OSA
Optical Society of America

OF&T

Optical Fabrication and Testing

October 11-13, 2004
Rochester, New York

Collocated with:

Diffractive Optics and Micro-Optics (DOMO), and
Frontiers In Optics / Laser Science XX

Program Committee

- Oliver Faehnle, Fisba Optics, Switzerland, **General Chair**
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- Chris Evans, *Zygo Corp., USA*
- Stephen Jacobs, *Univ. Of Rochester, USA*
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- Lisa Rich, *Corning Tropel Corp., USA*
- Amy Rigatti, *Univ. of Rochester, USA*
- Axel Schindler, *Leibniz-Institut für Oberflächenmodifizierung, Germany*
- Phil Stahl, *Marshall Space Flight Ctr., USA*
- Anthony Yen, *Cymer, Inc., USA*

About OF&T

The 2004 Optical Fabrication and Testing meeting will bring together experts working in this field to discuss recent advances and to identify future trends. The meeting will feature topics covering the fabrication and testing of micro, medium and large optics ranging from unique one-of-a-kind items to mass production. Topics will extend from sphere and asphere fabrication and testing to applied material science, finishing science and education in optics fabrication. Papers on applied OF&T research and reports on process lessons learned from experiences in production and testing are also solicited.

A "Glass Art Contest" will be held on site, giving institutions, companies and/or individuals the floor to present their unique approaches to the design and manufacture of "optical glass" artwork. Awards will be given for various categories that could include: uniqueness of materials used, level of craftsmanship in fabrication, innovativeness, delicacy or robustness of design, artistic expression, message conveyed, etc. Participants will be asked to "describe" their submissions.

Meeting Topics

Topics to be covered:

Finishing science

- Grinding, precision grinding, diamond turning, ultrasonic machining
- Finishing techniques, e.g. (pitch) polishing, MRF, ion beam polishing, jet polishing, etc.
- New finishing processes, synthetic pitch
- Glass molding
- New polishing abrasives and novel abrasive formulations
- Fixed abrasive polishing

Optical materials science

- Material response to fabrication processes
- Optical crystals and new materials
- Education and training in optical fabrication

Optical assembly

- Cementing

- Adhesives

Thin films

- Cleaning processes, e.g. chemical and ultrasonic
- New applications

Optical testing

- Testing for subsurface damage (ssd), shape, roughness, scratch/dig
- In process measurement techniques for shape, surface structure and ssd
- White light interferometry
- Testing in adverse environments: vibration, atmosphere, cyrogenic, vacuum etc.
- Surface profilometry - optical and scanning probe
- Power spectral density, scattering and BRDF
- Contamination control
- Standards in optics

Cost effective optics manufacturing and testing

Automation in optics manufacturing

Process lessons and experiences from the shop floor

Large optics fabrication and testing

Micro optics fabrication and testing

Invited Speakers

The preliminary list of invited speakers includes:

- OMA1, **Innovations in optics manufacturing**, *Stephen D. Jacobs; Univ. of Rochester, USA.*
- OMA2, **TBD**, *Bruce Smith, USA.*
- OMB1, **Thin-film-optics design and manufacturing challenges for large-aperture high-peak-power, short-pulse lasers**, *James B. Oliver; Univ. of Rochester, USA.*
- OMC1, **Diamond fixed abrasive lapping of brittle substrates**, *Tim D. Fletcher, Feben T. Gobena, Vince D. Romero; 3M Co., USA.*
- OMC2, **Selectivity in polishing of silicon dioxide and nitride thin films using mixtures of abrasives**, *Sharath Hegde, S. V. Babu; Clarkson Univ., USA.*
- OMD1, **New industrial applications of magnetorheological finishing (MRF)**, *Marc Tricard, Paul R. Dumas, Don Golini; QED Technologies Inc., USA.*
- OTuA1, **Glass material response to the fabrication process: Example from lapping**, *John Lambropoulos, R. Varshneya; Univ. of Rochester, USA.*
- OTuB1, **Leveraging interferometric metrology for precision manufacturing**, *Paul E. Murphy; QED Technologies Inc., USA.*
- OTuB2, **Vibration insensitive interferometric optical testing**, *James C. Wyant; Univ. of Arizona, USA.*
- OTuC1, **Advances in non-contacting surface metrology**, *Ian Lee-Bennett; Taylor Hobson Ltd., United Kingdom.*
- OTuD1, **"Absolute testing" and uncertainty**, *Chris Evans; Zygo Corp., USA.*
- OTuD5, **Stitching subaperture data for testing aspheric surfaces**, *Greg Forbes, Paul Murphy, Jon Fleig; QED Technologies Inc., USA.*
- OWA1, **Future space telescope mirror technology requirements**, *H. Philip Stahl; NASA Marshall Space Flight Ctr., USA.*
- OWA2, **Design and performance of a large aperture, high-sensitivity, dynamic wavefront sensor**, *Alan Wertheimer[1], David J. Fischer[1], Richard A. Hutchin[2]; [1]Eastman Kodak Co., USA, [2]Optical Physical Co., USA.*

