
2021
Annual Report
Institute of
Applied Physics
Friedrich-Schiller-Universität Jena

Imprint

ADDRESS	Friedrich-Schiller-Universität Jena Institut für Angewandte Physik Albert-Einstein-Straße 15 07745 Jena
DIRECTOR	Prof. Dr. Andreas Tünnermann
CONTACT	andreas.tuennermann@uni-jena.de Phone (+49) 3641 I 9 47800 Fax (+49) 3641 I 9 47802
WEBSITE	www.iap.uni-jena.de
EDITORIAL	Ira Winkler
LAYOUT	Ira Winkler
PICTURES/ GRAFICS	Institute of Applied Physics (IAP), Fraunhofer IOF [W. Oppel, C. Süß], Friedrich Schiller University Jena [J.-P. Kasper, J. Meyer], p.36: aboutpixel.de/Lektüre©marshi

Cover: Dr. Tobias Vogl, Kim Lammers and Dr. Falk Eilenberger happy with the DLR Award. Image: Anne Günther (University of Jena)

Content

PREFACE / VORWORT

We were all surprised by the permanence of the pandemic situation. Thus, we could not return to the normal operation of our institute in 2021 and had to master the balancing act between home office and presence work for another year. Nevertheless, we were also very successful in various areas in 2021!

Of particular strategic importance for further research work at the Institute of Applied Physics and the Fraunhofer IOF is the establishment of the Quantum HUB Thuringia with the support of the Free State of Thuringia, which promotes the networking of research in quantum technologies and also generates visibility for our work. We are already active in a large number of projects in quantum communication, quantum computing and quantum sensors and imaging, and are an important partner for science and industry - in the future we will be able to achieve greater synergy effects here.

Special recognition went to Dr. Tobias Vogl and Prof. Stefan Nolte who, together with our partner CiS GmbH (Erfurt), received the "INNOspace Masters Award" of the German Aerospace Center (DLR), worth 400,000 euros, for the idea of "universally applicable quantum circuits".

A core project for our two institutes IAP and Fraunhofer IOF for the coming years is the BMBF-funded project "PhoQuant - Photonic Quantum Computer". Together with other partners, we are developing a quantum computer on a photonic platform - a demonstrator will be built in Jena within 2.5 years (contact: Prof. Andreas Tünnermann and Dr. Frank Setzpfandt).

The results of the research group "Soft X-ray Spectroscopy and Microscopy" (Dr. Jan Rothhardt) are also highly impressive. Through the synthesis of laser technology, precision optics and modern imaging methods, a detailed insight into complex nanostructures in the extreme ultraviolet (EUV) spectral range has been achieved. The combination of high spatial resolution and high material contrast enables material identification in complex structures on the nanometre scale. Areas of application include battery research. Through cooperation with the Fraunhofer IOF and the Helmholtz Institute Jena within the "Joint EUV-XUV Technology Lab", we have been able to place ourselves at the leading edge of the world.

Only your personal commitment and the cross-institutional cooperation in research, technology and administration enabled us to attain these outstanding achievements. Many thanks to you and our partners in science, economy, society and politics. I look forward to continuing this successful cooperation in 2022.

Sincerely,

Andreas Tünnermnann

Uns hat sicher alle die Dauerhaftigkeit der pandemischen Lage überrascht. So konnten wir auch 2021 nicht in den Normalbetrieb unseres Instituts zurückkehren und mussten ein weiteres Jahr den Spagat zwischen Homeoffice und Präsenzarbeit meistern. Nichtsdestotrotz waren wir auch in 2021 in verschiedenen Bereichen sehr erfolgreich!

Von besonderer strategischer Bedeutung für die weiteren Forschungsarbeiten am Institut für Angewandte Physik und am Fraunhofer IOF ist die Etablierung des QuantenHUB Thüringen mit Unterstützung des Freistaats, der projektübergreifend die Vernetzung der Forschung in den Quantentechnologien befördert und zudem Sichtbarkeit unserer Arbeiten generiert. Bereits heute sind wir in einer Vielzahl von Projekten in der Quantenkommunikation, im Quantencomputing und in der Quantensensorik und -bildgebung aktiv und wichtiger Partner für Wissenschaft und Wirtschaft – hier können wir zukünftig verstärkt Synergieeffekte erzielen.

Besondere Anerkennung erhielten Dr. Tobias Vogl und Prof. Stefan Nolte, die gemeinsam mit unserem Partner CiS GmbH (Erfurt) den mit 400.000 Euro dotierten „INNOspace Masters Award“ des Deutschen Zentrums für Luft- und Raumfahrt (DLR) für die Idee zu „universell einsetzbaren Quantenschaltkreisen“ ausgezeichnet wurden.

Ein Kernprojekt für unsere beiden Institute IAP und Fraunhofer IOF für die kommenden Jahre ist das durch das BMBF geförderte Projekt „PhoQuant – Photonischer Quantencomputer“. Gemeinsam mit weiteren Partnern entwickeln wir einen Quantencomputer auf einer photonischen Plattform – innerhalb von 2,5 Jahren wird ein Demonstrator in Jena entstehen (Ansprechpartner: Prof. Andreas Tünnermann und Dr. Frank Setzpfandt).

Beeindruckend sind aber auch die Ergebnisse der Forschungsgruppe „Soft X-ray Spectroscopy and Microscopy“ (Dr. Jan Rothhardt). Durch die Synthese aus Lasertechnologie, Präzisionsoptik und modernen Bildgebungsverfahren ist ein detaillierter Einblick in komplexen Nanostrukturen im extremen ultraviolett (EUV) Spektralbereich gelungen. Die Kombination von hoher räumlicher Auflösung und hohem Materialkontrast ermöglicht Materialidentifikationen in komplexen Strukturen auf der Nanometerskala. Anwendungsgebiete umfassen u.a. die Batterieforschung. Durch die Kooperation mit dem Fraunhofer IOF und dem Helmholtz Institut Jena im „Joint EUV-XUV Technology Lab“ konnten wir uns an der Weltspitze positionieren.

Nur durch Ihr persönliches Engagement und die institutsübergreifende Zusammenarbeit in Forschung, Technik und Verwaltung konnten wir diese hervorragenden Leistungen erzielen. Ihnen und unseren Partnern in Wissenschaft, Wirtschaft, Gesellschaft und Politik herzlichen Dank. Ich freue mich auf die Fortschreibung der erfolgreichen Zusammenarbeit in 2022.

