

# Light Driven Water Splitting Using Semiconductor Based Devices (SolarFuel15)

Mallorca, Spain, 10-13 March 2015

Chairs: Wolfram Jaegermann and Bernhard Kaiser

## Conference Program

<b>10 March – Day 0 Tuesday</b>	
17.00 – 19.00	Registration Opened
19.00 – 19.30	Welcome Drink
<b>11 March – Day 1 Wednesday</b>	
8.45-13.00	<b>General Session G1</b> Room Marivent Chairs: B. A. Parkinson, R. Van de Krol, L. Peter & T. Jacob
8.45	Opening Chairs: B. A. Parkinson & R. Van de Krol
09.00	<u>John A. Turner</u>
G1.I1	The immobilization of a molecular catalyst on a photocathode for hydrogen evolution
09.30	<u>Wolfram Jaegermann</u>
G1.I2	Advanced photoelectrochemical cells for water splitting- materials science challenges and improved device structures
10.00	<u>Ib Chorkendorff</u>
G1.I3	The challenge of interfacing protection layers and catalysts on a tandem device for water splitting
10.30	<u>Thomas Hannappel</u>
G1.I4	Epitaxial layer structures for preparing high-efficiency tandem structures for water splitting
11.00	<b>Coffee break</b> Chairs: L. Peter & T. Jacob
11.30	<u>Akihiko Kudo</u>
G1.I5	Solar hydrogen production from water using photocatalysts
12.00	<u>Sixto Gimenez</u>
G1.I6	Novel insights into photo-oxidation of water with metal oxide semiconductors
12.30	<u>Roel van de Krol</u>
G1.I7	Towards highly efficient metal oxide photoelectrodes for water splitting
13.00	<b>Lunch</b>
15.00-17.00	<b>Parallel Session A1</b> Room Vent Chairs: M. Beller & T. Hannappel

15.00 A1.01	<u>Cristian Fabrega</u> , Carles Ros, Teresa Andreu, M.D. Hernandez-Alonso, German Penelas, <u>J.R. Morante</u> Endurance analysis of silicon photocathodes for water reduction based on atomic layer deposition methods
15.15 A1.02	<u>Sebastian Fiechter</u> , Diana Stellmach, Peter Bogdanoff, Roel van de Krol, Onno Gabriel, Rutger Schlatmann, Bernd Stannowski, Philipp Kurz, Holger Dau PV-hybrid electrolyzer using modified superstrate triple-junction silicon solar cells as water splitting devices
15.30 A1.03	<u>Félix Urbain</u> , Vladimir Smirnov, Jan-Philipp Becker, Uwe Rau, Friedhelm Finger, Florent Yang, Jürgen Ziegler, Bernhard Kaiser, Wolfram Jaegermann Multijunction thin film silicon photocathodes with photovoltages up to 2.8 V for the application in integrated PEC devices
15.45 A1.04	<u>Dowon Bae</u> , Thomas Pedersen, Ole Hansen, Ib Chorkendorff, Peter C.K. Vesborg Carrier-selective contacts: non pn-junction Si photocathode for efficient H <sub>2</sub> production
16.00 A1.05	<u>Elena Selli</u> , Gian Luca Chiarello, Maria Vittoria Dozzi Photocatalytic hydrogen production: mechanistic aspects, new materials and devices
16.15 A1.06	<u>Radim Beranek</u> Towards efficient photoanodes for water splitting in tandem cells: novel absorbers and their coupling with electrocatalysts
16.30 A1.07	<u>David Tilley</u> , M. Graetzel, L. Steier, P. Dias, C.T. Sousa, J.P. Araújo, J. Azevedo, A. Mendes, M. Stefik On the stability enhancement of cuprous oxide water splitting photocathodes by low temperature steam annealing
16.45 A1.08	<u>Anahita Azarpira</u> , Michael Lublow, Aafke Bronneberg, Chrisitan Höhn, Dieter Greiner, Anna Fischer, Thomas Schedel Niedrig Cu(In,Ga)Se <sub>2</sub> /Pt:TiO <sub>2</sub> photocathodes and Si/SiO <sub>2</sub> /RuO <sub>2</sub> photoanodes with current densities >12 mA/cm <sup>2</sup> and stability >24 hours in acidic electrolytes
15.00- 17.00	<b>Parallel Session B1</b> Room Mar Chair: Maria Rosa Antognazza
15.00 B1.11	Patrick Fortin, Graeme Suppes, Pankaj Chowdhury, <u>Steven Holdcroft</u> Photoelectrochemistry at conjugated polymer films
15.30 B1.01	<u>Salvatore Filippone</u> , Nazario Martín Fullerene-based n-type materials with catalytic activity
15.45 B1.02	Tiphaine Bourgeteau, Bernard Geffroy, Denis Tondelier, Vincent Artero, <u>Bruno Jusselme</u> A H <sub>2</sub> -evolving photocathode based on P3HT-PCBM bulk heterojunction solar cells and a MoS <sub>3</sub> catalyst
16.00 B1.03	<u>Antonio Guerrero</u> , Marta Haro, Sixto Gimenez, Juan Bisquert Stable organic photoelectrochemical cells for solar production of hydrogen
16.15 B1.04	Sebastiano Bellani, Francesco Fumagalli, Marta Haro, Silvia Leonardi, Ludmilla Steier, Ali Ghadirzadeh, Matthew Meyer, Alessandra Tacca, Laura Meda, Juan Bisquert, Michael Graetzel, Sixto Gimenez, Fabio Di Fonzo, <u>Maria Rosa Antognazza</u> Photoelectrochemical hydrogen production through hybrid organic/inorganic interfaces
16.30 B1.05	<u>Laura Meda</u> , Alessandra Tacca, Fabio Di Fonzo, Maria Rosa Antognazza Solar fuels from new generation catalysts: an overview