- OWA5, **Optics for the next generation of telescopes: Ambitious, or insane?**, *Buddy Martin; Univ. of Arizona, USA.*
- XWA1, **New technologies for aspherical grinding/polishing of micro/meso optics**, *Tsunemoto Kuriyagawa, Nobuhito Yoshihara; Tohoku Univ., Japan.*

Publications

Conference Program

The *Conference Program* will be available on the web in September 2004. Authors submitting papers, past meeting participants and current committee members will automatically be notified by email when the *Conference Program* is available.

Technical Digest

The FiO 04/LS XX, DOMO and OF&T *Technical Digest* on CD-ROM will contain PDFs of paper summaries presented during the meeting as they were submitted by the authors; the *Technical Digest* will be produced only on CD. At the meeting, each registrant will receive a copy of the *Technical Digest* on CD-ROM. Extra copies can be purchased at the meeting for a special price of US$ 45.

Agenda of Sessions

On This Page:

Sunday, October 10, 2004

Time	Event/Location
10:00 AM - 12:00 PM	**DSuA**, Applications I *Hyatt Grand Ballroom ABC*
12:00 PM - 1:30 PM	Lunch Break
1:30 PM - 3:15 PM	**DSuB,** Waveguide Devices *Hyatt Grand Ballroom ABC*
3:15 PM - 3:45 PM	Coffee Break *Hyatt Grand Ballroom D*
3:45 PM - 5:30 PM	**DSuC**, Applications II *Hyatt Grand Ballroom ABC*

Monday, October 11, 2004

Time	Event/Location
8:15 AM - 10:00 AM	**OMA**, Advances in Optical Fabrication and Testing *Hyatt Grand Ballroom EFG*
9:45 AM - 10:30 AM	Coffee Break *Hyatt Grand Ballroom D*
10:30 AM - 12:15 PM	**DMA**, Design and Fabrication *Hyatt Grand Ballroom ABC*
10:30 AM - 12:00 PM	**OMB**, Thin Films *Hyatt Grand Ballroom EFG*
12:00 PM - 1:30 PM	Lunch Break
1:30 PM - 3:30 PM	**DMB**, Design *Hyatt Grand Ballroom ABC*

1:30 PM - 3:30 PM	**OMC**, Grinding and Polishing *Hyatt Grand Ballroom EFG*
3:30 PM - 4:00 PM	Coffee Break *Hyatt Grand Ballroom D*
4:00 PM - 5:30 PM	**DMC**, DOMO Poster Session *Hyatt Grand Ballroom D*
4:00 PM - 5:45 PM	**OMD**, Finishing *Hyatt Grand Ballroom EFG*
7:30 PM - 9:30 PM	**OME**, OF&T Glass Art Contest *Hyatt Grand Ballroom EFG*

Tuesday, October 12, 2004

Time	Event/Location
8:00 AM - 10:00 AM	**OTuA**, Materials Science *Hyatt Grand Ballroom EFG*
8:15 AM - 10:00 AM	**DTuA**, Applications III *Hyatt Grand Ballroom ABC*
10:00 AM - 10:30 AM	Coffee Break *Hyatt Grand Ballroom D*
10:30 AM - 12:00 PM	**OTuB**, Interferometry *Hyatt Grand Ballroom EFG*
10:30 AM - 12:00 PM	**DTuB**, Subwavelength Optics I *Hyatt Grand Ballroom ABC*
12:00 PM - 1:30 PM	Lunch Break
1:30 PM - 3:15 PM	**OTuC**, Fabrication and Testing *Hyatt Grand Ballroom EFG*
1:30 PM - 3:30 PM	**DTuC**, Subwavelength Optics II *Hyatt Grand Ballroom ABC*
3:15 PM - 4:00 PM	Coffee Break *Hyatt Grand Ballroom D*
4:00 PM - 6:00 PM	**DTuD**, Applications IV *Hyatt Grand Ballroom ABC*
4:00 PM - 5:45 PM	**OTuD**, Testing *Hyatt Grand Ballroom EFG*
5:00 PM - 8:30 PM	FiO/LS/DOMO/OF&T Joint Reception *Clarion*