Herzlichst,

The Institute of Applied Physics (IAP) at the Friedrich Schiller University (FSU) Jena has a long-standing tradition and competence in design, fabrication and application of active and passive optical and photonic elements. It is also very well-known for its developments in the area of high power laser technology and nowadys also in quantum optics. Collaborative projects with companies ensure practical relevance and feasibility.

Research Profile

The institute conducts fundamental and applied research in the fields of micro-, nano- and quantum optics, fiber and waveguide optics, ultrafast optics as well as optical engineering.

Our researchers develop novel optical materials, elements and concepts for information and communication technology, life science and medicine, environment and energy as well as process technology including material processing and optical measurement techniques.

Current research topics - investigated by over 150 scientists - concern function, design, fabrication and applications of micro- and nano-optical elements. Those are e.g. plasmonic resonant nanometric structures, polarizers from IR to DUV range, 3D nano-structuring of crystals with ion beam and Atomic Layer Deposition of optical coatings. Also light propagation and non-linear light-matter interaction in e.g. photonic nanomaterials, including metamaterials, photonic crystals, as well as effective media, quantum phenomena and integrated quantum optics, application of photonic nanomaterials and advanced photonic concepts for astronomical instruments are investigated.

Further research fields are the applications of femtosecond laser pulses, such as material processing and spectroscopic analyses, as well as micro- and nano-structuring, medical (laser) application and additive manufacturing usage of ultrashort laser pulses. For further aims, new concepts for solid-state lasers with focus on fiber laser technology are to be developed, such as novel large core diameter fibers, fiber optical amplification of ultra short laser pulses and Mid-IR up to soft x-ray laser sources. With those, absorption spectroscopy with ultrahigh spectral resolution, especially in the (extreme) ultraviolet (XUV) region can be realized.

Classical optical design as well as design of modern optical systems, like freeform optics, illumination systems, laser and delivery systems are considered in our research, as well as aberration theory, quality, performance and tolerancing evaluation of optical systems.

By investigating these fields of research, particularly in close cooperation with the Fraunhofer Institute of Applied Physics and Precision Engineering (IOF) as well as many partners in science and economy, the IAP covers numerous parts of the innovation chain - from interdisciplinary fundamental research to the demonstration of prototypes. This expertise offers remarkable contributions to solve issues in the mentioned before emerging fields.

Excellence in research is confirmed by the structural anchoring of the Competence Centre (ZIK) ultra optics into one of three key research areas of the Abbe Center of Photonics (ACP), four awarded ERC Grants " Powerful and Efficient EUV Coherent Light Sources - PECS" (2009), "Advanced Coherent Ultrafast Laser Pulse Stacking - ACOPS" (2014), "Multi-dimensional interferometric amplification of ultrashort laser pulses - MIMAS" (2015) and "High-flux Synchrotron alternatives driven by powerful long-wavelength fiber lasers - SALT" (2019), the International Research Training Group GRK 2101 (2015) as well as the pilot project "Max Planck School of Photonics" (2017).

But not only excellent research makes the Institute splendid, also outstanding laboratory equipment, an excellent educated staff and an high commitment to the training of students and scientists in cooperation with the Abbe School of Photonics belongs to the self-understanding of the IAP.

THE INSTITUTE

Research Facilities / Resources

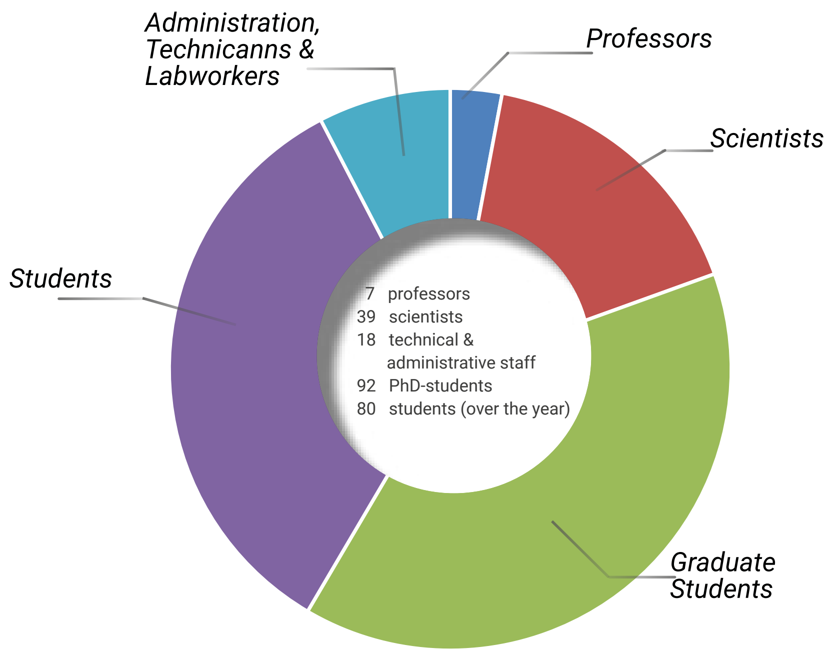
Excellence in research requires high quality equipment for experimental questions and analysis. The state-of-the-art technical infrastructure is driven constantly forward by acquired adaptions for scientific questions, done by an experianced crew.

860 m² class 10,000 to 10 clean room area for:

- Electron beam lithography equipped with variable shaped beam and cell projection
- Laser lithography & Photolitography
- Coating technologies (sputtering, electron beam evaporation, ALD)
- Dry etching (RIE, RIBE, ICP)
- Cross beam, scanning electron microscopy, equipped with EDX and EBSD
- Helium ion microscopy
- Scanning nearfield optical microscopy
- Interference optical surface profilometry
- UV-VIS spectrometry & FTIR spectrometry
- Ellipsometry
- Nonlinear optical waveguide characterization
- High repetition rate ultrashort pulse laser systems (25fs to 20ps) including wavelength conversion covering the range from 4nm to 10µm
- High-precision positioning and laser scanning systems
- Laser micro-structuring and additive technology
- Rigorous optical simulation
- Field tracing techniques

