Lifetime and reliability issues in PV

Manno TI, September 10th 2015

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2008 – present
Head at the Institute for Applied Sustainability to the Built Environment (Istituto Sostenibilitˆ Applicata all'Ambiente Costruito ISAAC), University of Applied Sciences and Arts of Southern Switzerland (Scuola universitaria professionale della Svizzera italiana, SUPSI).
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Watt D'Or award for energy technology. Development and management of interdisciplinary projects with focus in smart grids. Senior Researcher in environmental and technical innovation projects in the field of transportation, mobility and energy. Member of the *Conseil du Développement* Durable of the Federal Office of Environment for the first Action Plan for Switzerland.
1989-2008
Research Assistant at the Department of Geography at the University of Fribourg (Switzerland). Researcher at the Economic Research Institute IRE, Università della Svizzera Italiana USI Lugano.

Dr. Christoph Harder

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Dr. Christoph S. Harder received the Electrical Engineering Diploma from the ETH in 1979 and the Master and PhD in Electrical Engineering in 1980 and 1983 from Caltech, Pasadena, USA. He is co-founder of the IBM Zurich Laser Diode Enterprise which pioneered the first 980nm high power pump laser for telecom optical amplifiers. He has been managing during the last few years the high power laser diode R&D effort in Zurich expanding, working closely with a multitude of customers, the product range into 14xx pumps as well as 808 and 9xx multimode pumps for industrial applications. He has published more than 100 papers and 20 patents and has held a variety of staff and management positions at ETH, Caltech, IBM, Uniphase, JDS Uniphase, Nortel and Bookham.

Thomas Weber

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Thomas Weber studied environmental engineering at the University of Applied Science Berlin. He completed his diploma, with a topic of post-annealing treatments of silicon thin-film solar cells, at the Helmholtz Center Berlin. Since June 2008 he has been working as a project manager at PI-Berlin, specializing in TFPID and electroluminescence.

Potential-induced degradation of thin-film modules: Prediction of outdoor behaviour
The current standards (IEC 61646 and IEC 61730-2, and IEC 62804 draft for c-Si only) are clearly insufficient to guarantee satisfactory long-term stability and energy yield for thin-film modules, given that reports from the field, as well as from laboratory test results (beyond IEC testing), in some cases show significant degradation of IEC-certified modules. Accordingly, thin-film modules can also exhibit degradation effects, such as TCO corrosion and power degradation, because of potential-induced degradation (PID). This paper presents the results obtained for thin-film modules subjected to bias and damp-heat (BDH) conditions in both indoor and outdoor tests. In order to assess module lifetimes for different thin-film technologies with respect to PID, indoor- and outdoor-determined leakage currents are compared and analysed, taking into account weather data and results from accelerated ageing tests. Finally, on the basis of simulations and investigations for different installation locations, module lifetimes are estimated and discussed.

Alberto Pozza

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Alberto Pozza received his Master's Degree in electronic engineering from the University of Padova in 2003. He worked as a researcher on the development of silicon radiation detectors until 2007 and on the development of advanced crystalline silicon solar cells from 2008 to 2012. Since 2013 he has worked at the JRC in Ispra on lifetime prediction studies of photovoltaic devices.

Standardized tests to assure the reliability of photovoltaic modules have played an important role in the successful growth of photovoltaic market in recent years. This talk outlines the current status of qualification tests, highlighting the importance of accelerated stress tests to predict photovoltaic modules reliability, and presents the ongoing activities to develop lifetime prediction models for photovoltaic modules.

Thomas Söderström

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Thomas Söderström received a Master in Science degree from the EPFL in 2005 and a PhD in 2009 from the University of Neuchâtel (UNINE, Switzerland). His PhD in UNINE and postdoctoral in University of New South Wales (UNSW,Australia) work was focusing on thin-film silicon solar cells. He is currently leading the Transfer, Process and Innovation Module department at Meyer Burger AG and focuses on the development and industrialization of the Heterojunction Smart Wire Bifacial Module Technology.

From solar module reliability to bifacial solar module production line
Meyer Burger develops a high-efficiency line concept with a silicon heterojunction (HJT) cell based module. This line produces 2400 6-inch busbarless cells per hour and includes cells and modules characterization. The underlying high-efficiency bifacial module technology relies on the Smart Wire Connection Technology (SWCT) and on a Glass-Glass (GG) module design. The SWCT and GG concepts have been developed to benefit from the natural symmetry and bifaciality of the HJT cell. Our preliminary results demonstrate that our HJT cells can be incorporated into a record 60 156mm*156 mm cell module of 316 W. This paper reports on modules made on our pilot line in Switzerland and in Germany and presents outdoor measurement performances comparing our HJT bifacial modules with other technologies such as CdTe, CIGS and c-Si. Modules from this technology are currently being stressed in thermocycling and damp heat chamber and shows no degradation after 600 cycles/4000 hours.

