Oral presentations for Session 2.4.2 | Thursday, 27 October | Room 3612 / 3613

Session Chair:
Johnson WONG (SERIS, Singapore)
Sebastien DUBOIS (CEA/LITEN/DTS, INES, France)

2.4.2a (14:00 - 14:15)
Dr Andreas Fell
Fraunhofer ISE, Germany

3D Simulation of Full-Area Silicon Solar Cells: Less Assumptions for High Accuracy and Confidence
A. FELL[1], F. SCHINDLER[1], M. SCHUBERT[1] et al.
[1] Fraunhofer ISE, Germany

Abstract
A new implementation of a numerically efficient model to solve carrier transport in silicon solar cells is presented, which will form the core of Quokka version 3. It enables the full three-dimensional discretization and solution of full-area solar cells. Benefits of such an approach with respect to solution accuracy and confidence in comparison to more complicated approaches are highlighted. An exemplary simulation of a 156 mm x 156 mm mc-PERC cell agrees well with corresponding ELBA calculations. With ever increasing computational power, such full-cell simulations are anticipated to increasingly be employed in years to come.

Biography
Andreas Fell received the Ph.D. degree in physics from the University of Konstanz, Germany in 2010. From 2006 - 2011 he was a researcher at Fraunhofer ISE, Germany, on the topic of modeling and development of laser processes for silicon solar cells. He then joined the Australian National University for 5 years as a research fellow in the same field, where he expanded his research to device simulation and developed the popular silicon solar cell simulation tool "Quokka". Since 2016 he is back at Fraunhofer ISE as a Marie-Curie fellow to further advance modeling and simulation of solar cells.

2.4.2b (14:15 - 14:30)
Dr Jonathan Mitchell
National Institute of Advanced Industrial Science and Technology (AIST), Japan

Terahertz Emission Spectroscopy for a-Si:H Passivated Hit Solar Cells

J. MITCHELL[1], A. ITO[2], T. MOCHIZUKI[1] et al.
[1] National Institute of Advanced Industrial Science and Technology (AIST), Japan
[2] SCREEN Holdings Co. Ltd.

Abstract
Understanding the surface boundary conditions of an a-Si:H/c-Si solar cell, as with others, is typically only possible through time-of-flight techniques for MIS-based structures and capacitance-voltage (C-V) analysis. However, the incorporation of metallised contacts strongly influences the internal electric field of both the silicon and the a-Si:H layer, and for the latter, the polarisation state. Here, we present an analysis of the surface band state at the a-Si:H/c-Si interface by terahertz (THz) spectroscopy using Laser Terahertz Emission Microscopy (LTEM). We are able to determine the polarity and the surface band-bending which occurs when both intrinsic and stacked (i/n or i/p) a-Si:H are deposited onto either n-type or p-type c-Si. Inversion of the surface states is observed, as well as shifts towards flat-band conditions depending on the deposited layer type. Additionally, THz imaging through is newly applied to extract valuable information not accessible by other emission spectroscopy techniques, including photoluminescence.

Biography
Completed a Doctorate at The Australian National University investigating heterojunction photovoltaic technology. His research activities specialise in plasma and surface physics, advanced research in different areas of energy, materials and processing, and green urbanisation development. Now based at The National Institute of Advanced Industrial Science and Technology (AIST) in Fukishima, Japan, his main topic of research focus is on amorphous silicon and its integration with crystalline-based silicon solar cells.

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2.4.2c (14:30 – 14:45)
Dr Ashley Morishige
Massachusetts Institute of Technology, USA

Lifetime Spectroscopy Investigation of the Root Cause of Light-Induced Degradation in p-type Multicrystalline Silicon PERC

A. MORISHIGE[1], M. JENSEN[1], D. BERNEY NEEDLEMAN[1] et al.
[1] Massachusetts Institute of Technology, USA

Abstract
When untreated, light-induced degradation (LID) of p-type multicrystalline silicon-based passivated emitter and rear cell (PERC) modules can reduce power output by up to 10% relative. Recently, we described two engineering solutions to mitigate p-type PERC LID. We now evaluate the root cause of the defect to prevent its occurrence in future device architectures. Lifetime spectroscopy analysis, including both injection and temperature dependencies (IDLS and TIDLS), offer insights into the root-cause defect(s). Using TIDLS, we determine that the responsible defect has an energy level between 0.3 and 0.7 eV above the valence band and a capture cross-section ratio between 23 and 32.6. Additionally, we narrow the list of candidate impurities and calculate their concentrations.

Biography
Dr. Ashley Morishige is a postdoctoral researcher in the MIT Photovoltaic Research Laboratory. She started working with Professor Tonio Buonassisi in the MIT Photovoltaic Research Laboratory in 2011. As a graduate student, Dr. Morishige was a National Defense Science and Engineering Graduate Fellow. She received her Ph.D. in 2016. Her research is on characterization and gettering of impurities in crystalline silicon during solar cell processing and enabling next-generation crystalline silicon solar cells.

