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INTERNATIONAL CONFERENCE

Organized by

The Scientific Liaison Office of Wallonia Brussels in Sweden

4th Edition

Solar Photovoltaic Research and Applications: New Collaborations for Innovative Perspectives

Uppsala, 5th – 6th of February 2015

Venue : Lindahlsalen, Evolutionary Biology Center, Norbyvägen 14-18

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Day I – Thursday, 5th of February 2015

8.30 Registration

9.00 Welcome and Introduction

Henri Sprimont – *Scientific Liaison Officer WBI*

Peter Egardt – *Governor of Uppsala*

Johan Tysk – *Vice Rector of the Disciplinary Domain of Science and Technology at Uppsala University*

9.20 Solar ERA-Net & Horizon 2020: Possibilities of funding for Solar PV

Ulf Westerlund – *Uppsala University*

Ulf Westerlund will present selections from the MARIE SKŁODOWSKA-CURIE ACTION: **European Training Networks (ETN)** aim to train a new generation of creative, entrepreneurial and innovative early-stage researchers, able to face current and future challenges and to convert knowledge and ideas into products and services for economic and social benefit. **Individual Fellowships (IF)** provides opportunities to acquire and transfer new knowledge and to work on research in a European context (EU Member States and Associated Countries) or outside Europe. The scheme particularly supports the return and reintegration of researchers from outside Europe who have previously worked here. It also develops or helps to restart the careers of individual researchers that show great potential, considering their experience.

Ulf Westerlund has worked as an EU Research Officer at Uppsala University since 2010 with the mission to attract EU funding to the University. Earlier employment at the Swedish Research Council FORMAS as International Research Officer with focus on EU-funding results in long experience in research funding in general and EU-funding in particular.

Tobias Walla – *Swedish Energy Agency*

The two foremost funding possibilities for joint PV projects between European regions/countries are right now SOLAR-ERA.NET and Horizon 2020. Horizon 2020 is suitable only for bigger projects as these often involve a great deal of project administration. There are several Horizon calls that are closing the 5th of May. SOLAR-ERA.NET also has an open call, which closes the 27th of March.

SOLAR-ERA.NET
Joint call on PV and CSP, closes the 27th of March
Total budget: 12 MEUR
More information: http://solar-era.net

Participants from Sweden
Total budget: 0,86 MEUR

Contact: Tobias Walla, tobias.walla@swedishenergyagency.se
Linn Sjöström, linn.sjostrom@swedishenergyagency.se

Participants from Belgium-Wallonia
Total budget: 0,5 MEUR (flexible)
Contact: Julie Marlier, julie.marlier@spw.wallonie.be, +32 81 33 45 49 (for eligibility issues)
Laurence Polain, laurence.polain@spw.wallonie.be, +32 81 48 63 42 (for scope)

Horizon 2020: Energy challenge

The first work programme for "Secure, Clean and Efficient Energy" has a budget of 6,16 billion EUR 2014-2020, and will be split into the following focus areas:

- Energy Efficiency
- Low Carbon Technologies
- Smart Cities & Communities

Most ongoing calls in Low Carbon Technologies close at the 5th of May.

National contact points: http://www.vinnova.se and http://www.ncpwallonie.be

As a program manager at the Swedish Energy Agency, Tobias Walla oversees several national R&D programs and international collaborations. He holds a Master's degree in Energy Systems Engineering from Uppsala University, with a focus on solar electricity and other renewable electricity sources. For the time being he is responsible for the Swedish participation in SOLAR-ERA.NET and IEA PVPS.

9.50 The Photovoltaic Landscape in Wallonia

Cédric Brüll – *Cluster TWEED*

Cédric Brüll is since 2009 Managing Director at TWEED, the Cluster of Energy, Environment, and Sustainable Development technologies in Wallonia (Belgium). He received a Msc in business engineering (HEC-Ulg Business School – Université de Liège) and a MSc in environment management (UCL - Université Catholique de Louvain).

10.10 Thin Film Solar cells above 20 % efficiency, ideas and concepts

Marika Edoff – *Uppsala University*

Thin Film Solar cell materials are characterized by their exceptionally high absorption coefficients. Therefore they can absorb all available sunlight in only 1 micrometer thickness or even less. The use of exceptionally thin layers require a high degree of optimization of the back contact in order to avoid recombination and to allow for reflection of long wavelength photons. In this talk I will discuss different possibilities to thin down the absorber layer without loosing efficiency. I will also present some recent advances in the area of thin film solar cells.

