Thank you very much for your participation!
We are looking forward to welcoming you again at the next Symposium OCLA 2025.

Vilnius, Lithuania
May 8th, 2025

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OCLA

9th Symposium on Optical Coatings
for Laser Applications

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Program
2024

OCLA

9th Symposium on Optical Coatings
for Laser Applications

April 16th, 2024

OCLA 2024 is hosted by RhySearch
and organized by

Fraunhofer IOF

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RhySearch Das Forschungs- und Innovationszentrum Rheintal

optonet Photoniknetzwerk Thüringen

SWISS PHOTONICS

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Welcome

We're pleased to have you with us for this year's OCLA Symposium!

The conference is now in its ninth year and the presentations will again cover a wide range of topics related to the design, coating and characterization of Optical Coatings for Laser Applications and associated manufacturing technologies. Thank you for coming.

Best regards on behalf of the programme committee

Heidi Thomé, heidi.thome@rhysearch.ch

Program Symposium

Tuesday, April 16, 2024

Morning session

8:30-9:15 a.m.	Registration and Welcome Coffee
9:15-9:20 a.m.	Welcome: Dr. Richard Quaderer (RhySearch)
9:20-9:50 a.m.	Keynote: Quantum Computing – The Path to Quantum Advantage Dr. Heike Riel (IBM Research)
9:50-10:10 a.m.	Lecture: Production and characterization of low losses Coatings for Laser applications Dr. Alex Ribeaud (Bühler Alzenau GmbH)
10:10-10:30 a.m.	Lecture: Characterization of nanometre thin films by infrared nanoscopy Dr. Bogdan Sava (attocube systems AG)
10:30-11:00 a.m.	Coffee break and Poster Presentations
11:00-11:20 a.m.	Lecture: Synthesis of broadband dispersive mirrors within the spectral range of 3-18 µm: algorithms and challenges Dr. Tatiana Amochkina (OTF Studio GmbH)
11:20-11:40 a.m.	Lecture: Ion beam sputtered Fluoride and Oxide coatings for UV-coatings at 193 nm Dr. Matthias Falmbigl (Veeco Instruments Inc.)
11:40-12:00 p.m.	Lecture: PARMS Depositions for UV to IR Laser Applications Dr. Navas Kutty (Bühler Alzenau GmbH)
12:00-12:20 p.m.	Lecture: Magnetron sputter deposition of quantized nano-laminates: a novel type of meta materials Dr. Silvia Schwyn Thöny (Evatec AG)
12.20- 12.25 p.m.	Sponsor Pitch: Dr. Markus Hofer (Bühler AG, Uzwil)
12:25-2:00 p.m.	Lunch Break supported by Bühler AG, Uzwil
01:15-2:00 p.m.	Poster Presentations

Afternoon session

2:00-2:30 p.m.	Keynote: New tool concepts for deterministic polishing of optical glasses Prof. Dr.-Ing. Jens Bliedtner (Ernst-Abbe-Hochschule Jena)
2:30-2:50 p.m.	Lecture: Standard methods of light scattering measurement in a wide spectral range Puja Kadkhoda (Laser Zentrum Hannover e.V.)
2:50-3:10 p.m.	Lecture: Towards benchmarking of optics lifetime or how predict inevitable in femtosecond lasers? Dr. Justinas Galinis (UAB Lidaris)
3:10-3:30 p.m.	Lecture: State of the Art Optical Thin Film Analyses for Industrial Applications Dr. Christian Patzig (Fraunhofer Institute for Microstructure of Materials and Systems IMWS)
3:30-4:00 p.m.	Coffee break and Poster Presentations
4:00-4:20 p.m.	Lecture: Round-robin absorption measurements of HR-coatings at 1064 nm Dr. Christian Mühlig (Fraunhofer IOF)
4:20-4:40 p.m.	Lecture: Optimizing Thin-Film Material Combinations for Immersed Narrow-Bandpass Filters in the VIS and NIR Range Rico Benz (RhySearch)
4:40-5:00 p.m.	Lecture: Nano-imprint lithography of broad-band and wide-angle antireflective structures for high-power lasers Ph.D. Marco Abbarchi (Solnil)
5:00-5:10 p.m.	Conclusion Heidi Thomé (RhySearch)
5:15-6:45 p.m.	Apéro Riche supported by Swiss Photonics

