07:00—08:15 • Conference Breakfast, *Tamaya Veranda*

07:00—17:30 • Registration, *Tamaya Ballroom Lobby*

Tamaya Ballroom ABCD

08:15—08:25
Opening Remarks
Presented by Conference General Chair, Li Li, *National Research Council Canada, Canada*, and Program Chair, *Robert Sargent ,VIAVI Solutions, USA*

08:25—09:05
Keynote Presentation: New Trends and Developments in the Field of Optical Interference Coatings, Norbert Kaiser, *Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Germany.* Consumer electronics, semiconductor lithography, medicine, life sciences, solar energy, architecture, aerospace, automotive, telecommunication, and quantum devices are pushing optical thin film technology to new frontiers, which are far beyond the present capabilities of established deposition processes and production strategies.

09:05—09:30
MA • Polarization Coatings
Presiders: Robert Schaffer; Evaporated Coatings, Inc, USA and Christopher Stolz; Lawrence Livermore National Laboratory, USA

MA.1 • 09:05
Infrared Wire-grid Polarizers with Improved Broadband Transmission Based on a Combination of a Nanogap Control and an Antireflection Coating, Wonyoung Kim[1], Tae Young Kim[1], Kyu-tae Lee[1], Minbaek Lee[1], Chang Kwon Hwangbo[1]; *[1]Inha Univ., Korea.* We demonstrate infrared wire-grid polarizers with enhanced transmittances over a broad range of wavelengths from 3 to 12 µm exploiting a combination of a nanogap control and an antireflection coating.

MA.2 • 09:10
Design and Fabrication of Superior Depolarized Beam Splitter Applied in Laser Beam Combining Technology, Hongfei Jiao[1], Xinshang Niu[1], Jinlong Zhang[1], Xinbin Cheng[1], Zhanshan Wang[1]; *[1]Tongji Univ., China.* We design a superior non-polarizing beam splitter using a special depolarized initial film structure. The structure fabricated by electron-beam evaporation retains T>98.57%@990nm and R>99.52%@976nm when the angle of incidence is 45 degree.

MA.3 • 09:15
Anisotropic Optical Coatings for Polarization Control in High-power Lasers, Lina Grineviciute[1], Rytis Buzelis[1], Karolis Gricius[1], Tomas Tolenis[1]; *[1]Center for Physical Sciences and Technology, Lithuania.* The novel approach of high band-gap birefringent coatings was proposed and investigated. Zero-order retarders with low optical losses and the potential to withstand high laser fluences at 355 and 266 nm wavelengths were produced.

MA.4 • 09:20
Study on the Polarization Contrast of Polarization Modulated Mirror Affected by Simulated Space Atomic Oxygen, Weibo Duan[1], Baojian Liu[1], Daqi Li[1], Deming Yu[1], Dingquan Liu[1]; *[1]Shanghai Inst. of Technical Physics, China.* The effect of space atomic oxygen on the polarization contrast of polarization modulated mirrors is investigated with different experimental doses. The results are important to the long-term space engineering application of the mirrors.

MA.5 • 09:25
Optical Coatings for a Spectrally Controlled Depolarization, Quentin Ailloud[1], Myriam Zerrad[1], Antonin Moreau[1], Julien H. Lumeau[1], Claude Amra[1]; *[1]Fresnel Inst., France.* We show how to control the wavelength variations of the polarization degree of a beam reflected by specific thin film depolarizers. The design, manufacturing and characterization of the depolarizing device is detailed.

09:30—10:00 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

10:00—11:00
MB • Coatings for Astronomy and Space
Presiders: James Barrie; The Aerospace Corporation, USA and Hsi-Chao Chen; National Yunlin Univ of Sci. and Tech., Taiwan

MB.1 • 10:00 Invited
Risk Mitigation and Testing of Optical Coatings for the Aladin LIDAR on the Aeolus Satellite, Denny Wernham[1]; *[1]The European Space Agency, Netherlands.* The Aladin instrument is the sole payload onboard of the Aeolus satellite. This paper describes the challenges during the instrument development paying particular regard to the optics in the laser and emission path, and the in-orbit performance.

MB.2 • 10:25
Behavior of 1064nm Coatings under Proton and Gamma Irradiation, Hongfei Jiao[1], Xuemin Zhang[1], Xinbin Cheng[1], Jinlong Zhang[1], Zhanshan Wang[1]; *[1]Tongji Univ., China.* The 1064nm coatings are fabricated, under irradiation with gamma rays(5Mrad) and exposure to low-energy (50keV) protons. It is proved that the coatings are stable in this condition by simulation of SRIM software and irradiation test.

MB.3 • 10:30
Investigations of Corrosion Feature Development on Protected Silver Mirrors during Accelerated Environmental Exposure, Kelsey A. Folgner[1], Chung-Tse Chu[1], Scott D. Sitzman[1], Sean C. Stuart[1], James D. Barrie[1]; *[1]Aerospace Corporation, USA.* Protected silver mirrors were subjected to accelerated environmental exposure testing to investigate the effects of layer composition on the development and growth of corrosion features along particular layer interfaces.

MB.4 • 10:35
Expanding the Far UV Range of Aluminum-coated Mirrors for Space-based Observations to Reflect Hydrogen Lyman Lines via Fluoride Multilayers, David D. Allred[1], Leoul E. Tilahun[2], Joseph G. Richardson[1,3], Robert S. Turley[1]; *[1]Brigham Young Univ., USA; [2]Applied Physics and Computer Engineering, Morehouse College, USA; [3]Code 551: optics branch, Goddard Space Flight Center, USA.* While no solid barrier layer is transparent below ~103nm, simulations show that ~9.5nm LiF on 8.5nm MgF_2 on Al could reflect some hydrogen Lyman lines better than a single fluoride layer does. Experiments are promising.

MB.5 • 10:40
Correlation of Long-duration and Accelerated Testing of Protected Silver Mirrors , Chung-tse Chu[1], Diana R. Alaan[1], James D. Barrie[1], Peter D. Fuqua[1]; [1]*The Aerospace Corporation, USA.* The stability of protected silver mirror coatings was studied by both long-exposure and a mixed-flowing-gas test with a goal of establishing accelerated testing parameters for Ag mirrors that are operated or stored in ambient conditions.

MB.6 • 10:45
Study on Anti-frosting Method by ITO for the Telescope in Antarctica, Jie Tian[1], Jinfeng Wang[1]; [1]*Nanjing Inst. of Astronomical Optics & Technology, CAS, China.* Antarctic is one of the best astronomical observation sites. However,mirror frosting is a problem that Antarctic astronomical instruments must overcome. This article will discuss ITO thin films used for frost prevention in reflection film system.

MB.7 • 10:50
Multi-dielectric Broadband Antireflection Deposition on the World's Largest Fused Silica Lens, Abdelhamid Ghrib[1], Adrien Hervy[1], François Riguet[1], Justin Wolfe[2], Christophe Couteret[1], Rémi Lhuillier[1], Hervé Leplan[1]; [1]*Safran Reosc, France;* [2]*Lawrence Livermore National Laboratory, USA.* The antireflection coating of the world's largest fused silica lens is presented. The final coating exhibits more than 97% of averaged throughput for 300-1100nm spectral band. Coating has been performed with a qualified PVD process.

MB.8 • 10:55
Research Development of Ultra Wideband High Reflection Films for Astronomical Telescopes, Jinfeng Wang[1], Jie Tian[1]; [1]*Nanjing Inst Astronomical Optics & Tech, China.* More critical performance is required for astronomical mirrors, such as wider wavelength region and better environment durability. In this paper, the design and experimental progress of ultra-wideband high-reflective film are introduced.

11:00—12:00 • MAB • Monday Morning Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

MA.1	MB.2
MA.2	MB.3
MA.3	MB.4
MA.4	MB.5
MA.5	MB.6
	MB.7
	MB.8

12:00—13:30 • Conference Lunch, *Cottonwoods Pavilion and Patio*

13:30—14:50
MC • Energy Management and Infrared Coatings
Presiders: Jennifer Kruschwitz, University of Rochester, USA and James Oliver, University of Rochester, USA

MC.1 • 13:30 Invited
Surface Coatings for Improving Solar Cell Efficiencies, Qing Shen[1]; [1]*The Univ. of Electro-Communications, Japan.* The efficiencies of the next generation solar cells such as quantum dot (QD)-based solar cells and perovskite solar cells can be improved largely through surface coating on the interfaces and the mechanism have been investigated.

MC.2 • 13:55
Selective Color Perovskite Solar Cell Modulated by Organic Fabry-Perot Interference Structure, Ming-Hsien Yen[1], Hsi-Chao Chen[1], Shu-Wei Guo[1], Ya-Jun Zheng[1], Yu-Ren Zhao[1], Jia-Wei Liang[1]; [1]*National Yunlin Univ of Sci. and Tech., Taiwan.* The Fabry-Perot cavity principle was used to selective color organic perovskite solar cell, and the color is selected by the thickness controlling of the resonant cavity then is applied to the building integrated photovoltaic.

MC.3 • 14:00
Symmetrical TiN-SiO_2 Multilayer as an Absorber for Solar Thermo-photovoltaic System, Yi-Jun Jen[1], Meng-Jie Lin[1], Zheng-Xing Li[1], Ming-Zheng Li[1]; [1]*National Taipei Univ. of Technology, Taiwan.* A symmetric film stack with TiN and SiO_2 was designed using admittance tracing method as an ultra-thin light absorber. With optical property of TiN, the film stack is suitable to be applied for solar thermo-photovoltaics.

MC.4 • 14:05
Effective, Angle-independent Radiative Cooler Based on One-dimensional Photonic Crystal, Huanxin Yuan[1], Weidong Shen[1], Chenying Yang[1], Yueguang Zhang[1], Xu Liu[1]; [1]*Zhejiang Univ., China.* We proposed an effective radiative cooler based on one-dimensional photonic crystal, which has an average emissivity of 96% within the atmospheric transparency window (8-13µm) and the maximum cooling power density of 113.0W/m^2 at night.

MC.5 • 14:10
Thermochromic VO_2 Coatings for Energy Control, Bill Baloukas[1], Rodrigue Beaini[1], Simon Loquai[1], Oleg Zabeida[1], Jolanta-Ewa Klemberg-Sapieha[1], Ludvik Martinu[1]; [1]*Engineering Physics, Polytechnique Montreal, Canada.* Thermochromic VO_2 coatings offer opportunities in a variety of applications such as smart windows and smart radiators. By incorporating these films into appropriately designed material architectures, significant performance enhancements are obtained.

MC.6 • 14:15
VO_2-polymer Nanostructured Coatings for Smart Windows: A Numerical Study, Cindy Péralle[1], Renée Charrière[1], Jenny Faucheu[1]; [1]*Mines Saint-Etienne, France.* Thermochromic vanadium dioxide loaded into a polymer opal photonic crystal is studied through optical simulations. The possibility of using this material as flexible transparent energy efficient smart material is explored.

