NREL
NATIONAL RENEWABLE ENERGY LABORATORY

# AGENDA AND POSTER SESSION FOR NREL 2013 PHOTOVOLTAIC MODULE RELIABILITY WORKSHOP

FEBRUARY 26 & 27, 2013

National Renewable Energy Laboratory | Golden, CO, USA


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Office of Energy Efficiency and Renewable Energy,operated by the Alliance for Sustainable Energy, LLC.**

# AGENDA FOR NREL 2013 PHOTOVOLTAIC MODULE RELIABILITY WORKSHOP

## TUESDAY FEBRUARY 26, 2013

**7:30** Continental Breakfast

**8:00** Welcome, by Kevin Lynn of DOE

**8:15** Linkage to Previous QA Task Force Workshops (Introduce NWIP), by Sarah Kurtz of NREL

**8:30** Accelerated Stress Testing, Qualification Testing, HAST, Field Experience – What Do They All Mean? by John Wohlgemuth of NREL

**9:00** Field Experience: Failure and Degradation Modes of PV Modules in a Hot Dry Climate – Results After 11 to 26 Years of Field Exposure, by Govindasamy Tamizhmani of ASU

**9:30** Delamination Failures in Long-Term Field-Aged PV Modules, by Tsuyoshi Shioda of Mitsui Chemical

**10:00** Break and Posters for Field Experience of Crystalline Si and Thin-Film Modules

**10:45** Discussion: Field Experience/Accelerated Stress Testing (Led by Tony Sample of JRC and Ralph Romero of Black and Vetch)

**11:45** Group 2: Thermal and Mechanical Fatigue – Introduction, by Chris Flueckiger of UL

**12:00** Group 2: Thermal Cycling Combined with Dynamic Mechanical Load: Preliminary Report, by Tadanori Tanahashi of ESPEC Corp.

**12:30** Group 2: Accelerating Fatigue Testing for Cu Ribbon Interconnects, by Nick Bosco of NREL

**1:00** Lunch

**1:45** Posters for Area 2 (Thermal and Mechanical Fatigue) and Other Accelerated Stress Tests and Combinations of Stress tests

**2:30** Group 2: Discussion (Led by Chris Flueckiger of UL and Nick Bosco of NREL)

**3:30** Group 4: Diodes, Shading and Reverse Bias – Introduction, by Paul Robusto of Intertek

**3:45** Group 4: ESD Testing of Diodes, by Kent Whitfield of Solaria

**4:15** Group 4: Environmental Testing of Diodes, by Yasunori Uchida of JET

**4:30** Beak and Posters for Group 4 (Diodes, Shading and Reverse Bias) and PV Standards

**5:30** Group 4: Discussion (Led by Paul Robusto of Intertek and Kent Whitfield of Solaria)

**6:30** Adjourn for day 1

## WEDNESDAY FEBRUARY 27, 2013

**7:30** Continental Breakfast

**8:00** Group 3: Humidity, Temperature and Voltage – Introduction, by John Wohlgemuth of NREL

**8:15** Group 3: Understanding the Temperature and Humidity Environment Inside a PV Module, by Michael Kempe of NREL

**8:45** Group 3: PID Failure of c-Si and Thin-Film Modules and Possible Correlation with Leakage Currents, by Peter Lechner of ZSW

**9:15** Break and Posters for Area 3 (Humidity, Temperature and Voltage)

**10:00** Group 3: Discussion (Led by John Wohlgemuth of NREL and Tony Sample of JRC)

**11:00** Group 5: UV, Temperature and Humidity – Introduction, by David Miller of NREL and Michael Koehl of Fraunhofer ISE

**11:15** Group 5: Light Sources for Reproducing the Effects of Sunlight in the Natural Weathering of PV Materials, Components and Modules, by David Burns of 3M and Kurt Scott of Atlas

**11:45** Group 5: Accelerated UV Aging and Correlation with Outdoor Exposure of EVA Based PV Encapsulants, by Charlie Reid, Jayesh Bokria, and Joseph Woods of STR

