

DOE/NREL Hands-On PV Experience (HOPE) July 24–30, 2016

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.**

SCHEDULE FOR DOE/NREL HANDS-ON PV EXPERIENCE (HOPE) JULY 24–30, 2016

SUNDAY, JULY 24, 2016

12:00 – 17:00: Room check-in Colorado School of Mines (CSM), Maple Hall, 1733 Maple St., Golden, CO 80401.

Dinner on your own. There are many restaurants within a 10- to 20-minute walk. There is a Safeway within a 10-minute walk.

19:00 – Introductions and expectations for the week CSM, Maple Hall, Lounge.

MONDAY, JULY 25, 2016 – INTRODUCTION AND BEGINNING SOLAR CELL FABRICATION – NEED COMPUTERS

7:00 Breakfast

7:35 Board shuttle bus CSM, from next to cafeteria

7:40 Shuttle bus will be departing

7:55 Check-in – NREL

SERF Auditorium (C108)

8:15 Safety orientation (Doug Hiebert)

8:30 Welcome (Sarah Kurtz)

8:45 “Understanding the power of PV and how our research will be used” Deidra Hodges

9:45 “Desired properties of new PV materials” Discussion led by Rakesh Agrawal

10:15 Break

10:30 Mini Concentrator Construction Project (Ray Kostuk)

11:45 Discuss lessons learned from mini concentrator activity

12:00 Lunch (Ray Kostuk, Rakesh Agrawal, Ray Kostuk, Jimi Burst, Joe Berry, Jeff Christians, Nick Bosco, Mike Kempe, Maikel van Hest, Deidra Hodges, Nancy Haegel, Adele Tamboli, Sarah Kurtz)

Group 1 (CdTe) Alexandra, Scott, Sudhajit

Group 2 (Perovskites) Yao-Tsung, Jimmy, Shaimum

Group 3 (Si) Roderick, Silvana, Natis

Group 4 (Tandem) Mehdi, Sarah, Elisabeth

13:00 Solar cell fabrication: Materials deposition

Group 1 (CdTe S&TF 203) Jimi Burst

Group 2 (Perovskites – Deposition and JV degradation SERF W129) Joe Berry & Jeff Christians, Maikel van Hest

13:00 Groups 3 & 4 (PV Module: Types of module packages, failures and how to test for them – Introduction in SERF Auditorium) Nick Bosco

13:45 Lamination of PV modules SERF E216 (Groups 3 & 4) Mike Kempe

14:30 Break – to be taken whenever convenient for each group

14:45 Tour of test chambers Outdoor Test Facility (Groups 3 & 4) Peter Hacke

15:15 Tour of array field Outdoor Test Facility (Groups 3 & 4) Tim Silverman

15:45 PV module characterization Outdoor Test Facility (Groups 3 & 4) Keith Emery

16:30 PV cell characterization SERF E221 (Groups 3 & 4) Keith Emery

17:00 Shuttle bus (meet in SERF auditorium) will take everyone to dorms

17:45 Walk together to New Peach Garden

18:00 Gathering at New Peach Garden with NREL Post Docs

TUESDAY, JULY 26, 2016 – FINISH SOLAR CELL FABRICATION

7:00 Breakfast

7:40 Shuttle bus will be departing CSM, from next to cafeteria

7:55 Arrive at NREL – SERF C108

8:00 Solar cell fabrication: Device processing CdTe S&TF 203

Group 1 (CdTe device processing – Part 2) Jimi Burst

Group 2 (Perovskites contacts and interfaces, photoemission PDIL) Joe Berry & Phil Schulz

8:00 Solar cell fabrication: Materials deposition

Introduction to Silicon PV SERF auditorium – Pauls Stradins (Groups 3 & 4)

8:30 Group 3 (Si surface passivation SERF clean room and S&TF PDIL) Vinnie LaSalvia, Bill Nemeth, Pauls Stradins

8:30 Group 4 (Intro to III-Vs SERF auditorium) Dan Friedman

9:00 Group 4 (Tandem – GaAs cell growth SERF W127) Myles Steiner, Jeff Carapella

10:00 Break – to be taken whenever convenient for each group

10:15 Solar cell fabrication continued from before the break

12:00 Lunch SERF Auditorium (Ray Kostuk, Deidra Hodges, Pauls Stradins, Bill Nemeth, Dan Friedman, Phil Schulz, Myles Steiner, Keith Emery, Kirstin Alberi, Jeff Carapella, Peter Hacke, Adele Tamboli, Sarah Kurtz)

13:00 Solar cell fabrication: Device processing

Group 3 (Si passivation SERF clean room and S&TF) Vinnie LaSalvia, Bill Nemeth, Pauls Stradins

Group 4 (Tandems – GaAs top cell processing SERF Clean Room) Kirstin Alberi

13:00 Groups 1 & 2 (PV Module: Types of module packages, failures and how to test for them – Introduction in SERF Auditorium) Nick Bosco

13:45 Groups 1 & 2 (Lamination of PV modules SERF E216) Mike Kempe

14:30 Break

14:45 Groups 1 & 2 (Tour of test chambers Outdoor Test Facility) Peter Hacke

15:15 Groups 1 & 2 (Tour of array field Outdoor Test Facility) Tim Silverman

15:45 Groups 1 & 2 (PV Module characterization Outdoor Test Facility) Keith Emery

16:30 Groups 1 & 2 (PV Cell characterization SERF 221) Keith Emery

17:00 Shuttle bus (meet in SERF auditorium) will return to CSM

18:00 Meet at Maple Hall to walk to Poster Session – Marquez Atrium Food will be provided at the poster session.