MC.7 • 14:20
Infra-red Multi-layer Coatings Using YbF_3 and ZnS in an Ion Beam Sputtering System, Alex Ribeaud[1], Jürgen Pistner[1], Harro Hagedorn[1], Shay Joseph[2]; [1]*Bühler Leybold Optics, Germany;* [2]*Rafael Advanced Defense System, Israel.* Optical and mechanical properties from Infra-Red Anti-Reflective coatings deposited using YbF_3 and ZnS as layer materials in an Ion Beam Sputtering system.

MC.8 • 14:25
Laser-related Broadband Dichroic Filters Based on Ge/YbF_3 and ZnS/YbF_3 Thin-film Materials, Tatiana Amotchkina[1], Michael K. Trubetskov[2], Marcus Schulz[3], Vladimir Pervak[1]; [1]*Ludwig-Maximilians-Univ. Munich, Germany;* [2]*Max-Planck-Institut für Quantenoptik, Germany;* [3]*Agilent Technologies, Germany.* We developed broadband filters for pump-probe spectroscopy studying ultrafast dynamics of biological molecules. ZnS/YbF_3 and Ge/YbF_3 filters operating at Brewster angle of ZnSe substrate transmit mid-infrared and reflect near-infrared radiation.

MC.9 • Withdrawn

MC.10 • 14:35
Durable Infrared Optical Coatings Based on Pulsed DC Sputtering of Hydrogenated Carbon, Des Gibson[1]; [1]*Univ. of the West of Scotland, UK.* Optical, mechanical, stress and environmental properties of room temperature pulsed DC sputter deposited hydrogenated carbon are presented. Results show suitable optical, environmental and durability performance for durable infrared optical coatings.

MC.11 • Withdrawn

MC.12 • 14:45
Peeling Prevention by SiO Layer for Far-infrared Filter Consisting of Ge/Na_3AlF_6, Koichi Muro[1]; [1]*ASAHI SPECTRA Co., Ltd., Japan.* We found the effect of peeling prevention by SiO layer on the Na_3AlF_6 ultra-thick film constituting the far-infrared filter (Ge/Na_3AlF_6). Using this filter, the HFC gas imaging was performed with a thermal camera.

14:50—15:15 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

15:15—16:15
MD • Novel Coating Processes and Materials
Presiders: Daniel Poitras; National Research Council of Canada, Canada and Jue Wang; Corning Advanced Optics, USA

MD.1 • 15:15 Invited
Progress in Optical Interference Filters Manufactured by Thermal Drawing, Hooman Banai[1]; [1]*Everix Optical Filters, USA.*

MD.2 • 15:40
Glancing-angle–deposited Silica Films for Ultraviolet Wave Plates, Sara MacNally[1], Chris Smith[1], John Spaulding[1], Justin Foster[1], James B. Oliver[1]; [1]*Laboratory for Laser Energetics, USA.* Birefringent silica films are formed by glancing-angle deposition to fabricate quarter- and half-wave plates at a wavelength of 351 nm. A multilayer design is implemented to achieve low-loss transmittance with a high 351-nm laser-damage threshold.

MD.3 • 15:45
High Reflectivity Coatings Based on Sculptured Thin Films, Tomas Tolenis[1], Lina Grineviciute[1], Andrius Melninkaitis[2], Rytis Buzelis[1]; [1]*Department of Laser Technologies, FTMC, Lithuania;* [2]*Vilnius Univ., Lithuania.* Novel route is presented to manufacture high reflection coatings using only SiO_2 material and GLAD method. A numerous analyses indicate the superior properties of all-silica coatings when compared with standard methods for Bragg mirrors production.

MD.4 • 15:50
Solution-processed Angle-insensitive Structural Colors via Electrodeposition of Thin-films, L. Jay Guo[1], Saurabh Acharya[1], Chengang Ji[1]; [1]*Department of Electrical Engineering and, USA.* Applications of structural-colors has been limited due to their high fabrication cost. Here, we introduce an electrodeposition-process for the fabrication of structural -colors at ambient conditions, thereby avoiding the need for vacuum-based systems.

MD.5 • 15:55
Fluorinated Hybrid Coatings Deposited by IBACVD, Oleg Zabeida[1], William Trottier-Lapointe[2], Erwens Broustet[1], Ludvik Martinu[1]; [1]*Polytechnique Montreal, Canada;* [2]*R&D, Essilor International, France.* SiOCHF films deposited in a standard box coater fitted with a broad beam ion source demonstrate low refractive index combined with a relatively high hardness and elastic recovery values, making them attractive for use in ophthalmic applications.

MD.6 • 16:00
Contamination-resistant Multifunctional Coatings, Nadja Felde[1,2], Anne-Sophie Munser[1,2], Anne Gärtner[1,2], Sven Schröder[1], Andreas Tünnermann[1,2]; [1]*Fraunhofer IOF, Germany;* [2]*Friedrich-Schiller Univ., Germany.* Combining thin film design with structural design enables contamination-resistant coatings with high optical quality to be realized. Balancing self-cleaning and light scattering relevant structural components is of particular importance.

MD.7 • 16:05
Enhanced Optical Absorption Achieved via Laser Induced Nano-porous Silicon Thin-film for Photovoltaic Devices, Chirag Paladiya[1], Amirkianoosh Kiani[1]; [1]*Univ. of Ontario Inst. of Tech, Canada.* Laser induced diverse silicon nano-porous structures were studied to comprehend its light absorption capabilities within visible range of light. In addition, various characterization methods like SEM and EDX were employed for sound comprehension.

MD.8 • 16:10
Kinetic Study of Polystyrene Thin Film Depositions by Cationic Chemical Vapor Deposition, Dominic Giambra[1], Wyatt Tenhaeff[1]; [1]*Univ. of Rochester, USA.* Cationic initiated chemical vapor deposition (catCVD) synthesizes high quality polymer thin films. catCVD is nonliving, follows a second order rate law, and has an activation energy on the same order of magnitude as solution polymerizations.

16:15—17:30 • MCD • Monday Afternoon Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

MC.2	MD.2
MC.3	MD.3
MC.4	MD.4
MC.5	MD.5
MC.6	MD.6
MC.7	MD.7
MC.8	MD.8
MC.10	
MC.11	
MC.12	

19:00—20:00
Evening Presentation: Invisibility Cloaks and Other "Impossible" Optics—Metamaterials: From Revolutionary Science to Disruptive Technology, David R. Smith, *Duke University, USA.* Metamaterials have provided a new framework for the design of optical and electromagnetic devices, giving way to the demonstration of unique materials and structures such as negative index media and "invisibility cloaks." In this talk I'll provide an introduction to metamaterials and an overview of their profound impact on optics and their current transition to commercial products.

Photography, videography and audio recordings can be a distraction to speakers and are not permitted in technical sessions.

07:00—08:15 • Conference Breakfast, *Tamaya Veranda*

07:30—17:30 • Registration, *Tamaya Ballroom Lobby*

Tamaya Ballroom ABCD

08:15—09:30
TA • Metamaterials and Metal-based Coatings
Presiders: Norbert Kaiser; Fraunhofer IOF, Germany and Michel Lequime; Institut Fresnel, France and Hiroshi Murotani; Tokai Univ., Japan

TA.1 • 08:15 Invited
Optical Coatings for Metamaterials, Yi-Jun Jen[1]; *[1]National Taipei Univ. of Technology, Taiwan.* With design methods used in optical coatings, the equivalent admittance and refractive index of stratiform metamaterial can be tailored for low loss metamaterial, ultra-thin dark metamaterial, angular insensitive filter and hyperbolic metamaterial.

TA.2 • 08:40
Broadband Absorption of Indium Tin Oxide Nanograting Hyperbolic Metamaterials in Near-infrared Region, Tae Young Kim[1], Jihye Yoo[1], Minsuk Kim[1], Wonyoung Kim[1], Kyu-tae Lee[1], Chang Kwon Hwangbo[1]; *[1]Inha Univ., Korea.* We investigated optical properties of indium tin oxide(ITO) nanograting hyperbolic metamaterial(HMM) and present a broadband absorption behavior of ITO nanograting HMM that exploit epsilon-near-zero and epsilon-near-pole resonances in near-infrared.

TA.3 • 08:45
Tuning Absorption in Angular Selective Slanted Column Films, Sasha Woodward-Gagné[1], Oleg Zabeida[1], Bill Baloukas[1], Ludvik Martinu[1]; *[1]Polytechnique Montreal, Canada.* Core-shell slanted column thin films (SCTF) are made through atomic layer deposition of TiN over SiO_2 SCTFs. The films exhibit angular selectivity similar to metallic SCTFs with the added benefit of highly tunable absorption.

TA.4 • 08:50
Demonstration of Dual-channel Two-dimensional Reflection Grating Filter, Jianyu Zhou[1], Xinbin Cheng[1], Jinlong Zhang[1], Hongfei Jiao[1], Zhanyi Zhang[1], Haoran Li[1], Zhanshan Wang[1]; *[1]Tongji Univ., China.* The dual-channel two-dimensional reflection grating filter is demonstrated. The design of anti-reflective thin films suppresses the sidebands and the corresponding excitation modes of dual-channel reflection peaks are determined.

TA.5 • 08:55
Photonic Spin Hall Effect Based on Broadband High-efficiency Metasurfaces, Zhanyi Zhang[1,2], Haigang Liang[1,2], Tao He[1,2], Zhanshan Wang[1,2], Xinbin Cheng[1,2]; *[1]Tongji Univ., MOE Key Laboratory of Advanced Micro-Structured Materials, China; [2]School of Physics Science and Engineering, Tongji Univ., Inst. of Precision Optical Engineering, China.* The photonic spin Hall effect metasurfaces utilizing broadband high-efficiency half-wave plate were proposed, which can generate broadband high-intensity left and right circular polarized light that could be applied in chiroptical spectroscopy.

TA.6 • 09:00
Metamaterials to Design a Class of Optical Coatings with Identical Properties, Claude Amra[1], Ahmed Alwakil[1], Myriam Zerrad[1,2], Michel Lequime[1,2]; *[1]Institut Fresnel, CNRS, France; [2]Aix Marseille Univ, France.* We use transformation optics to design optical coatings all having identical amplitude properties.

TA.7 • 09:05
Metal Dielectric Grating with High Laser Damage Threshold, Fanyu Kong[1], Xi Zou[2,3], Jiao Xu[3,1], Junming Chen[3,1], Yibin Zhang[1], Yonglu Wang[1], Yunxia Jin[1], Hongchao Cao[1], Peng Chen[3,1], Jianda Shao[1]; *[1]Shanghai Inst of Optics and Fine Mech, China; [2]School of Physical Science and Technology, ShanghaiTech Univ., China; [3]Univ. of Chinese Academy of Sciences, China.* A new 800nm center-wavelength metal dielectric grating with all SiO_2 grating structures is designed and tested, which has a high laser damage threshold of $0.40J/cm^2$ on grating surface at pulse duration of 32fs.