Structure of the Institute 2021

Staff in 2021



ABASIFARD Mostafa
ABBASIRAD Najmeh
ABBE Sylvia
ABDELAAL Mahmoud
ABED Omid
ABTAHI Fatemeh Alsadat
ACKERMANN Roland
AFSHARNIA Mina
AKAL Muhammed
ALAM Shawon
ALASGARZADE Namig
ALBERUCCI Alessandro
ALEMU Temesgen
ALESHIRE Christopher
ALLANDE-CALVET Neus
ANDRANGO A. Gabriela
ANDRIYENKO Olexandr
APELL Jonatan
ARUMUGAM Stree
AVERIN Anton
BADAR Irfan
BALADRON ZORITA Olga
BALAJI Vignesh
BEER Sebastian
BELADIYA Vivek
BENNER Maximilian
BERGNER Alexander
BERLICH René
BERNET Simon
BERRANG Bianca
BERTI LIGABO Joao
BEST Sabine
BINGOL Eda
BIRCKIGT Pascal
BLESSING Pascal
BLOTHE Markus
BODEN Justus
BÖRNER Stefan
BÖTTNER Paul
BRAASCH Marie
BRADY Aoife
BRAMBILA-TAMAYO Emma
BULDT Joachim
CABREJO PONCE Meritxell
CAI Danyun
CHAMBONNEAU Maxime
CHANDROTH PANNIAN Jisha
CHAUHAN Purujit
CHEN CHanaprom
CHOLSUK Chanaprom
CIBUK Burat
DIETRICH Patrick
DISTLER Victor
DITTRICH Yvonne C.
DZIADIA Samuel
EBNANG Emanuel
EILENBERGER Falk
ELMANOV Ilia
ESCHEN Wilhelm
FALKNER Matthias
FRASCH Johannes
FUCHS Hans-Jörg
FÜßEL Daniel
GABLER Thomas
GÄBLER Tobias Bernd
GÄRTNER Anne
GEBHARDT Martin
GEIß Reinhard
GEROLD Kristin
GHAZARYAN Lilith
GIERSCHKE Philipp
GILI Valerio Flavio
GOEBEL Thorsten A.
GOUR Jeetendra
GRÄFE Markus
GREBING Christian
GROSS Herbert
HAFIZ Md Golam
HÄUßLER Sabine
HENGSTER Julia
HEUERMANN Tobias
HILBERT Magdalena J.
HILBERT Vinzenz
HÖHNE Daniel
HÖLZER Gesa
IMOGORE Thimothy O.
IWAMA Masaki
JAFAROVA Konul
JAUREGUI MISAS Cesar
JOSHI Prafullakumar
JUNGNICKEL Tom
JUNGNICKEL Tom
KABIS Patrick
KAISER Thomas
KARST Maximilian
KÄSEBIER Thomas
KAUFMANN Johannes
KESSLER Victor
KETTERER Ryan
KHOLAIF Sobhy
KIRSCHE Alexander
KLAS Robert
KLECKNER Arno
KLENKE Arno
KLUGE Anja
KNOPF Heiko
KOCH Timea
KOHL Hagen
KOHOUT Oskar
KRÄMER Ria
KRAUSE Josefine
KRETZSCHMAR Johannes
KRICZ Andrej
KRSTI´C Aleksa
KUMAR Anand
KUMAR Mohit
KUMAR Pawan
KUMAR Sreejesh
KUNDU Rohan
KUPPDAKKATH Athira
LAHNOR Johannes
LAI Chenting
LAM Shiu Hei
LAMMERS Kim
LAMMERS Tom
LANDMANN Martin
LEE Ming
LEIPE Markus
LENSKI Mathias
LEON TORRES Josué R.
LI Jinhao
LI Pucong
LI Quingfeng
LI Xunyu
LI Yang-Teng
LI Zhi
LIMPERT Jens
LIN Zhiqiang
LINß Sebastian
LIPPOLDT Tom
LIU Chang
LIU Jiaming
LIU Zhishuai
LÖCHNER Franz
LÖTGERING Lars
LOTTMANN Moritz
LU Xiang
LUGANI Jasleen
LUKOWITZ, VON Henrik
MARTIN Bodo
MATHEW Steev
MATTHÄUS Gabor
MATZDORF Christian
MENG Sixu
MERX Sebastian
MISHUK Mohammad
MOHAMED Ahmed E.A.
MOHANTA Jyotirmaya
MONICA Monica
MÜLLER Michael
MUNSER Anne-Sophie
NARANTSATSRALT Bayarjargal
NATARAJAN R. Vishnoo
NGO Gia Quyet
NISSEN Mona
NOLTE Stefan
NUDING Jannik
NWATU Daniel
OTTO Christiane
OWUSU APPIAH Sheila
PACIOREK Karolina
PRADUTSCH Sven
PAEZ LARIOS Francisco
PAKHOMOV Anton
PALMA VEGA Gonzalo
PAUL Pallabi
PENAGOS MOLINA Daniel S.
PENG Rong
PÈREZ PÈREZ Inmaculada
PERTSCH Thomas
POHLE Lisa
PRAKASH Priyanka S.
PRIYA Jain
QU Zeng
RAN Yang
REPP Daniel
RICHTER Daniel
RICHTER Hannes
RIßMANN Cornelia
RITTER Sebastian
ROCKSTROH Sabine
ROCKSTROH Werner
ROTHHARDT Jan
SAFARI ARABI Masoud
SANGINI Sohrab
SANSA PERNA Adria
SANTOS SUÁREZ Elkin André
SARAVI Sina
SAUER Gregor
SCHADE Lisa
SCHARMER Floris
SCHEIBINGER Ramona
SCHELLE Detlef
SCHMELZ David
SCHMIDT Holger
SCHMIDT Martin
SCHMITT Paul
SCHMITTNER Christian
SCHREMPEL Frank
SCHUBERT Karl
SCHULZ Sophia
SCHUSTER Vittoria
SEGBERS Mats
SEKMAN Yusuf
SERGEEV Natali
SETZPFANDT Frank
SEVILLA GUITTÉRRES Carlos
SEYFARTH Brian
SHESTAEV Evgeny
SHI Rui
SIEFKE Thomas
SIEGMUND Florian
SIEMS Malte
SINGH Vikram
SINELNIK Artem
SOLTANI Afsoun
SPÄTHE Anna
SPERRHAKE Jan
SPIESS Christopher
SPIRA Susanne
STARK Lars Henning
STEFANIDI Dmitrii
STEINBERG Carola
STEINERT Michael
STEINKOPFF Albrecht
STEINLECHNER Fabian
STEMPFHUBER Sven
STEPHANIE Margareta
STIHLER Christoph
STOCK Carsten
SZEGHALMI Adriana
TANAKA Katsya
TANG Ziyao
TISCHNER Katrin
TÜNNERMANN Andreas
ULLSPERGER Tobias
VEGA PEREZ Andres R.
VETTER Julia
VOGL Tobias
VOIGT Daniel
WALTHER Markus
WANG Sici
WANG Yuhua
WANG Ziyao
WEIßFLOG Maximilian
WEITZING Sonja
WHITE Jonathon
WIDHOLZ Georg
WIDIASARI Fransiska R.
WINKLER Ira M.
WOHLFEIL Shulin
WYROWSKI Frank
XING Zhen
XU Mao
XU Quian
YOUNESI Mohammadreza
YU Zihuan
YÜREKLI Burak
ZAKOTH David
ZEITNER Uwe D.
ZHANG Jiahang
ZHANG Luosha
ZHANG Mingxuan
ZHANG Xiangyun
ZHANG Yueheng
ZHANG Zifei
ZHAO Xiaodong
ZHONG Huiying
ZIMMERMANN Tobias

Guests

Guests indicate the national and international visibility of research results and enrich the structures of the Institute with new thinking and perspectives - not only in research and teaching, but also open eyes to other cultures and strengthen the network by personal relations.

