## PROCEEDINGS OF SPIE

# Physics, Simulation, and Photonic Engineering of Photovoltaic Devices IX

Alexandre Freundlich Masakazu Sugiyama Stéphane Collin Editors

4–6 February 2020 San Francisco, California, United States

Sponsored and Published by SPIE

Volume 11275

Proceedings of SPIE 0277-786X, V. 11275

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 Physics, Simulation, and Photonic Engineering of Photovoltaic Devices IX, edited by Alexandre Freundlich, Masakazu Sugiyama, Stéphane Collin, Proceedings of SPIE Vol. 11275 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

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

ISBN: 9781510633131 ISBN: 9781510633148 (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 © 2020, 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/20/\$18.00.

Printed in the United States of America Vm7 i ffUb 5ggc WUHY gz & 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

- vii Authors
- ix Conference Committee

### ADVANCES IN PHOTONIC DESIGNS AND MATERIAL DEVELOPMENTS FOR HIGH EFFICIENCY TANDEMS

- 11275 02 Modeling and realization of photonic structures for silicon-based tandem solar cells (Invited Paper) [11275-1]
- 11275 04 Design, modeling, and experimental results for CPV arrays built using heterogeneously integrated III-V micro-cells [11275-3]

#### HOT CARRIER SOLAR CELLS

- 11275 07 Fabrication and optical characterization of ultrathin III-V transferred heterostructures for hotcarrier absorbers [11275-6]
- 11275 0A Advanced analysis for hot-carriers photoluminescence spectrum [11275-9]

#### **DESIGN AND SIMULATION OF PEROVSKITES PV**

- 11275 0B Computational device optimization and parameter extraction for perovskite-based solar cells (Invited Paper) [11275-10]
- 11275 0C Optical analysis and optimizations of semi-transparent triple cation perovskite solar cells for tandem applications [11275-11]

#### PEROVSKITES AND EMERGING PHOTOVOLTAICS

11275 0H Controlling crystal growth of non-toxic Bismuth iodide (Bil<sub>3</sub>) semiconducting material for efficient photovoltaics [11275-16]

#### CHARACTERIZATION OF SOLAR CELLS

11275 0J Non-contacting optical probing of photovoltaic device performance (Invited Paper) [11275-18]

- 11275 0L A comparison of the optoelectronic properties of high-efficiency polycrystalline and epitaxial Cu(In,Ga)Se<sub>2</sub> photovoltaic films [11275-20]
- 11275 0M Electron beam induced current characterization of solid-state dye sensitized solar cell [11275-21]

#### CARRIER TRANSPORT IN QUANTUM/NANO-ENGINEERED SOLAR CELLS

- 11275 00 Trade-off study on the radiative efficiency and carrier transport of multiple-quantum-well solar cells [11275-25]
- 11275 OR Dynamical view of charge transport and separation in nanojunctions [11275-26]

#### ADVANCED LIGHT MANAGEMENT IN SOLAR CELLS

- 11275 0S Nanostructures and design challenges in photovoltaic devices (Invited Paper) [11275-27]
- 11275 OT Design of photonic light-trapping structures for ultra-thin solar cells [11275-28]
- 11275 0U Benefits of Lambertian light distribution across widely deployed photovoltaic materials [11275-29]

#### **IBSC AND QD SOLAR CELLS**

- 11275 0X Quasi-Fermi level splitting in InAs quantum dot solar cells from photoluminescence measurements (Invited Paper) [11275-32]
- 11275 0Y Physics of the inter-subband transition in quantum-dot intermediate-band solar cell [11275-33]

#### POSTER SESSION

- 11275 15 **Propagation of the blackbody radiation in a periodic metamaterial** [11275-40]
- 11275 17 **Optimization of solar cell packing models for flexible surfaces** [11275-42]
- 11275 18 Solar panels for the lunar base [11275-43]
- 11275 1A FDTD study of anti-reflective properties of photonic crystal slabs in silicon [11275-45]
- 11275 1B Enhancement of silicon nanowire micro-TEG using a plasmonic mid-IR absorber [11275-46]

11275 1EPlasmonic nanostructures for enhanced performance of microcrystalline silicon solar cells<br/>[11275-49]