TA.8 • 09:10
Optical Properties of Uniform and Nanostructured TiN Thin Films, Yi-Jun Jen[1], Ming-Zheng Li[1], Zheng-Xing Li[1], Meng-Jie Lin[1]; *[1]National Taipei Univ. of Technology, Taiwan.* TiN thin films and nanorod array are grown in magnetron sputtering system. The tailored permittivity via changing the nitrogen flow rate is reported. The polarization dependent plasmonic modes are investigated by analyzing the absorptance spectra.

TA.9 • 09:15
Optimizing the Deposition of Sputtered Gold Island Films with Time Derivative Surface Reflectance, Antonin Riera[1], Bill Baloukas[1], Oleg Zabeida[1], Ludvik Martinu[1]; *[1]Polytechnique Montreal, Canada.* Analysis of the *in situ* reflectance spectra during sputtering of gold allows for the characterization of different growth regimes throughout the deposition. The validity of this method is assessed and discussed.

TA.10 • 09:20
Localized Surface Plasmon Investigation of Silver Islands Layer Formed by Thermal Evaporation Technique, Audrius Valavičius[1], Alfonsas Juršenas[1], Mantas Drazdys[1], Alexandr Belosludtsev[1], Ramutis Drazdys[1]; *[1]Laser Technologies, FTMC, Lithuania.* Investigation of optical, morphology, and localized surface plasmon properties of silver islands layers was done. Silver layer was formed by thermal evaporation. Dependencies on deposition temperature and silver layer thickness were studied.

TA.11 • 09:25
Patterned Absorbers in Visible to NIR Region, Zhen Wang[1], Weidong Shen[1], Chenying Yang[1], Yueguang Zhang[1]; *[1]Zhejiang Univ., China.* We propose a novel absorbers structure, based on Cr/Cr_2O_3 film stack which presents high absorption up to ~99% for 400-1200nm band. An etching method preventing corrosion of the glass substrate is also proposed.

TA.12 • Withdrawn

9:30—10:00 • Coffee Breaks and Exhibits, *Tamaya Ballroom EFGH*

10:00—11:00
TB • Nanostructured Materials
Presiders: Weidong Shen; Zhejiang Univ., China and Markus Tilsch; Viavi Solutions Inc, USA

TB.1 • 10:00 Invited
Semiconducting 2D Materials of Atomic Thickness in Optical Coatings: Towards Novel Applications, Falk Eilenberger[1,2]; [1]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Univ., Germany;* [2]*Center of Excellence in Photonics, Fraunhofer-Inst. for Applied Optics and Precision Engineering IOF, Germany.* I will discuss their specific properties, focusing on the development of excitonic systems and on highly nonlinear optical coatings for wavelength conversion and quantum light sources.

TB.2 • 10:25
Nanostructured Layers for Optical Coatings with Improved UV-transmission , Ulrike Schulz[1], Friedrich Rickelt[1], Peter Munzert[1], Nancy Gratzke[1]; [1]*Fraunhofer IOF, Germany.* Nanostructured low-index layers are produced on glass and plastics by coating and plasma-etching of organic and inorganic materials. The organic content was reduced afterwards to achieve antireflective coatings with increased UV-transparency.

TB.3 • 10:30
Quantized Nanolaminates as Versatile Materials for Optical Interference Coatings, Morten Steinecke[1], Holger Badorreck[1], Marco Jupé[1], Thomas Willemsen[2], Lars Jensen[1], Detlev Ristau[1]; [1]*Laser Zentrum Hannove e.V., Germany;* [2]*Laseroptik GmbH, Germany.* In this paper, the theoretical foundation of quantized nanolaminates is explained and the dependence of the optical band gap on the quantum well thickness is derived. The manufacturing is investigated applying molecular dynamics simulation.

TB.4 • 10:35
Manufacturing of Quantized Nanolaminates, Marco Jupé[1], Thomas Willemsen[2], Liu Hao[3], Morten Steinecke[1], Lars Jensen[1], Detlev Ristau[1]; [1]*Laser Zentrum Hannover e.V., Germany;* [2]*Laseroptik GmbH, Germany;* [3]*LNQE, Leibniz Universität Hannover, Germany.* The application of novel quantized nanolaminates delivers more flexible application and allows to optimize the properties. In the paper, the manufacturing of nanolaminates using different deposition techniques and material combinations are discussed.

TB.5 • 10:40
Elimination of Spatial Hole Burning in Solid-state Lasers Using Anisotropic Nanostructured Thin Films, Koffi Amouzou[1], Jean-Francois Bisson[1]; [1]*Universite de Moncton, Canada.* Birefringent layers deposited on top of laser mirrors enable the elimination of the nodes of the intra-cavity standing wave pattern by forcing the polarization states of counter-propagating waves to be orthogonal, resulting in single-mode emission.

TB.6 • 10:45
Design and Prototyping of Hybrid Interference Filters, Anna Sytchkova[1], Maria Luisa Grilli[2], Guohang Hu[2], Yingjie Chai[2], Daniele De Felicis[3], Hongbo He[2], Edoardo Bemporad[3], Angela Piegari[1], Jianda Shao[2]; [1]*Energy Department, ENEA Optical Coatings Group, Italy;* [2]*Key Laboratory of Materials for High Power Laser, SIOM CAS, China;* [3]*Engineering Department, Univ. Roma 3, Italy.* Nano-structured surfaces for hybrid interference optical filters were designed by finite-element method and their prototypes were fabricated using r.f. sputtering, focused ion beam lithography and direct laser writing.

TB.7 • 10:50
Anti-reflective Nanostructures and Coatings on Sapphire Substrates for Extreme Temperature Applications, Shay Joseph[1], Evyatar Kassis[1], Gal Reich[1], Doron Yadlovker[1], Arit Shinman[1]; [1]*Rafael, Israel.* Anti-reflective coatings and nanostructures were fabricated on sapphire substrates. The transmission measured was 98-99%, in contrast to the transmittance of uncoated sapphire which is 88%. The coatings and nanostructures survived up to 1200C.

TB.8 • Withdraw

11:00—12:00 • TAB • Tuesday Morning Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

TA.2	TB.2
TA.3	TB.3
TA.4	TB.4
TA.5	TB.5
TA.6	TB.6
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TA.10	
TA.11	

12:00—13:30 • Conference Lunch, *Cottonwoods Pavilion and Patio*

Tamaya Ballroom ABCD

13:30—14:45
TC • Design Problem and Design I
Presiders: Karen Hendrix; Viavi Solutions, USA and Yi-Jun Jen; National Taipei Univ. of Technology, Taiwan

TC.1 • 13:30 Invited
Results of the OIC 2019 Design Problem Contest, Jennifer D. Kruschwitz[1], Vladimir Pervak[2], Jason Keck[3]; *[1]Univ. of Rochester, USA; [2]Ludwig-Maximilians-Universität München, Germany; [3]Reynard Corporation, USA.* The design problems for OIC 2019 involved revisiting an OIC 2007 beamsplitter challenge and designing for a light-mixing system.

TC.2 • 14:00
Design of Multilayer Coatings Using Deep Search Methods, Michael K. Trubetskov[1]; *[1]Max Planck Inst. of Quantum Optics, Germany.* New deep search needle optimization, gradual evolution, and design cleaner methods are proposed. Novel methods have an outstanding performance and allow obtaining solutions of the most challenging design problems from scratch.

TC.3 • 14:05
Narrowband Angle Filter, William H. Southwell[1]; *[1]Table Mountain Optics, USA.* Narrowband pass filters are essentially narrowband angle filters, but only in the plane of incidence. It is shown that a combination of tilted polarization-insensitive narrowband pass filters will select light from narrow angle patches.

TC.4 • 14:10
Facet Coating Designs Robustness, Daniel Poitras[1]; *[1]National Research Council of Canada, Canada.*
In this work, we use Monte Carlo and Polynomial Chaos Expansion (PCE) approaches to evaluate the robustness of a waveguide facet coating design, and estimate the sensitivity indices its individual layers.

TC.5 • 14:15
Designing with Very Thin Optical Films, Ronald R. Willey[1], Fred T. Goldstein[2]; *[1]Willey Optical, Consultants, USA; [2]FTG Software LLC, USA.* Indices of refraction for very thin layers (<30 nm) change widely with the layer thickness, the bounding materials, and the processes used to produce the films. The tools to design with these layers are described.

TC.6 • 14:20
Angle-insensitive Decorative NIR Transmission Filter, Chenying Yang[1], Chengang Ji[2], Weidong Shen[1], Kyu-tae Lee[2], Yueguang Zhang[1], L. Jay Guo[2]; *[1]Zhejiang Univ., China; [2]Univ. of Michigan, USA.* We proposed a decorative but near-infrared-transmitting filter based on one-dimensional photonic crystal, which possesses high-efficiency and angular-insensitivity.

TC.7 • 14:25
Optimized Angular Insensitive Filter by Admittance Tracing Method, Yi-Jun Jen[1], Meng-Jie Lin[1], Zhi-Heng Yu[1]; *[1]National Taipei Univ. of Technology, Taiwan.* An angular insensitive narrow bandpass filter is designed using the admittance tracing method. In order to improve the effects of sideband, the initial bandpass spectra are improved here by adjusting thickness of each film.

TC.8 • 14:30
Focused Light on Thin-films Revisited: Analytical Results for Parallel and Tilted Apertures, Thomas Goossens[1,2], Chris Van Hoof[2,1]; *[1]KU Leuven, Belgium; [2]imec vzw, Belgium.* The central wavelengths of narrowband thin-film filters shift when illuminated at oblique incidence. We discuss new analytical results for focused light from the aperture of a lens. The results are also applicable to tilted apertures.

TC.9 • 14:35
Bandwidth of Principle Stopbands of Thin-film Thickness Modulated Designs, Bruce E. Perilloux[1]; *[1]Coherent Inc., USA.* Thickness modulated designs are investigated for bandwidth of principle stopbands (1,0) and (1,1) versus modulation frequency. The bandwidths of the (1,0) and (1,1) stopbands, and their sum are virtually constant for modulation frequencies 0.1-0.5.

TC.10 • 14:40
Experimental Validation of the Robust Optimization Algorithm for High-fluence Optical Coatings, Marine Chorel[1], Eric A. Lavastre[1], Thomas Lanternier[1], Bruno Bousquet[2], James B. Oliver[3], Amy Rigatti[3], Nicolas Bonod[4], Alexei A. Kozlov[3], Brittany Hoffman[3], Stavros Demos[3], Jerome Daurios[1], Jerome Neauport[1]; *[1]CEA , France; [2]Celia, Bordeaux Univ., France; [3]LLE, USA; [4]Institut Fresnel, France.* The robust-optimization algorithm is validated for the laser-induced damage threshold of multilayer-dielectric mirrors. The robust design approach shows a significant improvement compared to the classical design, validating our calculation method.