OCLA

Presentation abstracts and speaker biographies

Quantum Computing – The Path to Quantum Advantage

H. Riel

IBM Research
Säumerstrasse 4, 8803 Rüschlikon,
Switzerland

Presenter
Dr. Heike Riel

Despite the continued advances of digital computing including accelerators for artificial intelligence, there are still many important and relevant mathematical problems that are intractable to classical computers. Quantum Computers are a radically different approach and open a new trajectory to evolve computation and enable solving difficult and complex problems. In the past years significant progress has been made toward understanding the scope of quantum computing, pushing its hardware and software technology, developing applications, and advancing error mitigation/correction protocols. An entire new computing system is built from the bottom up.
Advancing the state-of-the-art as quickly as possible requires pursuing in parallel improvements in scale, quality, and speed of quantum systems, as well as simultaneously providing advanced capabilities to exploit the performance and make them easy to use. After a brief introduction I will present the recent developments highlights and prospects of quantum computing.

Dr. Heike Riel is IBM Fellow, Head of Quantum & Information Technologies, and Lead of IBM Research Quantum Europe & Africa. In her role she is aiming to create scientific and technological breakthroughs in Quantum Computing and Technologies, Physics of Artificial Intelligence, Nanoscience and Nanotechnology and to explore new directions to computing.
She received the master's in physics from the Friedrich-Alexander University of Erlangen-Nürnberg and the PhD in physics from University of Bayreuth and an MBA from Henley Business College.
She has received several prestigious honors, e.g., IEEE Andrew S. Grove Award, elected member of the Leopoldina – German National Academy of Sciences, the Swiss Academy of Engineering Sciences; the US National Academy of Engineering.

Production and characterization of low losses Coatings for Laser applications

A. Ribeaud[1], J. Pistner[1], I. Vela-Perez[1], C. Mühlig[2] , R. Benz[3] and C. Sturzenegger[3]

[1]Bühler Alzenau GmbH, Siemensstrasse 88, 63755 Alzenau, Germany
[2]Fraunhofer Institute for Applied Optics IOF, Albert-Einstein Strasse 7, 07745 Jena, Germany
[3]RhySearch, Werdenbergstrasse 4, CH-9471 Buchs (SG), Switzerland

Ion Beam Sputtering is a known deposition method to produce coatings of high film density with low absorption and low scattering. Those coatings are used for various laser applications having high fluences. It can be challenging to measure very low losses using Cavity Ring Down and other absorption measuring devices. Mirror coatings for different wavelength and on different grade of substrates have been deposited using Ion Beam Sputtering and will be evaluated for losses and absorption. The results of the different measurements of absorption, scattering and total losses using different equipment are presented and discussed. The contribution of the substrate will also be discussed.

Presenter
Dr. Alex Ribeaud

Dr Alex Ribeaud is working as Project Leader for the Ion Beam Sputtering Equipment at Bühler Leybold Optics, responsible for the development, process implementation for coatings in precision optics, laser application and low losses. He completed his Ph.D. in Applied Physics at the CEA in Gernoble, France in the thin films deposition for Opto-electronic Applications.

Characterization of nanometre thin films by infrared nanoscopy

B. Sava

attocube systems AG
Eglfinger Weg 2, 85540 Haar, Germany

Presenter
Dr. Bogdan Sava

Nanoscale resolved imaging & spectroscopy using tip-enhanced microscopy achieves spatial resolution of < 10-20 nm in the VIS, IR and THz frequency range. Further, nanoscale confinement of laser light at the AFM tip apex enables spectroscopic measurements with unprecedented surface sensitivity. nano-FTIR spectroscopy of ODT based corrosion protection coating on a copper surface verified measurements of characteristic IR thiol signatures in the 1600cm^{-1} spectral range with monolayer sensitivity [1]. Confirmational changes of single PEO molecules of a polymer brush with few nanometre thickness were analysed by spectral variations along the sample surface at length scales smaller than 100nm [2].