2.4.2d (14:45 – 15:00)
Mr Alexander To
University of New South Wales, Australia

Improved Understanding of the Recombination Rate at Inverted p+ Silicon Surfaces

A. TO[1], F. MA[1], B. HOEX[1]
[1] University of New South Wales, Australia

Abstract
Silicon nitride (SiNx) is the de facto standard passivating film for n+ surfaces, however, it does not perform particularly well on p+ surfaces, partly due to the fixed positive charge density in SiNx. In this work we will look into the effect of positive fixed charge on the recombination rate at SiNx-passivated p+ surfaces. It will be shown that a high positive fixed charge (Qf > 2x1012 cm-3) on a well passivated doped surface can result in a nearly injection level independent recombination rate in a certain injection level range, while conventional theory predicts a linear increase with the slope equal to J0e. Based on advanced computer simulations using Sentaurus TCAD it will be shown that the shape of the injection level dependent recombination rate can even be used to quantify the fixed charge density in dielectrics on highly doped surfaces, something that was not possible to date.

Biography
Alexander To completed has a Bachelors degree in Engineering (Hons 1st class) from UNSW specialising in Photovoltaic and Renewable energy engineering. He is currently working towards the completion of his PhD at UNSW in the first generation group with Dr. Bram Hoex and Dr. Alison Lennon. His research interests include advanced surface passivation techniques and understanding and high efficiency solar cell designs.

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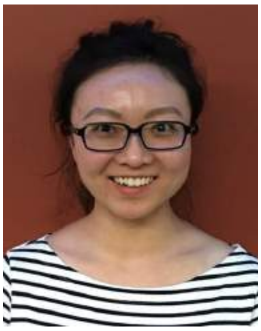

2.4.2e (15:00 - 15:15)
Jingnan Tong
The University of New South Wales, Australia

Unintentional Consequences of Dual Mode Plasma Reactors: Implications for Upscaling of Record Lab Results

J. Tong[1], A. LENNON[1], B. HOEX[1] et al.
[1] The University of New South Wales, Australia

Abstract
PECVD SiNx is the most extensively used ARC for c-Si solar cells because it simultaneously offers excellent levels of surface and bulk passivation.Typically,recipes are first optimised in lab-scale reactors and subsequently the best settings are transferred to high-throughput reactors.We show for one particular,but popular,PECVD reactor configuration this upscaling is severely hampered by an important experimental artefact.Specifically we report on the unintentional deposition of a dual-layer structure in a dual-mode plasma reactor from Roth&Rau which has extraordinary impact on its surface passivation.It is found the RF substrate bias ignites an unintentional depositing plasma prior to the ignition of the MW plasma.This RF plasma deposits a 18nm thick Si-rich intervening SiNx layer(n=2.4) while using a stoichiometric SiNx recipe,resulting in a 30mV gain in iVoc.This result may explain some "out of the ordinary" excellent surface passivation results reported for "nearly stoichiometric" SiNx films and has significant consequences when transferring to high-throughput deposition systems.

Biography
Jingnan Tong is a PhD student at the School of Photovoltaics and Renewable Energy Engineering at the University of New South Wales. She received her Bachelor of Engineering with Honors in Photovoltaics in 2013. Her research interests involve: solar cell passivation and characterisation, carrier selective contact solar cells and passivated contacts.

2.4.2f (15:15 - 15:30)
Mr Naoki Tokuda
University of Miyazaki, Japan

Effect of Light Irradiation on Carrier Mobility of n- and p-Type Si Substrates for Solar Cell Application

N. TOKUDA[1], H. SUZUKI[1], T. LKARI[1] et al.
[1] University of Miyazaki, Japan

Abstract
To investigate a dominant carrier scattering mechanism under a light-concentrating operation, we performed the Hall measurement for n- and p-type Si substrate samples with a light irradiation. In this study, the sample temperature was kept constant during the measurement to rule out the effect of the temperature. The observed Hall mobility decreased with increasing a sunlight concentration. When the sample is irradiated with the light, the sample temperature increases and the carrier mobility decreases. We concluded that mobility decrease was due to the carrier concentration increased by the photoexcitation. Additional photo-generated electrons and holes changed the total carrier concentrations and resulted in the change of the observed mobility of the sample. The photo-generated carrier concentrations increased with increasing the sunlight concentration. Although the number of photo-generated carriers was assumed to be the same for each of the n- or p-Si samples, they were different for the n- and p-Si, respectively.

Biography
University of Miyazaki, master's course, Miyazaki, Japan 2015 Apr – Candidate 2017 Mar ME, specialization in Solar Cells University of Miyazaki, Miyazaki, Japan 2011 Apr – 2015 Mar BE in Engineering