Wednesday, October 13, 2004

Time	Event/Location
8:00 AM - 10:00 AM	**DWA**, Fabrication *Hyatt Grand Ballroom ABC*
8:00 AM - 10:00 AM	**OWA**, Large Optics *Hyatt Grand Ballroom EFG*
10:00 AM - 10:30 AM	Coffee Break *Hyatt Grand Ballroom D*
10:30 AM - 12:00 PM	**XWA**, Joint DOMO/OF&T Session *Hyatt Grand Ballroom ABC*

Optical Fabrication & Testing 2004

Hyatt Grand Ballroom EFG
8:15 a.m.–10:00 a.m.
OMA • Advances in Optical Fabrication and Testing
Oliver Fähnle; Fisba Optik AG, Switzerland, Presider

OMA1 • 8:15 a.m. **(Invited)**
Innovations in optics manufacturing,
Stephen D. Jacobs; Univ. of Rochester, USA.
Innovative sub-aperture processes for manufacturing optics are described that include the use of pitch, pads, ions, clusters of ions, or a magnetic fluid. Most operate through CNC control and are commercially available.

OMA2 • 8:45 a.m. **(Invited)**
TBD,
Bruce Smith, USA.
No abstract provided.

OMA3 • 9:15 a.m.
TBD,
Andrew Kulawiec, USA.
No abstract provided.

OMA4 • 9:30 a.m.
Advances in small-tool polishing for free-form surfaces,
Richard R. Freeman[1], Anthony Beaucamp[1], David Walker[1,2], Roger Morton[1], Gerry McCavana[1]; [1]Zeeko Ltd., UK, [2]Dept. of Physics and Astronomy, Univ. College, UK.
Free-form surfaces look set to revolutionise optical design. We report on recent development of the *Precessions* process for polishing free-form surfaces from the precision-ground state, and correcting form-errors. On-going experimental results are presented.

OMA5 • 9:45 a.m.
TBD,
James Webb, USA.
No abstract provided.

Hyatt Grand Ballroom D
10:00 a.m.–10:30 a.m.
Coffee Break

Hyatt Grand Ballroom EFG
10:30 a.m.–12:00 p.m.
OMB • Thin Films
Stephen D. Jacobs; Univ. of Rochester, USA, Presider

OMB1 • 10:30 a.m. **(Invited)**
Thin-film-optics design and manufacturing challenges for large-aperture high-peak-power, short-pulse lasers,
James B. Oliver; Univ. of Rochester, USA.
High-peak-power, short-pulse laser systems require specialized thin-film coatings, primarily due to laser damage thresholds and increased spectral bandwidth. The influence of these effects is evident in wavefront performance, coating thickness, and design complexity.

OMB2 • 11:00 a.m.
Modeling the effects of silicone contaminants on the US Lab window assembly using optical thin-film analysis,
C. K. Carniglia[1], James Visintine[2], Paul Boeder[2], John Alred[2], Christopher Shaw[3]; [1]JDS Uniphase, USA, [2]Boeing Co., USA, [3]Boeing Defense and Space Group, USA.
Multi-layer thin-film analysis can model the effects of the deposition of DC-704 pump oil in the presence of VUV radiation onto a sample with an antireflection coating. The model suggests that the film is SiO_2.

OMB3 • 11:15 a.m.
Cleaning process versus laser damage threshold of coated optical components,
Amy L. Rigatti; Univ. of Rochester, USA.
Several tests were completed to measure the laser damage threshold of coated optics processed through different cleaning methods. Initial results indicate that the mechanical-scrub cleaning step is critical to high-laser damage performance.

OMB4 • 11:30 a.m.
Process tuning of silica thin-film deposition,
Jason C. Keck, James B. Oliver, Vernon Gruschow, John Spaulding, James D. Howe; Lab for Laser Energetics, Univ. of Rochester, USA.
Use of high-resolution deposition-rate monitoring and programmatic control of electron-beam position results in improvements in rate consistency and uniformity of source depletion during SiO_2 thin-film deposition by electron-beam evaporation.

