

PROCEEDINGS OF SPIE

Reflection, Scattering, and Diffraction from Surfaces V

Leonard M. Hanssen
Editor

28–29 August 2016
San Diego, California, United States

Sponsored and Published by
SPIE

Volume 9961

Proceedings of SPIE 0277-786X, V. 9961

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

Reflection, Scattering, and Diffraction from Surfaces V, edited by Leonard M. Hanssen, Proc. of
SPIE Vol. 9961, 996101 · © 2016 SPIE · CCC code: 0277-786X/16/\$18 · doi: 10.1117/12.2256406

Proc. of SPIE Vol. 9961 996101-1

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 SPIDigitalLibrary.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 *Reflection, Scattering, and Diffraction from Surfaces V*, edited by Leonard M. Hanssen, Proceedings of SPIE Vol. 9961 (SPIE, Bellingham, WA, 2016) Six-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510603134

ISBN: 9781510603141 (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 © 2016, 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/16/\$18.00.

Printed in the United States of America.

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

**SPIE. DIGITAL
LIBRARY**

SPIDigitalLibrary.org

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 six-digit CID article numbering system structured as follows:

- 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.

Contents

v	<i>Authors</i>
vii	<i>Conference Committee</i>

SESSION 1 THEORY AND MODELING I

- 9961 02 **Linking Rayleigh-Rice theory with near linear shift invariance in light scattering phenomena (Invited Paper)** [9961-1]
- 9961 03 **Comparison of the GHS_{Smooth} and the Rayleigh-Rice surface scatter theories** [9961-2]
- 9961 04 **Nonlocal scattering tensor due to electromagnetic coupling of surface plasmons to dirac plasmons in graphene** [9961-3]
- 9961 05 **Derivation of realistic surface and particulate scatter transfer functions and their application to incoherent imaging of high-contrast fine-detail scenes** [9961-4]

SESSION 2 MEASUREMENTS AND INSTRUMENTATION

- 9961 07 **Mueller matrix bidirectional reflectance distribution function measurements and modeling of textured silicon surfaces (Invited Paper)** [9961-6]
- 9961 08 **A novel image-based BRDF measurement system and its application to human skin** [9961-7]
- 9961 09 **Goniometric and hemispherical reflectance and transmittance measurements of fused silica diffusers** [9961-8]
- 9961 0B **Photon-material interaction based on single slit diffraction** [9961-10]
- 9961 0C **Portable fluorescence meter with reference backscattering channel** [9961-11]

SESSION 3 THEORY AND MODELING II

- 9961 0D **A simple model of a one-dimensional, randomly rough, non-Gaussian surface (Invited Paper)** [9961-12]
- 9961 0E **Evolution of the transfer function characterization of surface scatter phenomena** [9961-13]
- 9961 0F **Determination of the normalized surface height autocorrelation function of a two-dimensional randomly rough dielectric surface by the inversion of light scattering data in p-polarization** [9961-14]
- 9961 0G **Analysis of wave optics BRDF model elements for a moderately rough surface** [9961-15]

SESSION 4 MEASUREMENT METHODS

- 9961 0I **Development of twin-illumination and subtraction technique for detection of concave and convex defects on steel surfaces** [9961-17]
- 9961 0L **The design of microscope type spectral reflectometry for the depth measurement of high-aspect-ratio through silicon via** [9961-20]

SESSION 5 ANALYSIS METHODS

- 9961 0M **Automatic construction of probabilistic dynamic bidirectional reflectance distribution functions from reflection screen images (Invited Paper)** [9961-21]
- 9961 0N **Two-dimensional PSF prediction of multiple-reflection optical systems with rough surfaces** [9961-22]
- 9961 0O **Matrix methods for reflective inverse diffusion** [9961-23]
- 9961 0P **Zernike polynomials for mid-spatial frequency representation on optical surfaces** [9961-24]

SESSION 6 IMAGING METHODS AND APPLICATIONS

- 9961 0Q **Optical 3D imaging and visualization of concealed objects** [9961-25]
- 9961 0R **Extended-range AFM imaging for applications to reflectance modeling** [9961-26]
- 9961 0S **Topography measurement of freeform specular surfaces using experimental ray tracing and radial basis functions** [9961-27]
- 9961 0T **On-axis reverse Hartmann test in aspheric optical surface test with the optical flat calibration** [9961-28]
- 9961 0U **Real-time diameter measurement using diffuse light** [9961-29]

