4th EOS Conference on Manufacturing and Testing of Optical Components (EOSMTOC 2015)

World of Photonics Congress 2015

Munich, Germany
22-25 June 2015

ISBN: 978-1-5108-1778-4

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571

Some format issues inherent in the e-media version may also appear in this print version.

Printed by Curran Associates, Inc. (2016)

European Optical Society (EOS)
c/o Jyrki Saarinen
Länsikatu 15
FI-80110 Joensuu Finland

Phone: 358 50 595 4348
Fax: 358 13 2637 111

saarinen@myeos.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2634
Email: curran@proceedings.com
Web: www.proceedings.com

9:00 - 11:00 Opening Ceremony of World of Photonics Congress and LASER World of PHOTONICS, Room 1

14:00-15:45 High-Volume Manufacturing, Micro-Optics and Structured Surfaces 1

Location: Room 2, Ground Floor, Congress Centre
Session Chair: Reinhard Voelkel
Session Chair: Stefan Bäumer

14:00 Opening by General Chair & Session Chair

Invited Talk **14:15 High-Volume Manufacturing Methods for Precision Structured Surfaces** N/A

G. Michael Morris, Tasso Sales
RPC Photonics, Inc., Rochester

Recent developments in mastering and replication of precision, gray-scale structured surfaces will be discussed. Surface-relief masters in photoresist, with depths up to 80 microns, are produced using gray-scale lithography, employing both laser-based flat-bed and seam-less drum-type scanning systems. The resulting surface-relief masters are used to produce high-volume production tooling for polymer injection molding, polymer-on-glass wafer replication, hot embossing and seamless, roll-to-roll manufacturing systems. Particular emphasis will be given on the fabrication of Engineered Diffusers(TM) for beam shaping and homogenization of laser and LED light sources for a wide variety of applications, including consumer electronics, commercial, medical, and defense systems.

14:45 Wave-optical design beyond the thin element approximation 1

Simon Thiele, Alois M. Herkommer
University of Stuttgart, Germany

Fast wave-optical methods are necessary to design and optimize complex 3D micro optics in the diffractive regime. In many cases, symmetry can be used to reduce the complexity of such problems. The design example of a micro TIR lens shows the superiority of a wave-optical approach compared to geometric optics.

15:05 Free space optical communicator employing optical vortices 3

Rebeca Tudor[1,2], Cristian Kusko[2], Mihai Kusko[2], Mona Mihailescu[3]
[1]University of Bucharest, Faculty of Physics, Romania; [2]National Institute for R&D in Microtechnology IMT, Romania; [3]Politehnica University of Bucharest, Physics Department, Romania

We present a free space optical communicator employing optical vortices. The transmitter encodes the information using a cascade of reflective spiral phase plates, while the receiver decodes the information with fork-like holograms. The information channel capacity increases linear with the number of optical vortices.

15:25-15:45 Beamshaping and Homogenisation of High-Power Fibre Lasers using a Concave Toroidal Microlens-Array 5

Paul Blair, Natalia Trela, Matthew Currie, Eoin Murphy, Roy McBride
PowerPhotonic Ltd, United Kingdom

Homogenizing and shaping the low-M2 beam from a high-power fibre laser presents challenges in both design and fabrication, requiring trade-offs between diffraction and homogenisation, avoiding hotspots in the beam and using material that can handle very high CW power loading. We describe the design, fabrication and application of a concave toroidal microlens-array (MLA) diffracting homogenizer that achieves these goals. This complex and challenging optical surface is manufactured in fused silica using a freeform direct-write micro-optics fabrication process and the optic demonstrated in a commercial laser process head, generating a 8mm x 4mm uniform prolife, and operating in excess of 10kW.

16:00-16:30 COFFEE BREAK

16:30– 18:10 High-Volume Manufacturing, Micro-Optics and Structured Surfaces 2

Location: Room 2, Ground Floor, Congress Centre
Session Chair: Stefan Bäumer
Session Chair: Reinhard Voelkel

16:30 Robotic Automation in Computer Controlled Polishing 7

David Douglas Walker
Zeeko, University College London, Glyndwr University, United Kingdom
We describe the marriage of industrial robots and Zeeko CNC polishing machines, from the perspectives of i) automating currently manual operations on the Zeeko machines, and ii) providing a range of intermediate processes between CNC grinding and polishing. The goal is to improve overall process speeds, repeatability and risk.

