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Mark A. Kahan
Marie B. Levine-West
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Introduction

Optical systems are used just about everywhere today, in systems that both image and illuminate. From eyeglasses to machine vision/robotics to automotive uses, from commercial reprographic equipment to medical instrumentation to the production of integrated circuits, and from telecommunications through Earth Observations, Space Exploration, Interferometers, Nullers, and Weaponry, Optical Systems are making a difference in our world. This conference is part of a sequence of similar conferences held in prior years that are dedicated to the optical modeling of these evolving imaging and non-imaging systems and the associated test-equipment needed to bring them forward with performance certainty. Note that models continue to be increasingly important as time-to-market pressures escalate and new missions are at times extending beyond the ability to accurately pre-test performance.

To predict performance over such a broad range of optical systems and engineering disciplines, there are a great many mathematical methods and tools that are needed. Some need to correctly model nano-scale systems with feature sizes comparable to the wavelengths of illumination, while others may need to address precise representations of controlled LED light leakage out of purposely-roughened fibers or the fluorescent behavior of specific phosphors. Still others need to contend with components ranging from meta-materials with negative refractive index & cloaking to quantum dots, to special prisms or gratings, to large deployable telescopes where accuracies are measured in picometers or at levels approaching 1/10,000th wave RMS WFE. When we add in wavelengths and configurations that range from X-Rays to THz, and environmental aspects spanning HEL through cryogenic in configurations from the laboratory to under-water and outer-space, the number of modeling developments needed to accurately predict optical performance is immense.

Electro-Optical Modeling and Performance Predictions also often require integrating many interdisciplinary techniques and mathematical methods with underlying physics that build-upon and/or utilize (arranged by similarity, of-sorts):

Optical Models, Methods, and Performance Estimates

- geometrical and physical optics
- diffractive optics and holographic systems
- beam propagation
- meta-materials (including negative index, photonic crystals, cloaking)
- plasmonics
- polarization
- adaptive optics
- radiometry
- narcissus
- fiber-optics and photonics
- interferometers and nullers
- image doubling
- illumination (including lasers, LEDs, OLEDS, solar)
- stray light/ghosts
- quantum dots
- optimization
- phase/prescription retrieval
- tolerancing and probabilistic design.

Electro-optical Models Including Relating Factors

- detector quantum efficiency
- charge diffusion
- EMI/EMC influences on E-O performance.

Optical Coating Performance

- filters
- laser damage resistance.

MEMS and MOEMS

- electrostatics; Casimir forces
- structures.

Structural and Opto-mechanical Modeling

- ultra-lightweight optics, nano-laminates, membrane mirrors
- mounting stresses, G-Release, and /or launch and deployment
- high impact/shock& pressure loadings
- influence functions
- vibration and damping
- micro-dynamics and influences of piece-part inertia; friction/stiction
- mechanical influences such as scanning deformations and special zoom/servo effects
- thermo-elastic effects
- stress birefringence
- fracture mechanics, and/or micro-yield
- proof testing models
- aspects such as lay-up anisotropy and material inhomogeneity
- nodal accuracy; meshing.

Thermal and Thermo-optical Modeling

- effects of energy absorption with depth in transmissive elements
- thermal run-away in IR elements
- aircraft/UAV/Instrument windows, missiles, and domes
- solar loading
- thermo-optical material characterizations over new wavelengths and/or temperatures
- system sterilization
- hole drilling, welding, and laser heat- treating
- HEL effects including survivability and hardening
- recursive models where thermo-elastic changes in-turn impact heating
- effects of joint resistance on conduction changes
- effects on LEDs
- meshing.

Integrated Models

- closely coupled thermal-structural- optical models
- optical control systems
- global optimizers
- acquisition, pointing, and tracking
- end-to-end simulations.

Space-borne (and/or Microlithographic) Factors

- contamination control
- particulate/NVR models
- photopolymerization
- radiative damage, atomic O2
- spacecraft charging
- micro-meteoroid modeling, including spalling.

Aero-optics

- boundary layer and shock wave effects
- convective effects and air-path conditioning/self-induced turbulence.

Modeling of Vision Systems

- HUDs
- HMDs.

Application-specific Unique Optical Models and Performance Predictions

- adaptive optics
- bio and medical optics/sensing
- lasers/laser communication systems
- LEDs/solid state lighting
- MEMs/nano technology
- existing/evolving photonic devices and systems
- photonic devices
- solar technology.

