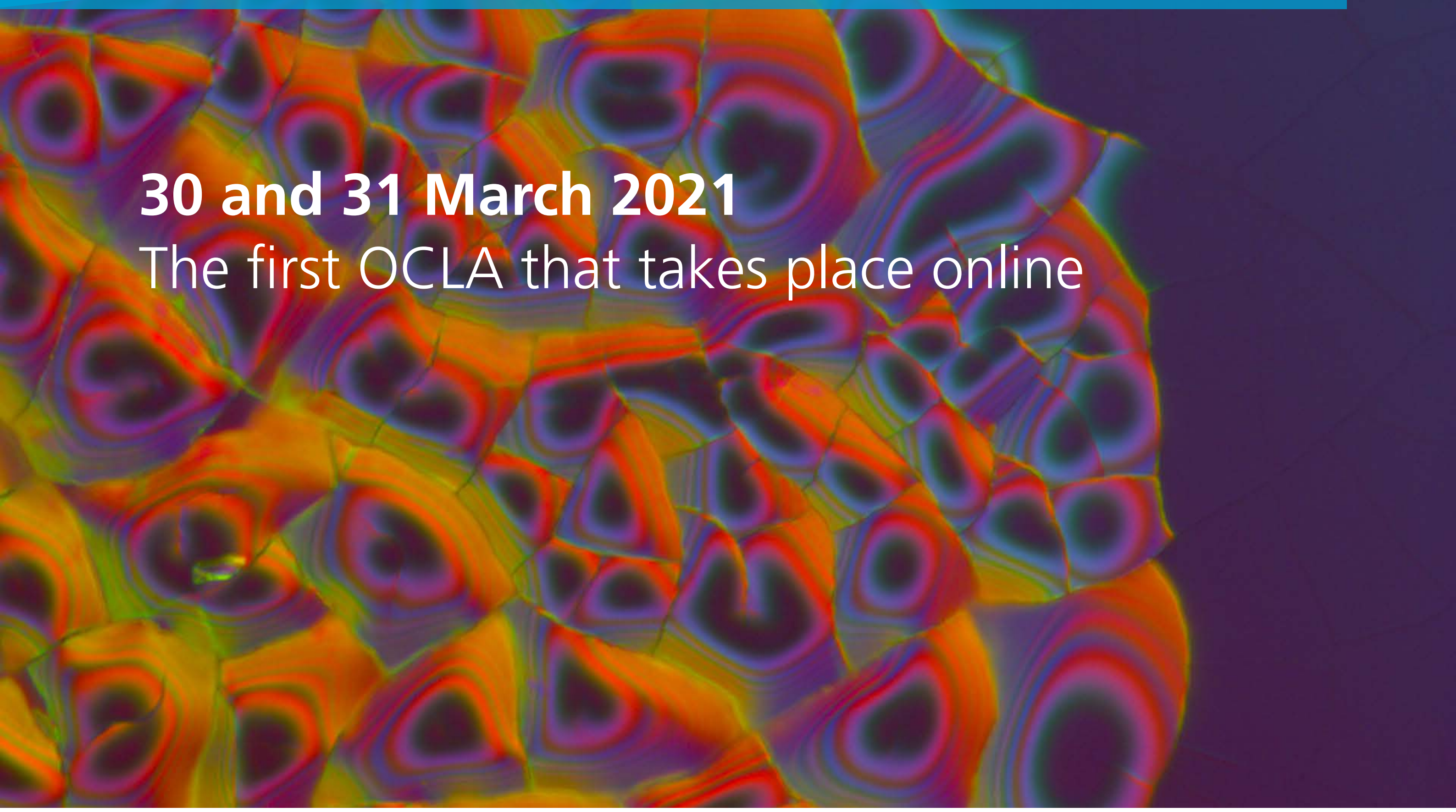
PROGRAMME

OCLA 2021

6th Symposium on Optical Coatings for Laser Applications



30 and 31 March 2021

The first OCLA that takes place online

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RhySearch Das Forschungs- und Innovationszentrum Rheintal

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Dear participant

We are pleased to welcome you at this year's OCLA symposium. Today we celebrate the symposium on Optical Coatings for Laser Applications for the sixth time. We are glad to present an interesting programme.

Take a look at the past OCLA!

