

PROCEEDINGS OF SPIE

Thin Film Solar Technology V

Louay A. Eldada

Michael J. Heben

Editors

25–26 August 2013

San Diego, California, United States

Sponsored and Published by

SPIE

Volume 8823

Proceedings of SPIE 0277-786X, V. 8823

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Thin Film Solar Technology V, edited by Louay A. Eldada, Michael J. Heben, Proc. of SPIE
Vol. 8823, 882301 · © 2013 SPIE · CCC code: 0277-786X/13/\$18 · doi: 10.1117/12.2045819

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Thin Film Solar Technology V*, edited by Louay A. Eldada, Michael J. Heben, Proceedings of SPIE Vol. 8823 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X

ISBN: 9780819496737

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2013, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/13/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.



SPIEDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID Number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID Number.

Contents

vii Conference Committee

CIGS FABRICATION AND CHARACTERIZATION

- 8823 02 **Crystallographic study of phases present in CuInSe₂ absorber layers produced by laser annealing co-electrodeposited precursors** [8823-1]
H. J. Meadows, Univ. of Luxembourg (Luxembourg); A. Bhatia, Univ. of Utah (United States); C. Stefan, S. Schorr, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (Germany); M. A. Scarpulla, Univ. of Utah (United States); P. J. Dale, Univ. of Luxembourg (Luxembourg)
- 8823 03 **CIGS thin film solar cell prepared by reactive co-sputtering** [8823-2]
J. Kim, Cheongju Univ. (Korea, Republic of); H.-S. Lee, N.-M. Park, Electronics and Telecommunications Research Institute (Korea, Republic of)
- 8823 04 **How does the selenium activity influence CuInSe₂ devices grown under Cu-excess?**
[8823-3]
V. Deprédurand, T. Bertram, S. Siebentritt, Univ. of Luxembourg (Luxembourg)

ADVANCES IN THIN FILM SILICON PV

- 8823 05 **Spectrally selective intermediate reflectors for tandem thin-film silicon solar cells** [8823-4]
A. Hoffmann, U. W. Paetzhold, T. Merdzhanova, A. Lambertz, Forschungszentrum Jülich GmbH (Germany); O. Höhn, Fraunhofer-Institut für Solare Energiesysteme (Germany); C. Ulrich, K. Bittkau, U. Rau, Forschungszentrum Jülich GmbH (Germany)
- 8823 06 **Optical and electrical modeling of an amorphous-silicon tandem solar cell with nonhomogeneous intrinsic layers and a periodically corrugated back-reflector** [8823-5]
M. Faryad, L. Liu, T. S. Mayer, A. Lakhtakia, Pennsylvania State Univ. (United States)
- 8823 07 **A novel light trapping concept for liquid phase crystallized poly-Si thin-film solar cells on periodically nanoimprinted glass substrates** [8823-6]
V. Preidel, D. Amkreutz, T. Sontheimer, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (Germany); F. Back, E. Rudigier-Voigt, SCHOTT AG (Germany); B. Rech, C. Becker, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (Germany)

ORGANIC AND DSSC THIN FILM PV

- 8823 08 **Study of the effect of the charge transport layer in the electrical characteristics of the organic photovoltaics** [8823-7]
R. Rahimi, A. Roberts, V. Narang, V. K. Kumbham, D. Korakakis, West Virginia Univ. (United States)
- 8823 09 **Characterization of N3 dye adsorption on TiO₂ using quartz-crystal microbalance with dissipation monitoring** [8823-8]
H. K. Wayment-Steele, L. E. Johnson, Pomona College (United States); M. C. Dixon, Biolin Scientific (United States); M. S. Johal, Pomona College (United States)

NANOSTRUCTURES AND ADVANCED LIGHT MANAGEMENT IN THIN FILM PV

- 8823 0C **Natural evolution inspired design of light trapping structure in thin film organic solar cells** [8823-11]
C. Wang, S. Yu, W. Chen, C. Sun, Northwestern Univ. (United States)
- 8823 0D **Submicron texturing for broadband light management in thin-film PV** [8823-12]
H. Melkonyan, S. Saylan, Masdar Institute of Science and Technology (United Arab Emirates); A. Heidelberg, H. Bloess, Masdar PV GmbH (Germany); M. Stefancich, J. Viegas, M. Dahlem, Masdar Institute of Science and Technology (United Arab Emirates)