OMB5 • 11:45 a.m.
Linear-to-circular polarization transformation upon optical tunneling through an embedded low-index film,
Rasheed M. Azzam, Cristina L. Spinu; Univ. of New Orleans, USA.
Quarter-wave retardation can be achieved in optical tunneling through a low-index thin film which is surrounded by a high-index medium over a range of incidence angles, for all index ratios > 2.414.

12:00 p.m.–1:30 p.m.
Lunch Break

Hyatt Grand Ballroom EFG
1:30 p.m.–3:30 p.m.
OMC • Grinding and Polishing
John Lambropoulos; Univ. of Rochester, USA, Presider

OMC1 • 1:30 p.m. (Invited)
Diamond fixed abrasive lapping of brittle substrates,
Tim D. Fletcher, Feben T. Gobena, Vince D. Romero; 3M Co., USA.
Advances in a new slurry-free diamond fixed abrasive technology developed by 3M for lapping of brittle substrates are reviewed. Results on brittle substrates such as glass, ceramics, CaF_2, ZnSe, SiC, and sapphire are presented.

OMC2 • 2:00 p.m. (Invited)
Selectivity in polishing of silicon dioxide and nitride thin films using mixtures of abrasives,
Sharath Hegde, S. V. Babu; Clarkson Univ., USA.
Dispersions of composite particles consisting of two different abrasives are capable of producing selective material removal rates. The role of surface charges that facilitate the preparation and application of these mixed abrasive systems are discussed.

OMC3 • 2:30 p.m.
A wafer-scale removal rate model for chemical mechanical planarization,

John Kelchner, Stephen Beaudoin; School of Chemical Engineering, Purdue Univ., USA.
A model to describe removal rates during silicon dioxide polishing has been developed and validated. The model includes submodels for the bulk pad behavior, the behavior of pad asperities, and the pad-wafer relative velocity.

OMC4 • 2:45 p.m.
Loose abrasive lapping of optical glass with different lapping plates and its interpretation,
Shai N. Shafrir[1], John C. Lambropoulos[1], Stephen D. Jacobs[2]; [1]Material Science Program, Dept. of Mechanical Engineering, Ctr. for Optics Manufacturing, Univ. of Rochester, USA, [2]Lab for Laser Energetics, Ctr. for Optics Manufacturing, Univ. of Rochester, USA.
Loose Abrasive Lapping was studied and analyzed for different lapping plates. An examination of lapping plate hardness and Preston's Coefficient showed an optimization in process efficiency with an intermediate lapping plate hardness.

OMC5 • 3:00 p.m.
Ultra-Form finishing process for optical materials,
Edward Fess[1], John Schoen[1], Mike Bechtold[2], Dave Mohring[1]; [1]Ctr. for Optics Manufacturing, USA, [2]OptiPro Systems, USA.
This paper will present the work being performed on the Ultra-Form finishing process. The goal of this process is to finish hard optical materials as well as typical glasses in aspheric and conformal shapes.

OMC6 • 3:15 p.m.
A model for ductile fine grinding of ceramics with diamond,
Ioan D. Marinescu, Christian E. Spanu; Precision Micro-Machining Ctr., USA.
An integrated analytical model for fine-diamond, double sided grinding of ceramic components in ductile mode was developed, validated, and qualified as a correct predictability tool for operation efficiency for a given set of process parameters.

Hyatt Grand Ballroom D
3:30 p.m.–4:00 p.m.
Coffee Break

Hyatt Grand Ballroom EFG
4:00 p.m.–5:45 p.m.
OMD • Finishing
Arne Lindquist; Schneider Optical Machines, USA, Presider

OMD1 • 4:00 p.m. (Invited)
New industrial applications of magnetorheological finishing (MRF),
Marc Tricard, Paul R. Dumas, Don Golini; QED Technologies Inc., USA.
MRF is a deterministic, sub-aperture finishing process with system stability, high material removal rates, and a shear mode of material removal that makes it uniquely well-adapted to a variety of optical and industrial applications.