Other

- phenomenology
- reliability
- rules of thumb and scale factors of use to individual disciplines
- cost models of optical systems.

This Conference brought forward new work in several of these areas. Our intent was to provide special attention to new methods of analysis that would help "anchor" various models and/or also provide parametric relationships to help correlate results with predictions. In this regard, several authors have helped to advance the state-of-the-art by contributing work that provides new insight into different aspects of optical modeling and predicting performance. Abstracts, some as originally submitted, are shown below; please note that some were modified in the final version of the papers presented. Note also that some presentations were followed by a relatively lively discussion, so stay tuned, as further work in the areas noted may well be presented at a future date. ☺

Session 1: Space Telescopes and Coronagraphs

Session Chair: Mark A. Kahan, Synopsys, Inc. (USA)

Dynamic/jitter assessment of multiple potential HabEx structural designs
Paper 10374-1 Author(s): Joseph B. Knight, H. Philip Stahl, NASA Marshall Space Flight Ctr. (United States)
Abstract Text: Dynamic/Jitter Assessment of Multiple Potential HabEx Structural Designs, J. Brent Knight*, H. Phillip Stahl* *NASA Marshall Space Flight Center, AL, USA 35812 Dynamic analyses of multiple configurations of a proposed Habitable Exo-Planet (HabEx) 4 m off-axis telescope structure were performed to predict effects of jitter on primary mirror wave front error and primary/secondary mirror alignment. The dynamic disturbance used as the forcing function was the James Webb Space Telescope reaction wheel assembly vibration emission specification level. The objective of these analyses was to predict order-of-magnitude performance for various structural configurations which will roll into efforts to define the HabEx structural designs global architecture. Structural design parameters varied included structural vs. non-structural tube and secondary mirror (SM) to science instrument enclosure. Primary Mirror (PM) wave front error, PM/SM alignment, and overall mass of each configuration are reported.

Challenges in coronagraph optical design
Paper 10374-2 Author(s): Russell A. Chipman, James Breckinridge, College of Optical Sciences, The Univ. of Arizona (United States)
Abstract Text: To accurately predict the performance of space-based terrestrial exoplanet coronagraphs, we have integrated several analysis methods: geometric ray tracing, polarized vector wave propagation and diffraction theory, and statistical optics. The space-based exoplanet coronagraph performance requires an accurate end-to-end (object to mask to detector) optical system model to guide science decisions, technology development to direct the optical system engineering needed to balance subsystem requirements and to define system ground & space calibration methodologies. Due to the extreme specifications for exoplanet coronagraphs, such as the goal of resolving planets with a brightness less than 10^-9 of their star located within 3 Airy disk radii, geometric ray-tracing alone provides insufficient information to estimate contrast & SNR for exoplanet characterization. Using the Polaris-M polarization analysis program, we have analyzed how uncorrected coating polarization aberrations couple light around 10^-5 of the incident light into crossed polarized diffraction patterns about twice the size of the Airy disk. Since these orthogonal polarized components exiting with wavefront aberrations different from the principal uncoupled beams, their wavefronts not corrected by the deformable optics

systems. Polarization aberrations expansions have shown how these polarization aberrations scale with mirror coatings, fold mirror angles, and numerical aperture. Form birefringence of the telescope mirrors is also analyzed to tolerance this poorly understood, but potentially damaging effect.

Optical performance prediction of space instruments using ray-tracing-based Earth system model

Paper 10374-4 Author(s): Dongok Ryu, Sug-Whan Kim, Yonsei Univ. (Korea, Republic of); Robert P. Breault, Breault Research Organization, Inc. (United States)

Abstract Text: We report a new end-to-end computation model for performance evaluation of space optical instrument. The model combines the observing instrument, the global earth as an observation target and the sun as a light source in non-sequential ray tracing environment. Simultaneous imaging and spectroscopic results are provided using this model with fully resolved spatial, spectral, and temporal coverage of sub-models of Earth. Especially, the global earth system model is defined with a set of optical characteristics representing its 16 types of lands, an ocean and 3D atmosphere components. The incident sun-light interacts with the earth components in terms of reflection, refraction, transmission, absorption and scattering before it enters into the instrument aperture. This new model is capable of evaluating spectroscopic performance as well as imaging and radiometric performances of the optical instrument almost simultaneously from integrated ray tracing computation. We applied this technique to HRI VIS instrument in EPOXI mission. A hypothetical two-mirror Cassegrain imager is designed with a 300 mm diameter aperture and 21.504 mm × 21.504 mm focal plane. The simulation images are compared with observations from HRI-VIS measurement for a day from UTC Mar.18, 2008. The surface scales are 55.0km/pixel for simulation and 54.9km/pixel for observation. Then we measured the defocus aberration of the instrument using a defocus mapping tool and edge spread function with six gradually defocused simulation images. The measuring result shows that optical path between primary and secondary mirror increases by 55.498 μm from the diffraction limited condition. This study shows the global Earth system model that includes an instrument model is new and powerful tool for evaluating the performance of an earth observing instrument when used in design, manufacturing and integration phases.