16:50 Customised Refractive Diffusers for High Power Laser Applications 9

Matthew Currie, Paul Blair, Natalia Trela, Eoin Murphy, Roy McBride
PowerPhotonic, United Kingdom
Customized diffusers for high power lasers operating in both CW and pulsed regimes are highly desirable for a number of different applications, ranging from materials processing to nuclear fusion research. We describe the design and fabrication of customized refractive diffusers for the beamshaping of high-power lasers. We used a freeform direct-write process to fabricate these highly non-uniform surfaces in fused silica, and we report on their application in generating a various useful intensity distributions.

17:10 Laser systems and technologies for manufacturing of micro-optical and diffractive elements on spherical surfaces 11

Victor P. Korolkov[1,3], Alexander G. Verhoglyad[2], Sergey A. Kokarev[2], Leonid B. Kastorsky[2], Marina A. Zavyalova[2], Alexander G. Poleshchuk[1], Nikolay G. Mironnikov[1,3], Anton E. Kachkin[1], Ruslan V. Shimansky[1], Dmitry I. Derevyanko[4], Vladimir V. Shelkovnikov[4]
[1]IAE SB RAS, Russian Federation; [2]TDI SIE SB RAS, Russian Federation; [3]Novosibirsk state university, Russian Federation; [4]NIOC SB RAS, Russian Federation
The paper is devoted to development of circular laser writing systems and technologies for manufacturing of micro-optical and diffractive elements on spherical surfaces. The technologies are based on different materials: photoresists, photosensitive hybrid polymer, and thin chromium films.

17:30 ransparent dust repellent coatings for optical windows 13

Tali Ytzhaki, Evyatar Kassis, Shay Joseph, Arit Sheinman
RAFAEL, Israel
Anti-static coatings, based on a transparent conductive oxide (TCO), were deposited on sapphire windows. The transmission loss of widows coated with the dust repellent TCO film due to dust exposure was less than 2%, in contrast to sapphire coated with a dielectric anti-reflection (AR) coating and uncoated sapphire which lost about 20%.

17:50 - 18:10 Stray light optimization of high efficiency spectrometer gratings fabricated with e-beam lithography 15

Martin Heusinger[1], Michael Banasch[2], Uwe Detlef Zeitner[1,3]
[1]Friedrich Schiller University, Germany; [2]Vistec Electron Beam GmbH, Germany; [3]Fraunhofer Institute for Applied Optics and Precision Engineering, Germany
In order to reduce the occurrence of spurious diffraction peaks in high efficiency spectrometer gratings we investigated 3 ways to optimize the e-beam writing process which was identified as the origin of the stray light ghosts. The achieved results show that a recalibration of specific calibration parameters combined with an adapted writing regime reduces the peaks significantly.

18:00– 19:00 International Year of Light 2015 Opening Reception, Foyer ICM

8:30– 10:05 Precise Optics Fabrication 1

Location: Room 2, Ground Floor, Congress Centre
Session Chair: Ramona Eberhardt
Session Chair: Oliver Faehnle

Invited Talk **8:35 Light scattering-based roughness measurement and defect detection in optical manufacturing** 17

Sven Schröder
Fraunhofer IOF, Jena
Surface roughness, inhomogeneities, and defects can critically affect the performance of optical components. Characterizing these imperfections close to, or even in, manufacturing processes is the key to achieving higher quality and higher efficiency in optical manufacturing. Light scattering is an extremely powerful approach for this task as it is a fast, non-contact, robust, and yet highly sensitive technique. In addition to laboratory instruments for angle resolved light scattering measurements, compact table-top tools and sensors are presented that can be used close to or even during manufacturing. Examples of application are discussed ranging from smooth mirrors to structured surfaces.