14:45—15:10 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

15:10—15:15 • In Memoriam: Stefan Günster, Marcus Turowski, *Tamaya Ballroom EFGH*

Tamaya Ballroom ABCD

15:15—16:10
TD • Sensing and Design II
Presiders: Ulrike Schulz; Fraunhofer IOF, Germany and Michael Trubetskov; Max Planck Inst. of Quantum Optics, Germany

TD.1 • 15:15 Invited
The Role of Optical Coatings in Super-resolution Optical Nanoscopy, Xu Liu[1]; *[1]State Key Lab of Modern Opt. Instrum., Zhejiang Univ., China.* The super-resolution microscopy is widely used for sub bio cell imaging.There are many new coating devices used in the imaging system. We review the applications of optical coatings in dfferent nanoscopy.

TD.2 • 15:40
Surface-enhanced Raman Scattering from Obliquely Deposited TiN Nanorod Arrays, Yi-Jun Jen[1], Meng-Jie Lin[1], Hou-Lon Cheang[1], Zhi-Heng Yu[1], Meng-Hsun Chung[1]; *[1]National Taipei Univ. of Technology, Taiwan.* Titanium nitride nanorod arrays were prepared as surface-enhanced Raman scattering substrates using glancing angle deposition. The signals of titanium nitride nanorod arrays with different porosities were measured to discuss the enhancement.

TD.3 • 15:45
Optimized All-dielectric Interference Coatings for Giant Field Enhancement in Sensing Applications, Dikai Niu[2,1], Myriam Zerrad[2], Aude Ledeu[2], Vincent Aubry[1], Fabien Lemarchand[2], Ali Passian[3], Juan Antonio Zapien[4], Claude Amra[2]; *[1]PSA Groupe, France; [2]Institut Fresnel, France; [3]Oak Ridge National Laboratory, USA; [4]City Univ. of Hong Kong, China.* A new synthesis method based on null-admittance location is presented. Its first application to the design of high sensitivity sensors is detailed and the expected

TD.4 • 15:50
Design and Investigation of Tunable Tamm Plasmons Based Device for Infrared Applications, Alexandr Belosludtsev[1], Naglis Kyzas[1], Victor Reshetnyak[2]; *[1]Center for Physical Sciences and Technol, Lithuania; [2]Physics Faculty, Taras Shevchenko National Univ. of Kyiv, Ukraine.* Tunable Tamm plasmons based device was design and investigated. The suggested device structure comprises the Bragg mirror and metallic layer. The influence of the layers thicknesses on the device transmittance, reflectance and absorption was studied.

TD.5 • 15:55
Automated Design of Optical Thin Films via Statistical Inference and Parallelized Computation, Amit Deliwala[1]; *[1]Light Matters LLC, USA.* The design of optical films for broadband applications is computationally intensive and algorithmically challenging. Demonstrated here is film design via pseudo-inverse transform sampling and parallelization for light bulb efficiency enhancement.

TD.6 • Withdrawn

TD.7 • 16:05
Numerical Modeling of Visible Electromagnetic Wave through Optical Filters Using One-dimensional Finite-difference Time-domain (1D-FDTD) Method, Remalyn V. Fajardo[1], Raymund Lee Antonio C. Sarmiento[2]; *[1]Univ. of San Carlos, Philippines; [2]Biology and Environmental Studies, Univ. of the Philippines, Philippines.* Various optical filter applications each demand specific device performance. With the quest for better design optimization, the 1D-FDTD method was utilized to model optical filters. The model was verified and found to give accurate results.

16:10—17:00 • TCD • Tuesday Afternoon Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

TC.2	TD.2
TC.3	TD.3
TC.4	TD.4
TC.5	TD.5
TC.6	TD.7
TC.7	
TC.8	
TC.9	
TC.10	

17:00—18:30 • TE • Postdeadline Papers Session, *Tamaya Ballroom EFGH*

07:00—08:15 • Conference Breakfast, *Tamaya Veranda*

08:00—17:30 • Registration, *Tamaya Ballroom Lobby*

Tamaya Ballroom ABCD

08:15—09:30
WA • Patterned and Variable Coatings / Process Control
Presiders: Harro Hagedorn; Bühler Leybold Optics, Germany and Chang Kwon Hwangbo; Inha Univ., Korea

WA.1 • 08:15 Invited
Progress in Patterned Filters for Optical Sensors, Georg J. Ockenfuss[1], Robert B. Sargent[1], Fred Van Milligen[1]; [1]*VIAVI Solutions Inc., USA.* The patterning of optical filters to enable sensors dates back more than 50 years. Today this technology serves numerous aerospace, industrial, and consumer electronics applications.

WA.2 • 08:40
Laser-induced Control of the Central Wavelength of Bandpass Filters, Antoine Bourgade[1], Frederic Lemarquis[1], Thomas Begou[1], Julien H. Lumeau[1]; [1]*Institut Fresnel - UMR 7249 – CNRS, France.* We perform theoretical and experimental demonstration of a-posteriori control of the central wavelength of bandpass filters. This approach relies on chalcogenide-based photosensitive layers. Examples of various Fabry-Perot filters is provided.

WA.3 • 08:45
Structured IR Thin Film Coatings for Multi-spectral Imaging, Rémi Lhuillier[1], Léopold Macé[1], El-Houcine Oubensaid[1], Benjamin Portier[1], Hervé Leplan[1], Olivier Gauthier-Lafaye[2], Antoine Monmayrant[2]; [1]*Safran Reosc, France;* [2]*LAAS-CNRS, France.* Safran Reosc deposits and patterns thin film coatings on the active region of infrared focal-plane-arrays for real-time multispectral imaging. Processes range from pixel to nano-scale structures and exploit both optical interferences and photonics.

WA.4 • 08:50
Angularly Tunable Bandpass Filter: Design, Fabrication and Characterization, Julien H. Lumeau[1], Fabien Lemarchand[1], Thomas Begou[1], Detlev Arhilger[2], Harro Hagedorn[2]; [1]*Institut Fresnel - UMR 7249 – CNRS, France;* [2]*Bühler, Germany.* We demonstrate an angularly tunable bandpass filter. Central wavelength is changed from 970 nm down to 880 nm when angle of incidence is change from 0 to 50°. Design, fabrication and characterization procedures are presented.

WA.5 • 08:55
Linearly Variable Filters Fabricated by Magnetron Sputtering Technology, Thomas Begou[1], Frederic Lemarquis[1], Antonin Moreau[1], Fabien Lemarchand[1], Holger Reus[2], Detlev Arhilger[2], Harro Hagedorn[2], Julien H. Lumeau[1]; [1]*Fresnel Institut, France;* [2]*Bühler Leybold Optics, Germany.* In this paper, we present the fabrication of linearly variable filters deposited by magnetron sputtering, using a Bühler HELIOS machine. Filters present a continuous shift of the central wavelength from 500 nm to 900 nm over 10 mm aperture.

WA.6 • 09:00
Linear Variable Bandpass Filter for Hyper-spectral Imaging Camera in Agriculture Applications, Shigeng Song[1], Des Gibson[1]; [1]*Univ. of the West of Scotland, UK.* Linear Variable Passband Filters were used to develop a prototype of portable, low-cost Hyper Spectral Crop Camera that demonstrated good spectral performances and disease detection capabilities in crops (based on spectral responses).

WA.7 • 09:05
High-resolution Optical Broadband Monitoring for the Production of Miniaturized Thin-film Filters, Florian Carstens[1], Henrik Ehlers[1], Sebastian Schlichting[1], Lars Jensen[1,2], Detlev Ristau[1,2]; [1]*Laser Zentrum Hannover e.V., Germany;* [2]*PhoenixD, Leibniz Universität Hannover, Germany.* To increase the accuracy of layer thicknesses in the production of miniaturized thin-film filters controlled by optical broadband monitoring, a high-resolution monitoring system was developed and evaluated by coating simulations and experiments.

WA.8 • 09:10
The Error Self-compensation Effect in the Broadband Monitoring of Multiband Filters, Xiaochuan Ji[1,5], Jinlong Zhang[1,5], Xinbin Cheng[1,5], Zhanshan Wang[1,5], Ivan Matvienko[2], Temur Isaev[3], Alexander V. Tikhonravov[4]; [1]*MOE Key Laboratory of Advanced Micro-Structured Materials, Tongji Univ., China;* [2]*Skolkovo Inst. of Science and Technology (Skoltech), Russian Federation;* [3]*Department of Physics, Moscow State Univ., Russian Federation;* [4]*Research Computing Center, Moscow State Univ., Russian Federation;* [5]*Inst. of Precision Optical Engineering, School of Physics Science and Engineering, China.* The paper investigates production of the multiband filter by broadband monitoring. A special 4-line filter was designed and the simulation demonstrated the layer thickness errors self-compensation effect that was quite significant.

WA.9 • 09:15
Hybrid Mode Optical Monitoring – Monochromatic and Broadband Algorithms in the same Coating Process , Stephan Waldner[1], Jürgen Buchholz[1], Rico Benz[1]; [1]*Evatec Ltd., Switzerland.* Broadband monitoring with high signal quality enables using both broadband and monochromatic layer termination algorithms in the same coating run. Examples of a bandpass filter and an absorbing layer show the benefits of this "hybrid" approach.

WA.10 • 09:20
Monochromatic and Broadband Optical Monitoring for Deposition of Band Pass Filters, Binyamin Rubin[1], Jason George[1], Sandeep Kohli[1], Kyle Godin[1], Riju Singhal[1], David Deakins[2]; [1]*Veeco, USA;* [2]*Meliora, USA.* Applications of monochromatic and broadband optical monitoring methods for deposition of different types of bandpass filters are considered. We demonstrate how optical monitoring system performance can be matched to filter specifications.

WA.11 • 09:25
Broadband Optical Endpoint Monitoring with Virtual Deposition System, Michael Chesaux[1], Dino Deligiannis[1]; [1]*Intlvac, Inc, Canada.* Hybrid broadband endpoint monitoring system with integrated virtual deposition process capability for optical multilayer monitoring. The technique was demonstrated on an ion assisted reactive sputtering system.

09:30—10:00 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

Tamaya Ballroom ABCD

10:00—11:00
WB • Magnetron Sputtering
Presiders: Roland Loercher; Carl Zeiss AG, Germany and Daniel Poitras; National Research Council of Canada, Canada

WB.1 • 10:00 Invited
Consumer Electronics Industry Demands on Optical Coatings and Equipment, Harro Hagedorn[1], Detlev Arhilger[1], Jens-Peter Biethan[1], Thomas Hegemann[1], Martin Stapp[1]; *[1]Bühler Leybold Optics, Germany.* We discuss the coating industry needs for equipment for the past 45 Years. Recent developments for sensor application in consumer electronic products regarding direct coating of CMOS and glass wafer with interference filters are presented.