Due to the pandemic situation in 2020 and 2021, intensive research visits and personal contacts were unfortunately not possible.

BOHN Justus	University of Exeter, Great Britain
DE LUCIA Francesco	Optoelectronics Research Centre, University of Southampton, Great Britain
EICHNER Timo	Deutsches Elektronensynchrotron DESY, Hamburg, Germany
FEDEROLF Mathias	Universität Ulm, Germany
NIV Avi	Ben-Gurion University of the Negev, Israel
POULTON Christopher	UTS University of Technology Sydney, Australia
SHARAPOVA Polina	Universität Paderborn, Germany
VINEL Vincent	University of Paris, France
XU Mike	Monash University Melbuorne, Australia
ZAND Ashkan	TU Kaiserslautern, Germany

Cooperations

The IAP has a strong network of partners regionally, nationally, and all over the world. Located in the heart of Jena's optics industry, it is connected to resident international players in the economy as well as research institutions. So, it has a close connection to other departments of the Faculty of Physics and Astronomy at Friedrich Schiller University, 2021 in particular the Otto Schott Institute of Materials Research. Since many years the IAP collaborates also with the University of Applied Sciences (EAH) Jena.

Our work is connected deeply to many important research associations of Germany, such as the Max-Planck-Institutions, especially in Erlangen and Garching, as well as the Institutes of the Leibniz and Helmholtz Association - such as the Institute for Astrophysics Potsdam (AIP) and the Leibniz Institute of Photonic Technology (IPHT), the Helmholtz Institute in Hamburg (DESY) and Jena (HIJ) – to name some of them. Firm European cooperation exist with French research institutions, such as the Centre national de la recherche scientifique (CNRS) in Paris and the ELI-ALPS, Extreme Light Infrastructure in Szeged, Hungary.

Traditionally, the IAP is linked closely to the Fraunhofer Institute for Applied Optics and Precision Engineering (IOF). Based on this networking between the two Institutes, one major goal is to develop an outstanding research and application results for micro- and nano-structured optics, whole optical systems, lasers and Quantum optics. Beyond this co-operation, the "Leistungszentrum Photonics" was associated together with other local players, such as Abbe Center of Photonics (ACP), Leibniz Hans Knöll Institute (HKI) Helmholtz Institute Jena and the Leibniz Institute of Photonic Technology (IPHT). With both of the last mentioned, the "Fasertechnologiezentrum" is being operated to develop and produce novel fibers for worldleading lasers.

In addition, the IAP maintains close contacts to universities and research facilities nearly all over the world for years: major international collaborations exist with the Centre of Ultrahigh bandwidth Devices for Optical Systems (CUDOS), the Australian National University, as well as universities in Belgium (Brussels & Ghent), Canada (Québec, Toronto & Varennes), China (2021 Wuhan & Nanjing), Russia (Nizhni Novgorod, St. Petersburg), Finland, Spain, Switzerland, Taiwan, The Netherlands and USA.

Through the Max Planck School of Photonics (MPSP) educational project, we also cooperate with many of the renowned German research institutions mentioned above.

For years, we work also close with regional industry partners - from medium-sized to internationally operating companies; current: Carl Zeiss AG in Jena and Oberkochen, Jenoptik AG, Layertec GmbH, OSRAM Licht AG, Active Fiber Sytems GmbH and many more.

By working together with all our partners, we are constantly expanding our know-how and our focus on problems and their solutions.

Further Cooperations with Joint Research Topics

AT Technologies
Veldhoven, The Netherlends
Mikhail Loktev

CELIA
Université Bordeaux, France
Prof. Inka Manek-Hönninger

Datalogic
Bolognia, Italy
Federico Canini

Engineering Science
University of Oxford, Great Britain
Prof. Martin Booth

Fraunhofer-Institut für Techno- und Wirt-schaftsmathematik ITWM
Kaiserslautern, Germany
Felix Riexinger

GrinTech GmbH
Jena, Germany
Dr. Bernhard Messerschmidt

Institut für Biomedizinische Optik
Universität Lübeck, Germany
Dr. Nobert Linz

Institut für Energieverfahrenstechnik
und Chemieingenieurwesen
TU Bergakademie Freiberg, Germany
Stefan Guhl

Institut für Quantenoptik
Max Planck Gesellschaft
Garching, Germany
Prof. Imanuel Bloch

Institute of Electronic Structure and Laser (IESL)
Foundation for Research and Technology
Hellas, Heraklion, Greece
Prof. Stelios Tzortzakis