**12:15** Lunch

**1:00** Posters for Area 5 (UV, Temperature and Humidity) and PV Materials

**1:45** Group 5: Discussion (Led by Michael Koehl of Fraunhofer ISE and David Miller of NREL)

**2:45** Break

**3:00** Overall Discussion: What are we missing? (Led by QA Task Force Steering Committee and Task Group 2 to 5 US Leaders)

**4:00** Closing Remarks, by John Wohlgemuth of NREL

**4:30** Close

# POSTER SESSION

## POSTER SESSION 1:

### TUESDAY FEBRUARY 26 AT 10:00 AM

Field Experience of Crystalline Si and Thin-Film Modules

1. M. Anderson, Z. Defreitas, and C. Hasselbrink of SunPower Corporation, "A System Degradation Study of 445 Systems Using Year-over-Year Performance Index Analysis"
2. R. Sundaramoorthy, J.R. Lloyd, D. Metacarpa, and P. Haldar of PVMC, CNSE, "Web Based Methodology for Photovoltaic Failure Reporting, Reliability Analysis and Corrective Action in a Completely Secured Platform"
3. M. Jankovec and M. Topic of University of Ljubljana, "Accuracy and Uncertainty of PV Module Temperature in Outdoor Monitoring"
4. M. Propst and N.A. Olsson of Pearl Laboratories,"STC Laboratory Testing: Necessary but not Sufficient"
5. L. McClung of SAIC,"The Impact of Module Reliability on PV Plant Lifetimes Exceeding 25 Years"
6. R. Uselton of Lennox Industries,"An Unanticipated System Vulnerability: Rodent Attack"
7. J. McCabe of Energy Ideas, "Salvage Values Determines Reliability of Used Photovoltaics"
8. R. Sundaramoorthy, J.R. Lloyd, D. Metacarpa, and P. Haldar of PVMC, CNSE, "Compilation of PV Failure Modes and Mechanisms, Types of Tests for Reliability Analysis Reported In the Literature for Thin Film Reliability Studies"
9. J. Sorensen of First Solar, "Understanding Differences in Induced Stresses to Improve Variation in Light Soak Response"
10. D. Pic, B. Bertrand, V. Bermudez, L. Parissi, and P. Calzi of Nexcis, "Effect of Metastabilities on the Dynamic Behavior of CIGS PV Modules"
11. S. Dongaonkar and M.A. Alam of Purdue University, "Shade Tolerant Design of Thin Film Modules"
12. A. Pineda and J. Meydbray of CleanPath, PVUSA and PV Evolutions, "Preliminary Analysis of Modules Deployed at PV-USA for 18–24 Years"
13. D.C. Jordan and B. Sekulic of NREL, "Impact and Detection of Pyranometer Failure on PV Performance"
14. M. P. Rogers, K.O. Davis, N. Dhere, A. Kaul, R. P. Brooker, and H. Seigneur of Florida Solar Energy Center, "Manufacturing Metrology for c-Si Module Reliability/Durability"
15. C.E. Packard, J.H. Wohlgemuth, and S.R. Kurtz of NREL, "Development of a Visual Inspection Checklist for Evaluation of Fielded PV Module Condition"
16. T. Johnson of TenKsolar, "Highly Reliable Photovoltaic Solar Topology"
17. L. Kazmerski of NREL, "Solar Energy Research Institute for India and the US (SERIIUS)"
18. A. Delgado, K. Kiriluk, P. Banda, J. Perez, and F. Celaya of Abengoa Solar, "Abengoa Solar Visual Inspection Tool"

## POSTER SESSION 2:

### TUESDAY FEBRUARY 26 AT 1:45 PM

Group 2: Thermal and Mechanical Fatigue, Other Accelerated Stress Tests, and Combinations of Accelerated Stress tests

