

21st Workshop on Crystalline Silicon Solar Cells & Modules: Materials and Processes

July 31 - August 3, 2011
Breckenridge, Colorado

SUNDAY, JULY 31

	REGISTRATION & CONTINENTAL BREAKFAST (provided)
WELCOME	
7:30 - 9:00 am	REGISTRATION & CONTINENTAL BREAKFAST (provided)
8:45 - 9:00 am	Bhushan Sopori, National Renewable Energy Laboratory
SESSION 1	ADVANCES IN MULTICRYSTALLINE SILICON
	Chair: Adam Lorenz (1366)
9:00 - 9:40 am	Roger Clark (AMG Idealcast Solar Corporation): "A Review of Novel Growth Technology For Large-grained Mono ² Cast Silicon"
9:40 - 10:20 am	Hui Zhang (Tsinghua University, Beijing): "Future Trends For High Efficiency and Low Cost Silicon-based Solar Production"
10:20 - 10:50 am	BREAK
10:50 - 11:20 am	Kamel Ounadjela (CaliSolar, Inc.): "Advances in Silicon Solar Cells From UMG Material"
DISCUSSION	Silicon Growth For Wafered Silicon
11:20 - Noon	Leader: Martin Binns (MEMC)
Noon - 1:30 pm	LUNCH BUFFET (provided)
SESSION 2	STATE-OF-THE-ART FOR MATERIALS CHARACTERIZATION
	Chair: Pete Sheldon (NREL)
1:30 - 2:15 pm	Martin Schubert (ISE Fraunhofer): "New Methods For Spatially Resolved Characterization of Defects in Silicon"
2:15 - 3:00 pm	Sebastien Dubois (CEA France): "Studies on Compensated and UMG Material and Solar Cells"
3:00 - 3:30 pm	BREAK
3:30 - 4:00 pm	Susanne Richter (Fraunhofer CSP): "Trace Elemental and Structural Analysis of Different Types of Si ₃ N ₄ Precipitates Grown in Block-cast Multicrystalline Solar Silicon"
DISCUSSION	Materials Characterization Issues
4:00 - 5:00 pm	Leader: Tonio Buonassisi (MIT)
DINNER BUFFET	
6:00 - 6:45 pm	Colorado Ballroom (enjoy your dinner while participating in the Rump Session)
RUMP SESSION	Theme: Thin Film, CPV, and Crystalline-silicon
6:45 - 8:30 pm	Leader: Bhushan Sopori (NREL) Panel: Vahan Garboushian (Amonix), Doug Rose (SunPower), TBD Each panelist will talk about: a) What is the strength and weakness of each technology? b) Competition for the same markets, or opening up new applications to PV? c) Investor's view (How are emerging technologies "pitched." Wiping silicon off the map, or complementing it?)

MONDAY, AUGUST 1

7:00 - 8:00 am | CONTINENTAL BREAKFAST (provided)

8:00 - 8:30 am | Minh Li (DOE): "DOE Programs, Including The 'Sunshot' Initiative"

SESSION 3

HIGH-EFFICIENCY SILICON: CAN THE INDUSTRY CLOSE THE GAP WITH THE EFFICIENCY LEADERS?

Chair: Ethan Good (SolarWorld USA)

8:30 - 9:15 am | Nils Harder (ISFH Germany): "A Review Of N-type High-efficiency Solar Cells"

9:15 - 10:00 am | Erwin Kessels (TU Eindhoven): "Review On The Prospects For The Use Of Al_2O_3 For High-efficiency Solar Cells"

10:00 - 10:30 am | BREAK

10:30 - 11:00 am | Jihun Oh (NREL): "High-efficiency Black Silicon Solar Cells With No Antireflection Coating"

DISCUSSION

High-efficiency Solar Cells

11:00 - Noon | Leader: Ron Sinton (Sinton Instruments)

Noon - 1:30 pm | **LUNCH BUFFET (provided)**

AFTERNOON BREAK FOR SIDE MEETINGS

RECEPTION

6:30 - 8:45 pm | Hors D'oeuvres and Cash Bar in Copper Top III Bar and Café

POSTER SESSION

7:00 - 9:00 pm | Presenters setup @ 5:30 pm in Copper Top III Bar and Café

TUESDAY, AUGUST 2

7:00 - 8:00 am CONTINENTAL BREAKFAST (provided)

SESSION 4 **ADVANCES IN METALIZATION TECHNOLOGIES**

Chair: Alan Carroll (Dupont Electronic Materials)

8:00 - 8:45 am Alison Lennon (UNSW): "**Metallisation for Silicon Solar Cells: Beyond Silver and Screen Printing**"

8:45 - 9:30 am Stefanie Riegel (University of Konstanz): "**Overview on Screen Printing Metallization on P-type Silicon**"

9:30 - 10:00 am Yangang Andrew Xi (Despatch Industries): "**High Resistive Emitter Metallization for Si Solar Cells**"