Marika Edoff is professor in Solid State Electronics at the department of Engineering Sciences at Uppsala University where she is heading the thin film solar cell group, since 2003. She is also co-founder of the spin-off company Solibro. Her area of research is in solar cell based on Cu(In,Ga)Se2, where recent development has led to new designs of back contacts for solar cells with very thin absorber layers. Since 2014, she is appointed deputy vice rector and dean of the faculty of Science and Technology.

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10.30 PV activities in CRM Group: focus on LIFE-PHOSTER project

Lionel Fourdrinier – *CRM Group*

LIFE-PHOSTER (PHOtovoltaic STeel ROof) project consists in the development of highly efficient eco-designed building integrated photovoltaic (BIPV) roofing element using innovative and greener manufacturing process. The project intends to strongly contribute in the expansion and the promotion of the solar energy and to address the climate change environmental problem. A prototype of a new universal solar steel roof envelope will be designed, manufactured, installed and monitored during the project's 48-month timeframe.

Lionel Fourdrinier obtained his PhD degree in nanoelectrics at the “Institut National Polytechnique de Grenoble” in 2009. He then joined “Advanced Nanocoatings and Energy” lab in AC&CS scrl (formerly ArcelorMittal Liège Research), part of CRM Group, as a researcher on the field of the preparation of advanced steel substrate for light and energy management. In 2011, he became project leader in charge of technical aspects of CIGS solar cell completion and became in 2014 Program Leader for technical developments in the field of photovoltaics for ArcelorMittal. He is currently coordinating “CZTS” project at Walloon level, “NOVACOST” project (Solar Eranet call) at international level and leading action B1 in the frame of LIFE-PHOSTER project. He is author or co-author of around 10 papers published in conferences or international peer-review journals.

10.50 Coffee Break

11.05 Bulk and interface contributions to efficiency losses in Cu2ZnSnS4 solar cells

Charlotte Platzer Björkman – *Uppsala University*

Cu2ZnSnS4 (CZTS) based thin film solar cells are attractive from the use of more abundant and cheaper elements as compared to CdTe and CIGS. CZTS solar cells are in an early stage of development, and has seen rapid improvement in device performance up to 12.6% efficiency over the last years. In this presentation I will discuss the efficiency limitations of CZTS devices with focus on contributions from interface and bulk recombination in devices made by our reactive sputtering and annealing process.

Docent Charlotte Platzer-Björkman received her PhD at Uppsala University 2006 on Cd-free buffer layers for CIGS solar cells. The focus was on atomic layer deposition of ZnO-based materials and interface and band alignment studies by photoelectron spectroscopy. She did a post doc in a silicon solar cell group at the Institute for Energy Technology in Kjeller, Norway 2009 doing reactive sputtering of metal hydride films. From 2010 she has been associate senior lecturer at Uppsala University, leading a group on CZTS based thin film solar cells. She was awarded a Wallenberg Academy Fellowship in 2012 and a Future Research Leader grant by SSF in 2013.

11.25 Thin films, surfaces and interfaces in perovskite PV devices

Jean-Jacques Pireaux – *Namur University*

New technologies require new materials and development of characterization techniques. At PMR-LISE, we focus our research activities in the preparation, modification, analysis of new materials in the form of (thin) solid films for devices of relevance, e.g. for microelectronics and energy questions. This presentation will focus on two subjects illustrating our most recent advances, namely: 1) the illustration of one switching behaviour of organic memories : with XPS-based depth profiling, and more convincingly with a particular most sensitive ToF-SIMS profiling approach, we clearly evidence conductive filament formation and breaking in the On/Off states of the memories, and 2) the deposition of CZTS absorbing layers : magnetron sputtering, and co-evaporation of the appropriate precursors are studied in parallel, in order to elucidate (with X-ray diffraction, Raman spectroscopy, XPS and UV-Vis) the formation of the layers.