[1] W. Zhao, et al., Corrosion Scie., 192, 109777 (2021)

[2] A. d. l. Santos Pereira, et al., Anal. Chem. 92, 4716 (2020).

Dr. Bogdan Sava works as an application scientist at attocube systems AG, business department “nanoscale analytics”. With a background in physics and diverse expertise in near-field using sSNOM (scattering type scanning near field optical microscopy) technology, accumulated over the last 5 years at attocube, Dr. Bogdan Sava has proven track record in conducting research with experts from different fields of science (photonics, chemistry, material science, surface investigation, etc.) in a very efficient way.

NANOMETRE THIN FILMS

Synthesis of broadband dispersive mirrors within the spectral range of 3-18 µm: algorithms and challenges

T. Amochkina[1], M. Turbetskov[1,2]

[1] OTF Studio GmbH, Watzmannring 71, 85748 Garching, Germany
[2] Max-Planck-Institute of Quantum Optics, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Multilayer dispersive mirrors play a pivotal role in modern mid-infrared (MIR) laser applications. The MIR spectral range (3-18 µm) is in focus of biological research since many organic molecules exhibit their molecular fingerprints there. In MIR laser systems, waveform-stable short pulses propagate through various crystals and accumulate highly dispersive group delay, that leads to deformation of the pulse shapes.
The critical specifications of the dispersive mirrors are bandwidth (exceeds 0.5 optical octaves), a group delay variation (up to 2000 fs), and high reflectance. We focus on accessibility of the specifications for a given combination of MIR thin-film materials and estimate in advance the required total coating thickness, number of layers, and the thickness of the thickest layer. We report algorithms enabling the fulfillment of feasibility demands while ensuring excellent spectral performance. The results hold practical significance for optical coating and laser engineers.

Presenter
Dr. Tatiana Amochkina

Dr. Tatiana Amochkina graduated from the M.V. Lomonosov Moscow State University (Russia) in 1994, received her PhD in 1998 and her State Doctorate degree in 2010. In 2012-2013 and in 2015-2021, Dr. Amochkina worked as a senior scientist at the Max-Planck-Institute of Quantum Optics and at the Ludwig-Maximilians-University München. She performed an EU Marie Skłodowska-Curie project. Her activity focuses on multilayer optics and development of thin film software. Since 2023, Dr. Amochkina works at OTF Studio GmbH in Garching, Germany. She is a senior Optica member since 2017 and a is topical editor in Optics Letter journal since 2018.

Ion beam sputtered Fluoride and Oxide coatings for UV-coatings at 193 nm

M. Falmbigl, A. Checco, J. George, B. Rubin

Veeco Instruments Inc., 1 Terminal Drive,
Plainview, NY 11803, USA

Deep ultraviolet laser light at 193 nm is nowadays utilized in a plethora of applications such as semiconductor integrated circuits, eye surgery, and micromachining. At this wavelength, the range of suitable materials for optical coatings becomes very limited. While ion beam sputtering is not a widespread technology for fluoride coatings, its ability to produce highly dense coatings with low defect concentration has proven to be well-suited for laser optics. Here, we will discuss hardware and process requirements to produce high-quality anti-reflective and mirror coatings at 193 nm using AlF_3 and GdF_3. These will be compared to similar ion beam sputtered coatings comprised of SiO_2 and Al_2O_3 layers.

Presenter
Dr. Matthias Falmbigl

Dr. Matthias Falmbigl holds a PhD-degree in Chemistry from the University of Vienna, Austria, and has authored over 50 scientific publications. Dr. Matthias Falmbigl has worked for Veeco for over five years in the advanced deposition and etching division. His areas of interest are ion beam technology and optical thin film coatings.

PARMS Depositions for UV to IR Laser Applications

N. Kutty, I. Schramm, S. Mingels, H. Hagedorn

Bühler Alzenau GmbH, Business Area Leybold Optics, Siemensstrasse 88, 63755 Alzenau, Germany

Presenter
Dr. Navas Kutty

Plasma Assisted Reactive Magnetron Sputtering (PARMS) technology offers optical coatings for a large variety of applications like lithography, fluorescence microscopy, Raman spectroscopy, 3D imaging or high-power lasing in a wide spectral range from DUV to IR. The challenges in this field such as the demand for low optical losses, flawless surface quality, high LIDT values, or realization of highly complex optical designs need to be addressed by the coating equipment. Applications and examples of coatings from magnetron sputtering deposition using mid frequency plasmas for high-volume manufacturing of complex optical filters and radio frequency plasmas for high-end laser mirrors with LIDT values > 90 J/cm^2 at 1064 nm and optical losses <100 ppm are presented.