9:05 Corrective Machining of Freefrom Surfaces 19

Frank Niehaus[1], Stephan Huttenhuis[1], Alex Pisarski[2]
[1]Schneider GmbH & Co. KG, Germany; [2]Schneider Optical Machines Inc., USA
The UPC 400 enables efficient and accurate machining of freeform surfaces by integrating the fabrication and measurement processes onto a single machine platform. Combining hardware with powerful data handling capabilities allows for corrective machining to achieve high precision freeform surfaces. This paper discusses the corrective re-machining of spheres that are produced off-axis requiring the full freeform capability of the machine. Based on the measurement results acquired by integrated optical metrology a new corrective surface is calculated that compensates for repeatable errors. After re-machining a form accuracy of better than +/- 0.1 µm was measured with the integrated optical sensor.

9:25 Free Form Manufacturing based on Plasma Jet Machining 21

Georg Boehm, Hendrik Paetzelt, Thomas Arnold
Leibniz-Institute for Surface Modification, Germany
A new manufacturing chain including atmospheric Plasma Jet Machining (PJM) technology will be presented. PJM is based on deterministic removal of material by a local chemical plasma-surface reaction and has the potential for flexible and cost-efficient manufacturing of optical free form elements e.g. for laser beam shaping.

9:45 - 10:05 Hybrid micro-optical elements by laser based fabrication of Fresnel lenses on the end face of gradient index lenses 23

Thomas Fricke-Begemann, Jürgen Ihlemann
Laser-Laboratorium Göttingen e.V., Germany
Fresnel lenses are fabricated directly upon the end face of gradient index (GRIN) lenses by F2-laser machining at 157 nm wavelength. These hybrid optical elements serve as the basis for high-performance micro-optical imaging systems with diameters below 2 mm and a high numerical aperture in various application areas.

10:00-10:30 COFFEE BREAK

10:30– 12:00 Precise Optics Fabrication 2

Location: Room 2, Ground Floor, Congress Centre
Session Chair: Oliver Faehnle
Session Chair: Ramona Eberhardt

10:30 Progress towards large aperture, large deviation, laser grade, High NA off axis parabola 25

Roland Geyl, Herve Leplan, Slimane Djidel
REOSC, France
The laser community, especially those scientists dealing with ps and fs ultra-short pulses, is more and more in the need of large aperture, large deviation and high NA, laser grade Off-Axis Parabola (OAP). Reosc has matured since many years it freeform high performance optical manufacturing technology and has undertaked the realization of a demonstration prototype piece.

10:50 FAME: Freeform Active Mirrors Experiment 27

Emmanuel Hugot[1], Lars Venema[2,3], Hermine Schnetler[4], Tibor Agocs[2,3], Zalpha Challita[1], Attila Jasko[5], Martin Black[4], Chris Miller[4], Gabby Kroes[2,3], Felix Bettonvil[2,3], Evelin Benyai[5]
[1]Aix-Marseille University, CNRS, France; [2]NOVA at ASTRON, The Netherlands; [3]ASTRON, The Netherlands; [4]UK-ATC, Scotland; [5]Konkoly astronomical institute, Hungary
This paper discusses the development of a freeform active mirror demonstrator and its applicability in high end astronomical systems. We give a system overview and technological progress in the mirrors building blocks: an extreme freeform thin face sheet, an active array, design tools and the metrology and control of the system.

11:10 In situ monitoring of surface roughness and contamination of polishing processes 29

Oliver Faehnle[1], Frank Zygalsky[1], Eckhard Langenbach[1], Andreas Ettemeyer[2], Markus Kahl[2], F Weimer[2]
[1]FISBA OPTIK AG, Switzerland; [2]NTB, Switzerland
Light scattering from within a sample at a surface under test enables in situ, on machine, monitoring of surface roughness levels during polishing. Surface roughness levels of 0.6 nm rms have been detected. In addition, its capability to function as in process contamination control of industrial polishing processes has been demonstrated.