Session 2: Instruments and Systems

Session Chair: Marie B. Levine-West, Jet Propulsion Lab. (USA)

Augmented method to improve thermal data for the figure drift thermal distortion predictions during the JWST OTIS cryogenic vacuum test

Paper 10374-5 Author(s): Sang C. Park, Smithsonian Astrophysical Observatory (United States); Timothy M. Carnahan, NASA Goddard Space Flight Ctr. (United States); Lester Cohen, Smithsonian Astrophysical Observatory (United States); Cherie B. Congedo, SGT, Inc. (United States); Michael J. Eisenhower, Smithsonian Astrophysical Observatory (United States); Wes Ousley, Genesis Engineering Solutions LLC (United States); Andrew Weaver, ATA Aerospace (United States); Kan Yang, NASA Goddard Space Flight Ctr. (United States)

Abstract Text (As Abstracted from the Final Presentation Page): STOP analysis is a critical part of the any space telescope, and seamless integration between thermal, structural and optical modeling/analysis is CRITICAL Limited sensor counts cause shortfalls of the

temperature distributions in the OTIS PMBSS, but the use of Pathfinder testing added confidence in the models, analysis, and processes used for the final OTIS CV test. The Team developed a new method (LDWI) for populating a structural FEM with limited test thermal diode data which assisted thermal modeling predictions. An advantage of the LDWI method is that it could execute in near real-time during the OTIS FD tests. The thermal model run times are often currently very lengthy and may not be suitable for in-situ test analysis. The post-test improved thermal model that uses LDWI may provide even better thermal nodal predictions, and should help in the successful completion of the thermal distortion tests of JWST.

Coupled-fiber Bragg grating sensor structure for cryogenic conditions
Paper 10374-7 Author(s): Umesh Sampath, Dae-gil Kim, Minho Song, Chonbuk National Univ. (Korea, Republic of)
Abstract Text: Fiber Bragg grating sensors have numerous advantages over other electro-mechanical sensors, such as zero electromagnetic interference, multiplexing capability, and can be embedded with less detrimental effects. Major drawback of the FBG sensors relies on cross sensitivity towards the applied temperature and the strain. Moreover, the low thermal sensitivity of silica at low temperatures creates additional difficulties in implementing FBG sensors at cryogenic conditions. In this work, we present the possibilities of simultaneous sensing of the strain and the temperature by measuring the reflected wavelengths from coupled fiber Bragg gratings in cryogenic temperatures. We aimed to overcome the cross-sensitivity problem of FBG as well as improving the temperature sensitivity of gratings at cryogenic temperatures. For the purposes, we used polymer resin as a coating material for a FBG sensor. The polymer coated FBGs (PCFBGs) show high sensitivities to cryogenic temperatures because of the thermal expansion of polymer resin. The average temperature sensitivity of 42 pm °C-1 was obtained for a range -195 °C to 25 °C. To obtain strain free PCFBG, one PCFBG is encapsulated inside a glass capillary tube. Analogously, to eliminate the thermal expansion of capillary material at the one end, FBG is cleaved free and the other end is fixed with temperature resistant epoxy resin. The optical system readout simultaneously the applied strain and the temperatures successfully at cryogenic conditions.

