

PROCEEDINGS OF SPIE

Reflection, Scattering, and Diffraction from Surfaces II

Zu-Han Gu
Leonard M. Hanssen
Editors

2–4 August 2010
San Diego, California, United States

Sponsored and Published by
SPIE

Volume 7792

Proceedings of SPIE, 0277-786X, v. 7792

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

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 *Reflection, Scattering, and Diffraction from Surfaces II*, edited by Zu-Han Gu, Leonard M. Hanssen, Proceedings of SPIE Vol. 7792 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X
ISBN 9780819482884

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 © 2010, 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/10/\$18.00.

Printed in the United States of America.

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

The logo for SPIE Digital Library features the word "SPIE" in a bold, sans-serif font above the words "Digital Library" in a smaller, lighter font. To the right of the text is a stylized graphic consisting of three vertical bars of increasing height, resembling a bar chart or a signal waveform.

SPIDigitalLibrary.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 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*

SESSION 1 SCATTERING THEORY

- 7792 02 **The idea of the Lambertian surface: history, idealization, and system theoretical aspects and part 1 of a lost chapter on multiple reflection (Invited Paper)** [7792-01]
C. Hahlweg, B. Meißner, W. Zhao, H. Rothe, Helmut Schmidt Univ. (Germany)
- 7792 03 **Polar decomposition applied to light scattering by structured 2D surfaces (Invited Paper)** [7792-02]
J. M. Sanz, J. M. Saiz, F. Moreno, F. González, Univ. de Cantabria (Spain)
- 7792 04 **A Kirchoff approximation for surface plasmon polaritons** [7792-03]
T. A. Leskova, A. A. Maradudin, Univ. of California, Irvine (United States)
- 7792 05 **Multiple scatter of vector electromagnetic waves from rough metal surfaces with infinite slopes using the Kirchoff approximation** [7792-04]
N. C. Bruce, Univ. Nacional Autónoma de México (Mexico)
- 7792 06 **Nonstandard refraction of light from one- and two-dimensional dielectric quasi-periodic surfaces** [7792-05]
Z.-H. Gu, Surface Optics Corp. (United States); A. Wang, Univ. of Science and Technology of China (China)
- 7792 07 **Polarization of dipole scattering by randomly oriented ellipsoids** [7792-06]
S.-M. F. Nee, T.-W. Nee, National Yang-Ming Univ. (Taiwan)

SESSION 2 INSTRUMENTS AND APPLICATIONS I

- 7792 09 **Development of a tunable polarimetric scatterometry system in the MWIR and LWIR** [7792-08]
T. M. Fitzgerald, M. A. Marciniak, S. E. Nauyoks, Air Force Institute of Technology (United States)
- 7792 0A **Time depending techniques for volume and discrete boundary surface scatterometry and part II of a lost chapter in Lambert's Photometria on multiple reflection** [7792-09]
C. Hahlweg, B. Meißner, W. Zhao, H. Rothe, Helmut Schmidt Univ. (Germany)
- 7792 0B **Design rules for catadioptric scatterometers based on measurement requirements** [7792-10]
W. Zhao, C. Hahlweg, H. Rothe, Helmut Schmidt Univ. (Germany)

SESSION 3 OPTICAL PROPERTIES AND DIAGNOSTICS I

- 7792 0D **Temperature dependence of the reflectance of metals at visible wavelengths** [7792-13]
S. Maity, GE Global Research (India); A. Banerjee, Indian Institute of Science Education and Research (India); C. Mitra, GE Global Research (India)
- 7792 0F **Polarization/depolarization of non-diffusive anisotropic photon-scattering biomedical tissues** [7792-15]
T.-W. Nee, H.-W. Wang, S.-M. F. Nee, S. H. Wu, National Yang-Ming Univ. (Taiwan)
- 7792 0G **Optical measurement for the concentrations of the pickling acid with near infrared spectroscopy in steel making industry** [7792-16]
G. Kang, K. Lee, H. Park, J. Lee, Y. Jung, K. Kim, Yonsei Univ. (Korea, Republic of)
- 7792 0H **Bidirectional reflectance distribution of a 2D thin-film photonic crystal patterned using an atomic-force microscope** [7792-17]
N. C. Herr, M. A. Marciniak, A. G. Li, L. W. Burggraf, Air Force Institute of Technology (United States)