Dr. Navas Kutty is working as R&D Project Manager at Bühler Leybold Optics, responsible for development of sputter tools, process optimization and inspection of defects in coatings for precision optics as well as semiconductor applications. He completed his PhD in Physics and later 6 years of post-doctoral work, in collaboration with Karlsruhe Institute of Technology (KIT) and University of Applied Sciences, Karlsruhe, Germany.

Optimizing Thin-Film Material Combinations for Immersed Narrow-Bandpass Filters in the VIS and NIR Range

R.Benz[1], M. Nazari[1], T. Amochkina[2], M. Trubetskovc[2,3]

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[2]OTF Studio GmbH, Watzmannring 71, 85748 Garching, Germany
[3]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Presenter
Rico Benz

Narrow bandpass filters featuring broad-band blocking ranges and low angular shift find extensive applications in industry. The filters are challenging since narrow trans-mittance width and large angular fields are inherently conflicting requirements.
We develop immersed bandpass filters exhibiting a narrow transmission range around 850 nm, blocking ranges at 200-780 nm and 900-1100 nm, and low blue shift for incidence angles up to 25°. The solution should also allow for the possibility of shifting the transmission range further into the visible or near-infrared regions. Optimal choice of materials should provide an ultra-broadband blocking range and high transmission zone. Therefore, materials absorbing in the blocking range and transparent outside of this range should be used. The design robustness is considered. Double-sided optical elements composed as front side filter and back side blocker hold promise in this regard. The solutions are oriented at Ion Beam Sputtering technique without load lock solution.

Rico Benz works as Project Leader Optical Coating at RhySearch. He is a highly accomplished professional with a diverse background in coating technology, specializing in optical applications across various fields, including Photonics, Optoelectronics, and Semiconductors. He began its educational journey by completing an apprenticeship as a mechanical engineer. Subsequently, he earned a bachelor's degree. Continuing its educational pursuits, he obtained a Master of Science in Micro- and Nanotechnology. The advanced degree further refined its expertise at the intersection of photonic and material science within this subject.

Magnetron sputter deposition of quantized nanolaminates: a novel type of meta materials

S. Schwyn Thöny[1], M. Bärtschi[2], R. Gmünder[1], S. Waldner[1], X. Maeder[3]

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[2]RhySearch, Werdenbergstrasse 4, 9471 Buchs, Switzerland
[3]EMPA, Feuerwerkerstrasse 39, 3602 Thun, Switzerland

Quantized nanolaminates (QNL) are a type of optical meta materials, which were discovered only recently. The concept postulates the decoupling of band gap and refractive index, which in regular dielectric materials is linked. The quantization effect can be observed by a shift in the absorption edge, which is stronger the thinner the nanolaminate layers. We will show that the quantization effect can be observed in nanolaminate structures of the material combinations Ta_2O_5-SiO_2 and amorphous silicon-SiO_2, which were deposited by magnetron sputtering. These nanolaminates were characterized by a variety of different methods, which confirmed the layer structure in the nanometer range. The use of the QNL as the high refractive index material in optical interference coatings was successfully demonstrated in anti-reflection and long pass filter coatings. This clearly shows that QNL can be deposited in a standard production magnetron sputter deposition tool and that the concept of QNL opens a wide field for novel applications.

Presenter
Dr. Silvia Schwyn Thöny

Silvia Schwyn Thöny joined Evatec's R&D team in 2010 as a Principal Scientist and is now in charge of scientific collaborations. She has a strong background in various physical vapor deposition technologies for applications such as precision optics or transparent conductive coatings. Previously she worked in the optical coatings industry and thus knows the industry from both the tool manufacturers and the coating manufacturing perspective. She received the diploma and Ph.D. degrees in experimental physics from Swiss Federal Institute of Technology in Zürich (Switzerland).