Prof. Dr. Jean-Jacques Pireaux, Ph.D. in Physics, Professor at the University of Namur, Belgium; research on characterization with photoelectron spectroscopy, surface treatment and film deposition of organic / polymer materials and interfaces; editor until 2010 of "Journal of Electron Spectroscopy and Related Phenomena"; President (2010-2013) of the IUVSTA - International Union for Vacuum Science, Technique and Applications; (co)editor of 18 books and proceedings, (co)author of about 400 publications, including 8 book chapters; 3 patents (pending) ; more than 80 invited presentations at international conferences and schools, and 80 seminars. Director of the "Laboratoire Interdisciplinaire de Spectroscopies Electroniques" (LISE) laboratory at the University of Namur, Professor Pireaux has been the coordinator of and participant to numerous European FPx , Belgian and Walloon projects. For example, he is actively implied into research contracts concerning carbon nanotubes and graphene, organic light emitting diodes, metal/polymer hybrids, adhesives, non volatile organic memories, fuel cells and photovoltaic cells.

11.45 Improving the window layer structure for CIGS solar cells

Tobias Törndahl – *Uppsala University*

This presentation treats the development of new window layer structures for CIGS solar cells. The main goals are to increase the electrical device performance and to make the solar cells cadmium free. Several possible improvements and design issues are discussed in relation to the most commonly used window layer structure of today, which consists of a triple layer of CdS/ZnO/ZnO:Al.

Tobias Törndahl is employed as an Associate professor in Engineering Science at Div. Solid State Electronics, Uppsala University. He defended his thesis for the degree of Ph. D. in 2004, with a background in Inorganic chemistry. In 2005 he started to work in the Thin film solar cell group at the Ångström laboratory, where he is currently leading a group focusing on developing the window layer structure of CIGS solar cells. The main expertise is in the fields of thin film deposition from chemical methods and in material characterization.

12.05 Electrical characterisation of graded and Al2O3 passivated CIGS solar cell

Ratan Kotipalli – *Université Catholique de Louvain*

The recent achievements of high-efficiency Cu(In,Ga)Se2 solar cells are reviewed with a special focus on the understanding of the electronic properties, intrinsic defects and the interfaces for the performance of the solar cells. Electrical characterization techniques offer unique insight, in understanding the basic physical mechanisms, the underlying charge carrier generation and transport properties and also in providing a deeper understanding of the solar cell parameters and their impact on device performance. To begin with, I will be discussing about the opportunities and challenges associated with the gallium (Ga) grading on Cu(In,Ga)Se2 (CIGS) solar cell performance. Then, we will examine the electrical characterization results obtained on graded and ungraded CIGS solar cells using drive-level capacitance profiling (DLCP) and admittance spectroscopy (AS) analyses. After that, I will explain the influence of Ga grading on the spatial variation of deep defects, free-carrier densities in the CIGS absorber, and their impact on the cell's open circuit voltage (Voc). And finally, I will move on to the electrical characterization of Al2O3/CIGS interfaces to understand the involved passivation mechanisms and discussing the influence of field-effect passivation on ultra-thin CIGS solar cell performance.

Ratan Kotipalli received the M.Sc. degree in Electrical engineering from the Technische Hochschule Deggendorf (Deggendorf, Germany) in 2010. From 2008 to 2010, he was at Fraunhofer Institute for Microelectronic Circuits and Systems (Duisburg, Germany), where he was engaged in research on the electrical characterization and reliability analysis of the 0.35 µm CMOS technology on SOI substrates. During his M.Sc. final research project with the same institute, he developed a novel dielectric-filled trench isolation process to avoid dielectric breakdown failures in CMOS devices. He is currently pursuing his Ph.D. degree in electrical engineering under the supervision of Prof Denis Flandre at Université catholique de Louvain (Louvain-la-Neuve, Belgium). His current research interests include new and innovative materials, structures and process technology of both thin film and wafer-based solar cells.

12.25 Lunch Break

14.00 Electrical metrology and modeling of semiconducting heterostructures for energy-harvesting devices

Duy Nguyen – *Liège University*

The performances of most electronic devices such as transistors, light-emitting diodes, photodiodes and photovoltaic cells critically depend on the quality of the materials used for their fabrication. Electronic traps in the active regions, associated to defects or long-range perturbations in cristalline media giving rise to energy states in the band gap, negatively affect electronic charge transport in the materials and, subsequently, the electrical and opto-electrical characteristics of the devices built therefrom. The study of the physical properties of these energy levels, through dedicated electrical measurements, is thus of crucial interest, not only from a fundamental point of view, but also for technological motivations. In this contribution, we will present a particular approach to address the challenges related to the electrical characterization of these semiconducting heterostructures, based on the measurement of the electrical admittance and which combines the use of equivalent circuits and numerical modeling at device scale. Several results obtained with this methodology will be shown, including examples in GeSn-based heterostructures, CIGS thin films and Ti-doped mesoporous hematite films.