SESSION 4 BRDF MODELING

- 7792 0I **A general BRDF/BSDF model including out-of-plane dependence (Invited Paper)** [7792-18]
M. E. Thomas, R. I. Joseph, W. J. Tropf, A. M. Brown, The Johns Hopkins Univ. (United States)
- 7792 0J **Experimental confirmation of the Rayleigh-Rice obliquity factor** [7792-19]
J. C. Stover, The Scatter Works Inc. (United States)
- 7792 0K **Investigations on back scatter of typical projectiles for application of laser based trajectory measurement** [7792-20]
W. Zhao, C. Hahlweg, H. Rothe, Helmut Schmidt Univ. (Germany)
- 7792 0L **Restoration of scene information reflected from a non-specular surface** [7792-21]
M. G. Hoelscher, M. A. Marciniak, Air Force Institute of Technology (United States)

SESSION 5 INSTRUMENTS AND APPLICATIONS II

- 7792 0M **Developing a multispectral HDR imaging module for a BRDF measurement system** [7792-22]
D. B. Kim, M. K. Seo, K. Y. Kim, K. H. Lee, Gwangju Institute of Science and Technology (Korea, Republic of)
- 7792 0N **A stereoscopic imaging system for laser back-scatter-based trajectory measurement in ballistics** [7792-23]
E. Wilhelm, U. Chalupka, C. Hahlweg, W. Zhao, H. Rothe, Helmut Schmidt Univ. (Germany)
- 7792 0O **New scanning gonio-photometer for extended BRDF measurements** [7792-24]
P. Apian-Bennewitz, pab advanced technologies Ltd. (Germany)
- 7792 0Q **Optical inspection of flat reflective surfaces by a wave front sensor** [7792-26]
I. Lazareva, A. Nutsch, L. Pfitzner, Fraunhofer IISB (Germany); L. Frey, Fraunhofer IISB (Germany) and Friedrich-Alexander-Univ. Erlangen-Nuremberg (Germany)

- 7792 OR **Reflectance measurements for black absorbers made of vertically aligned carbon nanotubes** [7792-27]
X. J. Wang, O. S. Adewuyi, L. P. Wang, B. A. Cola, Z. M. Zhang, Georgia Institute of Technology (United States)

SESSION 6 COHERENCE AND SCATTERING

- 7792 OS **Wavelength-tunable focal length of a nanopatterned metallic planar lens with strong focusing capability (Invited Paper)** [7792-28]
L. D. Wellem, D. Huang, Air Force Research Lab. (United States); T. A. Leskova, A. A. Maradudin, Univ. of California, Irvine (United States)
- 7792 OT **A partially coherent slowly diffracting beam** [7792-31]
E. R. Méndez, Ctr. de Investigación Científica y de Educación Superior de Ensenada (Mexico); E. E. García-Guerrero, Univ. Autónoma de Baja California (Mexico); Z.-H. Gu, Surface Optics Corp. (United States); T. A. Leskova, A. A. Maradudin, Univ. of California, Irvine (United States)
- 7792 OU **Coherence effects: from spectral change to nondiffraction** [7792-29]
Z.-H. Gu, Surface Optics Corp. (United States)

SESSION 7 OPTICAL PROPERTIES AND DIAGNOSTICS II

- 7792 OV **Mechanical surface treatment to obtain optically cooperative surfaces vis-à-vis fringe projection** [7792-33]
O. Abo-Namous, M. Kästner, E. Reithmeier, M. Nicolaus, K. Möhwald, F.-W. Bach, Leibniz Univ. Hannover (Germany)
- 7792 OW **Roughness influence on periodic gratings and application to optical metrology of roughness** [7792-34]
A. Vauselle, Institut Fresnel, CNRS, Aix-Marseille Univ. (France) and STMicroelectronics (France); L. Arnaud, G. Georges, C. Amra, C. Deumié, Institut Fresnel, CNRS, Aix-Marseille Univ. (France); P. Maillot, STMicroelectronics (France)
- 7792 OX **PASCAL: instrument for accurate precise characterization of Lambertian materials** [7792-35]
V. Murgai, J. M. Nixt, E. M. Moskun, C. M. Jones, C. E. Payton, J. D. CdeBaca, Raytheon Space & Airborne Systems (United States)
- 7792 OY **A model for the optical properties of amorphous carbon (soot)** [7792-36]
M. E. Thomas, D. E. Freund, R. I. Joseph, The Johns Hopkins Univ. (United States)