16.45 B1.O6	<u>Matthew Mayer</u> , Marcel Schreier, Jingshan Luo, David Tilley, Michael Graetzel Tandem approaches to solar-to-fuels conversion featuring perovskite photovoltaics
17.00- 19.00	<b>Drinks and Poster Session</b>
<b>12 March – Day 2 Thursday</b>	
9.00- 13.00	<b>General Session G2</b> Room Marivent Chairs: A. Kudo, J. Durrant, W. Schuhmann & K.W. Jacobsen
	Chairs: A. Kudo & J. Durrant
09.00 G2.I1	<u>Matthias Beller</u> Development of earth-abundant catalysts for hydrogen generation and storage
09.30 G2.I2	<u>Detlef Bahnemann</u> Solar photocatalytic water splitting: some critical issues
10.00 G2.I3	<u>Philipp Kurz</u> Behaviour of birnessite coated electrodes operated as water oxidation anodes
10.30 G2.O1	Sevilay Cosgun, Cyriac Massué, Martin Rohloff, Michael Lublow, Soenke Mueller, Rainer Eichberger, Andreas Bartelt, Caren Goebel, Anna Fischer, Malte Behrens, <u>Martin Lerch</u> Tantalum oxide nitride-based photocatalysts - band gap engineering by variation of crystal structure type and N/O ratio
10.45 G2.O2	Anahita Azarpira, Michael Lublow, Kasia Olech, Johannes Pfrommer, Alexander Steigert, Anna Fischer, Matthias Driess, <u>Thomas Schedel-Niedrig</u> Novel thin film photoelectrocatalysts based on transition metal oxide-semiconductor composites for visible-light driven hydrogen and oxygen evolution
11.00	<b>Coffee break</b> Chairs: W. Schuhmann & K.W. Jacobsen
11.30 G2.I4	<u>Laurence Peter</u> Light-driven water splitting - the role of interfacial kinetics
12.00 G2.I5	<u>James Durrant</u> The kinetics of water oxidation on oxide photoelectrodes
12.30 G2.O3	<u>Katsushi Fujii</u> , Kayo Koike, Takenari Goto, Shinichiro Nakamura, Masakazu Sugiyama, Yoshiaki Nakano Hypothesis for carrier transfer mechanism of water oxidation electrochemical catalyst considering from n-type GaN photoelectrochemical water oxidation
12.45 G2.O4	<u>Maytal Caspary Toroker</u> Recent advances in modeling transition metal oxides for solar energy applications
13.00	<b>Lunch</b>
15.00- 17.30	<b>General Session A2</b> Room Marivent Chairs: J. Turner
15.00 A2.I1	<u>Bruce Parkinson</u> A cooperative approach to solve the problem of solar water splitting

