

IEEE JOURNAL OF PHOTOVOLTAICS

Cosponsors

Electron Devices Society

PAUL YU, *President*
Univ. California, San Diego

SAMAR SAHA, *VP of Publications*
SuVolta Inc., Los Gatos, CA

Industrial Electronics Society

G. A. P. CAPOLINO, *President*
Valle de Passe-Temps

MARCO LISERRE, *VP of Publications*
Politecnico di Bari

Nanotechnology Council

STEPHEN M. GOODNICK, *President*
Arizona State Univ.

ARISTIDES A. REQUICHA, *VP of Publications*
Univ. Southern California

Photonics Society

HIDEO KUWAHARA, *President*
Fujitsu Labs Ltd.

RODNEY S. TUCKER, *VP of Publications*
Univ. Melbourne

Power & Energy Society

NOEL SCHULZ, *President*
Mississippi State Univ.

SAIFUR RAHMAN, *VP of Publications*
Virginia Tech.

Power Electronics Society

DUSHAN BOROVEVICH, *President*
Virginia Tech.

JOHN SHEN, *VP of Publications*
Univ. Central Florida

Reliability Society

DENNIS HOFFMAN, *President*
Lockheed Martin Aeronautics

ROBERT J. LOOMIS, *VP of Publications*
ManTech, Inc.

J-PV Steering Committee

Electron Devices Society

NARAIN D. ARORA
Silterra, Inc.

CHENNUPATI JAGADISH (CHAIR)
The Australian National Univ.

SANTOSH K. KURINEC
Rochester Inst. of Technol.

ANTHONY OATES
Taiwan Semiconductor Mfg. Co.

EDS Executive Director

CHRISTOPHER JANNUZZI
IEEE Operations Center
Piscataway, NJ

ENRICO SANGIORGI
Università di Bologna

RAJENDRA SINGH
Clemson Univ.

YUAN TAUR
Univ. California, San Diego

DOUG VERRET
Texas Instruments

Industrial Electronics Society

GIOVANNI SPAGNUOLO
Università di Salerno

Nanotechnology Council
GUANGYONG LI
Univ. Pittsburgh

Editor-in-Chief

TIMOTHY J. ANDERSON
Univ. of Massachusetts
Amherst, MA

Photonics Society

ROBERT MERTENS
IMEC

ALAN KOST (SECRETARY)
Univ. Arizona

Power & Energy Society
SAIFUR RAHMAN
Virginia Tech

Power Electronics Society

PATRICK CHAPMAN
SolarBridge Technologies

Reliability Society
PRASAD CHAPARALA
Alta Devices

Administrative Contact:

JO ANN MARSH
445 Hoes Lane, Piscataway, NJ 08854
Tel: +1 732 562 6855 E-mail: j.marsh@ieee.org

Please submit all manuscripts to <http://mc.manuscriptcentral.com/jpv>

Editors

Crystalline Silicon PV
STEFAN GLUNZ
Fraunhofer Inst. Solar Energy Sys.

PV Characterization
KEITH EMERY
NREL

PV Characterization
CLEMENS HESKE
Univ. of Nevada

Organic PV
ALEX K.-Y. JEN
Univ. of Washington

III-V, Concentrator and Space PV
RICHARD R. KING
Spectrolab, Inc.

III-V, Concentrator and Space PV
FRANK DIMROTH
Fraunhofer ISE

*Amorphous, Nanostructured,
and Film Si PV*
MICHIO KONDO
AIST

*Amorphous, Nanostructured,
and Film Si PV*
CHRISTOPHER WRONSKI
Pennsylvania State Univ.

Thin Film PV
ROMMEL NOUFI
NREL

*Thin Film and
PV Characterization*
ANGUS ROCKETT
Univ. of Illinois

Photovoltaic Balance of Systems
ANGELE H. M. E. REINDERS
Delft Univ. Tech.

Fundamentals and New Concepts
RICHARD CORKISH
Univ. of New South Wales

Fundamentals and New Concepts
STEVEN RINGEL
Ohio State Univ.

PV Systems-Grid Interactions
BENJAMIN KROPOSKI
NREL

PV Systems Control
GIOVANNI SPAGNUOLO
Univ. Salerno

Associate Editors

HARRY ATWATER
California Inst. of Technol.

ALLEN BARNETT
The Univ. of New South Wales

ANDREAS BETT
Fraunhofer ISE

DAVID CAHEN
Weizmann Inst. of Science

ANDRES CUEVAS
Australian National Univ.

VIKRAM DALAL
Iowa State Univ.

NEELKANTH DHERE
Univ. of Central Florida

REBEKAH FEIST
Dow Chemical Co.