The Programme Committee

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PROGRAMME DAY 1

09.30 - 10.00	**Welcome Café / Check-in**
10.00 - 10.20	**Welcome** Dr. Richard Quaderer and Prof. Dr. Carsten Ziolek
10.20 - 11.00	**Keynote: Optics got damaged below specified LIDT: whom to blame when everybody is right?** **Dr. G. Bataviciute,** Lidaris Ltd., Lithuania
11.00 - 11.30	**Breakout Sessions on different topics***
11.30 - 11.45	Break
11.45 - 12.15	**Photothermal deflection measurements in LBO crystals at 355 nm** **Dr. H. Cattaneo,** University of Applied Sciences OST, Buchs, Switzerland
12.15 - 12.45	**Deposition of multilayer optical coatings on corrugated surfaces for high-power micro-lasers** **L. Grineviciute,** Center of Physical Sciences and Technology, Lithuania
12.45 - 13.25	Lunch Break
13.25 - 13.55	**Linear and nonlinear absorption in optical coatings** **Dr. Ch. Mühlig,** Leibniz-IPHT, Jena, Germany
13.55 - 14.25	**Breakout Sessions on different topics***
14.25 - 14.55	**Vacuum Coating Equipment for low-loss laser coatings** **Dr. H. Hagedorn,** Bühler Alzenau GmbH, Alzenau, Germany
14.55 - 15.10	Break
15.10 - 15.40	**Comparison of monochromatic and broadband optical monitoring for deposition of non-quarter wave filter designs** **Dr. B. Rubin & Dr. K. Godin,** Veeco Instruments Inc., Plainview, USA
15.40 - 16.10	**Breakout Sessions on different topics***
16.10 - 16.20	**End of Day 1** **Thomas Gischkat,** RhySearch, Buchs

* The Breakout Sessions are devided into smaller groups to facilitate networking and discussion

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PROGRAMME DAY 2

09.30 - 10.00	**Welcome Café / Check-in**
10.00 - 10.20	**Welcome** Dr. Richard Quaderer and Prof. Dr. Carsten Ziolek
10.20 - 11.00	Keynote: **Nanostructured diffractive optics for high-energy laser applications** **Dr. F. Döring, XRNanotech,** Villigen, Switzerland
11.00 - 11.30	**Breakout Sessions on different topics***
11.30 - 11.45	Break
11.45 - 12.15	**Determination of adhesion and mechanical properties of optical coatings by nanoscratch and nanoindentation** **Dr. J. Nohava,** Anton Paar TriTec SA, Corcelles, Switzerland
12.15 - 12.45	**Mid-Infrared IBS Coatings for Laser Applications** **Dr. V. Wittwer,** University of Neuchâtel, Switzerland
12.45 - 13.25	Lunch Break
13.25 - 13.55	**Beyond high power laser mirrors** **Dr. H. Hartung,** Layertec GmbH, Mellingen, Germany
13.55 - 14.25	**Breakout Sessions on different topics***
14.25 - 14.55	**3D-Patterning using a short pulse laser to manufacture thermal sensors with high sensitivity and robustness** **R. Bernhardsgrütter,** IST AG, Ebnat-Kappel, Switzerland
14.55 - 15.10	Break
15.10 - 15.40	**Breakout Sessions on different topics***
15.40 - 16.00	**Update on the activities at RhySearch and conclusion of OCLA 2021** **Dr. R. Botha, RhySearch,** Buchs, Switzerland
16.00	**End of Day 2**

* The Breakout Sessions are devided into smaller groups to facilitate networking and discussion

The Symposium on Zoom

This is the first OCLA to take place online.

The event runs via Zoom. Please use the link we sent you via email. We advise you to download Zoom instead of just running it in the browser. Make sure that you use the latest Zoom version: 5.5.4
If Zoom is not installed on your computer, select the „participate using your browser“ option.

If you have any questions regarding the Zoom Meeting do not hesitate to contact Beni Muller via telephone +41 44 271 20 77.

Breakout Sessions

The Breakout Sessions are divided into smaller groups to facilitate sharing personal views and experiences. You may choose a group of your interest every time the breakout rooms are opened.