Session 3: Aero-Optic Models and Systems

Session Chair: Mark A. Kahan, Synopsys, Inc. (USA)

Improved ray tracing simulation for aero-optical effect of a hypersonic projectile in wind tunnel using multiple gradient-index layer method
Paper 10374-8 Author(s): Seul Ki Yang, Yonsei Univ. (Korea, Republic of); Sehyun Seong, Dongok Ryu, Yonsei Univ. (Korea, Republic of), SphereDyne Co., Ltd. (Korea, Republic of); Sug-Whan Kim, Yonsei Univ. (Korea, Republic of), Ctr. for Galaxy Evolution Research (Korea, Republic of), Yonsei Univ. Observatory (Korea, Republic of); Sang-Hun Jin, LIG Nex1 Co., Ltd (Korea, Republic of); Ho Jeong, Hyun Bae Kong, LIG Nex1 Co., Ltd. (Korea, Republic of)
Abstract Text: We propose improved the simulation method of the aero-optical effect for a hypersonic projectile using multiple gradient-index (GRIN) layer method. The method discretizes anisotropic inhomogeneous media into multiple refractive index layers. Each layer constructs the refractive index distribution function derived from the flow field by Computational Fluid Dynamics (CFD) analysis. In this study, the target used the flow field in

the hypersonic wind tunnel corresponds to Mach 7 in speed, 16km in altitude for density. The wedge shaped projectile has semi-vertex angle 12° and fused silica seeker window. The observation instrument inside the wind tunnel consists of a He-Ne fiber laser, a beam expander, a folding mirror, a beam reducer and a Shack Hartmann sensor. The light source generated 2828 rays and numerical aperture (NA) is 0.12 with beam incident angle variation from 60° to 78°. The Shack-Hartmann sensor has 68×68 pixels and each pixel diameter is 0.108 mm. The simulation results show that the 2D optical path length (OPD) map was estimated in the real optical test measurement, the OPD change value was calculated by the difference OPD map between with and without the flow field. The RMS OPD had a tendency to decrease linearly as the beam incident angle increases and is 0.0141□□ at 78° in beam incident angle. For comparison with other method, we simulated ray equation methods and obtained comparable results.

The fluid field flow and optical system performance analysis

Paper 10374-9 Author(s): Ming-Ying Hsu, Ting-Ming Huang, Instrument Technology Research Ctr. (Taiwan)

Abstract Text: Optical system performance is easily affected by variable surrounding conditions, including the precision optical system, as its performance is changed with flow field in the air or surrounding water. The air content of water vapor, carbon dioxide concentration, and dry air has a ratio that will affect the air refractive index. Water is another material of general optical systems, affected by surrounding conditions as well. Lithography and the microscope lens are commonly used for contact with water, with their refractive nature, changed by the pressure and density in the flow field. In addition, temperature and light wavelength are two important parameters of the air and water refractive index. This study calculates fluid field pressure and velocity distribution, and then transfers it to air and water refractive index differences in the optical system. We also evaluate optical performance variations with fluid field changes, which can improve optical design and system alignment progress by avoiding surrounding condition changes.

A fiber-optic ice detection system for large-scale wind turbine blades

Paper 10374-10 Author(s): Dae-gil Kim, Sampath Umesh, Minho Song, Chonbuk National Univ. (Korea, Republic of)

Abstract Text: Recently, because of environmental issues, the demand for wind energy has rapidly increased world widely including colder and higher altitude regions. The cold weather operation of wind turbines, however, lead to problems, such as the ice accretion on surfaces and the impacts of low temperature on the materials of wind turbine blades. Due to imbalance, disrupted aerodynamics, or damages, icing can cause substantial problems in the reliability of large-scale wind turbines. In this paper, for the purpose of detecting the ice growth, a fiber-optic sensor system is proposed. The system is based on the measurement of Fresnel-reflection intensities from the ends of single mode fibers, and it consists of a broadband light source, an AWG (arrayed waveguide grating), an optical circulator, and a spectrometer. The input broadband light illuminates the AWG via the optical circulator. After de-multiplexing by the AWG with different central wavelengths, the Fresnel-reflection signals from all channels are multiplexed again, detected, and analyzed by a spectrometer which consists of a volume phase grating and a photo-detector array. The intensity variation of each channel corresponds to the ambient refractive index variation of the measurement point. The transition in Fresnel-reflection intensity can identify the status of ambient medium, such as the ice, the water, and the air. Experimental results show that the proposed system can clearly detect the growth of ice in real time.