New tool concepts for deterministic polishing of optical glasses

*[1]J. Bliedtner[1], C. Schulze[1], S. Henkel[1], D. Schultheiß[1]
O. Faehnle[2], K. Kern[2], H. Surberg[2], J. Bode [3],
M. Wagner[3]*

*[1]Ernst-Abbe-Hochschule (EAH), 07745 Jena, Germany
[2]OST Ostschweizer Fachhochschule Campus Buchs (OCB), 9471 Buchs, Switzerland
[3] Satisloh GmbH, 35578 Wetzlar, Germany*

Presenter
Prof. Dr.-Ing. Jens Bliedtner

The precision machining of optical glass plays a crucial role in various high-tech applications, including optics, microelectronics and medical technology. In this context, continuous progress is being made in the development of polishing tools to improve the machining accuracy and efficiency of the processes. The article also presents new polishing tools that have been specially developed for the flexible and deterministic processing of optical glass. The tools are manufactured from innovative materials with defined adjustable hardness gradients using a special 3D printing process. The performance of these tools was demonstrated by using advanced simulation techniques and experimental validation. The results show a significant improvement in processing accuracy and efficiency as well as a very high degree of flexibility in the use of the new polishing tools compared to conventional approaches. These new polishing tools have the potential to improve the precision processing of optical glass in various industries and facilitate the production of high-quality optical components.

Jens Bliedtner studied precision engineering at the Friedrich Schiller University in Jena. He wrote his doctoral thesis in the fields of development of pulsed laser systems and special methods in macro material processing. Since 2000, Bliedtner has been a professor at the Ernst Abbe University of Applied Sciences in Jena and the head of the department production engineering and automation of production processes. Currently, he is working in the research fields of optical technology, laser material processing and additive manufacturing.

Standard methods of light scattering measurement in a wide spectral range

P. Kadkhoda

Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover, Germany

The improvement of the topographical properties of optical components has led to the development of increasingly sensitive measurement methods, including methods for measuring light scattering. We report here on different types of light scattering measurement that have been developed over several decades as a universal tool for various optics characterization issues.
Tactile metrology methods, such as atomic force microscopy, are very time-consuming and their results relate to small areas of the examined optics. In contrast, scattering can be used as a loss mechanism to determine the properties of the test objects, such as surfaces quality, homogeneity, and defect density.
We present the latest developments by fast mapping of the Total Scattering losses according to the International Standard ISO 13696 as a routine characterization method for the industrial production environment. In addition, angle resolved scattering can be used as a non-destructive and non-invasive test to obtain information about the topographical characteristics of the entire optical surface, functional multilayer coatings, and volume structure of an optic. Defects in the form of particles are often incorporated in an optical functional coating during the deposition process. We present a setup based on scattering for particle detection in physical vapor deposition systems under vacuum conditions, which registers the successive occurrence of particles during the coating process. By assigning the particles count produced to the respective process parameters, their influence on the formation of defects can be investigated in more detail.

Presenter
Puja Kadkhoda

P. Kadkhoda is research scientist at the department of Optical Components at LZH since 1995.
At Laser Zentrum Hannover, P. Kadkhoda is responsible for Total Scattering and Angle Resolved Scattering (ARS) investigations of optical components, and development of systems for spectral photometry in the Deep Ultraviolet range.

Towards benchmarking of optics lifetime or how predict inevitable in femtosecond lasers

J. Galinis, A. Aleksiejūtė, A. Melninkaitis

UAB Lidaris, Saulėtekio al. 10, 10223, Vilnius, Lithuania

The landscape of laser technology is undergoing a transformative shift, marked by pronounced trends towards higher pulse repetition rates and shorter pulse durations. Depending on laser beam size, peak intensity, spectral range, working environment, etc., optics degrade rather quickly, eventually experiencing catastrophic failure. Traditional methods used to characterize laser damage performance under such conditions are no longer sufficient and need to be extended.
In this presentation, we share insights from recent testing experiences at LIDARIS, focusing on the exploration of optics lifetime through an extended S-on-1 testing approach. We will show that distinct categories of laser damage may manifest on dielectric optics [1]. Such failure modes, characterized by non-catastrophic color change or catastrophic crater formation, can coexist independently. Our analysis reveals that segregating these damage modes in statistics enables the estimation of how rapidly optics deviate from their specified properties over time. Moreover, these trends can also be used to predict the useful life of optics [2]. In essence, the capability to predict optics lifetime opens new possibilities for further advancement of laser optics, thereby mitigating failures in femtosecond laser systems.