Simon Züfle

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Simon Züfle studied pyhsics at KIT and did his diploma thesis in the group of Uli Lemmer on modeling of temperature-dependent transport in organic solar cells in 2009. In 2014 he started his PhD at ZHAW working in the group of Beat Ruhstaller on combined experimental and numerical investigation of degradation mechanisms in OPV and OLEDs.

Complementary techniques to investigate degradation mechanisms in solar cells
Degradation mechanisms in solar cells can be understood better by applying systematic optoelectrical characterization techniques at different degradation stages. A combinatorial analysis of steady-state, transient and impedance measurements allows to identify the most relevant processes under the given conditions. In addition to parameter extraction routines numerical simulations are employed, giving higher parameter reliability.

Dr. Fanny Sculati-Meillaud

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Dr. Fanny Sculati-Meillaud got her PhD thesis from the University of Neuchâtel in 2006. Since 2008, she is team leader at the Photovoltaics and Thin-Film Electronics Laboratory of EPFL. After years of research focused on thin-film silicon solar cells, Dr. Sculati-Meillaud recently decided to broaden her expertise to the fundamental aspects of PV modules reliability.

Reliability of PV modules and long-term performance prediction
Predicting lifetime and performance over time of PV modules in outdoor conditions is critical and requires a detailed understanding of the possible failure modes. In this frame, the presentation will focus on water ingress and related failures with modeling results based on Finite Elements Method as well as data achieved thanks to miniaturized humidity/temperature sensors embedded in the encapsulant material.

Dr. Adriana Paracchino

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Dr. Adriana Paracchino received a Master degree in Material Science from the University of Turin (Italy) in 2007. She then joined the group of Prof. Michael Grätzel at EPFL and received a PhD degree in Chemistry in 2012 with a thesis on photoelectrochemical water splitting. She worked on OPV in the group of Prof. Frank Nüesch at EMPA. She is currently Material Scientist at Dyesol. She has hands-on experience and theoretical understanding of several photovoltaics technologies (DSSC, perovskite solar cells, OPV).

Durability of perovskite-based mesoscopic solar cells
(Adriana Paracchino, Nancy Jiang, Timothy Lee, Kristen Tandy, Celeste Choo and Dongchuan Fu)
Recently inorganic–organic hybrid perovskite solar cells have shown great potential as a low-cost and high-efficiency photovoltaic technology, owing to unique material properties. This talk will present stability results obtained under light soaking and thermal stress for different perovskite solar cells architectures (DSC-like, low-temperature carbon and porous carbon counter-electrode) and different humidity levels.

Dr. Mauro Pravettoni

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Dr. Mauro Pravettoni got his PhD in physics at the Imperial College London. In 2008 he contributed to the development of the world record efficiency luminescent solar concentrator, while doing research for the European Commission. In SUPSI since 2010, he is a member of IEC/TC82 and of the British Society for the Philosophy of Science. He wrote more than 20 peer-reviewed papers.

Pre-normative characterization of multi-junction photovoltaic modules
Spectral tuning of solar simulators is used in the experimental practice with multi-junction cells for concentrating photovoltaics and space applications. Multi-junctions are used also in flat panel modules and in novel perovskite/silicon structures and a dedicated standard characterization procedure is now in draft. LED lamps show at SUPSI the potential to allow spectral tuning on conventional xenon solar simulators.

Prof. Urs Muntwyler

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Urs Muntwyler is Professor for Photovoltaic and leader of the PV Lab of the Berner Fachhochschule (BHF) in Burgdorf since 2010. He was manager of the *Tour de Sol 1985-1992*, the first solar mobile race in the world. Muntwyler is involved in the PV since more than 40 years. He published more than 200 articles and books on solar energy, photovoltaics, electric vehicles and solar cars.

Lifetime and reliability issues in PV
The electricity production with photovoltaics is a big success. Since more than 30 years the annual production is growing. The price of the PV-modules went down at a factor of more than 200 in forty years. The reliability and the efficiency of the PV modules went up in that period. Solar electricity is now cheaper than electricity in a household. PV is a disruptive technology and will change the electricity market together with wind energy. What can we expect in the next decades and how will this change the PV technology?

Prof. Dr. Frank Nüesch

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Frank Nüesch ist diplomierter Physiker der ETH Zürich und hat sein Doktorat auf dem Thema der Farbstoffzellen bei Prof. Michael Grätzel an der EPFL Lausanne durchgeführt. Seit 2004 leitet Frank Nüesch die Abteilung Funktionspolymere an der Empa in Dübendorf und forscht auf dem Gebiet der organischen Optoelektronik sowie der dielektrischen Elastomeraktoren. Er unterrichtet organische Halbleiter an der EPFL, wo er seit 2011 eine Titularprofessur innehat.