PROCEEDINGS OF SPIE

Current Developments in Lens Design and Optical Engineering XXI

R. Barry Johnson Virendra N. Mahajan Simon Thibault Robert M. Bunch Ching-Cherng Sun Editors

24 August – 4 September 2020 Online Only, United States

Sponsored and Published by SPIE

Volume 11482

Proceedings of SPIE 0277-786X, V. 11482

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

Current Developments in Lens Design and Optical Engineering XXI, edited by R. B. Johnson, V. N. Mahajan, S. Thibault, R. M. Bunch, C.-C. Sun, Proc. of SPIE Vol. 11482, 1148201 © 2020 SPIE · CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2581663

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 *Current Developments in Lens Design and Optical Engineering XXI*, edited by R. Barry Johnson, Virendra N. Mahajan, Simon Thibault, Robert M. Bunch, Ching-Cherng Sun, Proceedings of SPIE Vol. 11482 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510637702

ISBN: 9781510637719 (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.orc

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 \$21.00 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/\$21.00.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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

LENS DESIGN THEORY 11482 04 Exact caustic produced through separated doublets [11482-1] 11482 05 The entrance pupil of an on-axis stigmatic singlet lens [11482-2] 11482 06 Distortion controlled optical design using orthogonal surface polynomials [11482-3] 11482 07 The importance of Petzval correction in generalized Offner designs (Invited Paper) [11482-4] 11482 08 Evaluation of deep learning-generated lens design starting points [11482-5] MIRROR AND CATADIOPTRIC SYSTEM DESIGN 11482 0A Ultrashort throw lenses with catadioptric relay suitable for flat and curved screens [11482-7] **NEW DEVELOPMENTS IN VR/AR** 11482 0C Light field displays for near eye VR and AR [11482-9] MINIATURE AND CONSUMER OPTICS 11482 OE Wide angle lens with improved relative illumination characteristics [11482-11] 11482 0G Optimization of a mobile phone camera for as-built performance (Invited Paper) [11482-13] 11482 OH Inverse designed flat optics with multilevel diffractive lenses [11482-14] NEW DEVELOPMENTS IN OPTICAL SYSTEM 11482 OJ Optical design of triple-mode seeker [11482-16] 11482 OK Comparison of passive athermalization results of LWIR optical designs utilizing different infrared optical materials [11482-17]

POSTER SESSION

11482 0V	Design of an anastigmatic three-mirror telescope using freeform surfaces [11482-28]
11482 OY	Analytic formulation of a spherochromatic collimator lens [11482-31]