Session 4: Materials and HEL Related Models

Session Chair: Marie B. Levine-West, Jet Propulsion Lab. (USA)

Balancing diffraction efficiency and laser damage in diffractive optics
Paper 10374-11 Author(s): Steven T. Glass, Thomas J. Suleski, The Univ. of North Carolina at Charlotte (United States)
Abstract Text: Diffractive optics serve as an enabling technology for a host of applications requiring high power laser focusing and beam shaping, ranging from materials processing to military applications, among others. The ability of such components to resist damage under intense irradiation is of mounting importance as lasers attain ever higher power levels. Diffractive optics inherently contain sharp discontinuities that can enhance electric field distributions within the component, which can lead to increased laser damage. In many cases, diffractive optics are realized as multi- level step-wise approximations to an ideal shape. The increased number of phase levels increases the operating efficiency of the component, but also introduces additional surface discontinuities. As a consequence, it is useful to consider both diffraction efficiency as well as susceptibility to laser damage as performance criteria for diffractive optics in high-power laser systems. Researchers have previously analyzed subwavelength, AR gratings for geometrical field enhancement effects, but conventional diffractive elements with discontinuities have not received as much attention. In this paper, we apply FDTD simulations to determine a general relationship connecting field enhancement to basic grating parameters: period, depth, number of phase levels, step width, and step height. We discuss the results of these simulations, connecting them to diffraction efficiency, fabrication complexity, and laser damage thresholds in different optical materials.

Mounting and environmental effects on stress birefringence in silicon and zinc selenide windows
Paper 10374-12 Author(s): Kevin W. Peters, Thomas Yurovchak, Benjamin Dwyer, David E. Thompson, Robert T. Carlson, BAE Systems (United States)
Abstract Text: Stress birefringence in an output window affects the performance of polarization dependent remote sensing instruments, such as polarimeter based systems and certain lidar systems. In such instruments, stress birefringence results in reduced signal to noise ratios. Understanding the impact of window stress birefringence is crucial to understanding system performance. This paper utilizes a finite element model (FEM) to analyze the stress in Silicon and Zinc Selenide Windows induced by mounting and environmental conditions. Specifically, the impact of mounting induced twisting modes due to over tightened screws from the window mount to the platform are investigated. Additionally, the impact of environmental pressure differentials across the window are analyzed. The nodal results of the FEM model are interpolated to a uniform grid inside the window in order to simplify a polarization ray trace. Using these interpolated stresses in the window, the stress induced index ellipsoid matrix is calculated. Using this matrix, a Jones calculus based propagation is performed for an arbitrarily polarized input beam passing through the window. Since the accuracy of this method depends on the sampling in the window, a nodal analysis is performed to determine the minimum number of analysis layers that are necessary to achieve an accurate prediction of the stress birefringence. Using the method outlined, the impact of mounting and environmental effects on window performance is predicted and presented for both Silicon and Zinc Selenide windows. This paper also presents experimental results which validate the analysis method and its predictions.

Modeling the extremely lightweight Zerodur mirror (ELZM) thermal soak test

Paper 10374-14 Author(s): Thomas Brooks, NASA Marshall Space Flight Ctr. (United States); Tony B. Hull, The Univ. of New Mexico (United States); Ron Eng, H. Philip Stahl, NASA Marshall Space Flight Ctr. (United States)

Abstract Text: Schott's Extremely Lightweight Zerodur Mirror (ELZM) has been tested in the X-ray & Cryogenic Facility (XRCF) at Marshall Space Flight Center (MSFC). The mirrors surface was measured interferometrically at room temperature and at three soak temperatures (275K, 250K and 230K). The change in the mirrors figure caused by the change in the mirrors temperature is determined. A thermo-elastic model was built and the change in the mirror's optical surface is estimated for thermal gradients, mount effects, and coefficient of thermal expansion (CTE) inhomogeneity. The predictions of this model are compared to the test results, and the model is correlated to the test results by adjusting the mirror's spatial CTE distribution. The surface figure change per mirror depth caused by changing the temperature of a Zerodur mirror is estimated.

Calculation of density of states for modeling photoemission using method of moments

Paper 10374-15 Author(s): Daniel Finkenstadt, U.S. Naval Academy (United States); Samuel G. Lambrakos, Kevin L. Jensen, Andrew Shabaev, U.S. Naval Research Lab. (United States); Nathan A. Moody, Los Alamos National Lab. (United States)

Abstract Text: Modeling photoemission using the Moments Approach (akin to Spicer's "Three Step Model" is often presumed to follow simple models for the prediction of two critical properties of photocathodes: the yield or "Quantum Efficiency" (QE), and the intrinsic spreading of the beam or "emittance". The simple models, however, tend to obscure properties of electrons in materials, the understanding of which is necessary for a proper prediction of a semiconductor or metal's QE and emittance. This structure is characterized by localized resonance features as well as a universal trend at high energy. Presented in this study is a prototype analysis concerning the density of states (DOS) factor D(E) for Copper in bulk to replace the simple three-dimensional form currently used in the Moments approach. This analysis demonstrates that excited state spectra of atoms, molecules and solids based on density functional theory can be adapted as useful information for practical applications, as well as providing theoretical interpretation of density-of-states structure, e.g., qualitatively good descriptions of optical transitions in matter, in addition to DFT's utility in providing the optical constants and material parameters also required in the Moments Approach.