POSTER SESSION

- 9961 0V **Proposal for study on IR light and glucose phantom interaction for human glucose quantification applications** [9961-30]
- 9961 0W **Study on inverse estimation of radiative properties from directional radiances by using statistical RPSO algorithm** [9961-31]
- 9961 0X **Methods of processing biomedical image of retinal macular region of the eye** [9961-32]
- 9961 0Z **Spatial attributes of diffraction free fields** [9961-34]
- 9961 13 **Use of optical skin phantoms for calibration of dermatological lasers** [9961-38]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Alinoori, A., 0S
Bailey, Albert, 0M
Bellet, J.-B., 0Q
Berechet, I., 0Q
Berechet, S., 0Q
Berginc, G., 0Q
Bintz, Jeffrey R., 08
Burgi, Kenneth W., 0O
Burkov, Dmitry S., 0C
Butler, Samuel D., 08, 0G
Cenian, A., 13
Choi, Jun-Hyuk, 0W
Church, Eugene, 02
Cosio-León, María, 0V
Davies, Angela D., 0P
De los Santos G., S. I., 0Z
Dong, Liqun, 0T
Drahi, Etienne, 07
Early, Edward, 0M
Essameldin, M., 0S
Evans, Chris J., 0P
Fischer, Guillaume, 07
Fleischmann, F., 0S
Foldyna, Martin, 07
Freda, Samuel E., 0G
Galla, S., 13
Georgiev, Georgi T., 09
Germer, Thomas A., 07, 09
Goona, Nithin Kumar, 0B
Greynolds, Alan W., 05
Grishanov, Vladimir N., 0C
Gumbs, G., 04
Han, Kuk-Il, 0W
Hanssen, Leonard, 09
Harvey, James E., 03, 0E
Henning, T., 0S
Hoover, Brian G., 0R
Hosseinimakarem, Zahra, 0P
Huang, D. H., 04
Hui, Mei, 0T, 0U
Iizuka, Yukinori, 0I
Jiménez, G. D., 0D
Johnson, B. Carol, 09
Kennedy, Paul, 0M
Kim, Do-Hwi, 0W
Kim, Tae-Kuk, 0W
Kodama, Toshifumi, 0I
Kong, Lingqin, 0T
Kornilin, Dmitry V., 0C
Koshihara, Takahiro, 0I
Kryvi, J. B., 0F
Kuzin, O. O., 0X
Lavagna, Michele, 0N
Lemaillet, Paul, 09
Liu, Chih-Shang, 0L
Liu, Ming, 0T
Liu, Xiaohua, 0T
Lloyd, James Tommy, 08
Lo, Chun-Wei, 0L
Lopushenko, Vladimir, 02
Luo, Xiaohe, 0U
Luque-Morales, Priscy, 0V
Maradudin, A. A., 04, 0D, 0F
Marchwiński, M., 13
Marciniak, Michael A., 08, 0G, 0O
Martinez-Niconoff, G., 0Z
Martinez-Vara, P., 0Z
Mendenhall, Michael J., 08
Méndez, E. R., 0D
Mrzkova, Zuzana, 07
Munoz-Lopez, J., 0Z
Nauyoks, Stephen E., 0G, 0O
Nieto-Hipolito, Juan I., 0V
Ogawa, Akihiro, 0I
Ono, Hiroaki, 0I
Oshige, Takahiko, 0I
Oxley, Mark E., 0O
Pan, W., 04
Pareschi, Giovanni, 0N
Patrick, Heather J., 09
Pavlov, S. V., 0X
Pfisterer, Richard N., 03, 0E
Poplavskaya, A. A., 0X
Reddy, G. R. C., 0B
Reddy, P. S., 0B
Reyes, Pablo A., 0R
Romo-Cárdenas, Gerardo S., 0V
Roslyak, O., 04
Saldan, I. R., 0X
Sanchez-Lopez, Juan D., 0V
Schroeder, Sven, 02
Sękowska, A., 13
Shin, Jong-Jin, 0W
Simonsen, I., 0F
Singh, Priya, 0B
Sironi, Giorgia, 0N
Spiga, Daniele, 0N
Staats, Chris, 02

Stover, John C., 02
Tayabaly, Kashmira, 0N
Thomas, Robert, 0M
Torres-Rodríguez, M. A., 0Z
Vassilenko, V. B., 0X
Vazquez-Briseno, Mabel, 0V
Vovkotrub, D. V., 0X
Wang, Shanshan, 0U
Wei, Hsiang-Chun, 0L
Wróbel, M. S., 13
Xia, Zhengzheng, 0T
Yamasaki, Takahiro, 0I
Zakharov, Valery P., 0C
Zhao, Yuejin, 0T
Zhao, Zhu, 0T
Zhu, Qiudong, 0U

Conference Committee

Program Track Chair

Kathy Creath, Optineering (United States) and The University of Arizona (United States)

Conference Chair

Leonard M. Hanssen, National Institute of Standards and Technology (United States)

Conference Program Committee

G rard Berginc, Thales Optronique S.A.S. (France)

Aristide C. Dogariu, CREOL, The College of Optics and Photonics, University of Central Florida (United States)

John C. Fleming, Ball Aerospace & Technologies 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)

Michael A. Marciniak, Air Force Institute of Technology (United States)

Richard N. Pfisterer, Photon Engineering LLC (United States)

Benjamin K. Tsai, National Institute of Standards and Technology (United States)

Session Chairs

- 1 Theory and Modeling I
Brian G. Hoover, Advanced Optical Technologies (United States)
- 2 Measurements and Instrumentation
Michael A. Marciniak, Air Force Institute of Technology (United States)
- 3 Theory and Modeling II
Danhong Huang, Air Force Research Laboratory (United States)
- 4 Measurement Methods
G rard Berginc, Thales Optronique S.A.S. (France)
- 5 Analysis Methods
Alexei A. Maradudin, University of California, Irvine (United States)
- 6 Imaging Methods and Applications
Brian G. Hoover, Advanced Optical Technologies (United States)