KLA-Tencor
Milpitas, California, USA
Maarten van der Burgt

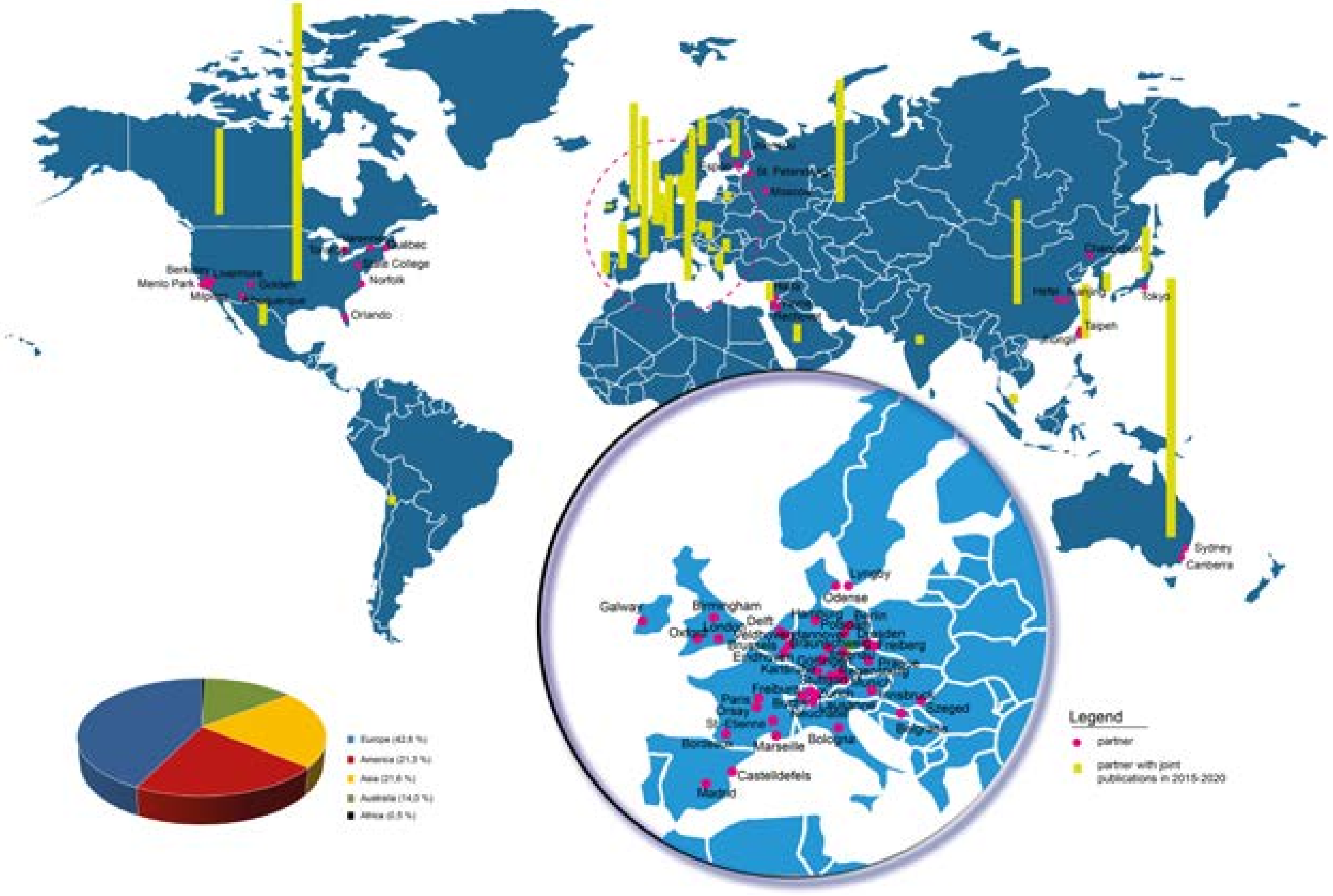
Light Prescriptions Innovators llc. (LPI)
Madrid, Spain
Dr. Ruben Mohedano

LP3 - Lasers, Plasmas et Procédés Photoniques
Aix-Marseille Université, CNRS, France
Dr. Olivier Uteza, Prof. François Goudail

Photonik und Medizintechnik
University of Applied Sciences and Arts (HAWK)
Göttingen, Germany
Prof. Christoph Russmann

Physikalisches Institut
Universität Tübingen, Germany
Prof. Christian Gross

The Institute of Photonic Sciences - ICFO
Barcelona, Spain
Dr. Juan P. Torres



Partners of the IAP and a quantitative figure of common publications in 2013-21.

EDUCATION

An essential part of the IAP is the training of young scientists on fundamental knowlegde and at the interface of physics, chemistry and material science. Together with our partner in education - the Abbe School of Photonics (ASP) - we offer an education in interdisciplinary international Master´s degree and graduation programs. Since 2017 the "Max Planck School of Photonics" (MPSP) is coordinated in Jena to qualify young scientists in pioneering research fields.

Lectures *Elective & Special Courses*

- Analytical Instrumentation
- Atome und Moleküle I & II
- Computational Photonics
- Computational Physics I
- Design & Correction of Optical Systems
- Experimental Optics
- Fundamentals of Modern Optics
- Grundlagen der Laserphysik
- Grundpraktikum Pharmazie
- Grundpraktikum Physik
- Grundpraktikum Physik für Humanmediziner
- Imaging and Aberration Theory
- Innovation Methods in Photonics
- Integrated Quantum Photonics
- Introduction to Nanooptics
- Introduction to Optical Modeling
- Lasers in Medicine
- Laser Physics
- Lens Design I & II
- Mathematical Methodes in Physics
- Micro/nanotechnology
- Optical Metrology and Sensing
- Physikalisches Kolloquium
- Quantum Communication
- Quantum Computing
- Quantum Imaging and Sensing
- Structure of Matter
- Thin Film Optics
- Ultrafast Optics
- Vakuum- und Dünnschichtphysik

Seminars of the Devisions

- Applied Computational Optics
- Applied Physics
- Atomic Layer Deposition
- Design of Optical Systems
- Fiber Lasers
- Graduate Seminar
- Microstructure Technologies - Microoptics
- Nano and Quantum Optics
- Ultrafast Optics

Bachelor Theses

Johanna Conrad
Realisierung von lasergeschriebenen Wellenleitern für quantenoptische Anwendungen

Darius Haitsch
Quantum Frequency Mode Masurement via an Array of Fiber Bragg Grating

Kevin Hanemann
Iridium-Dielektrika-Schichtsysteme für absorbierende Entspiegelungen im nahen infraroten Spektralbereich

Sven Padutsch
Laser-Pulver-Bett-Schmelzen von Kalk-Natron-Glas mit einem CO_2-Laser

Mats Segbers
Messung und Stabilisierung der Pulsdauer von Femtosekundenlasersystemen

Master Theses

Mahmoud Abdelaal
Ultrashort Pulse Characterization

Temesgen Alemu
Design of head-up displays

Cristina Amaya
Temporal Contrast Improvement for Multi-Pass Cell Nonlinear Compression

Maximilian Benner
Aufbau eines CEP-stabilen Seedlasers

Luis Javier Gonzalez Martin del Campo
Experimental Demonstration of High-Dimensional Hyperentangled Quantum States

Varun Raj Kaipalath
Spatial decomposition of biphoton states generated in spontaneous parametric downconversion

Johannes Kaufmann
Fundamental investigations of silicon structuring with Helium ions for a novel technology in the fabrication fo X-ray optics

Hagen Kohl
Modeling and validation of the LPBF process with pure copper

Ming Lee
Photonic Waveguide with Embedded Two-dimensional Material

Rongukan Leng
Light scattering based roughness analysis of transparent substrates

Ke Li
Towards single shot structured light 3D scanning: synthetic training data for robust deep learning approaches