WB.2 • 10:25
Freeform and Laser Optical Coatings by Inline Magnetron Sputtering, Daniel Gloess[1], Ullrich Hartung[1], Andy Drescher[1], Peter Frach[1], Hagen Bartzsch[1]; *[1]Fraunhofer FEP, Germany.* The upscaling of highly productive inline magnetron sputtering for precision optics and application examples like 1D and 2D lateral thickness gradients as well as laser mirrors will be presented.

WB.3 • 10:30
Mechanical and Thermal Properties of Si/SiO_2 Narrow-band Mid-infrared Filters for Space Applications, Anna Sytchkova[1], Bill Baloukas[2], Oleg Zabeida[2], Angela Piegari[1], Jolanta-Ewa Klemberg-Sapieha[2], Maria Luisa Grilli[1], Ludvik Martinu[2]; *[1]Energy Department, ENEA Optical Coatings Group, Italy; [2]FCSEL Engineering physics, Polytechnique Montreal, Canada.* The residual stress compensation of Si/SiO_2 narrow-band filters for the mid-infrared range, composed of a combination of a Fabry-Perot and a blocking filter, is studied.

WB.4 • 10:35
Low Loss, Plasma Beam Assisted Reactive Magnetron Sputtered Silicon Nitride Films for Optical Applications, Andreas Frigg[1,2], Andreas Boes[1], Guanghui Ren[1], Duk-Yong Choi[3], Silvio Gees[2], Arnan Mitchell[1]; *[1]RMIT Univ., Australia; [2]Evatec Ltd, Switzerland; [3]Australian National Univ., Australia.* CMOS-compatible SiN layers with ultra-low roughness were deposited using plasma beam assisted reactive sputtering. Material losses below 0.1 dB/cm making it a promising deposition method for photonic integrated circuits and multilayer coatings.

WB.5 • 10:40
Multiple Bandpass Filters with Magnetron Sputtered Amorphous Silicon as High Index Materia, Penghui Ma[1]; *[1]National Research Council Canada, Canada.* Multiple bandpass filters for very wide wavelength range are made with sputtered amorphous silicon and SiO2. Such difficult filters are possible only if we have good control of the optical properties and the processes.

WB.6 • 10:45
Volume Production of High Quality Optical Coatings by Plasma Assisted DC-Magnetron Sputtering (PAPMS), Ralf T. Faber[1]; *[1]Vacuum Process Technology, LLC, USA.* Plasma Assisted Pulsed DC Magnetron Sputtering (PAPMS) results in low loss,high performance optical coatings.Multilayers using metals and metaloxides demonstrate that this technology is suitable for volume production of complex high quality coatings.

WB.7 • 10:50
Comparative Study of Bandpass Filters Manufactured by Different Deposition Technologies, Antonin Moreau[1], Tomas Begou[1], Fabien Lemarchand[1], Frederic Lemarquis[1], Karine Mathieu[2], Julien H. Lumeau[1]; *[1]Institut Fresnel - UMR 7249 – CNRS, France; [2]CNES, France.* We perform a comparative study of the performances of thin-film bandpass filters fabricated using plasma assisted reactive magnetron sputtering and electron beam deposition. Design, fabrication and characterization of such filters are presented.

WB.8 • 10:55
Manufacturing of Unusual Optical Filter Possessing Stepwise Spectral Transmittance, Kazuki Sato[1], Hiroaki Higuchi[1]; *[1]Asahi Spectra Co., Ltd., Japan.* We have manufactured an optical filter possessing stepwise spectral transmittance by magnetron sputtering method. There is good agreement between designed and measured transmittance. We expect the actual thickness is close to the design thickness.

11:00—12:00 • WAB • Wednesday Morning Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

WA.2	WB.2
WA.3	WB.3
WA.4	WB.4
WA.5	WB.5
WA.6	WB.6
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WA.8	WB.8
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WA.10	
WA.11	

12:00—13:30 • Conference Lunch, *Cottonwoods Pavilion and Patio*

Tamaya Ballroom ABCD

13:30—14:40
WC • Manufacturing Problem and Stress in Coatings
Presiders: Ekishu Nagae; Shincron Co., Ltd., Japan and Wolfgang Rudolph; Univ. of New Mexico, USA

WC.1 • 13:30 Invited
OIC 2019 Manufacturing Problem Contest, Daniel Poitras[1], Li Li[1], Michael R. Jacobson[2], Catherine Cooksey[3]; *[1]National Research Council Canada, Canada; [2]Optical Data Associates, USA; [3]Optical Radiation Group, National Inst. of Standards and Technology, USA.* A filter with specified transmittance at 10° and 50° angles of incidence (s-pol) from 400 to 1100 nm is selected for the OIC 2019 Manufacturing Problem. The results will be presented at the OIC conference.

WC.2 • 14:00
Stress Compensation by Deposition of a Nonuniform Corrective Coating, James B. Oliver[1], John Spaulding[1], Brian Charles[1]; *[1]Univ. of Rochester, USA.* Surface deformation by coating stress is compensated by prefiguring the substrate with a radially nonuniform layer. Stresses in the compensation layer and reflector are modeled using finite-element analysis to determine the desired thickness profile.

WC.3 • 14:05
Quantitative Calculation of Substrate Bending Caused by Multilayer Thin Film Stress, Muneo Sugiura[1], Koichi Tamura[1], Mitsunobu Kobiyama[2]; *[1]Tokai Optical Co., Ltd., Japan; [2]Tecwave Co., Ltd., Japan.* Substrate bending by multilayer coating of Ta_2O_5/SiO_2 has been investigated quantitatively. By introducing fitting parameters to modified Stoney's formula, the amount of the bending has been calculated to accuracies of less than at 633nm.

WC.4 • 14:10
Improving Film Stress and Surface Roughness by Using a Plasma Source in Magnetron Sputtering, Silvia Schwyn Thöny[1], Silvio Gees[1], Edmund Schuengel[1]; *[1]Evatec Ltd, Switzerland.* Equipping a magnetron sputter deposition system with an additional plasma source allows to improve surface roughness and film stress independent of the sputter parameters.This will be shown at the example of HfO_2/SiO_2 mirrors and aSi:H single layers.

WC.5 • 14:15
Ultra-low Stress SiO_2 Ion Beam Deposition Coatings, Emmett Randel[1], Aaron Davenport[1], Ashot Markosyan[2], Martin M. Fejer[2], Riccardo Bassiri[2], Carmen S. Menoni[1]; *[1]Colorado State Univ., USA; [2]Stanford Univ., USA.* Ion beam deposition (IBD) films typically have high compressive stress. By using low energy primary source and high energy assist source with an O_2 plasma the compressive stress of SiO_2 can significantly be reduced.

WC.6 • 14:20
Precisely Stress Compensated Dielectric Laser Mirrors Deposited by PARMS on Thin Deformable Substrates, Jan Brossmann[1], Marc Lappschies[1], Stefan Jakobs[1]; *[1]Optics Balzers Jena GmbH, Germany.* Coated optical components with low surface form deviation require particular knowledge on thin-film stress. Contributing factors to stress in PARMS coatings are evaluated and results of laser mirrors, deposited on thin substrates, are presented.

WC.7 • 14:25
Investigation of the Anisotropic Stress and Optoelectronic Properties of MZO Film Deposited on Flexible Substrate with RF Magnetron Sputtering, Hsi-Chao Chen[1], Guan-Ting Peng[1], Tan-Fu Liu[1], Ru-Fong Lai[1], Min-Yi Jiang[1], Pin-Ju Yao[1], Ming H. Yen[1], Chun-Hao Chang[1]; *[1]National Yunlin Univ of Sci. and Tech., Taiwan.* The Mo-doped ZnO (MZO) thin films were deposited with RF magnetron sputtering on PET and PC flexible substrates with different substrate temperature and oxygen pressure. The anisotropic stress and optoelectronic properties were investigated.

WC.8 • 14:30
Stress-less Hard Film with High Hardness, Small Surface Roughness and Low Stress, Shiliu Yin[1], Mitsuhiro Miyauchi[1], Tuteng Ma[1], Yosuke Inase[1], Takuya Sugawara[1], Ekishu Nagae[1]; *[1]Shincron Co., Ltd, Japan.* Here we report newly developed stress-less hard coating prepared with radical-assisted sputtering. Multilayered film stack shows comparable hardness and better balance of stress and roughness with SLH replacing conventional Si_3N_4 as high-index layers.

WC.9 • 14:35
Investigation of the Anisotropic Stress of the Anti-reflector Multilayer Film Deposited on PET Flexible Substrate, Chun-Hao Chang[1], Hsi-Chao Chen[1], Yu-Ru Lu[1], Sheng-Bin Chen[1], Cheng-Xuan Wu[1], Ching-Chieh Hung[1]; *[1]National Yunlin Univ of Sci. and Tech., Taiwan.* The anti-reflection (AR) multilayer films of TiO_2/SiO_2 and Ta_2O_5/SiO_2 were deposited on PET substrate with e-gun evaporation. A phase shifting moiré interferometer with Mohr's circle method was used to measure the anisotropic residual stress.

14:40—15:15 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

15:15—16:05
WD • Sputtered Coatings and Uniformity
Presiders: Vladimir Pervak; Ludwig-Maximillians-Universität Munchen, Germany and Brian Sullivan; Iridian Spectral Technologies, Ltd, Canada

WD.1 • 15:15 Invited
Challenges in Depositing and Characterizing Large Precision Filters for the LSST, Robert W. Sprague[1]; *[1]Materion Precision Optics, USA.* The Six filters used for the Large Synaptic Survey Telescope (LSST) are **~750 mm** precision optics. We report the development of a spectrometer to directly map the transmission of these curved filters.

WD.2 • 15:40
Characterization of Silicon Oxynitride Films Deposited by HIPIMS Deposition Technique, Bohuei Liao[1], Chien-Nan Hsiao[1], Ming-Hua Hsiao[1], Shih-Hao Chan[2], Sheng-Hui Chen[2], Sheng-De Weng[1]; *[1]Instrument Technology Research Center, Taiwan; [2]National Central Univ., Taiwan.* Silicon oxynitride films were prepared by high-power impulse magnetron sputtering. The average transmittance of the SiON films on the glass in the visible range was 86 % and its hardness was 24 Gpa.

WD.3 • 15:45
Ion Beam Sputtering of Optical Coatings for InP- and GaAs-based Laser Diodes, Matthias Falmbigl[1], Sandeep Kohli[1], Riju Singhal[1], Jason George[1]; [1]*Veeco Instruments Inc, USA.* We report on the performance of ion beam deposited optical coatings for laser diodes. Our results demonstrate a precise control of deposition conditions to tailor thin film properties for anti-reflective and high-reflective coatings.