OMD2 • 4:30 p.m.
Polishing of pre-polished CVD ZnS flats with altered magnetorheological (MR) fluids,
Irina A. Kozhinova[1], Henry J. Romanofsky[1], Stephen D. Jacobs[1], William I. Kordonski[2], Sergei R. Gorodkin[2]; [1]Ctr. for Optics Manufacturing, USA, [2]QED Technologies, USA.
Magnetorheological (MR) fluid composition and chemistry were altered to study the finishing of pre-polished CVD ZnS flats. Surface roughness did not exceed 2 nm rms after removing as much as 2 μm of material.

OMD3 • 4:45 p.m.
Recent achievements on ion beam techniques for optics fabrication,

Axel Schindler, Thomas Hänsel, Frank Frost, Andreas Nickel, Renate Fechner, Bernd Rauschenbach; Leibniz-Inst. for Surface Modification, Germany.
The talk gives an overview on latest results on ion beam technology development for optics fabrication: figuring below 0.5nm rms, smoothing down to the 0.1nm rms and RIBE proportional transfer of 3-D micro- and nanostructures.

OMD4 • 5:00 p.m.
Color center formation on CaF_2 (111) surface investigated by low-energy-plasma-ion surfacing,
Jue Wang, Robert L. Maier; Corning Tropel Corp., USA.
Low-energy-plasma-ion treatment has been employed to identify color centers on CaF_2 components originating from fluorine depletion on CaF_2 surfaces. The initial time and saturation peak absorption depends on the surface processing conditions.

OMD5 • 5:15 p.m.
Ion beam figuring surface finishing of x-ray and synchrotron beam line optics using stitching interferometry for the surface topology measurement,
Thomas Hänsel, Andreas Nickel, Axel Schindler, Hans-Jürgen Thomas; Leibniz-Inst. for Surface Modification, Germany.
Deterministic surface finishing using small spot ion beam figuring combined with stitching interferometry surface shape measurements for the enhanced lateral resolution have been developed to achieve 20marcsec slope error on a 100mm flat Si SR-optic.

OMD6 • 5:30 p.m.
OF&T Glass Art Contest preview,
Lisa Rich; Consultant, USA.
Tonight's glass art contest is described. After a presentation on glass sculpture by a local artist, pieces fabricated by precision optics shops will be exhibited and auctioned off for charity.

Hyatt Grand Ballroom EFG
7:30 p.m.–9:30 p.m.
OME • OF&T Glass Art Contest, *Lisa Rich; Consultant, USA, Presider*

OME1 • 7:30 p.m.
Welcome and Introductions, *Lisa Rich; Consultant, USA.*

OME2 • 7:45 p.m.
Light and glass sculpture,
Fred Tschida; Alfred Univ., USA.
Prof. Tschida will use slides to offer a visual voyage through 30 years of research on light in sculpture.

Hyatt Grand Ballroom EFG
8:00 a.m.–10:00 a.m.
OTuA • Materials Science
Amy L. Rigatti; Univ. of Rochester, USA, Presider

OTuA1 • 8:00 a.m. (Invited)
Glass material response to the fabrication process: Example from lapping,
John Lambropoulos, R. Varshneya; Univ. of Rochester, USA.
We use three glass properties (Young's modulus E, hardness H, and fracture toughness Kc) to describe glass response to lapping. As an example, we discuss loose abrasive lapping of 11 commercially available Ohara glasses.

OTuA2 • 8:30 a.m.
Development of new synthetic optical polishing pitches,

Stephen P. Sutton; Sutton Technologies Inc., USA.
Amorphous polymers, formulated with specific additives, are shown to display viscous creep enabling application as synthetic polishing pitches. Characterization of creep, and formulation to match traditional pitch performance, are discussed.

OTuA3 • 8:45 a.m.
Multi-scratch effects on surface damage and removal in optical glasses,
Rattaporn Thonggoom, Paul Funkenbusch; Dept. of Mechanical Engineering, Univ. of Rochester, USA.
Multi-pass scratching is used to examine the effects of pre-existing damage on the removal behavior and morphology of optical glasses. A ductile-to-brittle like transition occurs at nominally sub-critical loads, dependent on the number of passes.

