

PROCEEDINGS OF SPIE

Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation IV

Ramón Navarro
Roland Geyl
Editors

14–22 December 2020
Online Only, United States

Sponsored and Published by
SPIE

Volume 11451

Part One of Two Parts

Proceedings of SPIE 0277-786X, V. 11451

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

Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation IV,
edited by Ramón Navarro, Roland Geyl, Proc. of SPIE Vol. 11451, 1145101
© 2020 SPIE · CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2591665

Proc. of SPIE Vol. 11451 1145101-1

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 *Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation IV*, edited by Ramón Navarro, Roland Geyl, Proceedings of SPIE Vol. 11451 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

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

ISBN: 9781510636897
ISBN: 9781510636903 (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 \$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.

**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 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

Part One

NOVEL AND DISRUPTIVE CONCEPTS

- 11451 07 **A decade of NASA strategic astrophysics technology investments: technology maturation, infusion, and other benefits** [11451-1]
- 11451 08 **NAIR: Novel Astronomical Instrumentation through photonic Reformatting** [11451-2]
- 11451 09 **Crossing the diffraction limit with an optical amplifier** [11451-3]
- 11451 0A **CASTLE: a curved-sensor-based wide-field telescope at Calar Alto** [11451-4]
- 11451 0B **A generalized Offner relay with an accessible pupil** [11451-5]

NOVEL AND DISRUPTIVE CONCEPTS II

- 11451 0C **An additive manufactured CubeSat mirror incorporating a novel circular lattice** [11451-6]
- 11451 0E **Modal noise mitigation in a photonic lantern fed near-IR spectrograph** [11451-8]

LARGE OPTICS AND SUPPORT SYSTEMS I

- 11451 0F **ELT secondary mirror manufacturing progress at Safran Reosc** [11451-10]
- 11451 0G **Design and production of segment mirrors for the Large-Sized Telescopes of the Cherenkov Telescope Array** [11451-11]
- 11451 0H **Application progress of stressed mirror continuous polishing technology in the segments fabrication of telescope primary mirror** [11451-12]
- 11451 0I **Design, development, and analysis of segment support system for TMT primary mirror** [11451-13]
- 11451 0J **NPF update: light-weight mirror development in Chile** [11451-14]
- 11451 0K **Primary mirror panels of the Millimetron Space Observatory** [11451-16]

OPTICAL FABRICATION

- 11451 0L **Optics for EUCLID telescope: challenges and developments** [11451-17]
- 11451 0N **A new manufacturing system for free form and large optics** [11451-19]
- 11451 0O **Design and MAIT status of the UH2.2 adaptive secondary mirror** [11451-20]
- 11451 0P **Microlenses for astrophotonic instruments manufactured by ultrafast-laser assisted etching** [11451-21]

LARGE OPTICS AND SUPPORT SYSTEMS II

- 11451 0Q **The ELT M1 support structure from prototype into volume manufacturing: an industrial perspective** [11451-22]
- 11451 0S **The coating plant for the segments of the primary mirror of the Extremely Large Telescope (ELT) in Chile** [11451-24]

TEST AND METROLOGY OF (SUB-)SYSTEMS I

- 11451 0V **Interferometer for surface figure of large convex hyperboloid mirrors** [11451-27]
- 11451 0W **CGH for ESO's ELT M2 reference plate: fabrication of high precision CGHs** [11451-28]

TEST AND METROLOGY OF (SUB-)SYSTEMS II

- 11451 0Y **New Fourier CGH coding using DMD generated masks for grayscale and color images** [11451-31]

MATERIALS

- 11451 14 **Effect of surface condition on the bending strength of cordierite ceramics** [11451-38]
- 11451 16 **Fundamental characteristics of three-dimensional additive manufacturing products of zero thermal expansion metal** [11451-40]
- 11451 18 **Precise control of negative thermal expansion in stainless invar type alloy for astronomical telescopes** [11451-42]

- 11451 19 **Space environment resistance of thermo-optical properties of low CTE ceramics and glass** [11451-43]
- 11451 1A **The primary mirror of the Ariel mission: cryotesting of aluminum mirror samples with protected silver coating** [11451-44]
- 11451 1B **CTE homogeneity of ZERODUR® in the ELT century** [11451-284]