Ngoc Duy Nguyen is professor of physics at the University of Liège in Belgium since 2010. He received an engineering degree in physics (1998) and a PhD in applied sciences (2004) from the University of Liège. As a postdoctoral researcher from 2004 to 2006, he was supported by the Interreg III Program in the framework of the OLED project. From 2006 to 2010, he pursued his career as a materials scientist at imec (Leuven, Belgium), where his activity was focused on Si and SiGe epitaxy, atomic layer doping and selective growth of III-V compounds. His current major research area is semiconductor science and technology, with a particular interest in heterostructures and nanostructures (growth, electrical characterization and device modeling).

14.20 Materials and processes for printed semitransparent organic photovoltaic modules

Olle Inganäs – *Linköping University*

We develop semitransparent polymer/fullerene solar modules printed on plastic, and use the semitransparent high conductivity conjugated polymer PEDOT both as anode and cathode. These are deposited by roll-to-roll printing to make photovoltaic devices connected into modules. Device geometry and serial connection help to reduce the size of currents that needs to be handled with the low conductivity but transparent polymer electrode. Depending on the bandgap of the active photovoltaic material, different colours result. With a low bandgap donor-acceptor copolymer TQ1, blue colour is obtained. Semitransparent cells can be stacked in tandem and triple junctions, reducing the transmission of light but generating more electrical power. With dielectric reflectors in the form of light scattering layers, light may be returned to the active layer for reabsorption and electrical power generation. They may also be used to balance the electrical power generation between several materials in tandem devices, creating a palette of weak and strong colours, transmissive or opaque.

Olle Inganäs is professor of biomolecular and organic electronics, IFM, Linköpings Universitet, Sweden. He received a MSc in engineering physics from Chalmers University of Technology (1977), a BSc in philosophy and economics from Göteborg University (1978), and a PhD in applied physics at Linköping University in 1984. He was appointed professor in 1999. Inganäs received the Göran Gustafsson prize in physics in 1997, and was appointed Wallenberg Scholar in 2010. He was elected a member of the Royal Swedish Academy of Sciences, class of physics, in 2006, and is a member of the Nobel committee for the prize in physics. He has contributed to a number of startup companies in the field of electronic polymers. Inganäs has focused on studies of the class of conjugated polymers throughout areas of polymer physics, electrochemistry, electronics and optics. The use of biopolymers as organisers of electronic polymers and as media for charge storage, and organic photovoltaics, are present topics of research.

14.40 Morphology-performance relations in polymer-based solar cells

Ellen Moons – *Karlstad University*

The active layer of a polymer solar cell consists of a blend of an electron donating conjugated polymer and an electron accepting fullerene derivative. We study the composition and structure of this layer and its influence on the solar cell performance. We will present results from a combination of microscopy and spectroscopy techniques for a polymer:fullerene system that gives solar cells with 7% conversion efficiency.

Ellen Moons graduated with a Licentiate in Physics from the University of Ghent, Belgium and a PhD from the Weizmann Institute of Science in Israel. After post-doctoral research at Delft University of Technology, The Netherlands, Ecole Polytechnique de Lausanne, Switzerland, and University of Cambridge in the United Kingdom, she worked as senior scientist at the spin-off company Cambridge Display Technology. In 2000 she joined Karlstad University in Sweden, where she was promoted to professor in materials physics in May 2012. In 2011 she was awarded the Göran Gustafsson prize in physics for her research on organic solar cells. Ellen Moons is vice-chair of the Scientific Council for Natural and Engineering Sciences of The Swedish Research Council.

15.00 Coffee Break

15.20 Theoretical Modelling of Electronic Processes at Interfaces in Organic and Hybrid Photovoltaic Devices

Jérôme Cornil – *Mons University*

Quantum-chemical calculations can prove very useful to shed light at the molecular scale on electronic processes at the Heart of organic and hybrid photovoltaic devices which are not easily accessed by experimental means. This will be illustrated here by considering for instance energy level alignment at hybrid interfaces in dye sensitized solar cells, the optical properties of dyes adsorbed on metal-oxide interfaces, the charge separation mechanisms in organic photovoltaic devices or charge transport in organic semiconductors.