15.30 A2.I2	<u>Wolfgang Schuhmann</u> , Kirill Sliozberg, Felipe Conzuelo, Ramona Gutkowski, Robert Meyer, Chinmay Khare, Helge Stein, Thomas Erichsen, Alfred Ludwig High-throughput characterization of thin film semiconductors for photoelectrocatalytic energy conversion
16.00	<b>Coffee break</b>
16.30 A2.O1	<u>Henrike K. Grossmann</u> , Sven O. Schopf, Tim Grieb, Wenqing Li, Agnieszka Kuc, Thomas Heine, Lutz Mädler Flame made mixed metal oxide catalyst systems for the photo induced water splitting process
16.45 A2.O2	<u>Ksenia Fominykh</u> , Peter Zehetmaier, Thomas Bein, Dina Fattakhova-Rohlfing Highly efficient (Photo)electrocatalytic water oxidation on ultrasmall nickel oxide and cobalt oxide based nanocrystals
17.00 A2.O3	Alfred Ludwig, <u>Chinmay Khare</u> , Kirill Sliozberg, Robert Meyer, Helge Stein, Wolfgang Schuhmann Combinatorial fabrication and high-throughput characterization of Ti-W-O and W-Fe-O thin film materials libraries
17.15 A2.O4	<u>Juan Bisquert</u> Resistances and capacitances of the photoelectrochemical interface
20.00	<b>Social Dinner</b>
<b>13 March – Day 3 Friday</b>	
9.00- 13.15	<b>General Session G3</b> Room Marivent Chairs: I. Chorkendorff, D. Bahnemann, P. Strasser & P. Kurz
	Chairs: I. Chorkendorff & D. Bahnemann
09.00 G3.I1	<u>Peter Strasser</u> Water splitting electrocatalysts for efficient solar fuel production in PEM and PEC devices
09.30 G3.I2	<u>Karsten W. Jacobsen</u> Atomic-scale design of light-absorbing materials
10.00 G3.I3	<u>Timo Jacob</u> Photoelectrochemistry with model systems
10.30 G3.O1	<u>Hiromu Kumagai</u> , Tsutomu Minegishi, Taro Yamada, Jun Kubota, Kazunari Domen Photoelectrochemical properties of Cu chalcogenide based photocathodes for sunlight-driven water splitting
10.45 G3.O2	<u>Robert O'Connor</u> , Justin Bogan, Nicole Fleck, Anthony McCoy, Conor Byrne, Patrick Casey Growth and characterization of thin manganese oxide corrosion barrier layers for silicon photoanode protection during water oxidation
11.00	<b>Coffee break</b> Chairs: P. Strasser & P. Kurz
11.30 G3.I4	<u>Mikhail V. Lebedev</u> Photoelectrochemical processes at the GaAs/electrolyte interfaces
12.00 G3.O3	<u>Sabina Grigorescu</u> , Lei Wang, Patrik Schmuki Tungsten doping of Ta <sub>3</sub> N <sub>5</sub> -nanotubes for band gap narrowing and enhanced photoelectrochemical water splitting efficiency

12.15 G3.O4	<u>Jan Mitschker</u> , Thorsten Klüner Quantum chemical and quantum dynamical studies of the photocatalytic water splitting on titanium dioxide
12.30 G3.O5	<u>Miguel Cabán-Acevedo</u> , Nicholas S. Kaiser, Caroline R. English, Dong Liang, Blaise J. Thompson, Hong-En Chen, Kyle J. Czech, John C. Wright, Robert J. Hamers, Song Jin Ionization of high-density deep donor defect states explains the low photovoltage of iron pyrite single crystals
12.45 G3.O6	<u>Sven Nordmann</u> , Birger Berghoff, Joachim Knoch A monolithic all-silicon multi-junction photovoltaic electrolysis device for solar hydrogen production by direct water splitting
13.00	<b><u>Closing</u></b>
13.15	<b><u>Lunch</u></b>