ALEX FREUNDLICH
Univ. of Houston

DAVID GINGER
Univ. of Washington

IVAN GORDON
IMEC

L. JAY GUO
Univ. of Michigan

SETH HUBBARD
Rochester Inst. of Technol.

CHENNUPATI JAGADISH
The Australian National Univ.

SYLVAIN MARSILLAC
Old Dominion Univ.

ANTONIO MARTI
Instituto de Energia Solar-ETSIT,
Universidad Politécnica de Madrid

SHIGERU NIKI
AIST

GIOVANNI PETRONE
Univ. of Salerno

NIKOLAS PODRAZA
Univ. of Toledo

MICHAEL POWALLA
Zentrum für Sonnenenergie-
und Wasserstoff-Forschung

MIKE SCARPULLA
Univ. of Utah

WILLIAM SHAFARMAN
Univ. of Delaware

RONALD SINTON
Sinton Instruments

JIM SITES
Colorado State Univ.

ARNO SMETS
Technische Universiteit Delft

FRANKY SO
Univ. of Florida

WILHELM WARTA
Fraunhofer ISE

JIANGENG XUE
Univ. of Florida

YANG YANG
Univ. of California, Los Angeles

AHMED F. ZOBAA
Brunel Univ.

PETER W. STAECKER, *President*
ROBERTO DE MARCA, *President-Elect*
MARKO DELIMAR, *Secretary*
JOHN T. BARR, *Treasurer*
GORDON W. DAY, *Past President*

IEEE Officers

MICHAEL R. LIGHTNER, *Vice President, Educational Activities*
GIANLUCA SETTI, *Vice President, Publication Services and Products*
RALPH M. FORD, *Vice President, Member and Geographic Activities*
KAREN BARTLESON, *President, Standards Association*
ROBERT E. HEBNER, *Vice President, Technical Activities*
MARC T. APTER, *President, IEEE-USA*

COR L. CLAEYS, *Director, Division 1*

IEEE Executive Staff

THOMAS SIEGERT, *Business Administration*
MATTHEW LOEB, *Corporate Strategy*
DOUGLAS GORHAM, *Educational Activities*
EILEEN M. LACH, *General Counsel & Corporate Compliance Officer*
BETSY DAVIS, *SPHR, Human Resources*
CHRIS BRANTLEY, *IEEE-USA*

DR. E. JAMES PRENDERGAST, *Executive Director & Chief Operating Officer*
ALEXANDER PASIK, *Information Technology*
PATRICK MAHONEY, *Marketing*
CECELIA JANKOWSKI, *Member and Geographic Activities*
ANTHONY DURNAK, *Publications*
KONSTANTINOS KARACHALIOS, *Standards Activities*
MARY WARD-CALLAN, *Technical Activities*

IEEE Periodicals

Transactions/Journals Department

Senior Director: FRAN ZAPPULLA
Editorial Director: DAWN MELLEY Production Director: PETER M. TUOHY
Senior Managing Editor: WILLIAM COLACCHIO Journals Coordinator: CHRISTOPHER PERRY

IEEE JOURNAL OF PHOTOVOLTAICS (ISSN 2156-3381) is published quarterly by The Institute of Electrical and Electronics Engineers, Inc. Responsibility for the contents rests upon the authors and not upon the IEEE, the Society/Council, or its members. **IEEE Corporate Office:** 3 Park Avenue, 17th Floor, New York, NY 10016-5997. **IEEE Operations Center:** 445 Hoes Lane, Piscataway, NJ 08854-4141. **NJ Telephone:** +1 732 981 0060. **Price/Publication Information:** Individual copies: IEEE Members \$20.00 (first copy only), nonmembers \$146.00 per copy. (Note: Postage and handling charge not included.) Member and non-member subscription prices available upon request. **Copyright and Reprint Permissions:** Abstracting is permitted with credit to the source. Libraries are permitted to photocopy for private use of patrons, provided the per-copy fee indicated in the code at the bottom of the first page is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For all other copying, reprint, or republication permission, write to Copyrights and Permissions Department, IEEE Publications Administration, 445 Hoes Lane, Piscataway, NJ 08854-4141. Copyright © 2013 by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved. Periodicals Postage Paid at New York, NY and at additional mailing offices. **Postmaster:** Send address changes to IEEE TRANSACTIONS ON ELECTRON DEVICES, IEEE, 445 Hoes Lane, Piscataway, NJ 08854-4141. GST Registration No. 125634188. CPC Sales Agreement #0013087. Return undeliverable Canada addresses to: Pitney Bowes IMEX, P.O. Box 4332, Stanton Rd., Toronto, ON M5W 3J4, Canada. IEEE prohibits discrimination, harassment and bullying. For more information visit <http://www.ieee.org/nondiscrimination>. Printed in USA.