Jérôme Cornil received his PhD in chemistry from the University of Mons (1996) and then went for postdoctoral stays at the University of California at Santa Barbara and at the Massachusetts Institute of Technology. He is currently a research director of the Belgian National Fund for Scientific Research (FNRS) and holds a position of Visiting Principal Research Scientist at the Georgia Institute of Technology. He is the author or co-author of 260 publications / book chapters and has given about 90 invited talks and seminars.

15.40 ELIOSYS – Your Accredited Testing Partner & New PV Technologie

Serge Peeters – *Eliosys*

The 1 st part is aiming at presenting ELIOSYS as a company. Starting with a short introduction about ELIOSYS, and illustrating its portfolio of testing services in the renewable energy segment. Ending this chapter by briefly summarizing some of the research projects with words about ELIOSYS' contribution. The 2nd part is targeting more specifically the photovoltaic segment. The tests capabilities are driven by some strategic choices about the solar simulators and test benches. We will illustrate some particular testing capabilities across a few realized test campaigns. Finally, it will become clear that ELIOSYS offers to all the actors either in R&D or in full production the opportunity to work with a reactive, reliable, and flexible partner whom will support them throughout their projects. For additional information: www.eliosys.eu

Serge Peeters graduated in 1986 as electronic system engineer specialized in microprocessor based design. He started his career in R&D projects respectively for the traffic signaling and for digital audio machines for about 4 years. He decided to take the turn to integrate the Intel distribution channel as application engineer for the Intel processors during a period of 10 years where he dealt with key Intel accounts in the banking segment and in the industrial automation. Later, still in the semiconductor market for about another 4 years, he did subsequently product marketing, product management and finally product/program strategy linked to micro computing solutions at AMI Semiconductor which I left in 2005. The applications were mainly targeting the electronic automotive industry. In 2006, he became business developer and large account manager in the embedded PC industry to develop new market opportunities in the defense and transportation segments. Finally in 2012, he joined the Eliosys team to lead the development of sales activities.

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Day II – Friday, 6th of February 2015

9. 00 Electronic structure of interfaces used for energy conversion

Håkan Rensmo – *Uppsala University*

The efficiency of the conversion process in solar cell systems is largely dependent on the properties of the interfacial region including material organisation as well as on energy matching between the different condensed phases including inorganic materials, molecular materials and electrolytes. Insight into the material organisation and electronic structure is therefore crucial in order to understand and optimize the function. X-ray based techniques such as photoelectron spectroscopy (PES) are powerful for obtaining such information at an atomic level due to the possibility for element specificity. This contribution reviews some of our synchrotron based PES results on molecular and perovskite solar cells and also indicates possibilities with future developments.

Håkan Rensmo is currently the head of the division of Molecular and Condensed Matter Physics containing world-leading expertise in X-ray science and spectroscopic development. Håkans research focuses on X-ray methodologies allowing for atomic level understanding of energy materials and their interfaces, specifically, the understanding of atomic and molecular interfacial structures, energy matching and charge re-distributions.

9.20 Structuration of functional inorganic materials for new generation solar cells

Catherine Henrist – *University of Liège*

Discovered in the early nineties, the dye-sensitized solar cells belong to the third generation of photovoltaic technologies. Their main component is a photoanode made of nanostructured semiconductor oxide on which the light absorber is coated. For this reason, the control of the nanostructure of the photoanode is of great importance. First, high specific surface ensures optimal dye loading and resulting photocurrent, even for very thin films (less than 5 microns). The control of porosity, in terms of pore size and 3D organisation, also play a key role when solid state electrolyte are envisaged. Indeed, those new electrolytes are viscous species that require an open and accessible porosity to promote high pore filling. The ordering of the semiconductors nanoparticles also helps the collection of photogenerated current towards the external circuit. This presentation shows the different synthesis strategies under research at GreenMAT for the fabrication of photoanodes with high control of thickness, porosity and ordering.

Catherine Henrist integrated the research group of professor Rudi Cloots at the University of Liège, Belgium, in 1998, at the end of a Master in Chemistry. She obtained her PhD in 2003, dealing with hybrid nano composites and templating synthetic routes. In the following years, she initiated solar research by adapting this templating approach towards photoanodes for dye-sensitized solar cells. Now a senior scientist at GreenMAT, she leads a research group of 7 people working on energy-related thin films.