## Poster Contributions

11 March – Day 1 Wednesday	
P1	<u>Teresa Andreu</u> , Sebastian Murcia-Lopez, Cristian Fàbrega, Carles Ros, Damian Monllor-Satoca, Maria D. Hernandez-Alonso, German Penelas, Joan R. Morante PLD deposition of BiVO <sub>4</sub> photoanodes for photoelectrochemical devices
P2	<u>Jan-Philipp Becker</u> , Félix Urbain, Vladimir Smirnov, Florent Yang, Jürgen Ziegler, Bernhard Kaiser, Wolfram Jaegermann, Sascha Hoch, Matthias Blug, Uwe Rau, Friedhelm Finger Implementation of metal layers to improve the catalytic activity and stability of thin film silicon based photoelectrochemical devices for solar water splitting
P3	Cyriac Massue, Marie-Mathilde Millet, Sevilay Cosgun, Martin Rohloff, Anna Fischer, Martin Lerch, Thomas Schedel-Niedrig, <u>Malte Behrens</u> MnOx co-catalysts for photocatalytic water splitting over tantalum oxide nitride
P4	<u>Anja Bieberle-Hütter</u> , Irem Tanyeli, Rochan Sinha, Reinoud Lavrijsen, Mauritius van de Sanden Nanostructured thin films by high ion flux He plasma exposure and their photoelectrochemical properties
P5	<u>Peter Cendula</u> , Ludmilla Steier, S. David Tilley, M. Graetzel, J. O. Schumacher Optoelectronic modeling of hematite photoelectrodes
P6	<u>Alina Chanaewa</u> , Michaela Meyns, Christian Klinke, Elizabeth von Hauff Hybrid nanosystems for solar water splitting
P7	<u>Holger Dau</u> , Diego Gonzales Flores, Marcel Risch, Petko Chernev, Elias Martinez Moreno, Jonathan Heidkamp, Reza M. Mohammadi, Chiara Pasquini, Sebastian Fiechter, Philipp Kurz Water oxidation by amorphous transition metal oxides
P8	<u>Sebastian Fiechter</u> , Lichao Jia, Matthias May, Omar Ali Carrasco, Chinmay Khare, Robert Meyer, Helge Stein, Alfred Ludwig, Ramona Gutkowski, Kirill Sliozberg, Wolfgang Schuhmann, Diana Stellmach Nanostructured iron tungstate films as photoelectrodes for light-induced water oxidation
P9	Ali Ghadirzadeh, <u>Francesco Fumagalli</u> , Fabio di Fonzo Vertical growth of nanostructured intercalated molybdenum oxide 2D semiconducting photoelectrodes
P10	<u>Diego González-Flores</u> , Ivelina Zaharieva, Jonathan Heidkamp, Petko Chernev, Elias Martínez, Chiara Pasquini, Anna Fischer, Holger Dau Electrodeposited calcium-manganese oxides for water oxidation catalysis

