gaillard; University of Hawaii, United States.