11:30 - 11:50 Periodically poled MgO doped LiNbO3 and LiTaO3 for coherent light frequency conversion 32

Vladimir Ya Shur[1,2], Ivan S. Baturin[1,2], Andrey R. Akhmatkhanov[1,2]
[1]Labfer Ltd, Russian Federation; [2]Ural Federal University
We present the recent achievements in periodical poling in MgO doped single crystals of lithium niobate (LN) and lithium tantalate (LT) based on the experimental study of the domain structure evolution by the complementary high-resolution domain visualization methods. The crystals with tailored periodically poled domain structures (PPLN and PPLT) produced with nano-scale period reproducibility have been used for Second Harmonic Generation (SHG) and Optical Parametric Oscillation (OPO) based on quasi-phase-matched nonlinear optical wavelength conversion. The compact and efficient sources of visible and mid-IR laser light have been developed.

12:00– 14:00 LUNCH BREAK

14:00– 15:20 Precise Optics Fabrication 3

Location: Room 2, Ground Floor, Congress Centre
Session Chair: Ramona Eberhardt
Session Chair: Oliver Faehnle

14:00 Stress polishing of a full scale 1.5m E-ELT primary mirror segments 34

Emmanuel Hugot, Marc Ferrari, Johan Floriot, Anais Bernard
Aix-Marseille University, CNRS, France
This presentation discusses the work done so far at LAM one the full-scale demonstrator of stress polishing of segments for the future European Extremely Large Telescope. We will browse the simulation results and optimizations, the mechanical design of the stress polishing harness and the experimental results

14:20 The challenge of big facilities for physics and astronomy: overview of the French community activities 36

Emmanuel Hugot[1], Jérôme Néauport[2]
[1]Aix-Marseille University, CNRS, France; [2]CEA CESTA, France
The French community is deeply involved in large facilities realization in terms of polishing of precision optics. We will review the common needs on the following projects: Laser Mega Joule, Extremely Large Telescopes, ITER, Advanced Virgo and the SOLEIL Synchrotron.

14:40 Ultra-precise manufacturing of aspherical mirrors based on a freeform technology for applications in the VIS spectral range 38

Stefan Risse[1], Matthias Beier[2], Johannes Hartung[1], Andreas Gebhardt[1], Ramona Eberhardt[1]
[1]Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Germany; [2]Friedrich-Schiller-Universität, Institute for Applied Physics IAP, Germany

The fabrication of metal mirrors with aspherical or freeform surfaces is increasingly discussed by the optical community. A further enabler is the implementation of freeform components into modern optical designs. Diamond machining operations like turning or milling are typical ultra-precise techniques.
Modern servo-assisted techniques like slow tool servo or fast tool servo combined with Magnetorheological Finishing (MRF) allow for the fabrication of aspherical, toroidal, or freeform mirrors with outstanding quality. The paper presents the combined fabrication process of diamond turning and MRF polishing and shows the results of aspherical metal mirrors based on a freeform technology.

15:00 - 15:20 Vacuum system for ion beam polishing of large-size optical components up to 2.5 m in diameter 40

Aleksandr A. Azerbaev, Magomed A. Abdulkadyrov, Aleksandr P. Semenov, Timur R. Mukhammedzyanov, Aleksandr Y. Papaev
LZOS,JSC, Russian Federation

Vacuum system for ion beam polishing of large-size optical components up to 2.5 m in diameter was created at JSC LZOS. Surface accuracy up to λ/60 RMS was achieved.

15:30-16:00 COFFEE BREAK

16:00– 18:00 EOSMTOC Poster Session

Location: Hall B0, Ground Floor, Congress Centre

POSTERS

Ultra-precision Machining of Aspheric Diffractive Molds 42

Marius Doetz, Fritz Klocke, Olaf Dambon, Julia Dukwen
Fraunhofer Institute for Production Technology, Germany

Diffractive optical elements in glass are a solution for actual trends towards miniaturization, function integration and higher imaging quality. For further development, diffractive and curved lenses are needed. To enable the molding process for mass production aspheric diffractive molds are necessary.