P11	<u>Marta Haro</u> , Antonio Guerrero, Sebastiano Bellani, Maria Rosa Antognazza, Laura Meda, Sixto Gimenez, Juan Bisquert Quantitative photocurrent injection from organic active layer to electrolyte solution in organic photoelectrochemical cells
P12	<u>Manuel Heimann</u> , Toni Kropf, Klaus Friedel, Malte Behrens Reactor system for facile OER catalyst screening using sacrificial agents
P13	Qian Wang, <u>Takashi Hisatomi</u> , Yanbo Li, Mamiko Nakabayashi, Naoya Shibata, Jun Kubota, Kazunari Domen Z-scheme water splitting using particulate semiconductors immobilized onto metal layers
P14	<u>Alexander G. Hufnagel</u> , Peter M. Zehetmaier, Ksenia Fominykh, Thomas Bein Kinetic studies on Co-catalysed hematite photoanodes prepared by atomic layer deposition
P15	<u>Qingxin Jia</u> , Ryo Niishiro, Akihito Iwase, Akihiko Kudo, Kazunari Domen A BiVO <sub>4</sub> electrode prepared by a microwave-assisted chemical bath deposition method for solar water splitting
P16	<u>Jin-Young Jung</u> , Min-Joon Park, Jung-Ho Lee, Sambhaji Shinde Hydrogen evolution utilizing a 20-um-thin silicon nanostructured photocathode
P17	<u>Yosuke Kageshima</u> , Hiromu Kumagai, Takashi Hisatomi, Tsutomu Minegishi, Jun Kubota, Kazunari Domen Photoelectrochemical cells for water electrolysis with CdS photoanode and redox couple of metal-complexes in non-aqueous solution by one-step photoexcitation.
P18	<u>Chinmay Khare</u> , Kirill Sliozberg, Robert Meyer, Aliaksandr Stepanovich, Pio. J. S Buenconsejo, Helge Stein, Wolfgang Schuhmann, Alfred Ludwig Scalable nanostructuring with combinatorial glancing angle deposition for improved photoanode performance
P19	<u>Joachim Klett</u> , Rolf Schäfer, Bernhard Kaiser, Wolfram Jaegermann Interface coupling of support materials to Pt-catalysts investigated by XPS
P20	<u>Kayo Koike</u> , Akihiro Nakamura, Kazuhiro Yamamoto, Satoshi Ohara, Masakazu Sugiyama, Yoshiaki Nakano, Katsushi Fujii Effect of the difference of electrolytes for photoelectrochemical water splitting of n-type GaN with and without NiO-loading
P21	<u>Ilina Kondofersky</u> , Halina Dunn, Alexander Müller, Dina Fattakhova-Rohlfing, Laurence Peter, Thomas Bein Electron collection in host-guest nanostructured hematite photoanodes for water splitting
P22	<u>Yongbo Kuang</u> , Taro Yamada, Hiroshi Nishiyama, Kazunari Domen Improving front-illumination water splitting efficiency of nano-porous BiVO <sub>4</sub> photoanode by sophisticated morphology control and ultra-thin NiOOH coating from deposited Ni
P23	<u>Agnieszka Kuc</u> , Wenqing Li, Thomas Heine, Henrike Grossmann, Lutz Mädler How to dope rutile nanoparticles to absorb visible light?
P24	B. Anke, T. Bredow, J. Soldat, M. Wark, <u>M. Lerch</u> Band gap engineering in photocatalysts by anion substitution: from Ba <sub>3</sub> Ta <sub>5</sub> O <sub>15</sub> to Ba <sub>3</sub> Ta <sub>5</sub> O <sub>14</sub> N
P25	<u>Zhaosheng Li</u> , Jianyong Feng Efficient LaTiO <sub>2</sub> N photoanodes by improving charge carrier transport among film particles
P26	<u>Rosa Llusar</u> , David Recatalá, Artem L. Gushchin, Ekaterina A. Kozlova, Yuliya A. Laricheva, Pavel A. Abramov, Maxim N. Sokolov, Roberto Gómez, Teresa Lana-Villarreal

	Photogeneration of hydrogen from water starting from hybrid Mo <sub>3</sub> S <sub>7</sub> clusters immobilized over TiO <sub>2</sub>
P27	<u>Stefan Lochbrunner</u> , Aleksej Friedrich, Stefanie Tschierlei, Antje Neubauer, Henrik Junge, Matthias Beller, Sergey Bokarev, Gilbert Grell, Oliver Kühn Time resolved spectroscopy of electron transfer and relaxation processes in photocatalytic systems
P28	<u>Michael Lublow</u> , Martin Rohloff, Anahita Azarpira, Thomas Schedel-Niedrig, Bouchra Bouabadi, Ivelina Zaharieva, Holger Dau, Anna Fischer Photo-assisted evolution of oxygen at electrocatalytic protection layers on silicon
P29	<u>Alessandro Mezzetti</u> , Mehrdad Balandeh, Alessandra Tacca, Silvia Leonardi, Gianluigi Marra, Giorgio Divitini, Caterina Ducati, Laura Meda, Fabio Di Fonzo Hyperbranched quasi-1D WO <sub>3</sub> nanostructures for an efficient photoanodic activity at low bias potentials
P30	Damián Monllor-Satoca, Mario Bärtsh, Cristian Fabrega, Sandra Hilaire, Teresa Andreu, Markus Niederberger, Jordi Arbiol, <u>J.R. Morante</u> Titanium as additive in Hematite-based photoanodes for solar hydrogen production
P31	L. Mendonça, R. Meira, M. Machado, <u>J. Morgado</u> Novel low-energy gap conjugated polymers for photovoltaics and hydrogen generation
P32	<u>Alexander Müller</u> , Alena Folger, Iilina Kondofersky, Rachel Zucker, Dina Fattakhova-Rohlfing, Craig Carter, Thomas Bein, Christina Scheu Three-dimensional analysis of photoelectrodes by FIB tomography
P33	<u>Dario Neri</u> , Silvia Leonardi, Francesco Fumagalli, Fabio Di Fonzo Quasi-1D SnO <sub>2</sub> -based transparent conductive oxides
P34	<u>Hong Nhan Nong</u> , Hyung-Suk Oh, Elena Willinger, Detre Teschner, Peter Strasser IrO <sub>x</sub> core-shell nanoparticle catalysts for efficient electrochemical water splitting
P35	<u>Hyung-Suk Oh</u> , Hong Nhan Nong, Detre Teschner, Peter Strasser Ir-nanodendrites supported on Sb-doped SnO <sub>2</sub> with high activity and stability for oxygen evolution reaction in water splitting system
P36	<u>Herbert Over</u> , Yunbin He, Timo Jacob, Josef Aton Model system RuO <sub>2</sub> (110)/TiO <sub>2</sub> (110) for the photocatalytic water splitting
P37	<u>Sandra Peglow</u> , Frank May, Shrouk Elashry, Marga-Martina Pohl, Angela Kruth, Volker Brüser Physical vapour deposition synthesis of Au, Ag, and Au/Ag core-shell nanoparticles on metal oxide semiconductors for photocatalytic applications
P38	Ying Chen, Francesco Fumagalli, Fabio Di Fonzo, Julia Kunze-Liebhäuser, <u>Engelbert Portenkirchner</u> Growth of hierarchical Cu–Ti–O nanostructures
P39	<u>Martin Rohloff</u> , Sevilay Cosgun, Cyriac Massué, Malte Behrens, Martin Lerch, Anna Fischer Design of tantalum oxide nitrides and nitrides photoanodes – influence of crystal structure and nanostructure
P40	<u>Sven O. Schopf</u> , Henrike K. Grossmann, Hendrik Naatz, Jorg Thöming, Lutz Mädler Characterization of charge transfer in dry printed nanoparticle layer electrodes for photocatalytic water splitting
P41	<u>Lee Seung Y.</u> , D. González-Flores, I. Zaharieva Screen printed metal oxide electrodes for water oxidation at neutral pH and its structure analysis by X-ray absorption spectroscopy
P42	<u>Stavroula Sfaelou</u> , Panagiotis Lianos Hydrogen production by photoelectrochemical procedures using photofuelcells

