Oral presentations for Session 2.4.3 | Thursday, 27 October | Room 3612 / 3613

Session Chair:
Andreas FELL (FRAUNHOFER ISE, Germany)
Andrew BLAKERS (ANU, Australia))

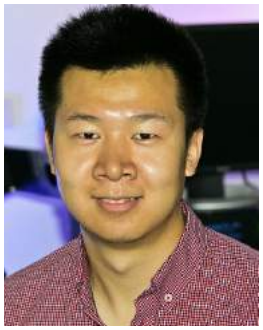
2.4.3a Invited Talk (16:00 – 16:15)
Dr Otwin Breitenstein
Max Planck Institute of Microstructure Physics, Germany

Local Efficiency Analysis of C-Si Solar Cells Using Luminescence Imaging and Lock-In Thermography

O. BREITENSTEIN[1], F. FRÜHAUF[1], J. BAUER[1] et al.
[1] Max Planck Institute of Microstructure Physics, Germany

Abstract
Photoluminescence and electroluminescence imaging and dark lock-in thermography (DLIT) are used for imaging the local series resistance Rs and saturation current density J01, which are essential parameters for local efficiency analysis. The limitation of DLIT is thermal blurring and a higher data acquisition time. However, J01 results for luminescence and DLIT analysis did not agree quantitatively. The reason is the assumption of the model of independent diodes for evaluating the data, whereas in reality Rs is a distributed resistance. This assumption leads to significant errors only for evaluating luminescence images, but not for evaluating DLIT, where the current is measured more directly. Recently two alternative PL evaluation methods were proposed, which are not based on the isolated diode model and lead to high-resolution J01 images comparable to DLIT ones. Together with EL and PL based local voltage analysis this enables a realistic Griddler analysis of inhomogeneous solar cells.

Biography
Otwin Breitenstein received his Ph.D. in physics at University of Leipzig, Germany, in 1980. Since 1992 he is with Max Planck Institute of Microstructure Physics in Halle, Germany, where he investigates defects in semiconductors. Since 1999 he is using lock-in thermography for detecting internal shunts in silicon solar cells. Since 2001 he has introduced this technique on a microscopic scale for isolating faults in ICs. As an associate professor at Halle University he gives a lecture on the physics of solar cells. He is author of a book on Lock-in Thermography and has published more than 200 contributions about his research in scientific journals and at international conferences.



2.4.3b (16:15 – 16:30)
Dr Jie Cui
Australian National University, Australia

Highly Effective Electronic Passivation of Silicon Surfaces by Atomic Layer Deposited Hafnium Oxide

J. CUI[1], A. CUEVAS[1]
[1] Australian National University, Australia

Abstract
This paper proposes the application of hafnium oxide (HfO2) thin film to crystalline silicon (c-Si) solar cells. Effective passivation of n- and p-type crystalline silicon surfaces has been achieved by the application of thin HfO2 films prepared by atomic layer deposition using tetrakis (ethylmethylamido) hafnium (IV) and deionised water as the reactants. Effective surface recombination velocities as low as 3.3 and 9.9 cm s-1 have been recorded with 15 nm thick films on n- and p-type 1 Ω·cm c-Si, respectively. A range of deposition parameters has been explored, with a growth rate of approximately 0.7Å/cycle at 250 °C providing optimum passivation. The passivation of HfO2 is activated by a forming gas anneal at 350 °C, and x-ray diffraction shows that the film remains largely amorphous after anneal. In summary, HfO2 is demonstrated to be an excellent candidate for surface passivation of high efficiency silicon solar cells.

Biography
Dr. Jie Cui received his doctoral degree from University of New South Wales, Australia in 2014 with the thesis focused on applications of anodic oxides in silicon solar cells. From 2015, he joined the solar PV group at the Australian National University as a research fellow, where he led an industrial project focusing on development of new materials for silicon solar cell surface passivation. He has broad research interests in surface passivation materials, carrier selective contacts and novel application of solar PV such as in water splitting and gas sensing.

Oral presentations for Session 2.4.3 | Thursday, 27 October | Room 3612 / 3613

2.4.3c (16:30 – 16:45)
Dr Bonne Eggleston
First Solar Inc, United States

Leveraging Virtual Wafer Tracking and Analytics in Advanced Solar Cell Production

S. BAKER-FINCH[1], B. EGGLESTON[1], R. EVANS[2] et al.
[1] First Solar Inc, United States
[2] Solinno Pty Ltd, Australia

Abstract
While ramping the novel low-cost high-efficiency TetraSun technology to 100 MW mass production, we leveraged and demonstrated the enormous value of single wafer tracking and advanced analytics in a modern PV production environment. Wafers are tracked virtually, with no physical (eg. laser) marking required, ensuring that no efficiency or yield loss is incurred, and no additional hardware is required. We present case studies attesting to the benefits of single wafer tracking: (i) powerful experiments and line optimisation; (ii) rapid response to yield loss issues with root cause analysis; (iii) improved quality control, particularly when applying advanced physics-based analysis to end-of-line measurement data.