- **Room LIDT**
  Topic: Thin films and laser induced damage (e.g. degradation, LIDT)
- **Room ALD**
  Topic: Thin films by Atomic Layer Deposition ALD (e.g. thin film properties, deposition rates)
- **Room CRD-LID**
  Topic: Methods to analyze high-end optical coatings (e.g. Cavity Ring Down CRD, Laser Induced Deflection LID, scattering, scratch test)
- **Room Microstructure**
  Topic: Microstructuring of thin films (e.g. methods, applications)
- **Room Coating**
  Topic: Coating technologies (e.g. end point detection, processes, technical aspects)

Dr. Gintare Bataviciute

Project Manager at Lidaris Ltd. Lithuania

Dr. Gintare Bataviciute is a project manager and co-founder of Lidaris company that specializes in laser damage testing. She has been studying and working with laser damage-related issues for over 10 years. Over this time, she has participated in multiple scientific projects, has contributed over 20 research papers related to laser damage issues, and has received an SPIE Laser Damage reward for presented research in LIDT metrology.

Optics got damaged below specified LIDT: whom to blame when everybody is right?

Dr. Andrius Melninkaitis, Ruta Pakalnyte, Linas Smalakys, Dr. Gintare Bataviciute, Egidijus Pupka.
Lidaris Ltd. Lithuania

Many optical elements are characterized by laser-induced damage threshold (LIDT). However, it is not uncommon for optics to be damaged while in use anyway. To understand this sort of irrational issue, some well-known myths in the laser damage field should be addressed. For instance, it is assumed, that the complex laser damage phenomenon can be universally characterized by a single number - LIDT. In practice, many reasons might lead to damage. These reasons can be roughly sorted into two groups: space- or time-related effects. Spatial effects are mainly responsible for localized manufacturing defects in optics that cause inhomogeneity of optics performance, while temporal effects are mainly related to degradation or fatigue of optics in time. Depending on dominating process optics must be treated differently by the means of LIDT testing. Thus, in this presentation, various damage testing approaches will be overviewed to address reality-constrained situations and the purpose of testing.

Ralf E. Bernhardsgrütter

IST AG, Ebnat-Kappel, Switzerland

Ralf E. Bernhardsgrütter studied physics at ETH Zurich, Switzerland, and received his Master's degree in 2017. In 2017 he joined Innovative Sensor Technology IST AG, Ebnat-Kappel, Switzerland, a member of the Endress+Hauser group. Currently, he is conducting his PhD in a cooperation between University of Freiburg (IMTEK), Germany, and IST AG. His research is currently focused on thermal sensors and flow sensors.

3D-Patterning using a short pulse laser to manufacture thermal sensors with high sensitivity and robustness

This presentation shows a method to manufacture thermal sensors where the sensitive element is protected against corrosion by an intermediate stainless-steel wall and features high sensitivity. Progress claims include: 1) The sensitive platinum thin film structure is directly applied on a round stainless-steel tube to reduce the thermal resistance, only a thin insulation layer is in between (see figure 1). 2) A short pulse laser is used to achieve the round 3D-patterning of the thin film (see figure 2). 3) Laser ablation of platinum is characterized for a short pulse laser and shows two different ablation regimes. The dominant process is melting in the low fluence regime and the evaporation in the high fluence regime (see figure 3). The findings can have a key role in future thermal sensors such as thermal conductivity, flow or also temperature sensors because a reduction of thermal mass means higher sensitivity, faster sensor behavior and less power consumption.

Dr. Roelene Botha,

RhySearch, Buchs, Switzerland

Roelene Botha holds a Masters in electrical and electronics engineering from the University of Johannesburg, South Africa. She completed her PhD in physics at Ecole Polytechnique, France and the ParisTech Doctoral Management Program from the ENPC School of International Management, Paris, in 2008. She worked in a variety of roles in industry in the Alpine Rhine Valley, in the fields of solar cell manufacturing, lithography, optical coatings, and as the manager of a cleanroom production line. From 2014 to 2019, Roelene Botha was Senior Research Engineer at NTB Buchs, responsible for the establishment of OCLA symposium, the LIDT and CRD activities. Since 2015 she also worked as a project manager for RhySearch, assisting in the establishment of the optical coating activities and expansion of the infrastructure. Since September 2019 Roelene Botha Heads the Optical Coating division at RhySearch.

Update on the activities at RhySearch

Ever increasing demands are placed on optical components used in hostile environments and for high laser power applications. Manufacturing the optical components with the required robustness and high power-handling capabilities is complex and requires the availability of state-of-the-art fabrication equipment, precise metrology as well as a deep understanding of all aspects of the manufacturing process chain. This talk will give an overview of the research activities at the Optical Coating division, the available expertise and infrastructure at RhySearch that cover the main aspects of the manufacturing chain and the future goal of bespoke mass production of optical components.