[1] Smalakys, L., Momgaudis, B., Grigutis, R., Kičas, S., & Melninkaitis, A. (2019)., Contrasted fatigue behavior of laser-induced damage mechanisms in single-layer ZrO$_2$, optical coating. Optics Express, 27(18), 26088-26101.

[2] Smalakys, L., & Melninkaitis, A. (2021). Predicting the lifetime of optical components, with Bayesian inference. Optics Express, 29(2), 903-915.

Presenter
Dr. Justinas Galinis

Dr. Justinas Galinis is an analyst in a company UAB Lidaris, that provides Internationally-recognized service of Laser-Induced Damage Threshold (LIDT) testing. He has PhD in Physics from Vilnius University (Lithuania). During his academic carrier he worked in Vilnius university and Palacky University (Czech Republic) where his main research fields were Nonlinear Optics and Quantum Optics. Current position in company Lidaris enrich his expertise in laser-induced damage field.

State of the Art Optical Thin Film Analyses for Industrial Applications

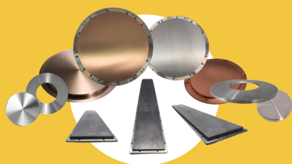
C. Patzig, R. Feder, S. Gierth, T. Höche

Fraunhofer Institute for Microstructure of Materials and Systems IMWS, Walter-Hülse-Straße 1, 06102 Halle (Saale), Germany

Most optical systems consist of a substrate that is functionalized with thin-film multilayers. For different examples, it will be shown how state-of-the-art nano-analytics is used to answer questions related to layer thickness, homogeneity, purity, crystallinity, or substrate-film interface issues such as delamination or contamination: hybrid systems, i.e. polymeric substrates that are functionalized with inorganic coatings, next-generation EUV-reflecting devices based on ultrathin multilayer stacks of LaN and B_4C, and sputter-deposited a-Si/SiO_2 nanolaminates. A combination of virtually artifact-free sample preparation with high-end analytical methods that deliver highest lateral resolution (e.g. TEM) as well as very high detection sensitivity (e.g., ToF-SIMS) give deep insights into the materials' nanostructure. Microstructure diagnostics is not only pivotal for failure analysis, but also forms the basis of the nanostructure-based development of thin film-based optical systems.

Presenter
Dr. Christian Patzig

Dr. Christian Patzig studied physics in Jena, and gained a PhD at the Leibniz Institute of Surface Modification IOM in Leipzig on an ion beam sputter deposition related topic. After finishing his PhD thesis, he worked for some time for a manufacturer specialized in thin-film laser optics. He joined the Fraunhofer Institute for Microstructure of Materials and Systems in 2010. Since then, the focus of his work is on the the micro- and nanostructural characterization of optical materials, such as glasses and glass-ceramic systems, but also effect pigments and in particular optical thin and ultra-thin film systems.



4KG

Round-robin absorption measurements of HR-coatings at 1064 nm

J. Lumenau[1], C. Mühlig[2], T. Gischkat[2], L. Gallais[1], S. Schröder[1]

[1]Institut Fresnel, Marseille, France
[2]Fraunhofer IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany

Presenter
Dr. Christian Mühlig

Absorption is a key parameter for optical materials and coatings in an increasing number of applications. Following the need for absorption measurements, a variety of different techniques have been established in the past 2 decades. Although all of them are very sensitive - allowing to measure down to the ppm absorption level – the absolute calibration remains a main challenge. For the first time to the best of our knowledge, we present data from a Round-Robin absorption test with a total of 11 participants from Europe, including scientific institutes as well as companies. The subject of the test is the measurement of two highly reflective (HR) coatings (Bühler Alzenau GmbH) with different expected absorption levels at a wavelength around 1064nm. Besides a look on the overall data scattering, one of the goals is to compare data obtained by identical test equipment at different locations. Additional CRD measurements provide total loss data that help to identify the upper limit of the coating absorption.