18:15 Poster presentations of thesis projects CSM, Marquez Atrium (all HOPE students will present posters, all education workshop attendees are invited to participate) Anton Malko will be host.

WEDNESDAY, JULY 27, 2016 – ACTIVITIES ABOUT PV – NEED COMPUTERS

- 7:00 Breakfast
7:40 Shuttle bus will be departing CSM, from next to cafeteria
7:55 Arrive at NREL – S&TF 127
8:00 “PV MythBusters” – Seth Hubbard
9:00 “Expected device performance for cells made this week” – Bob Opila
10:00 Break
10:15 “Solar Cell Measurements: Extracting information and avoiding pitfalls” – Jim Sites
11:15 “PV Jeopardy” – Zach Holman
12:15 Lunch (S&TF 127) (Bob Opila, Zach Holman, Yang Yang, Tonio Buonassisi, Elisa Miller, Nancy Haegel, Adele Tamboli, Sarah Kurtz)
13:00 “Interface Engineering in OPV and Perovskite Solar Cells” Yang Yang (SERF Auditorium)
14:00 “Testing Multijunction Solar Cells under Concentration” Myles Steiner
15:15 Break
15:30 Opportunities for post docs and grad students at NREL (Elisa Miller, Sarah Kurtz)
16:00 Defining what we mean by the TW Challenge (Sarah Kurtz)
17:00 Shuttle bus will return to CSM

THURSDAY, JULY 28, 2016 – MODELING AND MEASURING SOLAR CELLS – NEED COMPUTERS

- 7:00 Breakfast
7:40 Shuttle bus will be departing CSM, from next to cafeteria
7:55 Arrive at NREL – S&TF 127
Solar cell measurements: Perovskites, CdTe, Tandems, and Si
8:00 Group 1 (CdTe: I-V, QE, and CV S&TF 136) Matthew Reese, Katherine Zaunbrecher, Eric Colegrove
Group 2 (Perovskites: I-V, QE and other measurements SERF C215) Joe Berry, Kai Zhu, Matt Reese
Group 3 (Si: I-V and QE, PDIL) Ben Lee
Group 4 (Tandems: I-V and QE SERF C211 and SERF C125) Myles Steiner
10:00-11:30 Testing GaAs/Si tandems SERF E221 – Tom Moriarty (Anyone interested can come)
10:30 IDEAS Seminar ESIF Maxwell
11:30 Discussion of measured data (Sarah Kurtz)
12:15 Lunch: S&TF 127 (Ben Lee, Kai Zhu, Matt Reese, Tom Moriarty, Glenn Teeter, Darius Kuciauskas, Pat Dippo, Adele Tamboli, Sarah Kurtz)
13:15 Intro to Measurements & Characterization S&TF 127 – Glenn Teeter
14:15 PL, TRPL, and 2PE TRPL SERF E217 – Darius Kuciauskas & Pat Dippo (all students, will run 2 parallel sessions)
15:45 Break
16:00 Free time to meet with NREL scientists
17:00 Shuttle bus will return to CSM
Pizza will be provided at the panel, so feel free to skip dinner.
18:30 Pizza and Panel Discussion on “Career Directions Related to PV”
CSM, Maple Hall
Moderator: Nancy Haegel
Panel: Adele Tamboli, Tim Silverman, Ron Sinton, Scott Hammond