Scheduled Posters – 7 August 2017

Measurements of the optical anisotropy parameter of Tb:CaF_2 crystal

Paper 10374-16 Author(s): Alexey Yakovlev, Ilya L. Snetkov, Oleg V. Palashov, Institute of Applied Physics of the Russian Academy of Sciences (Russian Federation) Paper 10374-16 Author(s): Alexey Yakovlev, Ilya L. Snetkov, Oleg V. Palashov, Institute of Applied Physics of the Russian Academy of Sciences (Russian Federation)

Abstract Text: CaF2 crystals with Tb ions could be used as the magneto-optical material in Faraday isolators and rotators [1]. In such devices it is important to minimize of thermal depolarization that appears in magneto-optical element. One of the method of minimizing of thermal depolarization is based on its dependence on crystallographic axes [2]. Depolarization takes the minimum value in the optimal orientation of crystallographic axes, that is determined by the optical anisotropy parameter [3]. Because of weak absorption at 1070 nm, the depolarization in Tb:CaF2 (10at.% Tb) crystal does not show the dependence on laser power up to 1.5 kW [1] and it is not possible to apply the existing method of heating of the crystal to determine the optical anisotropy parameter [4]. In the experiment we used another method that is based on heating of the side surface of the cylindrical optical element. Obtained values for Tb:CaF2 were compared with data for CaF2 measured by both methods of heating of crystal. Using the obtained value of the optical anisotropy parameter at 1070 nm the optimal orientation of crystallographic axes for Tb:CaF2 was determined. Obtained value of the optical anisotropy parameter is necessary for numerical simulations and for minimizing of the thermal effects in such crystals.

Aqueous ethanol detection using a fiber-optic sensor based on Fresnel reflection

Paper 10374-18 Author(s): Umesh Sampath, Dae-gil Kim, Minho Song, Chonbuk National Univ. (Korea, Republic of)

Abstract Text: The measurement of ethanol concentrations in liquid environments is of vital importance for a variety of purposes such as food industry, ethanol production, chemical processing, fuel processing, and to use in forensic science and physiological research. Most common and commercial ethanol measurement techniques utilize semiconductor, electronic, and fuel cells. However, these systems are designed exclusively for vapor-phase measurements. Thus, they are usually bulky, and limited in range and selectivity. Also, the functionality is more limited than the required number of applications. These creates a demand for sensors to measure the ethanol concentrations in aqueous solutions with simple design and good accuracy. Optical fiber sensors have a great potential for various biological and chemical solute concentration measurement applications. In recent years, optical sensors have also been studied to measure the ethanol concentration. Various configurations, which include Ubent multimode fiber and tapered optical fiber with Graphene Oxide (GO) coating, have provided successful results to measure wide range of ethanol concentration in aqueous solutions. In addition to these, we propose a novel fiber-optic ethanol sensor based on Fresnel reflections. The proposed sensor system is functionalized with a thin-layer of ethanol-sensitive graphene oxide (GO) coating on a single mode optical fiber end. The trace of ethanol concentration was measured by the variations in Fresnel reflection intensity and the optical properties of graphene oxide. Aqueous ethanol concentration from 10% to 100% was measured successfully with the sensor system. The proposed fiber end with GO film exhibited real-time, remote measurements of ethanol concentration with high precision.

The optical schemes of head-mounted displays

Paper 10374-19 Author(s): Galina E. Romanova, Alexey V. Bakholdin, Vladimir N. Vasilyev, ITMO Univ. (Russian Federation)

Abstract Text: Recently there is a growing interest to the head up and head mounted systems. There are many variants of implementation of the head-mounted display system for various purposes with different characteristics. The configuration of the system is highly affected by both type of the image generator and the type of the used combiner. In many cases we need to design many variants of the scheme and even design new type to compare the characteristics and make a decision to manufacture and realize the system. We have considered several variants of the layout of the systems and compare their characteristics including the packaging and image quality. The systems were designed for operating with the same image generator.