10:00 - 10:30 am BREAK

DISCUSSION **Metalization Technologies**

10:30 - Noon Leader: Juris Kalejs (American Solar Technologies)

Noon - 1:30 pm **LUNCH BUFFET (provided)**

SESSION 5 **WHY USE CONVENTIONAL WAFERS?**

Chair: Martha Symko-Davies (NREL)

1:30 - 2:00 pm K.V. Ravi (Crystal Solar, Epi-Lift off Technology): "**Poly-less, Ingot-less, Kerf-less Production of Very Thin (< 50 microns) Single Crystal Si Wafers, Solar Cells and Modules**"

2:00 - 2:30 pm Leo Mathew (AstroWatt): "**A Novel Low Cost Kerfless Exfoliation and Device Architecture for 25um Thin Crystalline Si Solar Cells**"

2:30 - 3:00 pm Oliver Anspach (PV Silicon): "**Understanding the Slurry-based Wafering Process in the Wire Sawing Channel**"

3:00 - 3:30 pm BREAK

3:30 - 4:00 pm Rommel Noufi (NREL): "**The Making of a High Efficiency CIGS Solar Cell**"

DISCUSSION **The "No Question is Too Basic or Obvious" Discussion. A free-wheeling discussion of the questions YOU came to the workshop to understand.**

4:00 - 5:00 pm Leader: Giso Hahn (University of Konstanz)

RECEPTION

6:30 - 8:45 pm Hors D'oeuvres and Cash Bar in Copper Top III Bar and Café

POSTER SESSION

7:00 - 9:00 pm Presenters setup @ 5:30 pm in Copper Top III Bar and Café

WEDNESDAY, AUGUST 3

7:00 - 8:00 am | HOT BREAKFAST BUFFET (provided)

SESSION 6***RELIABILITY, COST, AND ALTERNATIVES TO CRYSTALLINE SILICON***

Chair: Sarah Kurtz (NREL)

8:00 - 8:45 am | Peter Hacke (NREL): "**Potential-Induced Degradation and Failure of Modules by System Voltage Stress**"

8:45 - 9:15 am | Doug Rose (SunPower): "**Levelized Cost of Electricity (LCOE) Issues for Crystalline Silicon Modules**"

9:15 - 9:45 am | John Benner (NREL): "**University Research in DOE SETP's Advanced Manufacturing Partnerships**"

9:45 - 10:15 am | BREAK

DISCUSSION**Wafer Mechanical Properties**

10:15 - 11:00 am | Leader: George Rozgonyi (North Carolina State University)

SESSION 7***WRAP UP***

11:00 - Noon | Moderator: Bill Mulligan (Mulligan Consulting, LLC)

Noon WORKSHOP ADJOURNS

Thank you for your participation....see you next year!!!

MONDAY POSTER SESSION

- ***Understanding Phosphosilicate Glass (PSG) Deposition Via $POCl_3$ for Control of Emitter***
R. Chen, H. Wagner, A. Dastgheib-Shirazi, H.-G. Guo, M. Frei, M. Kessler, Z. Zhu, P.P. Altermatt and S.T. Dunham
- ***Transformational Approaches to Front-face Metallization***
David Hook, Seymen Aygun, William Borland and Jon-Paul Maria
- ***In-line Alkaline Texturing for Monocrystalline Silicon Solar Cells***
Vanesa Fano, Velia Rodríguez, Luis Tejado, Juan Carlos Jimeno
- ***Imaging Study of Multi-crystalline Silicon Wafers Throughout the Manufacturing Process***
Steve Johnston, Fei Yan, Katherine Zaunbrecher, Mowafak Al-Jassim, Omar Sidelkheir, and Alain Blossé
- ***Design and Performance of Boron Epitaxial Emitters for IBC Cells***
M. Recamán Payo, W. Xu, I. Gordon and J. Poortmans
- ***Transition Metal Gettering Studies in Epitaxial Thin-film Silicon Solar Cells With an Intermediate Porous Silicon Reflector***
Hariharsudan S. Radhakrishnan, Jan Van Hoeymissen, Stein Van Bezouw, Frédéric Dross, Jef Poortmans, and Robert Mertens
- ***Improved Photovoltaic Performance by Metal Contamination Removal from Silicon Solar Wafers***
L.-M. Chen, O. Sathoud, H. Bankowski, P. Zhang, T. Baum, L. H. Dubois, P. Hamer, Y. Li, and A. Lennon
- ***A Comparison of Liquid Passivation Methods Using Lifetime Measurements on Good-Quality Silicon Wafers***
S. Devayajanam, P. Rupnowski, S. Shet, B.L. Sopori, N.M. Ravindra, D. Caskey, J. Chang, and J. Covington
- ***Coupled Simulation of Fabrication Processes, Carrier Lifetime and Device Performance for Optimization of Silicon Solar Cells***
Scott T. Dunham, Bart C. Trzynadlowski, Wenjun Jiang, Renyu Chen, and Armin Yazdani
- ***Multi-scale Characterization Methods for Understanding Performance Limitations in Poly-Si Wafers***
Harvey Guthrey, Brian Gorman, Mowafak Al-Jassim
- ***Research Activities for High Efficiency Silicon Solar Cells***
Sang-Kyun Kim, Myung-Ick Hwang, Jin-Ho Choi, Won-Jae Lee and Eun-Chel Cho
- ***Fabrication of High-Efficiency N-type Bifacial Solar Cells with Boron Emitter and Phosphorus BSF Formed by Ion Implantation***
Young-Woo Ok, Ajay D Upadhyaya, Francesco Zimbardi, Ian B. Cooper, Adam M. Payne, Ajeet Rohatgi