GRATINGS

- 11451 1C **Machined InP immersion grating perfectly covering J-band** [11451-45]
- 11451 1D **Échelle grating with improved polarization characteristics used for Earth observation** [11451-46]
- 11451 1G **Ge immersed grating manufacturing and optical verification for the METIS high-resolution spectrograph** [11451-49]

COATINGS, FILTERS

- 11451 1M **Primary mirror aluminizing operations at the Large Binocular Telescope** [11451-55]

TECHNOLOGIES FOR CRYOGENIC INSTRUMENTS

- 11451 1O **A cryogenic actuator for the image derotator on ELT-METIS** [11451-60]
- 11451 1P **H2020 opticon WP5 overview: investigating the use of additive manufacturing for the design and build of multifunctional integrated astronomical components** [11451-61]

ACTIVE INSTRUMENTS

- 11451 1W **Results of the ELT M1 position actuators validation campaign** [11451-70]
- 11451 1X **The prospects for applying magnetic smart materials combined with shape memory alloys to produce correctable and deployable space telescopes** [11451-71]
- 11451 1Z **The InfraRed Imaging Spectrograph (IRIS) for TMT: support structure final design** [11451-74]

OPTICAL FIBERS, POSITIONERS I

- 11451 20 **A focal-ratio-degradation resistant multimode fiber link using mode-selective photonic lantern** [11451-76]
- 11451 21 **Initial measurements of focal ratio degradation in ZBLAN fluoride fibers for K band spectroscopy** [11451-77]
- 11451 23 **Optical fibre pseudo-slits for astronomy** [11451-79]
- 11451 24 **Multi-core fibre-fed integral field spectrograph (MCIFU) IV: the fiber link** [11451-80]
- 11451 25 **An easily scalable Theta/Phi fiber positioner to reduce risks, lead times, and costs for multi-object spectrographs** [11451-81]
- 11451 26 **Mix and match as you go: beam switch module that splits wavelengths, scrambles beams, and switches fibers in multiplexed replicated astronomical spectrograph systems such as VIRUS2** [11451-82]

OPTICAL FIBERS, POSITIONERS II

- 11451 27 **Design and testing of the MOONS fibre positioning units** [11451-83]
- 11451 29 **Photonic integrated circuit for absolute metrology** [11451-85]

SLIT SPECTROSCOPY AND IMAGE SLICERS

- 11451 2D **Boosting dispersive spectrograph stability 1000x using an interferometer with crossfaded delays** [11451-89]

POSTER SESSION: ADDITIVE MANUFACTURING AND CFRP

- 11451 2H **Initial development of high accuracy carbon fiber reinforced plastics (CFRP) reflector segment for the 60-meters submillimeter telescope** [11451-115]
- 11451 2I **Quality control of the CFRP mirror manufacturing process at NPF** [11451-116]
- 11451 2J **Mitigating print-through effects through an optimized method for CFRP mirror production in Chile** [11451-117]
- 11451 2M **Freeform active mirror designed for additive manufacturing** [11451-121]
- 11451 2N **Additive manufacturing: innovative concepts of compliant mechanisms** [11451-122]

POSTER SESSION: MATERIALS

- 11451 2Q **Optical materials for space applications** [11451-127]
- 11451 2R **Lightweighting strategies for main support structures of ELT instrumentation** [11451-128]
- 11451 2S **Characterization of the reflectivity of various black and white materials** [11451-129]

Part Two

POSTER SESSION: OPTICAL FABRICATION

- 11451 2X **F-molding: a new production method for largely aspherical mirrors of Cordierite** [11451-148]
- 11451 2Y **Fabrication of mirror arrays with an ultra-precision cutting technique for a near-infrared integral field unit SWIMS-IFU** [11451-149]
- 11451 30 **Polishing and testing of TMT reference sphere** [11451-151]
- 11451 31 **NIRPS: gluing optics with epoxy, lessons learned** [11451-153]
- 11451 32 **Thermal tests of birefringent plates in molecular adhesion for spatial ultra-violet polarimetry** [11451-154]