Analysis of positioning errors at slow tool servo machining of optical freeform and reference surfaces 44

Lars Dick
JENOPTIK Polymer Systems GmbH, Germany

Freeform optical elements find more and more application in different markets. High precision freeform optical and reference surfaces can be machined by modified ultra precision diamond turning processes with slow tool servo. A negative impact to the form deviation are axis positioning errors. The poster will describe the influence of the surface characteristic and the dynamic machine parameters with respect to the axis positioning errors. In result interconnections can be seen and optimized machine parameters were found to machine high precision optical freeform surfaces by ultra precision slow tool servo technology.

Application of specular spectroscopic scatterometry for profile depth measurement at diffractive optics fabrication 46

Victor P. Korolkov, Alexander S. Konchenko
IAE SB RAS, Russian Federation

The aim of the work was to expand application of specular spectroscopic scatterometry to measurement of profile depth for wide class of diffractive structures including amplitude-phase and continuous-relief ones because the method allows non-contact, fast and precise on-line inspection.

Aspherization of off-axis highly aspherical mirrors with optional external contour on computer-controlled machines 48

Aleksandr P. Semenov, Magomed A. Abdulkadyrov, Aleksandr Y. Papaev, Vladimir E. Patrikeev
LZOS,JSC, Russian Federation

Technology with the use of automatic computer-controlled system and a set of special instruments, which makes possible aspherization of optical elements with deviation from the nearest sphere of more than 1 mm, was developed.

Automated fabrication of freeform lens prototypes for LED applications 50

Marco Speich, Jonas Raab, Andreas Kelm, Rainer Börret
Aalen University, Germany

This work describes the usage of industrial robots for the automated prototype fabrication of freeform shaped lenses for LED applications. The robots were used for milling and polishing tasks starting with the raw material. The topic of this work arose out of the funded research project ZAFH LED-OASYS.

Design and fabrication of combined diffractive optical elements for optical devices and display systems 52

Sergey Odinokov[1], Evgeniy Zlokazov[1,2], Alexander Betin[1], Artem Solomashenko[1]
[1]Bauman Moscow State Technical University, Russian Federation; [2]National Research Nuclear University 'Moscow Engineering Physics Institute', Russian Federation

Combined diffractive optical elements (DOEs), which perform the functions of deflection, focusing or transformation of wavefronts and together with the spectral-angular selection of the incident polychromatic radiation, obtained on a single substrate, the method of their design and fabrication are presented. In this case conventional DOEs such as diffraction gratings, Fresnel lenses, etc., perform the wavefronts transform function as well as holographic mirrors, plasmon diffraction gratings and color holograms may be used as spectral-angular filters. Such combined DOEs can be used as elements of multi-color sign-symbolic holographic indicators, holographic sights, beams focusers and other similar optical devices and systems.

Development of test artefacts for the characterization of asphere measuring instruments 54

Gernot Blobel, Axel Wiegmann, Michael Schulz
Physikalisch-Technische Bundesanstalt, Germany

To characterize measuring instruments used for surface metrology of aspheres, suitable comparison artefacts that differ from typical aspheres are needed. Test artefacts with special features have been developed and manufactured. These are applicable for tactile and optical asphere measuring instruments, e.g. for testing their resolution and absolute radius uncertainty. They have been manufactured by a diamond turning process and consist of copper with a NiP layer. Measurement results for the characterization of the surfaces, absolute radii of curvature measurements and the results for the characterization of a Tilted Wave Interferometer with these artefacts will be presented.

Direct Laser Fabrication of Blaze Gratings 56

Michael Pfeifer, Steffen Weissmantel
Hochschule Mittweida, Germany

Fluorine laser microstructuring provides an effective alternative to lithography techniques for direct laser fabrication of blaze gratings. This technique enables the manufacturing of gratings with nearly optimum blaze geometry and completely plane and smooth reflecting areas.