ADVANCED PV MATERIALS, PROCESSES, AND STRUCTURES

- 8823 0G **Characterization of printed CZTSSe films for photovoltaic applications** [8823-17]
W. Wu, Y. Cao, J. V. Caspar, Q. Guo, L. K. Johnson, I. Malajovich, H. D. Rosenfeld, K. Roy Choudhury, L. Silverman, DuPont (United States)

POSTER SESSION

- 8823 0O **Plasmonic nanodot array optimization on organic thin film solar cells using anodic aluminum oxide templates** [8823-26]
K. Bae, K. Kim, Yonsei Univ. (Korea, Republic of)
- 8823 0Q **Structural and substructural features of chemically deposited zinc oxide thin films** [8823-28]
A. S. Opanasyuk, T. O. Berestok, Sumy State Univ. (Ukraine); P. M. Fochuk, Chernivtsi National Univ. (Ukraine); A. E. Bolotnikov, R. B. James, Brookhaven National Lab. (United States)
- 8823 0R **Thin multi-junction solar cells of III-V materials to advance solar energy harvesting** [8823-29]
S. Castelletto, A. Parker, RMIT Univ. (Australia)

- 8823 OT **Structural and interfacial properties of large area n- α -Si:H/i- α -Si:H/p- c -Si heterojunction solar cells** [8823-32]
Ö. Pehlivan, TUBITAK (Turkey); D. Menda, Yildiz Technical Univ. (Turkey); O. Yilmaz, A. O. Kodolbaş, TUBITAK (Turkey); O. Özdemir, Yildiz Technical Univ. (Turkey); Ö. Duygulu, Middle East Technical Univ. (Turkey); K. Kutlu, Yildiz Technical Univ. (Turkey); M. Tomak, Middle East Technical Univ. (Turkey)
- 8823 OU **Surface photovoltage as a tool to monitor the effect of hydrogen treatment on α -Si:H/c-Si heterojunction** [8823-33]
L. Martini, Univ. degli Studi di Roma La Sapienza (Italy); L. Serenelli, ENEA Research Ctr. Casaccia (Italy); R. Asquini, D. Caputo, G. de Cesare, Univ. degli Studi di Roma La Sapienza (Italy); M. Izzi, M. Tucci, ENEA Research Ctr. Casaccia (Italy)

Author Index

Conference Committee

Symposium Chair

Martha Symko-Davies, National Renewable Energy Laboratory
(United States)

Conference Chairs

Louay A. Eldada, Quanergy, Inc. (United States)
Michael J. Heben, The University of Toledo (United States)

Conference Program Committee

Bulent Basol, EncoreSolar, Inc. (United States)
Howard M. Branz, National Renewable Energy Laboratory (United States)
Paola Delli Veneri, ENEA (Italy)
David S. Ginley, National Renewable Energy Laboratory (United States)
Ivan Gordon, IMEC (Belgium)
William N. Shafarman, University of Delaware (United States)
Ayodhya N. Tiwari, EMPA (Switzerland)

Session Chairs

- 1 CIGS Fabrication and Characterization
Michael J. Heben, The University of Toledo (United States)
- 2 Advances in Thin Film Silicon PV
Michael J. Heben, The University of Toledo (United States)
- 3 Organic and DSSC Thin Film PV
Michael J. Heben, The University of Toledo (United States)
- 4 Nanostructures and Advanced Light Management in Thin Film PV
Louay A. Eldada, Quanergy, Inc. (United States)
- 5 Window and Contact Materials for Thin Film PV
Yanfa Yan, The University of Toledo (United States)
- 6 Advanced PV Materials, Processes, and Structures
Louay A. Eldada, Quanergy, Inc. (United States)