1. S. Dietrich, M. Pander, M. Sander, and M. Ebert of Fraunhofer CSP, "Characterization of Dynamic Loads on Solar Modules with Respect to Fracture of Solar Cells"
2. L. Bruckman, N. Wheeler, J. Ma, E. Wang, C. Wang, I. Chou, J. Sun, and R. French of Case Western Reserve University, "Statistical and Domain Analytics Applied to PV Module Lifetime and Degradation Science"
3. T. Friessen of SUPSI, "Round Robin results For Hail Grain Characterization"
4. M. Brown, M.W. Rowell, S. J. Coughlin, and D. W. Harwood of Westpak and D2 Solar, "Hail Impact Testing on Crystalline Silicon Modules with Flexible Packaging"
5. S. Kurtz of NREL, "Development of a Rating System for a Comparative Accelerated Test Standard"
6. F. Galliano, V. Chapuis, C. Schlumpf, C. Ballif, and L.E. Perret-Aebi of Ecole Polytechnique Federale de Lausanne (EPFL), "Compressive Shear Test to Accurately Measure Adhesion of PV Encapsulants"
7. A. Colli and J.P. Looney of Brookhaven National Laboratory, "A Multi-Perspective Approach to PV Module Reliability and Degradation"
8. P.D. Burton, B. H. King, and B. Yang of Sandia National Laboratories, "Standardized Grime for Photovoltaic Soiling Studies"
9. F. Real, N. Bogdanski, G. Mathiak, S. Raubach, C. Schloth, W. Herrmann, and B. Wangenheim of TUV Rheinland, "Experimental Testing of PV Modules under Inhomogeneous Snow Loads"
10. A. Korostyshevsky, A. Fox, E. Straily, O. Jonsson, and H. Field of PV Measurements Inc., "Quantum Efficiency Measurement Artifacts of Solar Cell Modules"
11. L.Pratt, M. Plass, M. Yamasaki and N. Riedel of CFV Solar Test Lab, "Failure Rates from Certification Testing to UL and IEC Standards for Flat Plate Modules"
12. E. Li and P. Chaparala of Alta Devices Inc., "High-Efficiency GaAs Thin-Film Solar Cell Reliability"
13. D. Meakin of Fraunhofer CSE, "Fraunhofer PVDI Program–Comparison of Mechanical Stress Tests"

## POSTER SESSION 3:

### TUESDAY FEBRUARY 26 AT 4:30 PM

Group 4: Diodes, Shading, and Reverse Bias and PV Standards

1. Z. Zhang, J. Wohlgemuth, and S. Kurtz of NREL, "The Thermal Reliability Study of Bypass Diodes in PV Modules"
2. J. Posbic and E. Rhee of MEMC, "High Temperature Reverse By-pass Diodes Bias and Failure"
3. H. Barikmo and G. Kelly of Sunset Technology, "PV Standards: What New Things Does the IEC Have for You?"

# POSTER SESSION *(CONTINUED)*

4. L. Sherwood of Solar ABCs, "Recent Reports from the Solar America Board for Codes and Standards"
5. A. Mikonowicz of PowerMark, "IEC TC82 Description – What Is a TAG and How Does One Use It?"
6. S. McWilliams of PVMC, "Infrared Thermography Working Group at the U.S. Photovoltaic Manufacturing Consortium"