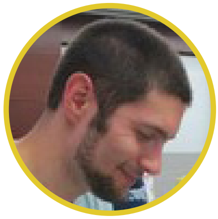
Christian Mühlig studied physics at the Friedrich-Schiller-University (FSU) in Jena and completed his doctoral research study in 2005 on absorption in highly transparent DUV optical materials at the Institute of Photonic Technology (IPHT) in Jena. He reached an MSc in Physics of Laser Communications at the University of Essex in Colchester, UK. From 1998 to 2021 he worked as research associate at Leibniz IPHT in Jena. He moved then to Fraunhofer IOF in Jena where he is now responsible for characterization of optical materials and coatings with the particular focus on direct absorption measurements and cavity ring-down spectroscopy.

Nano-imprint lithography of broad-band and wide-angle antireflective structures for high-power lasers

Marco Abbarchi

Solnil, 95 Rue de la République, 13002 Marseille, France

Anti reflection coatings are key components of high power laser systems. However, conventional nano-fabrication methods for these devices pose several issues in terms of costs, use of toxic resists, chemicals, and fluorinated gases. Here we show efficient anti reflection coatings based on adiabatic index matching on fused silica with high transmission and achromaticity (99.5% < T < 99.8% from 390 to 900 nm and 99% < T < 99.5% from 800 to 1400 nm) and wide angular acceptance (T > 99% up to 50 degrees for pp and ss polarization). Our components exhibit high LIDT in the sub-picosecond regime (>5 J/cm^2 at 1030 nm, 500 fs), nanosecond regime (>150 J/cm^2 at 1064 nm, 12 ns and >100 J/cm^2 at 532 nm, 12 ns), and low absorption in the CW regime (<1.3 ppm at 1080 nm). They are obtained with a sustainable method, sol-gel coating and nano-imprint lithography of metal oxides. It is a direct moulding process compatible with plate-to-plate and roll-to-plate, and is ready for industrial production.



Presenter
Marco Abbarchi

Marco Abbarchi earned his PhD in Physics with a focus on solid state physics from the University of Florence and LENS Laboratory in 2008, located in Florence, Italy. Following that, he was a JSPS Fellow at NIMS in Tsukuba, Japan from 2009 to 2010, and then a Marie Curie Fellow at Ecole Normale Supérieure in Paris, France from 2010 to 2012. He then served as an Associate Professor at Aix-Marseille University from 2013 to 2023 before becoming the CSO at SOLNIL, where he currently works. His background includes expertise in the physics of semiconductor nanostructures, quantum optics, and nano-fabrication of photonic devices.

Posters and presenters

Particle detection in a vacuum chamber

H. Cattaneo, T. Strüning, M. Roth, A. Scholtz, M. Gutsche

Institute for Microtechnology and Photonics, OST, Buchs (SG), Switzerland

Small particles originating from various process steps during optical coating can lead to coating defects and failure and hence lower the quality and yield of the final product. Therefore, optimization of the coating process to reduce particulate contamination is essential. To that aim in-situ monitoring of small particles during the coating process can help to avoid the formation of the defects. In this study, laser scattering has been used to detect the presence of miniature particles under vacuum conditions in a chamber. As a light source a fiber-coupled 400 mW laser at 458 nm has been used to probe the target area inside the chamber. Various imaging schemes have been tested for the detection of the scattered light to find the most sensitive and practical approach to be used in industrial applications.

Presenter
Dr. Heidi Cattaneo

Dr. Heidi Cattaneo holds a PhD in physics from Tampere University of Technology, Finland. After PhD, she worked several years in research and development activities in industry. She joined OST in 2018 and works as a scientific coworker for several projects at the national and international level.