OTuA4 • 9:00 a.m.
Fracture toughness of ULE, Zerodur, Astrosital and Corning 9600,
Christophe Bouvier[1,2], John C. Lambropoulos[1,2], Stephen D. Jacobs[1,2,3]; [1]Dept. of Mechanical Engineering, Univ. of Rochester, USA, [2]Ctr. for Optics Manufacturing, USA, [3]Lab for Laser Energetics, Univ. of Rochester, USA.
Using Vickers indentations and applying the Evans model, the fracture toughness of ULE and Corning 9600 was found to be 0.87MPa $m^{1/2}$ and 0.56MPa $m^{1/2}$ respectively, Zerodur and Astrosital exhibited a similar value: 0.64MPa $m^{1/2}$.

OTuA5 • 9:15 a.m.
Periodic scratch marks on ground surfaces,
Sha Tong, Sheryl Gracewski, Paul Funkenbusch; Univ. of Rochester, USA.
We have observed scratch marks corresponding to the k ratio and chatter frequencies during contour grinding with resin tools (2~4 micron diamond abrasives). Both scratch marks are described quantitatively and possible generation mechanisms are presented.

OTuA6 • 9:30 a.m.
Subsurface damage in single-crystal sapphire,
Frank H. Mrakovcic[1,2], Joseph A. Randi[1,2], John C. Lambropoulos[1,2], Stephen D. Jacobs[3]; [1]Dept. of Mechanical Engineering, Univ. of Rochester, USA, [2]Ctr. for Optics Manufacturing, USA, [3]Lab for Laser Energetics, Univ. of Rochester, USA.
Subsurface damage (SSD) and material removal rates in the C, A, and M crystallographic faces of single-crystal sapphire have been examined. SSD is related to the peak-to-valley surface microroughness by SSD<= 1.4 x PV.

OTuA7 • 9:45 a.m.
Chemical durability of phosphate laser glasses,
Anne E. Marino, Katie Spencer, Jessica E. DeGroote, Stephen D. Jacobs; Univ. of Rochester, USA.
A test was begun to evaluate humidity resistance for two phosphate glasses to be used in new laser systems. Initial data show increased roughness for one glass stored at 75% RH (ambient) after 8 weeks.

Hyatt Grand Ballroom D
10:00 a.m.–10:30 a.m.
Coffee Break

Hyatt Grand Ballroom EFG
10:30 a.m.–12:00 p.m.
OTuB • Interferometry
H. Philip Stahl; NASA, USA, Presider

OTuB1 • 10:30 a.m. (Invited)
Leveraging interferometric metrology for precision manufacturing,

Paul E. Murphy; QED Technologies Inc., USA.
Commercial interferometers can be both quite accurate and easy to use. Advanced surface specifications and manufacturing techniques, however, require a greater awareness of gauge capabilities. We discuss how to critically analyze metrology for such situations.

OTuB2 • 11:00 a.m. (Invited)
Vibration insensitive interferometric optical testing,
James C. Wyant; Univ. of Arizona, USA.
The accuracy of an interferometric optical test is generally limited by the environment. This paper discusses two single-shot interferometric techniques for reducing the sensitivity of an optical test to vibration; simultaneous phase-shifting and spatial carrier.

OTuB3 • 11:30 a.m.
Improved optical metrology using phase retrieval,
Gregory R. Brady, James R. Fienup; Inst. of Optics, Univ. of Rochester, USA.
The use of phase retrieval presents opportunities for greatly simplifying the techniques and apparatus used for characterizing optical surfaces and systems, particularly aspherical surfaces. We describe the method and some early results.

OTuB4 • 11:45 a.m.
Phase recovering using phase shifting interferometry and a correlation algorithm,
Adriana Nava Vega[1], Alejandro Cornejo[2]; [1]Observatorio Astronomico Natl. de San Pedro Martir, Inst. de Astronomia- UNAM., USA, [2]Inst. Natl. de Astrofisica Optica y Electronica, Mexico.
We developed and applied a novel correlation algorithm to recover the phase of a surface under test using phase shifting interferometry. Numerical simulations analyzed patterns and applying the correlation algorithm. Experimental interferogramas were studied.

12:00 p.m.–1:30 p.m.
Lunch Break

Hyatt Grand Ballroom EFG
1:30 p.m.–3:15 p.m.
OTuC • Fabrication and Testing
Chris Evans; Zygo Corp., USA, Presider

OTuC1 • 1:30 p.m. (Invited)
Advances in non-contacting surface metrology,
Ian Lee-Bennett; Taylor Hobson Ltd., UK.
This paper describes the recent advances made in scanning white light interferometry. It presents a tool capable of characterizing diamond turning, polishing and super polishing down to sub-Angstrom levels of surface finish.