Abrar Fahim Liaf
Influence of a Titanium seed layer on the optical properties of ultrathin aluminum layers prepared by evaporation

Jiaming Liu
Simulation and optimization of gas plasma based THz generation

Elshan Mahmudlu
Inscription and Analysis of Multiple Eccentric Fibre-Bragg-Gratings in Polymer Optical Fibres for Bend Sensors

Sarath Maratha Palli
Cooling of Strontium atoms in an optical lattice

Zhang Qu
Atomic layer deposition of Yb_2O_3. Process development using $Yb(Cp)_3$ as ALD precursor

Vishnoo Natarajan Rajkumar
Deposition of Al_2O_3 on HTS SQUIDs at room temperature using ALD

Sebastian Ritter
Femtosecond fringe patter projection systems for 3D measurement of ultrafast processes

Karl Schubert
OPCPA-free, tunable, effcient, ultrafast source

Rana Khaled Hassan M. Sebak
Engineering the Spatial Properties of Entangled Photon for Space-readiness

Alam Shawon
Optical and mechanical properties of ternary oxide thin-films of SiO_2:HfO_2, Al_2O_3: HfO_2, and HfO_2:TiO_2 by atomic layer deposition (ALD) for high power laser applications

Tong Tian
Imaging Characteristics of Light Sources with Different Degrees of Coherence

Yuhua Wang
Design and correction of head mounted displays

Shiyao Wang
Physical Optics Modeling of Optical Systems for X-Ray Applications

Tymoteusz Wrzeszcz
Investigations on straylight in Echelle spectrometer gratings

Shufeng Yan
Simulation of Dual-direction Propagation Light Guide

Yu Zhang
A self-aligned fiber to chip coupler for cryogenic quantum photonic integrated circuits

Jiahang Zhang
Diffractive and Fresnel-type Lens Modeling by Channel Concept

Liying Zhang
Physical Optics Analysis of Various Lens System

Xinchang Zou
Investigation of direct writing methods for large area gratings

Doctoral Theses

Jonas Berzins
Optically-Resonant Nanostructure-based Systems for Spectral Selectivity

Ulrike Blumröder
Untersuchung der THz-Emission von Silizium in Abhängigkeit von Grenzflächen- und Kristalldefekten

Victor Arved Diestler
Neue Konzepte für Hochleistungsfaserlaser

Matthias Goy
Aktive Metallspiegel für Anwendungen in der satellitenbasierten Beobachtung

Michael Jenne
Orts- und zeitaufgelöste Analyse der Volumenbearbeitung von Glas mit raum-zeitlich geformten ultrakurzen Laserpulsen

Robert Klas
Development of tailored XUV sources for applications in Laser spectroscopy and imaging experiments

Heiko Knopf
Verstärkung der Licht-Materie-Wechselwirkung funktionaler Monolagen durch deren Einbettung in Resonatorschichtsysteme

Franz Löchner
Second-Order Nonlinear Frequency Generation in Nanostructured Surfaces

Xiang Lu
Modelling and simulation of light scattering in optical systems

Sebastian Merx
Beam shaping of Bessel beams with high power laser systems

Michael Müller
The Scaling Limits of Beam-Splitter-Based Coherent Beam Combining

Anton Pakhomov
Efficient modeling and optimization of second-harmonic generation from nanophotonic components

Rui Shi
Vectorial Physical-Optics Modeling of Microscopy Systems

Zhongzhao Wang
Fourier transform techniques for fast physical optics modeling

Daniel Werdehausen
Nanocomposites as Next- generation Optical Materials: Fundamental Properties and Potential

Liangxin Yang
Optical Design for Far-field Light Shaping

Huiying Zhong
Field tracing in graded-index media

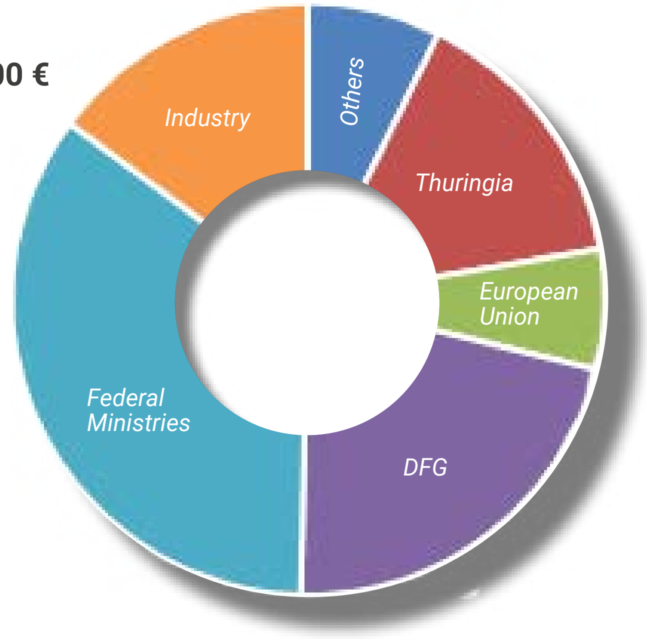
RESEARCH

RESEARCH - Projects

"Applied Physics“ is implemented in numerous projects in different application fields that contain fundamental research as well as application aspects. Accordingly, strong partners were explored and cooperation expanded. Thus, the IAP can continuously link the results and transfer those from basic research into innovative and novel demonstrators.

Third-party expenditure

Federal Ministries	2,937,000 €
DFG (German Research Society)	1,823,000 €
State of Thuringia	1,269,000 €
Contract Research	1,258,000 €
Foundations / Others	615,000 €
European Union	553,000 €
Total:	**8,455,000 €**



RESEARCH - Achievements & Results

An intense engagement with all the research topics of the institute ultimately leads to the specialization of separate research groups on key challenges.
In turn, each group contributes with their results to the solution of partial tasks of the other work groups. This constantly self-fertilising approach itself leads to remarkable results. Measurably honored are such results by success in granting research contracts, the strong interest in cooperation with the IAP and the number of scientists and students who would like to work at IAP scientifically.

Some highlights of current research topics from our research groups are presented in the following.

Authors:
Arno Klenke, Albecht Steinkopff, Cesar Jauregui Misas, Christopher Aleshire and Jens Limpert

kW-class multicore fiber laser system

The parallelization of amplification of ultrashort laser pulse in optical fiber has resulted in a drastic increase of their performance capabilities over the last years. This has extended the possible applications of such systems in industry and research. Recently, the focus has been on decreasing the complexity of these systems. In general, the aim is to reduce multiplication of components with the number of amplifier channels and directly realize them as discrete multi-channel components instead.