Dr. Heidi Cattaneo

Research scientist, University of Applied Sciences OST, Switzerland

Dr. Heidi Cattaneo holds a MSc in physics and a PhD in experimental physics and optics from Tampere University of Technology, Finland. After PhD, Dr. Cattaneo worked several years in research and development activities in industry in the Netherlands and Switzerland, where she was engaged in measurement techniques in semiconductor industry and lab automation. Dr. Cattaneo joined OST in 2018 and works there as a scientific coworker for several industrial and public projects at the national and international level.

Photothermal deflection measurements in optical materials at 355 nm

H. Cattaneo[1], D. Schachtler[2], R. Botha[2], C. Ziolek[1], O. Fähnle[1]
[1]Institute for Microtechnology and Photonics, OST, Buchs, Switzerland
[2]RhySearch, Buchs, Switzerland

Local variations in UV absorption has been used to detect sub-surface-damage (SSD) in optical materials such as LBO crystals and coated FS substrates. As a detection method, photothermal deflection in transmission with collinear pump and probe beams has been utilized. Using sensitive probe beam deflection detection, larger median cracks and coating errors on the sample surfaces are already visible even without UV excitation. To detect the small contamination particles on the surface and inhomogeneities in materials thermal properties require pumping at resonant wavelength. Using the proposed detection method different aspects like the effect of surface pretreatments prior coating or material alterations under LIDT sites can be investigated.

Dr. Florian Döring
XRNanotech, Villigen, Switzerland

Dr. Florian Döring is the CEO and founder of the high-tech startup XRnanotech. He received his PhD in materials physics from the University of Göttingen and subsequently completed an MBA. As a former scholarship holder of the Foundation of the German Economy, he was interested in management and entrepreneurship already at an early stage and has now founded the startup XRnanotech after his PostDoc at the Paul Scherrer Institute.

Nanostructured diffractive optics for high-energy laser applications

XRnanotech is an award-winning spin-off company from the Paul Scherrer Institut in Switzerland. We develop nanostructured diffractive optical elements for the high-tech industry and for large-scale research facilities. Our goal is to push the limits of diffractive optics by continuously, improving the resolution and efficiency for applications ranging from microscopy to scattering and spectroscopy.
Moreover, we expand the range of applications of diffractive optics from vacuum ultraviolet to hard X-rays by exploring new fabrication materials, processes, and designs. Using atomic layer deposition, we can coat our products, which helps us to overcome persistent challenges in the fabrication process and unlocks unprecedented performance. In this contribution, we will highlight the latest developments of diffractive optical elements in terms of resolution, efficiency and optical functionality.

Lina Grineviciute
Junior Researcher at Center for Physical Sciences and Technology FTMC, Lithuania

Lina Grineviciute is a last-year PhD student and a junior researcher in Centre for Physical Sciences and Technology (FMTC) and in Vilnius University (VU), Lithuania. Her PhD of materials engineering is dedicated to improve thin films deposition methods, adapting them to the development of novel optical elements applicable for both: high power standard laser systems and microlasers. Her skills and experience are focused on nanostructured optical coatings, photonic crystals, PVD technologies, atomic force microscopy, laser light interference lithography.

Deposition of multilayer optical coatings on corrugated surfaces for high-power micro-lasers

In high-power micro-lasers, when sufficient energy is generated, the properties of laser light beam deteriorates, i.e. the energy distribution deviates from the Gaussian form. Due to the small laser dimensions, standard multi-lens systems cannot be used for beam correction. In this work, we have demonstrated that physical vapor deposition combined with structured surfaces allows to achieve periodicity in two directions, forming a 2D photonic crystal, which by its properties acts as a spatial filter. However, in order to achieve the required characteristics of such elements, it is necessary to have not only a proper initial structure, but also a precise control of the deposited layers growth, ensuring the repeatability or even divergence of the initial structure geometry. In the presentation, the PVD technologies for the coatings on structured surfaces will be reviewed, paying main attention for glancing angle deposition method.

Dr. Harro Hagedorn

Bühler Alzenau GmbH, Alzenau, Germany

Dr. Harro Hagedorn studied physics at the University of Hamburg where he also completed his doctoral research study. In 1990 he started to work at NU Tech GmbH afterwards he continued to work at Leybold Optics. Currently he is working at Bühler Alzenau in the Optical Coating Departement.