OTuC2 • 2:00 p.m.
Surface characterization of CVD ZnS using power spectral density,
Jessica E. DeGroote, Shai N. Shafrir, John C. Lambropoulos, Stephen D. Jacobs; Univ. of Rochester, USA.
We discuss the use of power spectral density (PSD) analysis to characterize an optical surface. PSD analysis was performed on different sections of a magnetorheological finishing (MRF) spot on chemical vapor deposition zinc sulfide (ZnS).

OTuC3 • 2:15 p.m.
Applications of iTIRM,
Mark Meeder, Oliver Fähnle; Fisba Optik AG, Switzerland.

In-process surface measurement using the iTIRM principle is used for the optimisation and study of finishing processes and the analysis of contaminated polishing processes. Furthermore, its possible application to detect scratch and dig is demonstrated.

OTuC4 • 2:30 p.m.
Identification and compensation of fabrication errors in diamond turning of a large area sinusoidal grid surface,
Makoto Tano[1], Wei Gao[1], Takeshi Araki[2], Satoshi Kiyono[1]; [1]Tohoku Univ., Japan, [2]Hitachi Displays Ltd., Japan.
Error components in a sinusoidal grid surface fabricated by diamond turning, which are identified by an evaluation method based on 2-D DFT of interference microscope images of the surface, are compensated for through feedback.

OTuC5 • 2:45 p.m.
***In situ* shape monitoring of optical cement during UV curing,**
Mark Meeder, Oliver Fähnle; Fisba Optik AG, Switzerland.
Curing of an optical adhesive is monitored interferometrically during UV exposure. Analysis of the hardening process is evaluated in real time. Experiments show that intermittent UV exposure causes less stress than continuous exposure.

OTuC6 • 3:00 p.m.
The index profile of radial gradient index lens measured by imaging ellipsometry,
Kan-Yan Lee, Y. F. Chao; Dept. of Electro-Optical Engineering, Natl. Chiao Tung Univ., Taiwan Republic of China.
The index profile of a radial gradient index lens is measured by a three-intensity imaging ellipsometry. Its refractive index profile measured by this technique is well fitted to the spec of oxide glass lens.

Hyatt Grand Ballroom D
3:30 p.m.–4:00 p.m.
Coffee Break

Hyatt Grand Ballroom EFG
4:00 p.m.–5:45 p.m.
OTuD • Testing
Paul Dumas; QED Technologies, USA, Presider

OTuD1 • 4:00 p.m. (Invited)
"Absolute testing" and uncertainty,
Chris Evans; Zygo Corp., USA.
This presentation will provide a broad overview of self-calibration techniques used for flats and spherical optical surfaces. Major contributions to measurement uncertainty will be discussed.

OTuD2 • 4:30 p.m.
Characterization of precision spheres with XCALIBIR,
Quandou Wang, Johannes Soons, Ulf Griesmann; Natl. Inst. of Standards and Technology, USA.
The geometry of a nearly spherical surface is determined by the radius-of-curvature at one point and the form error of the sphere. The form error strongly affects the radius measurement with the radius bench method.

OTuD3 • 4:45 p.m.
Advances in micro-lens surface metrology: The role of retrace errors,
Neil W. Gardner, Angela Davies; Univ. of North Carolina at Charlotte, USA.

The random ball test is employed for self-calibration of micro-refractive lens measurements. It is shown that interferometer aberrations lead to retrace errors, which are a strong function of test part curvature on the micro-scale.

OTuD4 • 5:00 p.m.
Sequential interferometric techniques for measuring independent values of the refractive index and material thickness of semiconductor wafers,
Glen D. Gillen[1], Shekhar Guha[2]; [1]AFRL, Anteon Corp., USA, [2]AFRL, Materials and Manufacturing Directorate, USA.
A technique is presented using both Michelson and Fabry-Perot interferometry to independently measure the refractive index and the material thickness of semiconductor wafers. The method does not require accurate prior knowledge of either quantity.

OTuD5 • 5:15 p.m. (Invited)
Stitching subaperture data for testing aspheric surfaces,
Greg Forbes, Paul Murphy, Jon Fleig; QED Technologies, USA.
Stitching methods can boost aperture and aspheric-departure capabilities as well as resolution and accuracy in interferometric testing. However, non-trivial subaperture configurations are required for figure metrology on aspheres. We discuss strategies and recent results.