SESSION 8 OPTICAL PROPERTIES AND DIAGNOSTICS III

- 7792 OZ **Preliminary characterization study of a gold-coated concentrator for hemispherical longwave irradiance measurements** [7792-37]
J. Zeng, Utah State Univ. (United States); L. Hanssen, National Institute of Standards and Technology (United States); I. Reda, National Renewable Energy Lab. (United States); J. Scheuch, Labsphere, Inc. (United States)

- 7792 10 **Stress measurement of thin wafer using reflection grating method** [7792-38]
C. S. Ng, Nanyang Technological Univ. (Singapore) and Infineon Technologies Malaysia Sdn Bhd. (Malaysia); A. K. Asundi, Nanyang Technological Univ. (Singapore)
- 7792 11 **Optical material characterization through BSDF measurement and analysis** [7792-39]
A. M. Brown, D. V. Hahn, M. E. Thomas, D. M. Brown, J. Makowski, The Johns Hopkins Univ. (United States)

POSTER SESSION

- 7792 13 **Effective decomposition of pearlescent paints** [7792-32]
M. K. Seo, D. B. Kim, K. Y. Kim, K. H. Lee, Gwangju Institute of Science and Technology (Korea, Republic of)
- 7792 15 **Improvements of nanometer particle's measuring system based on photon correlation spectroscopy** [7792-42]
S. Deng, Q. Zhang, J. Xia, Y. Xiong, S. Guo, Y. Yang, National Univ. of Defense Technology (China)
- 7792 19 **A novel method for diameter estimation of small opaque objects using Fraunhofer diffraction** [7792-47]
K. Vyas, K. R. Lolla, Indian Institute of Science (India)
- 7792 1A **Topography measurement of specular and diffuse surfaces** [7792-48]
D. I. Serrano García, A. Martínez García, J. A. Rayas-Alvarez, Ctr. de Investigaciones en Óptica, A.C. (Mexico)

Author Index

Conference Committee

Program Track Chair

Katherine Kreath, Optineering (United States) and College of Optical Sciences, The Univ. of Arizona (United States)

Conference Chairs

Zu-Han Gu, Surface Optics Corporation (United States)
Leonard M. Hanssen, National Institute of Standards and Technology (United States)

Program Committee

G rard Berginc, Thales Optronique S.A. (France)
Neil C. Bruce, Universidad Nacional Aut noma de M xico (Mexico)
Gary E. Carver, Omega Optical, Inc. (United States)
Aristide C. Dogariu, CREOL, The College of Optics and Photonics, University of Central Florida (United States)
Gregory Gbur, The University of North Carolina at Charlotte (United States)
Hsueh Mei Graham, Lockheed Martin Corporation (United States)
Brian G. Hoover, Advanced Optical Technologies (United States)
Danhong Huang, Air Force Research Laboratory (United States)
Alexei A. Maradudin, University of California, Irvine (United States)
Eugenio R. M ndez, Centro de Investigaci n Cient fica y de Educaci n Superior de Ensenada (Mexico)
Soe-Mie F. Nee, National Yang-Ming University (Taiwan)
Arne Roos, Uppsala University (Sweden)
Hendrik Rothe, Helmut Schmidt University (Germany)
Shouhong Tang, KLA-Tencor Corporation (United States)
Michael E. Thomas, The Johns Hopkins University (United States)

Session Chairs

- 1 Scattering Theory
Alexei A. Maradudin, University of California, Irvine (United States)
- 2 Instruments and Applications I
Soe-Mie F. Nee, National Yang-Ming University (Taiwan)
- 3 Optical Properties and Diagnostics I
Neil C. Bruce, Universidad Nacional Aut noma de M xico (Mexico)

- 4 BRDF Modeling
Michael E. Thomas, The Johns Hopkins University (United States)
- 5 Instruments and Applications II
Hendrik Rothe, Helmut Schmidt University (Germany)
- 6 Coherence and Scattering
Danhong Huang, Air Force Research Laboratory (United States)
- 7 Optical Properties and Diagnostics II
Hsueh Mei Graham, Lockheed Martin Corporation (United States)
- 8 Optical Properties and Diagnostics III
Soe-Mie F. Nee, National Yang-Ming University (Taiwan)