Vacuum Coating Equipment for low-loss laser coatings

Dr. Harro Hagedorn, Jürgen Pistner, Holger Reus, Dr. Alex Ribeaud
Bühler Leybold Optics, Alzenau;

Interference coatings with very low total losses are essential components for enabling laser gyroscopes or laser interferometer gravitational-wave observatories. The substrate size between both applications has a significant difference: a couple of millimeter diameter is enough for fulfilling the needs of a laser gyroscope, but 200 – 400 mm are needed for a LIGO application. Physical vapor deposition techniques are used for the deposition of low loss coatings. Ion beam sputtering, magnetron sputtering and plasma enhanced evaporation are all able to produce low loss coatings. However there are distinct differences in their capability to produce low absorption, smooth coating interfaces, low defect densities and their ability to scale up for large and heavy substrates. Results for application in the visible and there near infrared for all three deposition techniques will be presented and compared for substrate sizes up to 600mm in diameter.

Dr. Holger Hartung

Layertec GmbH, Mellingen, Germany

Dr. Holger Hartung has studied physics at the Friedrich Schiller University (FSU) Jena, Germany. His PhD-thesis „Micro- and Nanostructuring of Lithiumniobate" was finalized in 2010 at the Institute of Applied Physics at the FSU Jena were he also worked several years as researcher. In 2016 he joined Laytertec as R&D engineer for lithographically structured optical thin films.

Beyond high power laser mirrors

In the last decades Layertec has evolved to a supplier of high power laser components including the manufacturing of optical substrates. Recently we focused on the integration of novel technologies into the fabrication process.
In our talk we address two of these technologies. Firstly, we present the application of an atmospheric chemical plasma treatment to fused silica surfaces allowing a processing at optical scales. Secondly, we established a fabrication process of structured layers and multilayered systems by lithography and sputter deposition. This allows the formation of surfaces with different optical functionality with a separation of a few micrometers.
Combining these technologies with Layertec's long term capabilities in optical coatings and optics enables a bunch of applications beyond the fabrication of high quality laser coatings.

Dr. Christian Mühlig

Leibniz-IPHT, Jena, Germany

Christian Mühlig studied physics at the Friedrich-Schiller-University (FSU) in Jena and completed his doctoral research study 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 he worked as research associate at Leibniz Institute of Photonic Technology in Jena where he is now a senior scientist responsible for characterization of optical materials and coatings with the particular focus on direct absorption measurements and cavity ring-down spectroscopy.

Linear and nonlinear absorption in optical coatings

Dr. Christian Mühlig
Leibniz-IPHT, Jena, Germany

Optical coatings are a key instrument to functionalize optical components. On the other hand, they are commonly the weak part in the optics when it comes to stability e.g. against laser irradiation. By means of our laser induced deflection (LID) technique, we are able to precisely and absolutely measure the coating absorption down to the sub-ppm level. The talk will cover the general LID concept, the setup, absolute calibration and different measurement concepts for common coating substrate geometries. Besides experimental results for thin film absorption in the DUV and NIR wavelength range, the focus of the talk will be on nonlinear absorption in TiO_2 thin films at 800nm and in HfO_2 thin films at 355nm and 400nm. In particular, the results for HfO_2 show a significant deviation from the expected behavior which are explained in comparison to previous data of bulk fused silica at 193nm.

Dr. Jiri Nohava

Anton Paar TriTec SA, Corcelles, Switzerland

Jiri Nohava is the Head of Product Competence at Anton Paar TriTec. He obtained his PhD in materials science at the Czech Technical University in Prague (Czech Republic). He joined Anton Paar TriTec in 2007 and has since become a specialist in instrumented indentation, tribology and scratch testing. His main task is development of new applications with Anton Paar instruments in frame of scientific and industrial projects. He regularly publishes in peer-reviewed journals and participates at international conferences

Determination of adhesion and mechanical properties of optical coatings by nanoscratch and nanoindentation

Jiri Nohava[1], Cecilia Augustin-Sanchez[2], Marta Brizuela[2]
[1]Anton Paar TriTec SA, Corcelles, Switzerland
[2]Tecnalia, Donostia-San Sebastian, Spain