What went wrong? Understanding laser damage root causes via microstructure analysis

R. Feder, C. Patzig, S. Gierth, T. Höche

Fraunhofer Institute for Microstructure of Materials and Systems IMWS, Walter-Hülse-Straße 1, 06102 Halle (Saale), Germany

Presenter
Dr. René Feder

Laser optical components (mirrors, beam splitters, ...) consist of an optical substrate that is functionalized with thin-film multilayers. For two different coatings, the potential of state-of-the-art nano-analytics to reveal the causes of laser induced damage will be demonstrated. The standardized workflow at IMWS will be introduced, starting with an optical inspection, and followed by a first analysis using SEM, FIB and EDS to characterize the defect. Subsequent virtually artifact-free sample preparation to enable high-end analytical methods that deliver highest lateral resolution (e.g. TEM) as well as very high detection sensitivity (e.g., ToF-SIMS), give deep insights into the defect formation. Understanding the root causes of laser induced damage also forms the basis of the nanostructure-based development and improvement of thin film-based laser optical coatings and in detailed dispersion parameter sets.

René Feder studied physics in Leipzig and gained a PhD at the Leibniz IOM on the correlation of secondary particle and thin film properties in IBSD. After working at the TU Clausthal and the University of Nebraska-Lincoln, he joined the Fraunhofer IMWS in 2017 on a co-operation project with Zeiss.

Liquid absorber for high-power laser beamdumps

M. Mureșan

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This study introduces a novel liquid absorber designed for efficient beamdumping of high-power lasers, specifically targeting UV to NIR spectral ranges of YAG lasers. The absorber is formulated by dispersing graphene oxide nanosheets in water, capitalizing on the exceptional optical and thermal properties of graphene oxide. Through comprehensive experimental investigations, we demonstrate the absorber's ability to effectively capture and dissipate laser radiation across the UV-NIR YAG laser spectrum. The graphene oxide nanosheets exhibit remarkable absorption characteristics, ensuring optimal performance in diverse laser applications. The proposed liquid absorber offers a versatile and cost-effective solution for managing intense laser beams in various applications, ranging from industrial laser systems to scientific research environments.

Presenter
Dr. Mihai-George Mureșan

Mihai-George Mureșan received his PhD from the Masaryk University in Brno, Czech Republic in „Plasma Physics" on thin-films deposited by PECVD. He works at HiLASE Centre for almost 10 years on high-average power laser diode-pumped solid-state laser (DPSSL) systems, helping to develop the systemes and their applications. Currently his attention is focused on laser-induced damage threshold testing of optics using short pulse regimes, developing new testing protocols.

Absorption measurement and simulation of photo induced effects in thin-film optical filters

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The rapid advancement in high-power laser technology necessitates a deep investigation of absorption within optical components and a comprehensive understanding of photo-induced effects on optical properties of thin film stacks. To address these challenges, a Lock-In Thermography (LIT) setup has been developed for measuring the absorption of optical coatings at 1 and 1.5 µm. The LIT experimental setup offers a non-destructive and non-contact measurement technique. High-power laser induces heating into the coated stack, and the resulting surface temperature rise is quantified using a thermal camera. A calibration procedure enables the retrieval of absorption level with a sensitivity of 1 ppm. The combination of a high-performance thermal camera and a high-power laser beam allows for low energy density, setting the measurement conditions significantly below the Laser Induced Damage Threshold of components. Thermal images acquisition facilitates absorption measurements on any substrate types and geometries and makes it effective for detection of absorbing defects.
Comparative measurements of absorption at 1 and 1.5 µm in multilayer stacks have been conducted for various optical functions and angles. The experimental results are compared to a numerical model predicting absorption values based on extinction coefficients and complex admittance computations. A finite element model using COMSOL has been developed to investigate the thermal response and mechanical deformations exhibited by thin film optics under high-power illumination. This model evaluates photo-induced variations in the refractive index and thickness of each layer within a thin film stack, enabling the prediction of shifts in optical function. The findings provide valuable insights into how laser-induced heating influences the optical properties of coatings and provide guidelines for designing robust and reliable photonic systems.

Presenter
Mathias Soulier

Mathias Soulier is currently Ph.D. student at the Fresnel Institute in collaboration with CILAS. His work focuses on absorption in thin film coatings. His academic journey began with a technical degree in physical measurement obtained at the University of Montpellier. Subsequently, he pursued his education at INSA Toulouse, where he graduated as a physics engineer with a focus on micro-nano technologies.

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