Fabrication and measurement of off-axis mirrors 58

Lutz Küpper, Rolf Rascher, Johannes Liebl, Karlheinz Penzkofer
Deggendorf Institute of Technology, Technology Campus Teisnach

In 2010 the project IFasO was started at the Technology Campus Teisnach, to develop a procedure to produce highly accurate telescope mirrors up to a diameter of two meters. The manufacturing center is in operation since 2013. Meanwhile, the entire range of mirror was produced from plan to spherical, aspherical and off-axis surfaces. In this paper, a detailed way of manufacturing an off-axis mirror and the accruing problems are discussed. The three main components of this lecture are the manufacturing process, the mirror mount and the necessary off-axis surface metrology.

Investigation in roughness transfer between mold and preform during precision glass molding 60

Alois Kasberger[2], Christian Wistl[2], Raimund Förg[1]
[1]Deggendorf Institute of Technology, Germany; [2]Technologie Anwenderzentrum Spiegelau, Germany

Effects on surface roughness of precision glass molded components and transfer mechanisms of micro and nano roughness aren't already figured out clearly. The following study show a practical investigation on the influence of mold surface and molding process parameters to the final surface quality (roughness and artefacts) of the glass product.

Transfer of astronomical mirror technologies – Project INTRAAST 76

Thorsten Döhring[1], Manfred Stollenwerk[1], Laura Proserpio[2], Anita Winter[2]
[1]University of Applied Sciences Aschaffenburg, Germany; [2]Max-Planck-Institute for extraterrestrial Physics, Germany

As mirrors of modern astronomical telescopes are large and their specifications are demanding, the corresponding manufacturing processes are critical. Technical and economic aspects of astronomical mirror production will be studied within the recently started interdisciplinary project INTRAAST. Funding of this project has been granted from January 2015 to December 2017. Thereby special attention will be given to the transfer of mirror technologies from astronomy to industry and from industry to astronomy. The intended work contains studies on the world market of ground-based astronomical mirrors and detailed technical proposals for the industrialization of glass mirror production for future satellite-based X-ray telescopes.

Self-organized Laser Nanodomain Formation in LiNbO3 and LiTaO3 Single Crystals 78

Vladimir Ya Shur[1,2], Dmitrii K. Kuznetsov[2], Evgenii A. Mingaliev[1,2], Alexey I. Lobov[2], Mikhail S. Kosobokov[2], Andrey R. Akhmatkhanov[1,2]
[1]Labfer Ltd, Russian Federation; [2]Ural Federal University

The formation of self-organized nanodomain structures after pulse laser heating was revealed and investigated experimentally in congruent lithium tantalate (CLT) and lithium niobate (CLN) single crystals. The obtained formation of the quasi-regular stable micro- and nanodomain structures under the action of the pyroelectric field can be used for domain engineering in various representatives of the LN and LT family. This effect can be considered as a perspective method for production of the PPLN and PPLT with submicron domain periods.

8:30– 10:00 Fabrication friendly Optical Design and Tolerancing

Location: Room 2, Ground Floor, Congress Centre
Session Chair: Norbert Kerwien
Session Chair: Gregory William Forbes

Invited Talk **8:35 Optical design with orthogonal freeform representations** 80

Christoph Menke
Carl Zeiss AG, Germany

One of the major challenges for the optical designer is the adequate description of complex optical surface shapes. Motivations for orthogonal representations of rotationally symmetric and freeform aspheres are discussed. Recent results are presented that demonstrate the use of orthogonal polynomials in optical design.

9:05 Forbes aspheres: Polynomial fitting with real measuring data 81

Andreas Beutler[1], Hero Weber[2]
[1]Mahr GmbH, Germany; [2]Jade University of Applied Science, Germany

It is investigated how form errors from the production process on aspheric lenses can be described with Forbes polynomials in a fitting process and how stable the aspheric coefficients can be determined. Different aspheres are measured and analyzed.

9:25 - 9:45 Towards Micro-Optical Freeform Elements for Imaging 83

Daniel Infante Gómez, Hans Peter Herzig
EPFL, Switzerland

Thin optical elements that produce good quality images and that are operational with different light sources are studied in this work. The influence of the design approach on the smoothness of their surfaces and on the image quality will be evaluated.