In some applications optical coatings can delaminate from the substrate due to mechanical stresses. It is therefore important to know the adhesion of the coating in order to ensure its high quality. One of the most suitable techniques is the nanoscratch method which uses a diamond indenter that scratches the coating with increasing normal load. The scratch is analyzed for determination of critical loads that indicate adhesive failure of the coating. The present work shows the results of the nanoscratch and nanoindentation methods applied on anti-reflective coatings. The nanoscratch tests showed that the adhesion of these coatings can be reliably determined using optical microscope. Hardness and elastic modulus of the coatings were measured by ultra-low load nanoindentation. The results allowed for differentiation between the tested coatings despite very low penetration depths used (~10 nm). Both methods used in this study can easily be applied to other optical coatings.

Dr. Binyamin Rubin

Veeco Instruments Inc., Plainview, USA

Binyamin Rubin holds PhD in Aerospace Engineering from Technion - Israel Institute of Technology and MSc and BSc from Moscow Institute of Physics and technology. His experience includes development of ion thrusters for space propulsion and development of ion beam deposition and etch equipment. He has worked for Veeco for 10 years and is currently a manager of the Advanced Deposition and Etch Technology group.

Kyle Godin

Veeco Instruments Inc., Plainview, USA

Kyle Godin is currently a Process Development Engineer at Veeco where he has been for two and a half years, working with the Spector ion beam sputter product line for thin film optics. He holds a PhD from Stevens Institute of Technology and has a background in microfabrication, crystal growth, and photonics.

Comparison of monochromatic and broadband optical monitoring for deposition of non-quarter wave filter designs

Binyamin Rubin[1], Kyle Godin[1], Jason George[1], Riju Singhal[1], David Deakins[2]
[1]Veeco Instruments, 1 Terminal Drive, Plainview, NY 11787 USA
[2]Meliora Scientific, 328 Air Park Drive, Suite 100, Fort Collins, CO 80524 USA

Optical monitoring is widely used in the optical coating industry for controlling the deposition of complex interference filter designs. Monochromatic turning-point monitoring was originally developed for controlling the deposition of band pass filters based on quarter wave stacks. Broadband optical monitoring is capable of monitoring a wide variety of interference filter designs, but it has limitations related to its spectral resolution. In the recent literature, multiple strategies to extend monochromatic optical monitoring for fabricating non-quarter wave designs have been presented. In addition, combined methods that use both monochromatic and broadband optical monitoring were also described. In this contribution we present a direct experimental comparison of monochromatic and broadband optical monitoring for the deposition of complex non-quarter wave interference filters.

Dr. Valentin Wittwer

University of Neuchâtel, Switzerland

Valentin Johannes Wittwer has received the Diploma in physics and the Ph.D. degree from the Federal Institute of Technology (ETH) in Zurich, Switzerland, After his graduation, he has been awarded a fellowship by the Swiss National Science Foundation to do a post-doc with the University of Cambridge (U.K.) in the group of Prof. A. C. Ferrari where he was developing graphene-based saturable absorbers for ultrafast lasers. Then he moved to the group of Prof. T. Südmeyer at the University of Neuchâtel. He is currently leading the ion-beam sputtering growth activities, managing collaborative projects with industry and research partners, and supporting the ultrafast thin-disk laser and frequency comb activities

Mid-Infrared IBS Coatings for Laser Applications

Dr. Valentin Wittwer, Prof. Dr. Thomas Südmeyer,
Laboratoire Temps-Fréquence, Institut de Physique, Université de Neuchâtel, Neuchâtel, Switzerland

The large progress in the field of ultrafast lasers in the last years has opened new application areas. This has increased the required specification on optical coatings. Ion Beam Sputtering (IBS) has proven to satisfy the high requirements on dielectric coatings in the UV, VIS and NIR spectral region, providing high precision, low optical losses and high damage threshold. It produces dense layers with a high accuracy and high damage threshold, low scattering and absorption of light and no need for high substrate temperatures. Besides using this technology to produce optics for ultrafast high-power lasers we extended in the last years their applications for laser applications in the mid-infrared (MIR) spectral region such as optics for ultrafast Cr:ZnS bulk laser oscillators and quantum cascade lasers. In this talk we will give an overview on our coating activities extending up to the MIR spectral region.

Save the Date

We are looking forward to welcoming you at OCLA 2022 in Buchs

13.04.2022

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