Clarion Hotel
5:00 p.m.–8:30 p.m.
FiO/LS/DOMO/OF&T Joint Reception

Hyatt Grand Ballroom EFG
8:00 a.m.–10:00 a.m.
OWA • Large Optics
Lisa Rich; Consultant, USA, Presider

OWA1 • 8:00 a.m. (Invited)
Future space telescope mirror technology requirements,
H. Philip Stahl; NASA Marshall Space Flight Ctr., USA.
Large-aperture lightweight space mirrors are critical for future NASA space science missions. This presentation summaries the optical mirror requirements necessary to enable several planned missions.

OWA2 • 8:30 a.m. (Invited)
Design and performance of a large aperture, high-sensitivity, dynamic wavefront sensor,
Alan L. Wertheimer[1], David J. Fischer[1], Richard A. Hutchin[2]; [1]Eastman Kodak Co., USA, [2]Optical Physics Co., USA.
A large aperture, 448-subaperture sensor measures full aperture wavefront changes occurring above 10 Hz. Tests have demonstrated success in measuring local wavefront tilt variations in the 10-1000 nanoradian range.

OWA3 • 9:00 a.m.
Low temperature bonding of optical materials,
Carol Click, Roxane O'Malley, Leo Gilroy; SCHOTT North America, USA.
We have developed a low-temperature bonding technology that yields mechanically stable, optically clear joints between glasses, glass-ceramics or ceramics at room temperature without high temperature or pressure for space science, microlithography, and general photonics.

OWA4 • 9:15 a.m.
Criterion on aspherical manufacturing used as guideline for design,
Christian du Jeu[1], Kjetil Dohlen[2]; [1]Société Européenne de Systèmes Optiques, France, [2]Lab d'Astrophysique de Marseille, France.

Optimal design criteria for aspheres are described through the use of merit functions. Example are given that use these criteria in the commercial manufacture of off-axis aspheres for large optical systems.

OWA5 • 9:30 a.m. (Invited)
Optics for the next generation of telescopes: Ambitious, or insane?
Buddy Martin; Univ. of Arizona, USA.
Telescopes with apertures between 20m and 100m will rely heavily on advances in optical fabrication and testing. Diverse designs have emerged for telescopes that would have appeared crazy a decade ago (and perhaps still do).

Joint DOMO/OT&T Session

Hyatt Grand Ballroom D
10:00 a.m.–10:30 a.m.
Coffee Break

Hyatt Grand Ballroom ABC
10:30 a.m.–12:00 p.m.
XWA • Joint DOMO/OF&T Session
Thomas J. Suleski; Univ. of North Carolina at Charlotte, USA, Presider

XWA1 • 10:30 a.m. (Invited)
New technologies for aspherical grinding/polishing of micro/meso optics,
Tsunemoto Kuriyagawa, Nobuhito Yoshihara; Tohoku Univ., Japan.
New technologies for ultra-precision aspherical grinding and polishing of aspherical optical lenses and molding dies are introduced, which are "parallel grinding method," "fluctuation-free grinding method" and "electrorheological fluid assisted micro-polishing."

XWA2 • 11:00 a.m. (Invited)
Measurement advances for micro-refractive fabrication,
Angela Davies, Brent Bergner, Neil Gardner; Univ. of North Carolina at Charlotte, USA.
Micro-refractive lenses are critical components in many devices, yet characterization remains challenging. We have developed calibration methods for micro-interferometry to improve form error, transmitted wavefront, and radius of curvature measurements.

XWA3 • 11:30 a.m.
Test of aspherics in the NIR with a diffractive optical element as null lens,
Frank Simon, Norbert Lindlein, Johannes Schwider; Inst. of Optics, Information and Photonics, Max-Planck-Res. Group, Univ. of Erlangen-Nuremberg, Germany.
By the use of a Combo-DOE it is possible to get the absolute deviations of an aspherical surface. A light source of the NIR region is used to allow the measurement of steep aspherics.

XWA4 • 11:45 a.m.
Traceable radius measurements of micro-lenses,
Ayman M. Samara, Brent C. Bergner, Angela Davies, Kate Medicus, Neil Garner; Univ. of North Carolina at Charlotte, USA.
We have developed a method to measure the radius of curvature of micro-lenses. It is based on a coordinate transformation from known errors in the motion as the micro-lens is moved between the measurement positions.