10:00-10:30 COFFEE BREAK

10:30-11:30 SPIE Plenary, Room 14 C, 1st Floor, Congress Centre

11:30– 12:55 Testing for Fabrication and Assembly 1

Location: Room 2, Ground Floor, Congress Centre
Session Chair: Christof Pruss
Session Chair: Jean-Michel Asfour

11:35 New methods for measurement and analysis of diffractive optical elements 85

Andreas Beutler
Mahr GmbH, Germany

For testing diffractive optical elements a tactile and a new optical measuring system are investigated. New methods for the analysis of the whole structure and each individual zone are presented.

11:55 Measurement and Analysis of Soft Ophthalmological Components in Wet Conditions 89

Katharina Frey[1], Grit Leuner[1], Holger Wiedemann[2], Mario Gerlach[3], Robert Brunner[1]
[1]Ernst-Abbe-Hochschule, Germany; [2]Mahr GmbH Jena; [3]Carl Zeiss Meditec Berlin

A confocal microscope was modified to allow the investigation of soft ophthalmological components such as contact lenses (CLs) or intra-ocular lenses (IOLs) in their actual physiological (wet) condition. The measurement setup allows simultaneously both the investigation of micro-structures such as diffractive profiles and the determination of global macro topographies with high accuracy.

12:15 Cross-certification of the diffractive corrector by diffractive imitator for Russian 6-m Large Altazimuth Telescope 91

Victor P. Korolkov[1], Ruslan K. Nasyrov[1], Alexander G. Poleshchuk[1], Alexander P. Semenov[2], Vladimir E. Patrikeev[2], Magomed A. Abdulkadyrov[2]
[1]IAE SB RAS, Russian Federation; [2]Lytcarino optical glass factory, Russian Federation
Diffractive corrector for Large Altazimuth Telescope with 6-m mirror has been developed and fabricated. Diffractive imitator has been manufactured for certification of the corrector. Imitator had off-axis geometry for elimination of the ghosts and improved certification reliability. Experimental results of the certification are presented.

12:35 Controlling lens vibrations using an adaptive state observer 93

Holger Maris Gilbergs[1], Huazhen Fang[2], Karsten Frenner[1], Wolfgang Osten[1]
[1]Institute uf Applied Optics, University of Stuttgart, Germany; [2]Department of Mechanical and Aerospace Engineering, University of California, San Diego, USA
An adaptive state observer is applied to wavefront tilt measurements to detect vibrations of the components of an optical system. A PD controller, based on the observer output, actively dampens the oscillations to restore optimal imaging conditions.

12:55– 13:45 LUNCH BREAK

13:45– 15:30 Testing for Fabrication and Assembly 2 (Joint session with SPIE)

Location: Room 14 C, 1st Floor, Congress Centre
Session Chair: Jean-Michel Asfour
Session Chair: Christof Pruss

13:45 PLENARY TALK

Never-ending struggles with mid-spatial frequencies
Greg Forbes,
QED Technologies and UNC at Charlotte

14:30 Calibration and Control of Wave Front Errors in Measurements of Cylindrical Optics 95

Florian Wolfgramm, Jan-Peter Richters, Rainer Schuhmann
BERLINER GLAS KGaA Herbert Kubatz GmbH & Co
The fabrication of large high-precision cylindrical optics creates challenges for the interferometric measurements of a complete map of the optical surfaces. This work discusses the analysis and the potential reduction of the influence of wave front errors of computer-generated holograms as common correction elements.

14:50 Overview of Characterization and Metrology Techniques for microlenses and microlense arrays 97

Myun-Sik Kim
SUSS MicroOptics SA
We review various metrology techniques for the characterization of refractive microlenses and microlens arrays (MLAs). The limitations and strength of each technique are analyzed. The goal is to obtain more stable and repeatable metrology routines for micro-optics manufacturing. This analysis comprises both techniques for the characterization of individual microlenses and the analysis of a very large number of microlenses in array configurations. Metrology of spherical and aspherical lens profiles, surface properties, aberrations, Strehl ratio, and focal properties will be presented 2. 2-apge abstract: attached in this e-mail in PDF format.