P43	Ramona Gutkowski, <u>Kirill Sliozberg</u> , Felipe Conzuelo, Chinmay Khare, Helge Stein, Alfred Ludwig, Wolfgang Schuhmann Optimization of photoelectrodes for solar water splitting using combinatorial electrochemical modification of photoabsorbers with co-catalyst and an optical scanning droplet cell (OSDC)
P44	<u>Helge Stein</u> , Kirill Sliozberg, Chinmay Khare, Bruce Parkinson, Wolfgang Schuhmann, Alfred Ludwig On the potential of the Fe-Cr-Al-O system for bias-free solar water splitting
P45	<u>Helge Stein</u> , Hassan Muhammad, Kirill Sliozberg, Chinmay Khare, Wolfgang Schuhmann, Alfred Ludwig Combinatorial study on the stabilisation of cuprous oxide based materials
P46	<u>Dereje H. Taffa</u> , Christian Dunkel, Michael Wark Coumarin modified zinc ferrite films obtained via electrochemical deposition
P47	<u>Diana Tranca</u> , Fermin Rodriguez-Hernandez, Gotthard Seifert Theoretical investigations of water splitting on neutral/charged titanium oxide clusters
P48	<u>Koichiro Ueda</u> , Tsutomu Minegishi, Takashi Hisatomi, Hiroshi Nishiyama, Masao Katayama, Jun Kubota, Taro Yamada, Kazunari Domen Photoelectrochemical properties of BaTaO <sub>2</sub> N photoanodes prepared by particle transfer method
P49	<u>Lei Wang</u> , Fabio Dionigi, Peter Strasser, Patrik Schmuki Tantalum nitride nanorod arrays introducing Ni-Fe layered double hydroxides as a cocatalyst strongly stabilizing photoanodes in water splitting
P50	<u>Florent Yang</u> , Jürgen Ziegler, Félix Urbain, Friedhelm Finger, Bernhard Kaiser, Wolfram Jaegermann Deposition of metal oxides as protective layers on thin film silicon based tandem cells for enhanced stability in water splitting devices
P51	<u>Ivelina Zaharieva</u> , Petko Chernev, Diego Gonzalez-Flores, Holger Dau Structural and functional parallels between a synthetic manganese-oxide catalyst for water oxidation and the Mn <sub>4</sub> CaO <sub>5</sub> biological active site

### Support