## POSTER SESSION 4:

### WEDNESDAY FEBRUARY 27 AT 9:15 AM

Group 3: Humidity, Temperature and Voltage

1. S. Hoffmann and M. Koehl of Fraunhofer ISE, "Effect of Humidity and Temperature on the Potential Induced Degradation"
2. D. Wu, J. Zhu, T. Betts, and R. Gottschalg of CREST Loughborough University, "The Degradation Study of the Peel Strength of Mini-modules under Damp Heat Conditions"
3. K. Nanjundiah and N.Nickel of Dow Chemical, "Encapsulant Based Solution to Potential Induced Degradation of PV Modules"
4. T. Ishiguro, H. Kanno, M.Taguchi, and S. Okamoto of Sanyo Electric, "Study on PID Resistance of HIT PV Modules"
5. S. Dietrich, J. Froebel, M. Ebert, and J. Bagdahn of Fraunhofer CSP, "Experience on PID Testing of PV Modules in 2012"
6. R. Rice of Tata Steel, "The Use of Humidity Sensors to Develop BIPV Packaging Solutions"
7. S. Suzuki, T. Tanahashi, T. Doi, and A. Masuda of ESPEC and AIST, "The Acceleration of Degradation by HAST and Air-HAST in c-Si PV Modules"
8. S. Suzuki, E. Obana, T. Doi, A. Masuda, and T. Tanahashi of ESPEC and AIST, "Sensitvities of I-V Parameters in c-Si PV Modules to Hygrothermal Stress"
9. P. Hacke and K. Terwilliger of NREL; S. Koch, T. Weber, and J. Berghold of PI-Berlin; S.Hoffmann, H. Ambrosi, and M. Koehl of Fraunhofer ISE; S. Dietrich and M. Ebert of Fraunhofer CSP; and G. Mathiak of TUV Rheinland, "Initial Round Robin Results of the IEC 62804 (draft) System Voltage Durability Qualification Test for Crystalline Silicon Modules"
10. C.A. Kosik Williams of Corning, "PID Elimination in Crystalline Silicon Modules"
11. A. Bonucci, J. Gigli, P. Gallina, and A. Hayden of SAES Getters, "Breakthrough Time and Mechanical Properties of Edge Sealing in Different Environmental Conditions"
12. T. Doi, A. Masuda, and M. Kondo of AIST, K. Masuda; H. Kato, Y. Uchida, and K. Shibata of JET; S. Kawai, Y. Fukumoto, and F. Tamai of Industrial Technology Center of Saga, "Potential Induced Degradation (PID) Tests for Commercially Available PV Modules"
13. H. Zenkoh, J. Tokuhiro, Takanobu and M. Odoi of Mitsui Chemicals, "High PID Resistance Cross-Linked Encapsulant Based on Polyolefin"
14. M. Kambe of Asahi Glass and Kojiro and Michio Kondo of AIST, "PID-Free c-Si PV Module Using Novel Chemically-Tempered Glass"

## POSTER SESSION 5:

### WEDNESDAY FEBRUARY 27 AT 1:00 PM

Group 5: UV, Temperature and Humidity, and Testing of PV Materials

1. L. Dunn, M. Gostein, and B. Stueve of Atonometrics, "Literature Review of the Effects of UV Exposure on PV Modules"
2. S. Fowler of Q-Lab Corporation, "UV Conditioning of PV Modules: A Practical and Cost Effective Way to Meet the IEC Requirements"
3. X. Gu, Y. Pang, CC. Lin, KT Tan, and J.W. Chin of NIST, "Accelerated Laboratory Testing Using Simultaneous UV Radiation, Temperature and Moisture for PV Encapsulants, Frontsheets and Backsheets"
4. K. Hirota, M. Tanaka, T. Amioka, and M. Terada of Toray Industries, "Test Procedure for UV Weathering Durability of Backsheet"
5. A.Lefebvre, G. O'Brien, T. Fine, and A. Bonnet of Arkema, "Weathering Performance of PV Backsheets"
6. J. Zhou, S. Davis, S. Chakravarti, and M. Davis of SABIC and J. Pickett of General Electric, "High-Performance Plastic Front Sheet and Back Sheet for Long-Term Reliability of PV Modules"
7. W. Gambogi, O. Fu, Y. Heta, K. Hashimoto, J. Kopchick, T. Felder, S. MacMaster, A. Bradley, B. Hamzavytehrany, V. Felix, T. Aoki, and T.J. Trout of DuPont and T. Sample of JRC, "A Comparison of Key PV Backsheet and Module Properties from Fielded Module Exposures and Accelerated Test Conditions"
8. A. Nachitigal of 3M, "Demonstrating Reliability of 3M Ultra-Barrier Film for Flexible PV Applications"
9. M. Xun, S. Garner, J., Webb and K. Gopalakrishnan of Corning, "Flexible Glass for Hermetic Barrier Applications"
10. J. Bratcher of Honeywell, "Reducing c-Si Module Operating temperature via PV Packaging Components"
11. M. W. Rowell and D. W. Harwood of D2 Solar, "Reliability of Electrically Conductive Adhesives for Silicon Solar Cell Interconnects"

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