PROCEEDINGS OF SPIE

Photonics for Solar Energy Systems VII

Ralf B. Wehrspohn Alexander N. Sprafke Editors

23–25 April 2018 Strasbourg, France

Sponsored by SPIE

Cosponsored by Strasbourg the Europtimist (France) CNRS (France) Investissements d'Avenvir (France) iCube (France) Université de Strasbourg (France)

Cooperating Organisations Photonics 21 (Germany) EOS—European Optical Society (Germany) Photonics Public Private Partnership (Belgium) Comité National d'Optique et de Photonique (France)

Published by SPIE

Volume 10688

Proceedings of SPIE 0277-786X, V. 10688

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

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers 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 these proceedings:

Author(s), "Title of Paper," in *Photonics for Solar Energy Systems VII*, edited by Ralf B. Wehrspohn, Alexander N. Sprafke, Proceedings of SPIE Vol. 10688 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

ISSN: 0277-786X ISSN: 1996-756X (electronic)

ISBN: 9781510619029 ISBN: 9781510619036 (electronic)

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 © 2018, 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/18/\$18.00.

Printed in the United States of America Vm7 i ffUb 5ggc WUHY gž & Wži bXYf "]WY bgY Zfca GD-9.

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



Paper Numbering: Proceedings of SPIE follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of 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 and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five 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.

Contents

v Authors

vii Conference Committee

NANOPHOTONICS FOR PHOTOVOLTAICS

10688 03 Photonic structures for III-V//Si multi-junction solar cells with efficiency >33% (Invited Paper) [10688-2]

NANOPHOTONICS FOR SOLAR MODULES

10688 05 Advanced module optics of textured perovskite silicon tandem solar cells [10688-4]

NANOSTRUCTURED ANTIREFLECTION COATINGS AND ENERGY SAVING IN BUILDINGS

- 10688 0A Antireflective nanotextures for monolithic perovskite-silicon tandem solar cells [10688-9]
- 10688 0B Nanoimprinted sol-gel materials for antireflective structures on silicon solar cells [10688-10]
- 10688 0D A combined experimental and theoretical study into the performance of multilayer vanadium dioxide nanocomposites for energy saving applications [10688-12]

SPECTRAL CONVERSION AND LIGHT TRAPPING

10688 0K Modified PV structures with a nanostructured top electrode [10688-20]

DISORDERED PHOTONIC NANOSTRUCTURES III

10688 0V A slab waveguide source for discontinuous Galerkin time-domain methods [10688-31]

POSTER SESSION

10688 0Y	Algorithm for precise positioning of the sun position in solar energy system using the GPS/GLONASS system [10688-34]
10688 13	Stochastic modelling of hopping charge carrier transport mechansim in organic photovoltaic structures [10688-41]
10688 14	Formation of nanostructures on the surface of CIGS films by picosecond laser with different beam patterns [10688-43]
10688 15	Plasmonic nanoscatter antireflective coating for efficient CZTS solar cells [10688-44]
10688 16	Design methodology for selecting optimum plasmonic scattering nanostructures inside CZTS solar cells [10688-45]
10688 17	Design of optimum back contact plasmonic nanostructures for enhancing light coupling in CZTS solar cells [10688-46]
10688 18	Angle-selective reflection surface for energy efficiency [10688-47]
10688 19	Linear and nonlinear light sensors in SCC based maximum power point search algorithms [10688-48]
10688 1A	The multi-input photovoltaic maximum power point tracker with integrated linear light sensor [10688-49]
10688 1C	Wafer scale FeCl ₃ intercalated graphene electrodes for photovoltaic applications [10688-52]
10688 1D	Potassium-alumina-boron glass doped with copper ions for solar cell down-convertors [10688-51]
10688 1F	Conversion characteristics of silicon photovoltaic cells for optical beaming [10688-42]
10688 1H	Analysis of mirrors geometry of V-trough solar concentrator in photovoltaic system [10688-36]