WD.4 • 15:50
Improvement of Uniformities of Thickness and Incident Angles of Particles by Swinging Rotation Motion on Reactive Sputtering Deposition, Masahiro Akiba[1]; [1]*Topcon Corporation, Japan.* On reactive magnetron sputtering, we developed swinging rotation motion. It improves uniformities of thickness and incident angles of particles. The uniformities and the area size are easily adjustable with the range of the swinging motion.

WD.5 • 15:55
Complex IBS Coatings on Curved Surfaces, Tammo Bontgen[1], Lars Jensen[1], Marc Neufert[1]; [1]*Laser Zentrum Hannover e.V., Germany.* We explore a technique to precisely engineer the uniformity of a coating on non-flat substrates. This allows deposition of complex coatings such as edge filters by limiting the effects of spectral shift and angular spread.

WD.6 • 16:00
Deposition of Demanding Optical Coatings on Curved Substrates, Michael Vergoehl[1], Chris Britze[1], Stefan Bruns[1], Andreas Pflug[1], Volker Kirschner[2]; [1]*Fraunhofer Institut, Germany;* [2]*European Space Reseach and Technology Centre, Netherlands.* A band pass filter with a broad blocking on the convex side of a lens with constant central wavelength across the surface was produced with the EOSS machine. The shape of masks was designed with the PIC-MC code using 3D plasma simulation.

16:05—17:30 • WCD • Wednesday Afternoon Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

WC.2	WD.2
WC.3	WD.3
WC.4	WD.4
WC.5	WD.5
WC.6	WD.6
WC.7	
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WC.9	

18:00—20:00 • Conference Banquet, *Cottonwoods Pavilion and Patio*

Photography, videography and audio recordings can be a distraction to speakers and are not permitted in technical sessions.

07:00—08:15 • Conference Breakfast, *Tamaya Veranda*

08:00—17:30 • Registration, *Tamaya Ballroom Lobby*

Tamaya Ballroom ABCD

08:15—09:30
ThA • Coatings for Lasers and Laser Damage
Presiders: Carmen Menoni; Colorado State Univ., USA and Robert Sprague; Materion Precision Optics, USA

ThA.1 • 08:15 Invited
Trends Observed in Ten Years of Thin Film Coating Laser Damage Competitions, Christopher J. Stolz[1], Raluca A. Negres[1], Eyal Feigenbaum[1]; *[1]Lawrence Livermore National Laboratory, USA.* Optimum material selection for high fluence interference coatings is wavelength dependent (increased bandgap with decreased wavelength) whereas the deposition process depends on pulse length (increased densification with decreased pulse length).

ThA.2 • 08:40
Large-aperture Coatings for Fusion-class Laser Systems, James B. Oliver[1], Amy Rigatti[1], Tom Noll[1], John Spaulding[1], Jeff Hettrick[1], Vern Gruschow[1], Gary Mitchell[1], Dan Sadowski[1], Christopher Smith[1], Brian Charles[1]; *[1]Univ. of Rochester, USA.* Optical coatings for fusion lasers pose unique challenges, given the large substrate sizes, high intensities, and system-focusing requirements. Deposition processes are described for producing these components.

ThA.3 • 08:45
Temporal Dependency of Llaser Damage on Dielectric Mirrors for Petawatt Applications in the Picosecond Regime, Alexandre Ollé[1,2], Jacques Luce[1], Nadja Roquin[1], Claude Rouyer[1], Martin Sozet[1], Laurent Gallais[2], Laurent Lamaignère[1]; *[1]CEA , France; [2]Institut Fresnel, France.* We report on the impact the pulse duration has on the Laser Induced Damage Threshold (LIDT) and on defects initiated damage for dielectric mirrors irradiated by picosecond pulses.

ThA.4 • 08:50
High Laser-induced Damage Threshold Mirrors Prepared by EPD, Tuteng Ma[1], Mitsuhiro Miyauchi[1], Shiliu Yin[1], Takayuki Matsudaira[1], Ekishu Nagae[1]; *[1]SHINCRON Co., Ltd, Japan.* High laser-induced damage threshold of 1064nm mirror prepared by the EPD system using SiO_2/Ta_2O_5. The LIDT value obtained 303.5J/cm^2 which is 4 times better than the 70.7J/cm^2 result prepared by the conventional IAD equipment.

ThA.5 • Moved to Tuesday, 3 June, TC.10

ThA.6 • 09:00
High Power Properties of Low Density Nano-columnar SiO2 Films for All-silica Mirrors, Phyo P. Lin[1], Joesph A. Randi[2], Sage DeFrances[2], Dave Bernot[2], Joseph Talghader[1]; *[1]Univ. of Minnesota, USA; [2]Pennsylvania State Univ., USA.* SiO2 nano-columnar films were fabricated using oblique angle deposition and characterized for their optical and mechanical properties. The films showed high damage thresholds, low scattering and intriguing transition to low stress at lower densities.

ThA.7 • 09:05
The Difference of Laser-induced Damage Behaviors between the Back and Front Surface, Bin Ma[1], Ke Wang[1], Jiaqi Han[1], Xinbin Cheng[1], Zhanshan Wang[1]; *[1]Tongji Univ., China.* The transient images of ejected particles, plasma shapes and morphologies of damage craters are presented to characterize the different damage processes of the back and front surface under 1064 nm laser irradiation.

ThA.8 • 09:10
Study of Downstream Impacts Induced by Defects of Sol-gel Antireflection Layers in High Power Lasers , Eric A. Lavastre[1], Julien Iriondo[1], Florian Tournemenne[1], Stéphane Bouillet[1], Romain Parreault[1], Laurent Lamaignère[1], Claude Rouyer[1]; *[1]Commissariat a l'Energie Atomique, France.* Downstream impact induced by defects of sol-gel antireflection layers is studied in the high power lasers context. First results of propagation and laser damage tests are presented about defects dimensionally similar but morphologically different.

ThA.9 • 09:15
Recommendations on Laser Damage Testing of Monolayers in Short Pulse Regime to Determine Accurate Intrinsic LIDT, Marine Chorel[1], Eric A. Lavastre[1], Thomas Lanternier[1], Bruno Bousquet[2], Jerome Daurios[1], Jerome Neauport[1]; *[1]CEA , France; [2]Bordeaux Univ., France.* By determining and evaluating the uncertainties on the LIDTint, we are able to recommend the best configuration to laser damage test monolayers in short pulse regime.

ThA.10 • 09:20
Dry Etching of HfO_2 and SiO_2 Optical Thin Films, Lingyun Xie[1,2], Huasong Liu[3], Jun Zhao[4], Hongfei Jiao[1,2], Jinlong Zhang[1,2], Zhanshan Wang[1,2], Xinbin Cheng[1,2]; *[1]MOE Key Laboratory of Advanced Micro-Structured Materials, China; [2]Inst. of Precision Optical Engineering, School of Physics Science and Engineering, Tongji Univ., China; [3]Tianjin Jinhang Inst. of Technical Physics, China; [4]Shanghai Inst. of Applied Physics,CAS, China.* HfO_2 and SiO_2 optical thin films were etched using IBE, RIE and ICPE techniques. The influence of reactive gas and ion bombardment energy on the etching rates and surface morphologies of these two coatings was comparatively studied.

ThA.11 • 09:25
Laser Coatings for ps Applications on Large Optics, Patrick Robert[1], Cédric Cammarata[1], Chantal Germain[1], Rob Clarke[2]; *[1]Thales SESO, France; [2]STFC Rutherford Appleton Laboratory, UK.* Lasers tend to have pulses duration going down to ps or even fs range. These applications require large optics (class 1m or above) for which Thales SESO has developed a coating technology withstanding 2J/cm2.

09:30—09:55 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

09:55—10:00 • In Memoriam: Mireille Commandré, *Tamaya Ballroom EFGH*

ThB • Nonlinear and Ultrafast Coatings

10:00—11:00
ThB • Nonlinear and Ultrafast Coatings
Presiders: Xinbin Cheng; Tongji Univ., China and Detlev Ristau; Laser Zentrum Hannover e.V., Germany

ThB.1 • 10:00 Invited
Nonlinear Optics Using Interference Coatings - Opportunities and Challenges, Wolfgang Rudolph[1], Amir Khabbazi Oskouei[1], Luke A. Emmert[1], Morten Steinecke[2], Marco Jupé[2], Lars Jensen[2], Detlev Ristau[2]; *[1]Univ. of New Mexico, USA; [2]Laser Zentrum Hannover, Germany.* Interference coatings for nonlinear optical applications, mainly third harmonic generation, is discussed. An inverse relationship between bandwidth and efficiency was found. Challenges arise from undesired processes that occur at high intensities.

ThB.2 • 10:25
Design and Conversion Scaling Laws of Frequency Tripling Mirrors Based on Dielectric Coating Stacks, Amir Khabbazi Oskouei[1], Luke A. Emmert[1], Wolfgang Rudolph[1], Morten Steinecke[2], Marco Jupé[2], Lars Jensen[2], Detlev Ristau[2]; *[1]Univ. of New Mexico, USA; [2]Laser Zentrum Hannover e.V., Germany.* The general architecture of frequency tripling mirrors with optimized conversion is discussed for different design criteria. The conversion and bandwidth of the mirrors are strong functions of the number of layers.

ThB.3 • 10:30
Design and Fabrication of Single, Smooth and Broadband Chirped Mirrors with a Top Nano-porous Layer, Penghui Ma[1], Adriana Szeghalmi[2], Ulrike Schulz[2], Friedrich Rickelt[2], Vivek Beladiya[3], Peter Zimmermann[4], Li Li[1]; *[1]National Research Council Canada, Canada; [2]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany; [3]Friedrich Schiller Univ., Inst. of Applied Physics, Germany; [4]Layertec, Mellingen, Germany.* The design and fabrication results of single, low-ripples and broadband chirped mirrors with an integrated nano-porous layer using two different processes, atomic layer deposition and plasma etching, will be presented.

ThB.4 • 10:35
Broadband Phase-shifting Mirrors for Ultrafast Lasers, Tatiana Amotchkina[1], Lukas Lehnert[2], Keyhan Golyari[2], Marcus Ossiander[2], Martin Schultze[1], Vladimir Pervak[1], Michael K. Trubetskov[2]; *[1]Ludwig-Maximilians-Univ. Munich, Germany; [2]Max-Planck-Institut für Quantenoptik, Germany.* Metal dielectric phase-shifting optical elements have been developed providing broadband, virtually dispersion free polarization manipulation down to the single optical cycle level.