Optical system for UV-laser technological equipment

Paper 10374-20 Author(s): Yuri V. Fedosov, Galina E. Romanova, Maxim Y. Afanasiev, ITMO Univ. (Russian Federation)

Abstract Text: Recently there is an intensive developing of intelligent industrial equipment. It can be rapidly adjusted for manufacturing and processing of certain details. This equipment can be robotic systems, automatic wrappers and markers, CNC machines and 3D printers. The equipment considered in the work is the system for selective curing of the photopolymer using the UV-laser, and using the UV radiation in such equipment leads to additional technical difficulties. In many cases for transporting the radiation from the laser to the point processed multi-mirror system is used, but such systems are usually difficult to adjust. Additionally, such multi-mirror systems are usually used as a part of equipment for laser cutting of metals using high-power IR-lasers. For the UV-lasers using many mirrors leads to crucial radiation losses because of many reflections. So, during the development of the optical system for technological equipment using UV-laser, we need to solve two main tasks: to transfer the radiation for working point with minimum losses and to include the system for managing the radiation spot position. We introduce the system for working with UV-laser with 1 W power and wavelength 423 nm based on fiber system. The modeling has shown that the optical system gives the sizes of the light spot of about 300□□m, the designed optical and mechanical systems (prototypes) were manufactured and assembled. In the paper we present the layout of the technological unit, the results of the theoretical modeling of the parts of the system and some experimental results.

Optical modeling of light scattering for refractive-index detection of liquids in a microcapillary with low-coherence rainbow diffractometry

Paper 10374-21 Author(s): Grzegorz Swirniak, Wroclaw Univ. of Science and Technology (Poland)

No Abstract Received

Density of states of Cs Sb calculated using density-functional theory for modeling photoemission

Paper 10374-22 Author(s): Daniel Finkenstadt, U.S. Naval Academy (United States); Samuel G. Lambrakos, Kevin L. Jensen, Andrew Shabaev, U.S. Naval Research Lab. (United States); Nathan A. Moody, Los Alamos National Lab. (United States)

No Abstract Received

The effect of laser ablation parameters on optical limiting properties of silver nanoparticles

Paper 10374-23 Author(s): Irmak Gürsoy, Roketsan A.S. (Turkey); Halime Gul Yaglioglu, Ankara Üniv. (Turkey)

No Abstract Received

Impact of the necking phenomenon on the spectral behavior of WO_3 aggregates

Paper 10374-24 Author(s): Krzysztof Skorupski, Wroclaw Univ. of Technology (Poland)

Abstract Text: Fractal-like aggregates are usually modelled as monodisperse particles positioned in point contact. However, this is a rough approximation which may lead to many inaccuracies in light scattering simulations. In reality, much more advanced connections between primary particles exist. Brasil studied the impact of the necking phenomenon on the morphological parameters of these geometries. He proposed a parameter for measuring the particle intersection level. It gives accurate results providing

that investigated aggregates are composed of monodisperse, spherical particles. In this work, new parameters for measuring both the intersection level and the neck level were introduced. In contrast to the study be Brasil, they can be used regardless of the particle size and shape. Additionally, the impact of the connection type on the spectral behavior of WO3 aggregates was studied. Two cases were investigated: when the volume of the aggregate (or two connected primary particles) was constant regardless of the connection type, and when it was dependent on the connection size and shape. For light scattering simulations, the ADDA algorithm was used. The wavelength varied from 400nm to 800nm. The number of dipoles per wavelength was never smaller than 200. The refractive index for WO3 was adapted from the paper by Vourdas et al. The results prove that necks have strong impact on the spectral behavior of WO3 aggregates. For example, in some cases, the relative cross section error can be even larger than 50%. They also prove that connections, which exist between primary particles, should not be excluded from aggregate models.

Associated Sessions:

Optical Engineering Plenary Session

Designing for one to one-million: how production quantities influence design
(Plenary Presentation) Paper 10376-201 Author(s): Leo B. Baldwin, Amazon.com, Inc. (United States)

The Large Synoptic Survey Telescope
(Plenary Presentation) Paper 10401-202 Author(s): Steven Kahn, Large Synoptic Survey Telescope (United States), SLAC National Accelerator Lab. (United States)

Opto-mechanical/Instrument Technical Group Event

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