The most important components of such system are so-called multicore fiber which integrate multiple amplification channels into a single fiber. To achieve competitive performance compared to multiple single-core fibers, the integration of advanced fiber design elements is of great importance. This includes the realization of the fiber in a rod-type geometry and the exclusive use of fused silica as the optical base material. A fiber with 4x4 cores and an integrated guidance mechanism for the emission for the optical pump diode that creates the optical inversion has been realized.

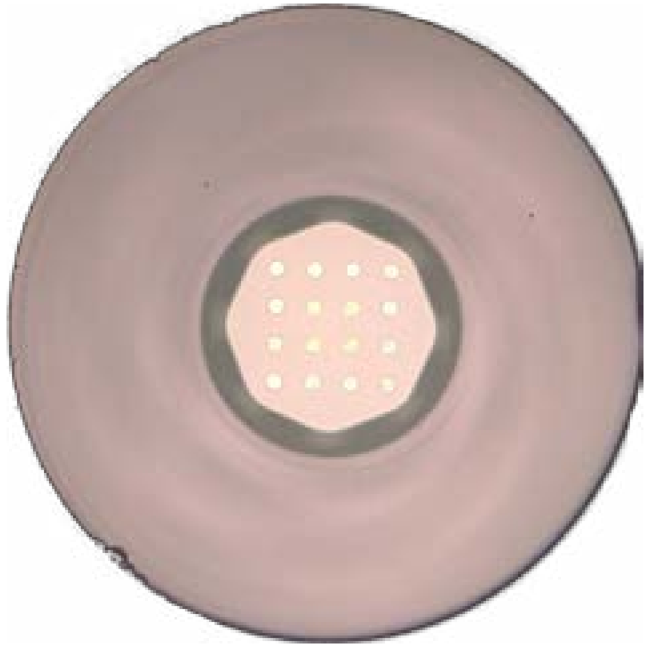


Figure 1:
Image of the rod-type Multicore fiber with 16 cores for amplification and integrated octagonal guidance for the optical pump light.

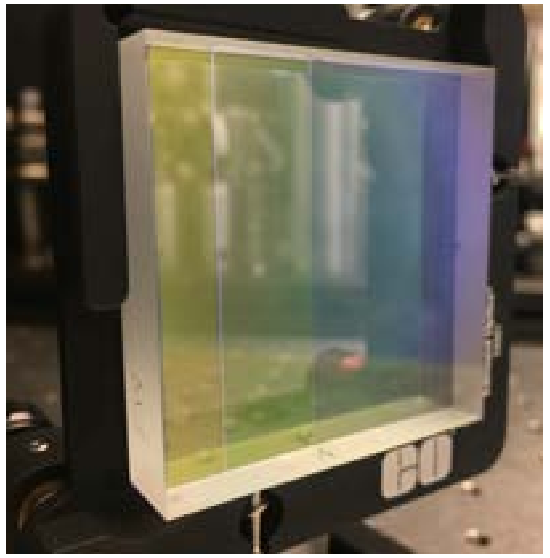


Figure 2:
Image of an SMS element for a beam splitting- or combination setup.

This fiber was embedded into a setup for beam splitting and combination that uses so-called segmented-mirror-splitter (SMS) elements. In order to achieve coherent combination of the output beam, control of the phases of each beam is required with a precision of clearly less than the wavelength of the light of 1µm. This is realized using a multi-channel phase stabilization system.

Using this amplifier setup, a laser system emitting up to 0.5kW of average power from a single one of these multicore fibers was realized. Additionally, up to 600µJ pulse energies were achieved. Thereby, performance characteristics of much larger laser systems have been reached. Further development of this technology, especially by increasing the number of cores in the fibers, will allow connecting highest laser performance with the advantages of fiber technology. Theoretical simulations have already demonstrated that average powers above 10kW in combination with more than 100mJ pulse energy will be achievable.

/1/ A. Klenke, et al: 500 W rod-type 4x4 multi-core ultrafast fiber laser. Opt. Lett. 47(2), 345-348, 2022.

/2/ A. Steinkopff, et al: The impact of thermo-optical effects in coherently-combined multicore fiber amplifiers. Opt. Express 28, 38093–38105, 2020.

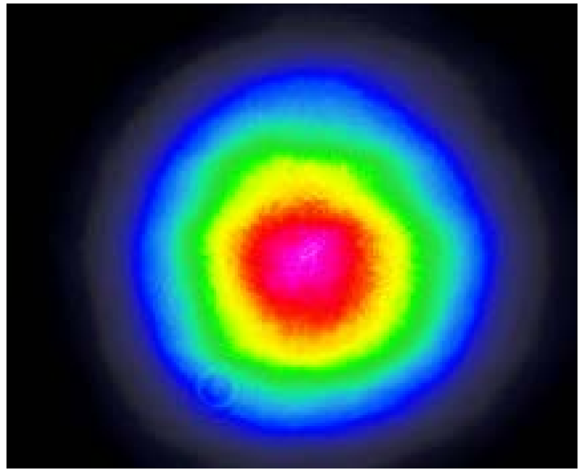


Figure 3:
Image of the combined output beam at 0.5kW average power

Authors:
Robert Klas, Jan Rothhardt and Jens Limpert

10 mW coherent XUV source at 1 MHz repetition rate

High harmonic generation (HHG) and its applications have been studied since more than three decades, enabling table-top extreme-ultraviolet (XUV) applications in fields as diverse as physics, biology and chemistry [1]. Nearly all of these applications would benefit from a higher XUV average power to e.g. decrease measurement times and increase signal to noise ratios.

In principle, the efficiency of the HHG process is maximized by using a driving laser with very short pulse duration and small wavelength. This allows driving the phase-matched HHG process with higher intensities and maximizes the recombination probability of the laser-driven electron, which causes the XUV emission /1/. An up-scaling of the XUV average power can be achieved by e.g. increasing the average power of the driving laser.