ThB.5 • 10:40
Broadband Si/SiO_2 Dispersive Mirrors for Ultrafast Mid-infrared Lasers, Vladimir Pervak[1], Tatiana Amotchkina[1], Qing Wang[2], Oleg Pronin[1], Ka Fai Mak[2], Michael K. Trubetskov[2]; *[1]Ludwig-Maximillians-Universität Munchen, Germany; [2]Max Plank Insitute of Quantum Optics, Germany.* We report Si/SiO_2 mirrors operating in the spectral range 2-3.2 um. The coatings exhibit high reflectance and provide GDD of (-100 fs^2) and (-200 fs^2). The mirrors are key elements of Cr:ZnS/Cr:ZnSe femtosecond lasers and oscillators.

ThB.6 • 10:45
Improved Optical Resistance of Broadband Chirped Mirrors, Simas Melnikas[1,3], Simonas Kičas[1], Andrius Melninkaitis[2]; *[1]Ctr for Physical Sciences & Technology, Lithuania; [2]Laser Research Center, Vilnius Univ., Lithuania; [3]Altechna Coatings, Lithuania.* Chirped mirrors covering 200 nm bandwidth were deposited for laser-induced damage threshold (LIDT) testing. Coating designs were optimized to achieve better LIDT performance. After LIDT testing morphology of damage sites was analyzed.

ThB.7 • 10:50
High Dispersive Mirrors for Femtosecond Laser System, Yanzhi Wang[1], Ruiyi Chen[1], Kesheng Guo[1], Yuhui Zhang[1], Meiping Zhu[1], Kui Yi[1], Jianda Shao[1]; *[1]Shanghai Inst. of Optics and Fine Mechanics, China.* We propose an initial multilayer structure to design high dispersive mirror (HDM) and aim at introducing large group delay dispersion (GDD). In film deposition, based on the uniformity, a HDM pair reduce the GDD oscillation effectively.

ThB.8 • 10:55
Laser Induced Thermal Stress in Optical Thin Films,, Austin Firth[1], Uma Srinivasan[1]; *[1]Optics R&D, Coherent Inc., USA.* Thermal stress of optical thin film materials SiO_2, HfO_2, Al_2O_3, TiO_2, and MgF_2 exposed to laser pulse is simulated using 2D finite element method. Thermal stress is compressive and MgF_2 film has the least value.

11:00—12:00 • ThAB • Thursday Morning Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

ThA.2	ThB.2
ThA.3	ThB.3
ThA.4	ThB.4
ThA.6	ThB.5
ThA.7	ThB.6
ThA.8	ThB.7
ThA.9	ThB.8
ThA.10	
ThA.11	

12:00—13:30 • Conference Lunch, *Cottonwoods Pavilion and Patio*

Tamaya Ballroom ABCD

13:30—14:40
ThC • Characterization I
Presiders: Claude Amra; CNRS, France and Michael Jacobson; Optical Data Associates, USA

ThC.1 • 13:30 Invited
OIC 2019 Measurement Problem, Sven Schröder[1,] Angela Duparré[1], Detlev Ristau[2], Marcus Trost[1]; *[1]Fraunhofer IOF, Germany; [2]LZH, Germany.* The Measurement Problem comprises the determination of the total backscattering, forward scattering, reflectance, and transmittance spectra of a multilayer system.

ThC.2 • 14:00
Residual Stress Birefringence Measurements of Highly Reflective Mirrors with Cavity Ring-down Technique, Shilei Xiao[1], Bincheng Li[1], Jing Wang[1]; *[1]Univ of Electronic Science & Tech China, China.* Residual stress birefringence of highly reflective mirrors structured with different HL layer numbers were measured with cavity ring-down technique by mirror rotation method and a differential loss approximation model.

ThC.3 • 14:05
Optical Characterization of High Refractive Index Glass Wafers for Augmented Reality Wearables, Jue Wang[1], Michael J. Cangemi[1], Jean Francois Oudard[1], Alex Bean[1], Tom Dunn[1], Chris A. Lee[2], Deanna A. Moschitta[2], Michael M. Moore[2], Nicholas M. Walker[2], Michael Kapusta[2], Karl W. Koch[2]; *[1]Corning Advanced Optics, USA; [2]Corning, USA.* Refractive index and optical thickness homogeneities of 99.979% and 99.984% were determined by using wafer-size metrologies. SiO_2 & Nb_2O_5 based low loss anti-reflective coatings in the visible were realized for augmented reality wearables.

ThC.4 • 14:10
Dual-angle Imaging System (DAISy) for Determining the Thickness of a Dielectric Thin Film, Yang Deng[1], Diana Magana[1], Zheng Tan[1], Jennifer D. Kruschwitz[1]; *[1]Univ. of Rochester, USA.* A team of undergraduate engineers in Optics were tasked to build a Dual-Angle Imaging System (DAISy) to measure the physical thickness of a dielectric film on silicon. This paper details their working prototype design.

ThC.5 • 14:15
Ellipsometric Modeling of Serially Bi-deposited Glancing-angle–deposition Coatings, Chris Smith[1], Sara MacNally[1], James B. Oliver[1]; *[1]Univ. of Rochester, USA.* Ellipsometric modeling of serially bi-deposited glancing-angle–deposition (GLAD) coatings with a high degree of accuracy is imperative for multilayer coatings. High-precision dispersion curves are demonstrated for a wide variety of applications.

ThC.6 • 14:20
In Situ and Ex Situ Spectroscopic Ellipsometry of Electrochromic NiO Films, Louis Dubé-Riopel[1], Bill Baloukas[1], Oleg Zabeida[1], Ludvik Martinu[1]; *[1]Polytechnique Montreal, Canada.* In situ ellipsometric measurements during cyclic voltammetry, supported by ex situ measurements, allow for the precise and continuous characterization of the optical properties of electrochromic NiO films in their various states of coloration.

ThC.7 • 14:25
Electric Field Assisted Dissolution of Nano-composite Coatings: An Spectroscopic Ellipsometric Study, Jordi Sancho-Parramon[1], Boris Okorn[1], Vesna Janicki[1]; *[1]Institut Ruder Boskovic, Croatia.* Application of DC voltage and moderate temperature induces dissolution of metal nanoparticles in nanocomposite materials. Ellipsometry is used to monitor changes in multilayer nanocomposite coatings as the dissolution process takes place.

ThC.8 • 14:30
Ellipsometry-based Study of Poled Glass Refractive Index Depth Profiles , Vesna Janicki[1], Ivana Fabijanic[1], Petar Pervan[1], Boris Okorn[1], Jordi Sancho-Parramon[1]; *[1]Institut Ruder Boskovic, Croatia.* Glass poling changes composition of the treated glass depleting the side facing anode from alkali species naturally present in glasses. The resulting change of the treated glass refractive index profiles was studied using ellipsometry.

ThC.9 • 14:35
How Thin an Optical Coating? The Case of Atomic Layer Deposited TiO_2 on Native Oxide/Si, Marcelo B. Pereira[1], Gustavo R. Toniello[1], Klester S. Souza[1], Flavio Horowitz[1]; *[1]Univ Federal do Rio Grande do Sul, Brazil.* A spectrally-extended Abelès method was used for probing ALD deposited TiO_2 films on native oxide/Si, whose AFM imaged nanotopology was roughly followed. Cauchy fitting to the experimental data was possible until ~1/10 quarterwave optical thickness.

14:40—15:15 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

Photography, videography and audio recordings can be a distraction to speakers and are not permitted in technical sessions.

Tamaya Ballroom ABCD

15:15—16:20
ThD • Characterization II
Presiders: Henrik Ehlers; Laser Zentrum Hannover e.V., Germany and Ric Shimshock; MLD Technologies, LLC, USA

ThD.1 • 15:15 Invited
Characterization of Transmittance, Reflectance and Optical Scattering of High-performance Interference Filters in the Visible and Near-infrared Spectral Regions, Myriam Zerrad[1], Michel Lequime[1], Claude Amra[1]; *[1]Institut Fresnel, France.* SALSA instrument allows an ultimate metrology of transmittance, reflectance and scattering functions of high performance optical coatings in the visible & near infrared range. Accuracy of measurements emphasizes an excellent agreement with the models.

ThD.2 • 15:40
Assessment of Surface Roughness, Homogeneity, and Defects of Substrates and Coatings for Space Applications, Tobias Herffurth[1], Marcus Trost[1], Ralph Schlegel[1], Stefan Schwinde[1], Sven Schröder[1]; *[1]Fraunhofer IOF, Germany.* Substrates and coatings for optical components are characterized using light scattering techniques. A robotic light scattering sensor enables curved samples with extended geometries to be mapped regarding roughness, homogeneity, and defects.

ThD.3 • 15:45
Simulation of Scattering from Nodules with Different Structures, Haoran Li[1,2], Lei Zhang[1,2], Jinlong Zhang[1,2], Sven Schröder[3], Marcus Trost[3], Hongfei Jiao[1,2], Zhanshan Wang[1,2], Xinbin Cheng[1,2]; *[1]Key Laboratory of Advanced Micro-structure Materials, Ministry of Education, China; [2]Inst. of Precision Optical Engineering, School of Physics Science and Engineering, Tongji Univ., China; [3]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* The scattering of nodules with different geometric constants were simulated. When the constant C is 8, the scattering intensity of each nodule is over 50 ppm. However, the intensity does not increase monotonically with bigger nodular geometry.

ThD.4 • 15:50
Optical Characteristics of Low-refractive-index Optical Thin Films Fabricated by Sputtering and Electron-beam Vacuum Deposition, Mai Hayamizu[1], Yoshiki Tsuno[1], Hiroshi Murotani[1], Shigeharu Matsumoto[2]; *[1]Tokai Univ., Japan; [2]Shincron Co., Ltd, Japan.* Low-refractive-index thin films with porous structures were fabricated by simultaneous sputtering and electron-beam vacuum deposition. This optical thin films can withstand ultrasonic cleaning which are having practical mechanical properties.

ThD.5 • 15:55
Mechanical Properties of Low-refractive-index SiO_2 Optical Films, Xiangyu Lu[1], Kenji Masuyama[1], Yoshiki Tsuno[1], Kei Yoshizawa[1], Hiroshi Murotani[1], Shigeharu Matsumoto[2]; *[1]Tokai Univ., Japan; [2]Shincron Co., Ltd, Japan.* SiO2 optical thin films deposited by a combination coating method achieved a low refractive index and high durability.

ThD.6 • 16:00
Design and Fabrication of Reflective Notch Filter Using Modified Thickness Modulated Al_2O_3 – SiO_2 Multilayer, Mukesh Kumar[1,2], Neelam Kumari[1], Amit L. Sharma[1], Vinod Karar[1], Ravindra K. Sinha[1]; *[1]CSIR-CSIO, India; [2]Academy of Scientific & Innovative Research, India.* A 44 layer thickness modulated Al_2O_3 – SiO_2 multilayer structure has been designed and fabricated using Ion Assisted electron-beam Deposition technique and it was characterized for its reflectance at angle of incidence of 45° using spectrophotometer.