FRIDAY, JULY 29, 2016 – SOLAR CELL MATERIALS MEASUREMENTS – NEED COMPUTERS

- 7:00 Breakfast
7:40 Shuttle bus will be departing CSM, from next to cafeteria
7:55 Arrive at NREL – S&TF 127
8:00 Reference cell testing (Si & GaAs), common measurement errors and how to properly use reference cells (Keith Emery) PDIL (Alexandra, Silvana, Yao-Tsung, Jimmy, Natis, Rod) Silvana’s GaAs sample, Alex’s Si and GaAs samples
8:00 TEM (Andrew Norman) SERF E010, E014 (Mehdi, Elisabeth) Elisabeth’s sample
8:00 UPS (Glenn Teeter) PDIL or S&TF 140 (Sarah, Scott, Shaimum, Sudhajit) Scott’s sample
9:45 Break
10:00 EBSD (Helio Moutinho) S&TF 141 (Elisabeth, Scott, Yao-Tsung, Sudhajit) Elisabeth’s sample
10:00 SPM techniques PDIL Bay 4 (CS Jiang, Nick Xiao) (Shaimum, Mehdi, Rod, Sarah)
10:00 TOF-SIMS (Steve Harvey) SERF E002 (Alex, Jimmy, Silvana, Natis) Jimmy’s sample
12:00 Lunch - S&TF 127 (Andrew Norman, Steve Harvey, Helio Moutinho, CS Jiang, Nick Xiao, Tim Silverman, Vinnie LaSalvia, Adele Tamboli, Sarah Kurtz)
13:00 Suns-Voc & PL imaging at cell level (Vinnie LaSalvia, Pauls Stradins) PDIL (Rod, Mehdi, Sarah, Jimmy, Natis) Jimmy’s sample
13:00 EL imaging of modules (Tim Silverman) OTF 110 (Alex, Scott, Elisabeth, Yao-Tsung, Silvana, Shaimum, Sudhajit)
14:00 Student preparatory time S&TF 127 (Sarah Kurtz)
15:00 Student informal presentations of what they’ll take back to home institution (5 min. each) S&TF 127
16:00 Review of HOPE and students’ suggestions for how it could be improved in future years S&TF 127 (Sarah Kurtz and Adele Tamboli)
17:00 Shuttle bus will return to CSM from front of S&TF. Dinner on your own

SATURDAY, JULY 30, 2016 – CHECK OUT (BY 10:00)

Students are welcome to coordinate hikes or other activities before returning home.

Participants			
University	Student's Name	Professor	Research Focus
University of Arizona	Silvana Ayala Pelaez	Raymond Kostuk	Segmented holographic spectrum-splitting concentrator; Analysis of in-situ performance of high-concentration photovoltaics
University of Delaware	James Hack	Robert Opila	Surface passivation for hybrid silicon-organic solar cells
University of California, Los Angeles	Yao-Tsung Hsieh	Yang Yang	Interface engineering and film formation for hybrid perovskite solar cells
Colorado State University	Alexandra Huss	James Sites	Characterization (including JV, QE, CF, and CV) of optimized CdTe cells
Arizona State University	Mehdi Leilaieoun	Zachary Holman	Growing III/V materials on Si. SHJ solar cells with GaP passivation layer. Modeling and simulation of recombination mechanisms in Si solar cells.
Lehigh University	Roderick Marstell	Nicholas Strandwitz	Charge and defect analysis and control of semiconductor/oxide interfaces
Purdue University	Scott McClary	Rakesh Agrawal	Solution-based processing of thin-film absorber layers based on emerging Earth-abundant PV materials
Rochester Institute of Technology	Elisabeth McClure	Seth Hubbard	Metal-induced crystallization to achieve low-cost substrates for III-V PV
University of Utah	Sudhajit Misra	Mike Scarpulla	Post-deposition laser processing of CdTe
University of Texas at Dallas	Natis Shafiq	Anton Malko	Performance of thin-film Si solar cells augmented by proximal nanocrystals
University of Texas at El Paso	Shaimum Shahriar	Deidra Hodges	Performance analyzing of organic inorganic hybrid halide perovskite as an emerging photovoltaic for various deposition techniques
Massachusetts Institute of Technology	Sarah Sofia	Tonio Buonassisi	Design of contacts for large-area 4-terminal tandem solar cells; Cost analysis of tandem solar cells

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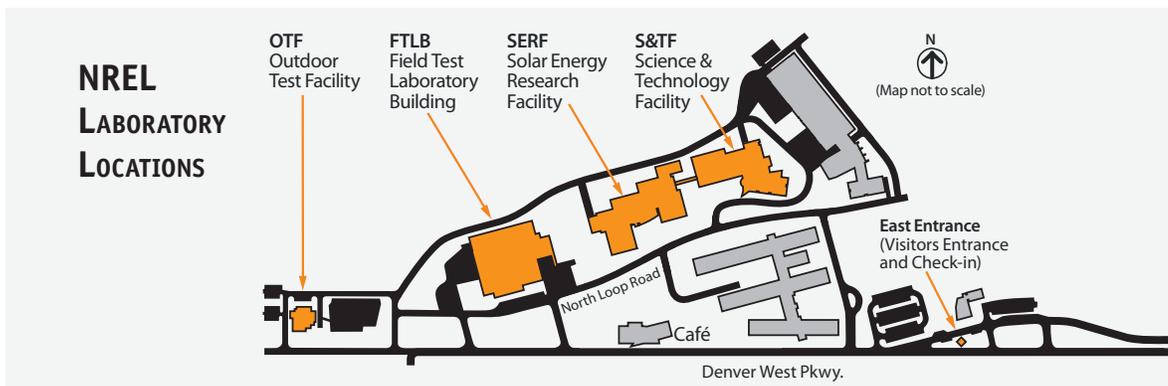
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