POSTER SESSION: TESTING AND METROLOGY AT COMPONENT OR INSTRUMENT LEVEL

- 11451 38 **HARMONI - first light spectroscopy for the ELT: final design of the integral field unit** [11451-162]
- 11451 39 **HARMONI - first light spectroscopy for the ELT: spectrograph camera lens mounts** [11451-163]
- 11451 3A **Cementing and testing of the 4MOST WFC/ADC doublets** [11451-166]
- 11451 3B **A metrological characterization of the SPEED test-bed PIAACMC components** [11451-168]
- 11451 3C **Fabrication and characterization of aluminum image slicers** [11451-169]
- 11451 3E **Methods used for testing large-size mirrors surface figure and on and off-axis surfaces optical parameters at the stage of figuring**[11451-171]
- 11451 3F **The Shack-Hartmann wavefront sensor for the Rubin Observatory** [11451-172]

POSTER SESSION: TECHNOLOGIES FOR CRYOGENIC INSTRUMENTS

- 11451 3M **Cryo-vacuum system for low temperature thermal cycling of MCT detectors** [11451-208]
- 11451 3P **Development of 30mW@4K hybrid J-T cooler for space application** [11451-211]
- 11451 3Q **Vibration reduction for stirling cryocooler system** [11451-212]
- 11451 3R **Design update of the central wheel mechanism** [11451-215]

POSTER SESSION: CORONOGRAPHY AND HIGH CONTRAST IMAGING

- 11451 3V **Development of a space spectropolarimeter for full Stokes parameters retrieval** [11451-220]
- 11451 3X **Optical sensitivity analyses of various reflective systems: on-axis, common off-axis, and confocal off-axis designs** [11451-223]
- 11451 3Y **Speckle reduction technique using the self-coherent camera for the common-path visible nulling coronagraph** [11451-224]

POST-DEADLINE

- 11451 40 **Surface-relief gratings with anti-reflective nanostructures for panchromatic astronomical low/medium/high resolution spectroscopic surveys** [11451-270]
- 11451 41 **Illuminating the degradation of lithium fluoride mirror coatings in humid environments** [11451-271]
- 11451 42 **PULSAR: development of a mirror tile prototype for future large telescopes robotically assembled in space** [11451-272]
- 11451 44 **Vortex phase masks of topological charge 4 and higher with diamond subwavelength gratings** [11451-274]
- 11451 45 **Development and implementation of crossed-sine wavefront sensor for simultaneous high spatial resolution imaging** [11451-275]
- 11451 47 **New high-accuracy solar guiding test technology** [11451-277]
- 11451 49 **Retardation of the oxidation of aluminum thin films in low-oxygen and cryogenic environments** [11451-279]
- 11451 4A **Design and analyses on a single panel of thermal enclosure for ELT class of instruments: mechanical structure and electrical interface** [11451-280]

- 11451 4C **Factors, affecting mirror figure stability, and methods used to eliminate them** [11451-282]
- 11451 4D **The Talbot effect's impact on the high contrast imaging modes of METIS** [11451-283]
- 11451 4E **An aplanatic meniscus lens for correcting astigmatism in Ritchey-Chrétien telescopes**
[11451-285]
- 11451 4F **Manufacture of 8.4 m segments for the GMT primary mirror** [11451-289]

POSTER SESSION: NOVEL DESIGNS AND CONCEPTS

- 11451 4G **ELT-HIRES the High Resolution Spectrograph for the ELT: status of the polarization ray tracing tool for the polarimetric unit** [11451-131]
- 11451 4I **The ASTRA project: a doorway to future astrometry** [11451-134]
- 11451 4K **Towards the attitude determination of nano-satellites with thermal imaging sensors** [11451-136]
- 11451 4O **Polarization model for the multi-application solar telescope at the Udaipur Solar Observatory**
[11451-140]
- 11451 4Q **Improved AFGSM (Alignment-Free Gapless Segmented Mirror) for astronomical large telescope** [11451-143]
- 11451 4R **Design of the automated CO₂ optics cleaning system for the Thirty Meter Telescope** [11451-144]

POSTER SESSION: ACTIVE INSTRUMENTS AND TELESCOPE STRUCTURES

- 11451 4T **Automated reflective optical system alignment with focal plane sensing and Kalman filters**
[11451-94]
- 11451 4U **Ultra-sonic super compact rotary stage for arrayed wide-angle camera system: prototype results** [11451-95]
- 11451 4V **Fast modulation and dithering for the NFIRAOS pyramid wavefront sensor** [11451-96]
- 11451 4Z **Development of a cold chopper for TAO/MIMIZUKU** [11451-101]
- 11451 50 **Warping harness actuator for the Thirty Meter Telescope primary mirror segments** [11451-102]
- 11451 52 **Development status of the segmented mirror control system in Seimei Telescope** [11451-105]
- 11451 53 **Selecting optimal glass combinations for atmospheric dispersion correctors** [11451-106]