9.40 Charge compensation in dye-sensitized solar cells

Gerrit Boschloo – *Uppsala University*

Electric fields that build up in a solar cell can affect their absorption spectrum due to Stark effects. In dye-sensitized solar cells (DSC) usually a spectral bleach is found upon photoinduced electron injection. The observed Stark effects is related to the charge compensation of electrons in mesoporous TiO_2 by cations in the electrolyte.

Gerrit Boschloo is leading the mesoscopic solar cell research group at the Department of Chemistry - Ångström Laboratory at Uppsala University. Research is focused on fundamental aspects of mesoporous semiconductor electrodes, dye-sensitized solar cells and perovskite solar cells, using a wide range of photoelectrochemical techniques. He is author of more than 150 peer-reviewed articles.

10.00 Dye-sensitized solar cells - Some aspects of materials and coordination chemistry

Lars Kloo – *KTH Royal Institute of Technology*

The dye-sensitized solar cell (DSSC), the so-called Grätzel cell, is in essence an electrochemical cell. As an electrochemical device it consists of only three components; two electrodes and an electrolyte. Recent developments involve both the use of new solvent systems for the electrolytes in liquid DSSCs and in solid state DSSCs based on organic and inorganic conducting materials. The presentation will focus on some recent insights into different types of DSSCs, and at the same time highlight some correlation between physical properties and local coordination effects.

Lars Kloo is since 1998 full professor at Applied Physical Chemistry, KTH Royal Institute of Technology, Stockholm. His main research has been devoted to the application of coordination chemistry to the design of reaction media for inorganic and organometallic synthesis operating at room temperature rather than at elevated temperatures, based on ionic liquids and hybrid fluids, as well as the design of electrolyte media for electrochemical devices, such as batteries and photoelectrochemical solar cells.

10.20 Coffee Break

10.35 Perovskite Solar Cell: Performance, Stability and Future Prospects

Sandeep Pathak – *University of Oxford*

The energy costs associated with separating tightly bound excitons (photoinduced electron-hole pairs) and extracting free charges from highly disordered low-mobility networks represent fundamental losses for many low-cost photovoltaic technologies. A low-cost, solution-processable solar cell, based on a highly crystalline perovskite absorber with intense visible to near-infrared absorptivity, that has a power conversion efficiency of 19 % so far in a single-junction device under simulated full sunlight. This “meso-superstructured solar cell” exhibits exceptionally few fundamental energy losses; it can generate open-circuit photovoltages of more than 1.1 volts, despite the relatively narrow absorber band gap of 1.55 electron volts. To attain reproducibility in the performance one of the critical factors is the processing conditions of the perovskite film, which directly influences the photo-- physical properties and hence the device performance. Here we study the effect of annealing parameters on the change in crystal structure of the perovskite films and correlate these changes with its photo-physical properties. We find that the crystal formation is kinetically driven by the annealing atmosphere, time and temperature. However, future response of this technology shall determined by its inherent stability and overall cost associated with energy generation.

Sandeep Pathak is since 2013 working as a Research Associate with Dr Henry Snaith at University of Oxford, Clarendon Laboratory, UK. He received a BSc in chemistry from GGD University Bilaspur, India (2000), a MSc in physical chemistry from GGD University (2002), and a PhD on superconducting material with Prof David Cardwell at the University of Cambridge, Dept of Engineering, UK (2010). His research is mainly focused on hybrid solar cell, high temperature superconductivity, and high performance polymers. He is founding member of the start-up "Social Solar" that won the initial support grant from European Union. He is also author of many peer-reviewed articles.

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10. 55 Perovskites and quantum dots; new materials for solar cell

Erik Johansson – *Uppsala University*

A few years ago it was discovered that a perovskite may be used as efficient light absorber on the nanostructured TiO_2 surface in a dye-sensitized solar cell. It was later reported that the perovskite $CH_3NH_3PbI_3$ or $CH_3NH_3PbI_2Cl$ may also be used in combination with organic hole transport materials for highly efficient solid state solar cells and recently a power conversion efficiency over 17 percent has been reported for these solar cells. In Uppsala we investigate the properties of the perovskite solar cells and how it may be further developed.
Quantum dots of semiconductor materials may also be used for light absorption in nanocomposite solar cells. The quantum dots in these solar cells are based on light absorbing semiconductors such as PbS or CdS and the light absorption spectrum can be tuned by varying the size of the quantum dot. The efficiency of solar cells based on quantum dots are today lower compared to the perovskite based solar cells, but the possibility for multiple exciton generation by a single photon, may in the future result in very high solar cell efficiencies.