2.4.3d (16:45 – 17:00)
Dr Rolf Stangl
Solar Energy Research Institute Singapore (SERIS), Singapore

XSolar-Hetero α-1.0.0: Launching a Dynamic Web Based Solar Cell Simulation platform for the Personalized Simulation of Various Solar Cell Architectures, Using Various Simulation Programs

G. ANAND[1], R. STANGL[1], C. KE[1] et al.
[1] Solar Energy Research Institute Singapore (SERIS), Singapore

Abstract
XSolar-Hetero, a dynamic web based solar cell simulation platform for the personalized simulation of various solar cell architectures, using various simulation programs, will be launched at this conference. XSolar-Hetero provides a "Software as a Service" (SaaS) solution, by (1) offering a standard device simulation interface for the most common solar cell architectures, (2) providing online calculation capability to run some commonly established solar cell device simulation programs in zero, one or two dimensions, (3) allowing to modify/save individual parameters in a personalized user database. It is a dynamic platform, thus new solar cell architectures, new materials and new simulation programs can be uploaded by the research community.

Biography
Dr Rolf Stangl is Head of the Novel Cell Concepts & Simulation Group at the Solar Energy Research Institute of Singapore (SERIS). He is also the Principal Investigator of three publicly funded projects funded by the Energy Innovation Programme Office (EIPO) of Singapore (on hybrid heterojunction solar cells, on contact passivation and on thin-film on silicon tandem solar cells), as well as Project Manager of several small-scale industry projects. Rolf Stangl holds a PhD degree in physics, for work on organic dye sensitized solar cells conducted at the Fraunhofer Institute for Solar Energy Systems (FhG ISE) in Freiburg, Germany. Prior to joining SERIS in 2011, he worked for several years as a Research Fellow on thin-film silicon solar cells and silicon wafer based heterojunction solar cells at the Helmholtz Centre Berlin for Materials and Energy (HZB), Berlin, Germany, and spent a sabbatical leave in Nanjing, China for two years.

Oral presentations for Session 2.4.3 | Thursday, 27 October | Room 3612 / 3613

2.4.3e (17:00 – 17:15)
Prof Marco Topic
University of Ljubljana, Slovenia

Design of Back Contact of Bifacial Silicon Heterojunction Cells

A. CAMPA[1], M. TOPIČ[1], A. VALLA[2] et al.
[1] University of Ljubljana, Slovenia
[2] CEA-INES, France

Abstract
The back contact of bifacial heterojunction silicon solar cell was investigated and improved by means of full 3-D optical and simplified 2-D electrical simulations. The standard heterojunction silicon solar cell structure with full surface back reflector was modified for use in bifacial applications. The fingers were applied at the bottom to make the contact transparent for the back illumination. With 3-D optical simulations the best texture was determined for improved light in-coupling. Furthermore, with the 2-D electrical simulations the position of the front and back finger contacts was optimized in order to improve the electrical performance of the bifacial heterojunction silicon solar cell.

Biography
Prof. Marko Topic, Head of Laboratory of Photovoltaics and Optoelectronics of the University of Ljubljana in Slovenia, was elected as the Chairman of the EU PV Technology Platform (EU PVTP) on 16th December 2014 in Brussels, Belgium. Prof. Topic has been the Chairman of the Slovenian Photovoltaic Technology Platform since 2006. He is a Full Professor at the Faculty of Electrical Engineering at the University of Ljubljana and he has a very broad research experience in Photovoltaics, Thin-film Semiconductor Materials, Electron Devices, Optoelectronics, Electronic Circuits, and Reliability Engineering. He is a member of the Slovenian Academy of Engineering and has received several prestigious awards, including the Zoisova nagrada 2008 (the highest award of the Republic of Slovenia for Scientific and Research Achievements).