15:10 Wave front calibration in 3D space 99

Johannes Schindler, Goran Baer, Christof Pruss, Wolfgang Osten
University of Stuttgart, Germany
A method to calibrate the test volume of a non-null interferometer is presented. It is also applicable to common null setups. This works aims at a unified view of established calibration approaches and the recently introduced and more general method. The validity and limits of both methods are quantitatively assessed.

15:30-16:00 COFFEE BREAK

16:00– 18:10 Testing for Fabrication and Assembly 3 (with SPIE)

Location: Room 14 C, 1st Floor, Congress Centre
Session Chair: Jean-Michel Asfour
Session Chair: Christof Pruss

Invited Talk **16:00 Traceability in Interferometric Form Metrology** 101
Michael Schulz, Gernot Blobel, Ines Fortmeier, Manuel Stavridis, Clemens Elster
Physikalisch-Technische Bundesanstalt, D-38116 Braunschweig

16:30 New method for optical shape measurement of refractive surfaces 103
Mohamed Bichra
Technische Universität Ilmenau
We present a new method for optical shape measurement of refractive surfaces. The concept is based on triangulation and proved to be suitable for measuring complex freeform surfaces with high inclinations.

16:50 Through-focus OTF based alignment testing of whole slide imaging systems 105
S. Mojtaba Shakeri[1], B. Hulsken[2], L.J. van Vliet[1], S. Stallinga[1]
[1]Technical University of Delft, The Netherlands; [2]Philips Digital Pathology, The Netherlands
We present a tool for testing and monitoring the optical quality of whole slide imaging systems based on through–focus OTF measurements. The tool enables differentiation between the inherent aberrations of the optical design and the aberrations that arise from misalignment of the components and suggests a way to optimize decenter and tilt of the objective lens.

17:10 Unique characteristics of the fiber optic reference technique in absolute cylindrical testing 107
Ayshah Alatawi
The University of Alabama in Huntsville
Increasing demand for highly accurate cylindrical optics requires absolute testing techniques where all the errors of the system are separated from the error of the tested part. The fiber optic reference technique has been merged with the random ball technique to achieve absolute cylindrical testing – the random fiber reference (RFR) technique. This technique can calibrate a cylindrical wavefront reference, with data provided in both the powered and planar directions. In this paper, some unique aspects of this RFR technique are discussed, with experimental results presented.

17:30 Measurement of aspheric and freeform optical surfaces with Diffractive Null Lenses with and without integrated Fizeau reference surface 108
Alexander G. Poleshchuk[1], Jean-Michel Asfour[2], Victor P. Korolkov[1], Ruslan K. Nasyrov[1], Weidner Frank[2]
[1]Institute of Automation and Electrometry, Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia; [2]DIOPTIC GmbH, Germany
We review our recent practical results on layout, fabrication and implementation of high precision binary diffractive null lens (DNL), diffractive Fizeau null lens (DFNL) and as well as high-efficiency diffractive optical elements (DOEs) with continuous-relief. Complementary advantages have been achieved by combining of the capabilities of the precision circular laser writing system (CLWS), direct laser thermochemical writing on chromium films and photosensitive materials with combination with optical lithography. The main limitations and tolerances of writing methods are identified, and their influence on optical performance of DNL, DFNL and DOEs are investigated.

17:50 - 18:10 Point Diffraction Interferometry based on the use of two Pinholes 110
Nikolay Voznesenskiy
VTT-NTM OÜ
Point diffraction interferometer (PDI) has become the high degree of accuracy device. In the optical wavefront testing the measurement accuracy is much higher than 1.0 nm RMS. The PDI plays an important role in the process of the development of high precision optical system. The measuring method of point diffraction interferometry is studied based on the two pinholes. The prototype with phase-shifting is developed on the testing principle. Using the ideal diffraction wavefront as interferometric reference, the high accuracy measurement has been achieved. The device can test high NA and the interference fringe contrast is adjustable.

18:15 - 20:30 EOS Annual General Assembly (AGA), Room 22