ThD.7 • 16:05
Trapped Light Scattering within Optical Multilayers, Claude Amra[1], Myriam Zerrad[1,2], Michel Lequime[1,3]; *[1]Institut Fresnel, CNRS, France; [2]Aix Marseille Univ, France; [3]Ecole Centrale Marseille, France.* We calculate the amount of trapped scattering within complex filters. This trapped light is carried by guided modes and results from a roughness-coupling effect. It is shown how it may dominate the far field scattering.

ThD.8 • 16:10
Measuring and Reducing of Cracks of Sol-gel Layers of Optical Components Having a High Damage Laser Threshold, Hervé Piombini[1], Jérémy Avice[1], Christophe Boscher[1]; *[1]CEA Le Ripault, France.* The Laser MégaJoule needs optical components which are coated by sol gel with a post-treatment. This process induces crazing. We present the characterizations to understand the phenomenon and suggest leads to solve this problem.

ThD.9 • 16:15
Results of Indentation of Thin Layers Manufactured by a Sol-gel Process., Hervé Piombini[1], Philippe Belleville[1], Clément Sanchez[2]; *[1]CEA Le Ripault, France; [2]75, Collège de France, France.* We introduce our indenter allowing the carrying out of measurements on transparent material having a weak Young's modulus and to identify whether our material have a self-repairing effect.

16:20—17:30 • ThCD • Thursday Afternoon Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

ThC.2	ThD.2
ThC.3	ThD.3
ThC.4	ThD.4
ThC.5	ThD.5
ThC.6	ThD.6
ThC.7	ThD.7
ThC.8	ThD.8
ThC.9	ThD.9

07:00—08:15 • Conference Breakfast, *Tamaya Veranda*

08:00—11:00 • Registration, *Tamaya Ballroom Lobby*

Tamaya Ballroom ABCD

08:15—09:25
FA • Coatings for Gravitational Wave Detection
Presiders: Des Gibson; Univ. of the West of Scotland, UK and Laurent Pinard; CNRS-IN2P3, France

FA.1 • 08:15 Invited
Progress in the Measurement and Reduction of Thermal Noise in Optical Coatings for Gravitational-wave Detectors, Massimo Granata[1], Alex Amato[1], Gianpietro Cagnoli[2], Matthieu Coulon[1], Jérôme Degallaix[1], Danièle Forest[1], Lorenzo Mereni[1], Christophe Michel[1], Laurent Pinard[1], Benoît Sassolas[1], Julien Teillon[1]; *[1]Laboratoire des Matériaux Avancés, France; [2]Université de Lyon, France.* We report on the research activity on low-thermal-noise coatings at the Laboratoire des Matériaux Avancés, from updated values for the current coatings of Advanced LIGO, Advanced Virgo and KAGRA to recent results from alternative sputtered coatings.

FA.2 • 08:40 Invited
Apparatus to Measure Optical Scatter of Coatings Versus Annealing Temperature, Joshua Smith[1], Rana Adhikari[2], Katerin Aleman[1], Adrian Avila-Alvarez[1], Garilynn Billingsley[2], Amy Gleckl[1], Jazlyn Guerrero[1], Ashot Markosyan[3], Steven Penn[4], Juan Rocha[1], Dakota Rose[1], Robert Wright[1]; *[1]California State Univ. Fullerton, USA; [2]LIGO, California Inst. of Technology, USA; [3]Stanford Univ., USA; [4]Hobart & William Smith Colleges, USA.* Light scattered by amorphous thin-film optical coatings limits the sensitivity of interferometric gravitational-wave detectors. We describe an imaging scatterometer to assess the role that crystal growth during annealing plays in this scatter.

FA.3 • 09:05
Assessing Substrate-transferred GaAs/AlGaAs Coatings for Gravitational-wave Detectors, Steven Penn[1], Maya Kinley-Hanlon[2], Gregory Harry[2], Ian MacMillan[3], Garrett Cole[4], Paula Heu[4], David Follman[4], Christoph Deutsch[5]; *[1]Hobart and William Smith Colleges, USA; [2]American Univ., USA; [3]Georgetown Univ., USA; [4]Crystalline Mirror Solutions, USA; [5]Crystalline Mirror Solutions GmbH, Austria.* Substrate-transferred, 70-mm diameter AlGaAs coatings were tested for possible use in gravitational wave detectors by measuring the elastic loss $\phi_{bulk} = (5.33 \pm 0.03) \times 10^{-4}$ and $\phi_{shear} = (0.0 +5.2-0.0) \times 10^{-7}$and excess loss from bonding defects ≈ 5%.

FA.4 • 09:10
Gamma Radiation Exposure of Crystalline Coatings for Space Applications, Gar-Wing Truong[1], Kenji Numata[2], Catherine Nguyen[1], Garrett Cole[1]; *[1]Crystalline Mirror Solutions, USA; [2]NASA/GSFC, USA.* The effect of gamma radiation on the optical loss of high reflectivity monocrystalline supermirrors will be presented. These effects will be critical for space applications of low Brownian-noise crystalline mirrors for precision interferometry.

FA.5 • 09:15
Growth and Characterization of Mixed Ta_2O_5 Thin Films by Reactive Biased Target Deposition, Mariana A. Fazio[1], Lilly Quintana Barrera[1], Ashot Markosyan[2], Riccardo Bassiri[2], Martin M. Fejer[2], Carmen S. Menoni[1]; *[1]Department of Electrical and Computer Engineering and NSF ERC for Extreme Ultraviolet Science and Technology, Colorado State Univ., USA; [2]Department of Applied Physics, Ginzton Laboratory, Stanford Univ., USA.* We present characterization of tantala films mixed with titania or scandia grown by reactive biased target deposition. The introduction of a dopant significantly affected the optical properties of the films and the crystallization temperature.

FA.6 • 09:20
Optical Properties and Mechanical Loss of Amorphous Ta_2O_5 Thin Films Bombarded with Low Energy Assist Ions, Le Yang[1], Emmett Randel[1], Gabriele Vajente[3], Alena Ananyeva[3], Eric Gustafson[3], Ashot Markosyan[2], Riccardo Bassiri[2], Martin M. Fejer[2], Carmen S. Menoni[1]; *[1]Colorado State Univ., USA; [2]Stanford Univ., USA; [3]California Inst. of Technology, USA.* Amorphous tantala (Ta_2O_5) thin films were deposited by reactive ion beam sputtering with simultaneous low energy assist Ar^+ or Ar^+/O_2^+ bombardment. The films' absorption and mechanical losses are not significantly affected by the ion bombardment.

09:25—10:00 • Coffee Break with Exhibits, *Tamaya Ballroom EFGH*

10:00—10:50
FB • X-Ray, EUV, and UV Coatings
Presiders: Sven Schröder; ENEA Optical Coatings Lab, Italy; and Anna Sytchkova; ENEA Optical Coatings Lab, Italy

FB.1 • 10:00 Invited
Recent Advances in Cr-based Interference Coatings for EUV and Soft X-ray Optics, Franck Delmotte[1], Catherine Burcklen[1,2], Evgueni Meltchakov[1], Regina Soufli[1,2], Jennifer Rebellato[1], Arnaud Jérome[1], Sébastien de Rossi[1]; *[1]Laboratoire Charles Fabry, France; [2]Lawrence Livermore Natinal Laboratory, USA.* We present recent advances in the development of Chromium-based interference coatings in the EUV/soft x-ray range. We achieved breakthroughs in coating efficiency by using advanced concepts including 3-material multilayers and interface engineering.

FB.2 • 10:25
Thermal and Temporal Stability of Nitridated Ru/B_4C Multilayer for High Flux Monochromator Application, Yang Liu[1], Qiushi Huang[1], Hui Jiang[2], Runze Qi[1], Yufei Feng[1], Guangzhi Yin[2], Xingmin Zhang[2], Zhong Zhang[1], Zhanshan Wang[1]; *[1]Tongji Univ., China; [2]Shanghai Synchrotron Radiation Facility, China.* Nitridated Ru/B_4C multilayers for hard X-ray monochromator were fabricated and annealed to analyze the thermal stability. The results show that the nitridated multilayer remains stable up to 300 °C and no structure changes were observed in 2 years.

FB.3 • 10:30
The Reflectance of the $Al+MgF_2$ Film in the Far-Ultraviolet, Jinyan Wang[1], Jinlong Zhang[1], Hongfei Jiao[1], Xinbin Cheng[1], Zhanshan Wang[1]; *[1]Tongji Univ., China.* The Al mirror protected with a fluoride film was produced, and the effect of the annealing to the reflectance was investigated. It showed the reflectance >85% in the wavelength of 121.6nm has been achieved.

FB.4 • 10:35
Narrowband Mg/SiC Multilayers Working around 30.4 nm, Zhe Zhang[1], Qiushi Huang[1], Qunze Qi[1], Jiaqi Chen[1], Qinxu Feng[1], Yufei Feng[1], Hongjun Zhou[2], Tonglin Huo[2], Zhanshan Wang[1]; [1]*Tongji Univ., China;* [2]*Univ. of Science and Technology of China, China.* Narrowband Mg/SiC multilayer mirrors working around 30.4 nm with a significantly reduced bandwidth (FWHM ≈ 0.7 nm) basing on high order reflection have been designed and fabricated by direct-current (DC) magnetron sputtering.

FB.5 • 10:40
UV Broadband Antireflection Coating Using Al_2O_3, HfO_2 and SiO_2 Multilayer by Atomic Layer Deposition, Qing-Yuan Cai[1], Ling-Shan Gao[1], Hai-Han Luo[1], Rui Cong[1], Dingquan Liu[1]; [1]*Shanghai Inst Tech Physics, CAS, China.* UV broadband antireflection film M2HL in 250~390 nm spectral range was prepared by ALD using HfO_2 as H layer. Higher transmittance was acquired when HfO_2-Al_2O_3 nano-laminate replaced of HfO_2 in the AR coating.

FB.6 • 10:45
The Stress and Microstructure of Reactively Sputtered Ni/Ti Multilayers with Different D-spacing, Yufei Feng[1], Runze Qi[1], Zhong Zhang[1], Qiushi Huang[1], Zhanshan Wang[1]; [1]*Tongji Univ., China.* The stress and microstructure of reactively sputtered Ni/Ti multilayers with different bilayer is investigated for applications in neutron optical devices. The microstructure of multilayers has been characterized by GIXR, XRD and XPS measurements.

10:50—11:00 • Closing Remarks, Program Chair, Robert Sargent, *Tamaya Ballroom ABCD*

11:00—12:00 • AB • Friday Morning Poster Session and Exhibits, *Tamaya Ballroom EFGH*

Posters included in this session are:

FA.3	FB.2
FA.4	FB.3
FA.5	FB.4
FA.6	FB.5
	FB.6

12:00—13:30 • Conference Lunch, *Cottonwoods Pavilion and Patio*

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