11451 57 **The HinOTORI Telescope and its remote control system** [11451-112]

POSTER SESSION: COATING, FILTERS, AND GRATINGS TECHNOLOGY

11451 5A **Developing the wide-spectral coverage, very high-efficiency gratings for MOIRCS on Subaru Telescope** [11451-177]

11451 5B **Machining a YJ band grism in ZnSe for the Rapid Infrared Imager Spectrograph (RIMAS): improvements in technique** [11451-178]

11451 5I **Precise blaze angle measurements of lithographically fabricated silicon immersion gratings** [11451-185]

11451 5J **In-situ monitoring of Subaru Telescope's optical performance using a portable spectrophotometer** [11451-186]

11451 5K **Dichroic coatings for astronomical instrumentation** [11451-189]

11451 5L **Materion precision optics LAO (Large Area Optics) lab** [11451-190]

11451 5N **Experimental demonstration of a Gabor zone-plate hologram for Space Exoplanet Telescope** [11451-192]

11451 5O **Optomechanical design of PAWS, the Potsdam Arrayed Waveguide Spectrograph** [11451-193]

11451 5Q **Spectral envelope control for a flat frequency comb spectrum** [11451-196]

11451 5R **Upgrades to the Magellan Telescopes mirror coating process** [11451-197]

11451 5T **Design and fabrication of metamaterial anti-reflection coatings for the Simons Observatory** [11451-199]

11451 5V **HARMONI - first light spectroscopy for the ELT: broadband reflective coatings** [11451-201]

11451 5W **HARMONI: Characterising the line-spread-function with a tunable Fabry-Pérot etalon** [11451-202]

11451 5X **Transmittance measurement of low/high-resistivity of CdZnTe at cryogenic temperature for material selection of the immersion grating of SPICA SMI** [11451-203]

11451 5Y **RIMAS: testing, and categorization of grism spectral performance** [11451-269]

POSTER SESSION: OPTICAL FIBERS AND POSITIONERS

11451 64 **An integrated field unit with thousands of optical fibers for a solar telescope** [11451-231]

- 11451 66 **Multi-core fiber-fed integral field spectrograph (MCIFU) – III: an ultrafast laser inscribed photonic reformatter and mask** [11451-233]
- 11451 68 **Optimization of telescope focal ratios for MLA-fiber coupled integral field units** [11451-236]
- 11451 6A **Application of atmospheric OH suppression technology to ground-based infrared astronomy** [11451-238]
- 11451 6B **Broadband mid-IR fiber optics for heterodyne spectroscopy in solar system exploration missions** [11451-239]
- 11451 6C **Development of the liquid nitrogen cooled hollow core waveguide fiber for the mid-infrared region** [11451-240]
- 11451 6F **Fiber modal noise mitigation by a rotating double scrambler** [11451-243]
- 11451 6G **Testbed for coupling starlight into fibers and astrophotonic instruments** [11451-244]
- 11451 6I **Assemblies of the microlenses on the front-end fibres of MOONS** [11451-247]
- 11451 6J **Final characteristics and performances of the fibres of MOONS** [11451-248]
- 11451 6L **Development of an integrated near-IR astrophotonic spectrograph** [11451-250]
- 11451 6M **Equalization and hole location modeling for large scale non-planar focal plane** [11451-251]
- 11451 6Q **Fiber assignment for multi-object fiber-fed spectrographs** [11451-255]
- 11451 6R **Design and study of visual fast detecting instrument for fiber positioners** [11451-256]
- 11451 6W **Development and characterization of a precisely adjustable fiber polishing arm** [11451-261]
- 11451 6Y **An innovative integral field unit upgrade with 3D-printed micro-lenses for the RHEA at Subaru** [11451-263]

POSTER SESSION: SLIT SPECTROSCOPY AND IMAGE SLICERS

- 11451 7I **MAVIS IFU with AO for VLT: image slicer concept and design** [11451-266]