2.4.3f (17:15 – 17:30)
Dr Jaap Beijersbergen
Levitech BV, Netherlands

Industrial Optimalization of Al2O3 Passivation Layers in New Cell Designs: A Comparison between PECVD and ALD

J. BEIJERSBERGEN[1], K. VANORMELINGEN[1], X. PAGES[1] et al.
[1] Levitech BV, Netherlands

Abstract
Although the market share of the Al BSF cell is still well above 80%, this cell design is rapidly being replaced by more advanced and hence more efficient cell designs. The majority of these new cell designs clearly benefit from the use of Al2O3 as surface passivation, e.g. PERC, EWT, n-type and IBC, resulting in increased efficiencies. The application of Al2O3 in industrial production has been made possible by the development of high throughput deposition systems. In this work, a comparison between PECVD and ALD is made based on layer integration and deposition system performance. When taking into account the intrinsic passivation properties and cost of ownership considerations, a layer thickness of 2nm for front side passivation and 5 to 6 nm for the backside passivation can be considered as good values for use in industrially produced solar cells. These thicknesses can easily be deposited using ALD, while for PECVD

Biography
Jaap got his PhD in Physics at the University of Amsterdam and the AMOLF. After a post-doc at RIKEN in Japan, Jaap joined ASM in the semiconductor business and was stationed in USA, Korea and Taiwan. In the beginning of the new millennium Jaap worked for BC Components and BESI before returning to ASM in 2005. In 2009 Levitech was formed through a management buy out. The focus of Levitech is on ALD in solar industry and on RTP in semiconductor industry.

Oral presentations for Session 2.4.3 | Thursday, 27 October | Room 3612 / 3613

2.4.3g (17:30 – 17:45)
Mr Kyung Kim
University of New South Wales, Australia

In-Situ Diagnostics Of Pecvd Alox Deposition By Optical Emission Spectroscopy

K. KIM[1], Z. HAMEIRI[1], S. WINDERBAUM[2]
[1] The University of New South Wales, AUSTRALIA
[2] Shamash Australia Pty Ltd, Australia

Abstract
Plasma enhanced chemical vapour deposition method is commonly used in industry. Aluminium oxide layer deposited using this method is becoming a common rear surface passivation layer for passivated emitter and rear solar cell. In this study, we investigate the correlation between the plasma properties using an in-situ monitoring and the film properties. Interestingly, no correlation between the density of the corresponding radicals (aluminium and oxygen) in plasma and the surface passivation quality has been found. This is a very surprising observation that highlights the limited knowledge currently exists within the photovoltaic community regarding plasma characterisation.

Biography
Kyung acquired an undergraduate degree in electronics engineering in South Korea. He worked for Samsung Electronics as a thin film process engineer in semiconductor division in South Korea for 6 years. He then moved to Australia and took his first step in renewable energy, the photovoltaics, in 2010. He worked for CSG Solar and Suntech R&D Australia from 2010 to 2014 as a process engineer in Sydney, Australia. He also did Master degree during this period and was granted a Master degree by research on silicon thin film solar cell at UNSW (The University of New South Wales) in 2015. He is now a PhD candidate from 2015, working on surface passivation for crystalline silicon solar cell using various plasma enhanced chemical vapor deposition (PECVD) systems. His research interest is various dielectric layers such as aluminium oxide (AlOx), silicon nitride (SiNx), and silicon oxy nitride (SiOxNy).

2.4.3h (17:45 – 18:00)
Dr Yuji Ino
Shizuoka Institute of Science and Technology, Japan

A New Evaluation Method of Fe Impurities in mc-Si Solar Cells by Mossbauer Spectroscopic Microscope

Y. INO[1], T. WATANABE[1], K. Hayakawa[1] et al.
[1] Shizuoka Institute of Science and Technology, Japan

Abstract
A new set-up of “Mössbauer Spectroscopic Microscope (MSM)” has been constructed to evaluate Fe impurities in multi-crystalline Si solar cells. The MSM is based on the Mössbauer effect of 57Fe nuclei, focusing 14.4 keV-γ-rays down to a spot size of 75 micrometer. The MSM is combined with a scanning electron microscope (SEM), an electron beam induced current (EBIC), an electron backscatter diffraction (EBSD), and a high energy electron spectrometer, which will open a new possibility to investigate the space correlations between Fe impurities and the lattice defects such as grain boundaries and dislocations in multi-crystalline Si solar cells.

Biography
Dr. Yuji Ino received bachelor's, master's, and Ph. D. degrees in electronics and electrical engineering from Keio University, Japan, in 2006, 2008, and 2013, respectively. Since 2013, he has been a researcher at Shizuoka Institute of Science and Technology, Japan, and engaged in development of a Mössbauer spectroscopic microscope.