- ***Recycle of Silicon Powder in Multi-wire-saw-sludge for Silicon Feedstock***
Shohei Miki, Norihisa Iio, Sho-ichi Taniguchi, Hiroshi Satone, Koji Arafune
- ***Electrical Evaluation of the Impact of Rapid Thermal Annealing on Grain Boundary Traps in Photovoltaic Multicrystalline Silicon***
Liya Yu and Geroge A. Rozgonyi
- ***Inline Bulk Lifetime Prediction Using QSSPC***
T. Mankad, R. Sinton, A. Ristow, N. Akil, E. Picard

TUESDAY POSTER SESSION

- ***An Improved Model of Dislocations in a Silicon Solar Cell***
Vinay Budhraj, Bhushan Sopori, N.M. Ravindra, and Durga Misra
- ***Influences of Fe and Ni Contaminations on Electrical Activities at Crystalline Defects in Multicrystalline Silicon Substrates***
Yuki Tsuchiya, Naoto Miyazaki, Takashi Sameshima, Tomihisa Tachibana, Yoshio Ohshita, Koji Arafune, and Atsushi Ogura
- ***Thermal Stability of Infrared-absorbing Hyperdoped Silicon***
C. B. Simmons, M.T. Winkler, J.T. Sullivan, D. Recht, M. Aziz, T. Buonassisi
- ***Rapid Measurement of Orientations and Sizes of Grains in Multicrystalline Silicon Wafers: A New Technique***
Bhushan Sopori, Debraj Guhabiswas, Przemyslaw Rupnowski, Sudhakar Shet, Srinivasmurthy Devayajanam, Helio Moutinho, and N.M. Ravindra
- ***Work in Progress: Validation and Refining of 1D Model for Crystallisation of Multicrystalline Silicon Ingots***
H. Dalaker and M. Syvertsen
- ***Dislocation Annihilation in Multicrystalline Silicon***
Hyunjoo Choi, Michelle Vogl, Sergio Castellanos, Douglas Powell, Mariana Bertoni and Tonio Muonassisi
- ***Application of Infrared Birefringence Imaging to Measure Residual Stress and Defect Distributions in Ingot Multicrystalline Slabs***
S. Castellanos, T. Buonassisi
- ***Annealing Effects on Recombination Activity of Nickel at (110)/(100) Direct Silicon Bonded Interface***
Takuto Kojima, Mari Aoki, Nobuaki Kojima, Yoshio Ohshita, Masafumi Yamaguchi
- ***Cross-sectioning Silicon Solar Cell***
Bhushan Sopori, Santosh Sahoo, Vishal Mehta, Debraj Guhabiswas, Sean Spiller and Helio Moutinho
- ***A Study of Dislocations in mc-Si***
B. Sopori, P. Rupnowski, S. Shet, V. Mehta, M. Seacrist, G. Shi, J. Chen, and A. Deshpande
- ***Effect of Oxygen and Its Associated Precipitates and Defects on the Mechanical Properties of Czochralski Silicon***
Meirong Shi, Khaled Youssef, Chantelle Radue, Ethan Good, and George Rozgonyi
- ***A Noncontact System for Screening Silicon Wafers Prior to Solar Cell Production***
Bhushan Sopori, Przemyslaw Rupnowski, Prakash Basnyat, and Vishal Mehta
- ***Crack Investigation in Monocrystalline Silicon Before and After Annealing***
C. Klute, L. Lam, S. Schoenfelder, J. Bagdahn

- ***Analysis of Slurry and Fixed Abrasive Diamond Wire-sawn Silicon Wafers***
Hao Wu, Kevin Skenes, Chris Yang, Frank Mess, Shreyes N. Melkote, Steven Danyluk
- ***Sub-Millimeter Crack Inspection in Si Solar Cells Using RUV System***
Yu. Emirov, A. Belyaev, D. Cruson, I. Tarasov, A. Kumar , H. Wu, S. Melkote and S. Ostapenko
- ***Surface and Subsurface Damage in Silicon Wafering***
Chris Yang, Shreyes Melkote, and Steven Danyluk
- ***Influence of Defects and Stresses on the Mechanical Properties and Crack Propagation of Silicon PV Wafers***
Khaled Youssef, P. Kulshreshtha, M. Shi, Ethan Good, and George Rozgonyi

GRADUATE STUDENT DONORS

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