Erik Johansson is docent in Physical Chemistry at Uppsala University. He obtained his PhD in physics at Uppsala University in 2006, and was post-doc 2007-2009 in Chemical Physics at Lund University with Villy Sundströms research group. His research focus is on solar cells based on nanoparticles, quantum dots or organic materials, and specifically the link between fundamental mechanisms and the device properties.

11. 15 Mesoscopic solar cell research at EPFL

Anders Hagfeldt – *Ecole Polytechnique Fédérale de Lausanne*

The main focus of research at the Laboratory of Photonics and Interfaces EPFL is on photo-systems that generated electric power or fuels from sunlight. The inverse process of producing light from electricity in organic light emitting diodes (OLEDS) is also being investigated. The great majority of devices examined in our laboratories employs mesoscopic structures composed of nano sized particles as a key substrate element. In fact, it was the Graetzel group at LPI that pioneered the use of such mesoscopic architectures for the solar production of electricity and fuels. The choice of mesoscopic oxides is supported by our extensive studies of photo induced electron- and energy-transfer processes of nanocrystalline systems of various kinds. The advantages of mesoscopic oxide substrates are manifold. Advances in our understanding on how to control/manipulate interfacial charge transfer enables to design efficient photo chemical systems that effect overall conversion of solar energy as electric power as in solar cells or as solar fuels such as H_2 from photoelectrochemical water splitting and reduction of CO_2 to methanol and other C1 products.

Anders Hagfeldt is, since 2014, appointed Full Professor at the Ecole Polytechnique Fédérale de Lausanne (EPFL), in Switzerland. He is a Guest Professor at Uppsala University where he obtained his PhD in 1993 before to accomplish his Post-Doc. with Michael Grätzel at the EPFL. He is one of the world leading experts in the field of mesoporous dye-sensitized solar cells. His research focuses on physical chemical characterisation of mesoporous electrodes for different types of opto-electronic devices. For the materials science aspects he is developing nanostructured oxide particles and films, ionic liquid redox systems, and chromophores. For the applied research he develops dye-sensitized solar cells based on a monolithic design. He has published more than 330 scientific papers that have received over 28,000 citations (with an h-index of 82), and has 8 patent applications. In 2011, he was ranked number 46 on the list of 100-top material scientists of the past decade by Times Higher Education, and in 2012 he was awarded the Nature Award for Mentoring in Science.

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11. 35 Powerweave : Development of DSSC PV yarns and energy storage yarns toward a self-powered textile fabric

Virginie Canart – *Centexbel*

This presentation will describe the objectives of the European project Powerweave which aims to develop a fabric containing both photovoltaic fibres and energy storage fibres. Some textile structures were especially designed to cope with these sensitive fibres and some dummy fabrics were demonstrated. Preliminary results will be presented for both energy storage and photovoltaic fibres by multilayer coating. The challenges to realize such fibres at industrial scale will be highlighted.

Virginie Canart got an engineering degree from HEI in Lille, France with a specialization in technical textiles from the Hochschule Niederrhein in Germany. For more than three years, she has been focussing on electronic integration in textile fabrics and in photovoltaic activities on textile. She is now project leader of European projects about electronics and photovoltaics at Centexbel.

11.55 Market needs for Building Integrated Photovoltaics

Michael Demeyere – *AGC Glass Europe*

AGC Glass Europe produces, processes and distributes flat glass for the construction and automotive industries. Taking its cue from both the industry itself and market trends, its R&D Centre in Charleroi, Belgium, employs approximately 250 people dedicated to making glass a material that meets an ever wider range of needs (energy management, comfort, health & safety, aesthetics). Sustainable development is the focal point: 70% of research projects aim at having a positive direct impact on the environment. In that field AGC Glass Europe has developed and continues to develop Building Integrated PhotoVoltaics (BIPV) glass for the Building market, as several drivers (among them the European Directive on "almost-zero energy buildings") push for a large expansion of this market. AGC's needs (technical and commercial, present and future) for BIPV will be presented at the seminair by Michael Demeyere, R&D Coordinator for active glass.

12.15 Concluding Remarks

12.25 Lunch

For more information, please contact

Henri Sprimont

Scientific Liaison Officer
Wallonia Brussels International

henri.sprimont@uadm.uu.se
+46 70 167 93 94