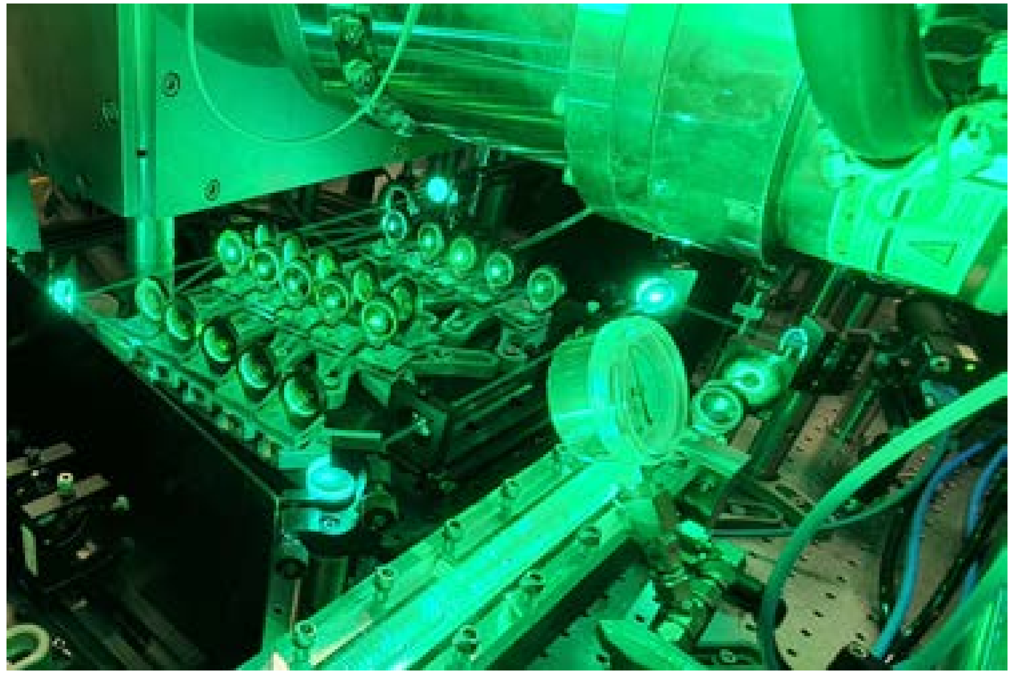


Figure 1:
Chirped mirror compressor operating at highest demonstrated average powers.

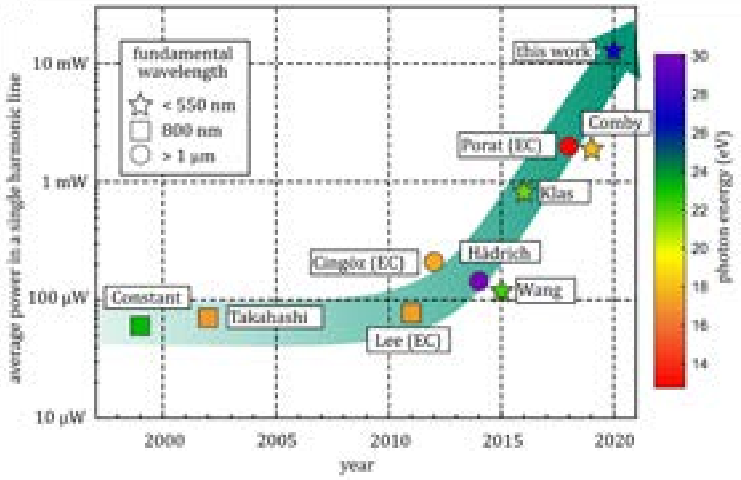


Figure 2:
State-of-the-art HHG sources over a time span from 1999 until to date.

The combination of ultra-short pulse duration, short wavelength and high average power poses challenges to the driving laser architecture and has not been demonstrated yet.

These challenges can, however, be met by a frequency doubled and post compressed femtosecond Yb-fiber laser system, which has been developed for this purpose. The laser delivers a unique combination of short wavelength (515 nm) and short pulse duration (18.6 fs) at a record-high average power of 51 W [2], surpassing previous demonstrations sources by a factor of five /3/. The first two parameters are responsible for an exceptional high HHG conversion efficiency of 2.5 $*10^{-4}$, which is among the highest demonstrated /2/. Furthermore, the high average power boosts the available photon flux to unprecedented levels, resulting in $3*10^{15}$ ph/s (13 mW) in a single harmonic line at 26.5 eV /2/. This power level is an order of magnitude higher than the state-of-the-art (Fig. 2).

In conclusion a new class of XUV light source is demonstrated. This compact source, which fits on an optical table, opens new opportunities in the growing field of photon hungry applications in the XUV, such as coherent diffractive imaging, ablation and pump-probe experiments.

/1/ Z. Chang: Fundamentals of Attosecond Optics, 2016.

/2/ R. Klas et al.: PhotoniX 2,4, 2021.

/3/ D. Descamps et al.: Opt. Lett. 46, 1804, 2021.

Authors:
Paul Schmitt and Adriana Szeghalmi

Thermally stable Iridium ALD mirrors for infrared applications

Metallic coatings are essential functional optical mirror coatings for numerous optical components and systems. Such coatings are applied, e.g., in spectroscopy, sensing, astronomy, and illumination. Due to their high and broadband reflectivity in the infrared (IR) spectral range, mirror coatings of silver (Ag) and gold (Au) are usually applied. However, these metal mirrors need to be coated with complex protective layers to protect the sensitive surface from degradation. However, these pro-tective layers reduce the reflectivity of the metal mirrors in the IR range due to vibrational modes. The thermal stability of these mirror systems is also limited. Hence, we developed stable iridium (Ir) mirror coatings without protective layers, which resist high temperatures and environmental influ-ences and provide a high reflectivity at the same time /1/.

Figure 1 illustrates that the reflectivity of unprotected iridium and protected silver and gold coatings is similar for wavelengths above 3 µm. For iridium, a stable reflectivity of about 96 – 98 % is obtained in a wavelength range from 3 – 20 µm. In contrast, the reflectivity in the IR range for silver and gold is reduced due to absorption bands of the dielectric protective layers. The stable iridium mirror coatings were deposited using atomic layer deposition (ALD). This deposition technique is based on sequential, self-limiting surface reactions, enabling high-quality and conformal iridium coatings on planar, highly curved, or micro-structured substrate materials.

In order to verify their thermal stability, the mirror coatings were treated sequentially at 200°, 400°C, and 600°C under vacuum for 24 hours each. The iridium ALD coatings are stable up to a tem-perature of 600°C. In contrast, the protected silver and gold mirror coatings exhibit significant re-flectivity losses already at 400°C. In addition, their environmental stability referring to the ISO 9211-3 norm was investigated, meaning for applications of optical coatings under normal outdoor ambi-ent conditions and cleaning without severe abrasion and scratching. The Iridium ALD mirror coatings are also stable against abrasion, cold, dry heat, damp heat, slow temperature changes, water, and solvents. None of these environmental influences resulted in coating defects or significant reflec-tance losses in the IR spectral range. Therefore, these stable and highly reflective iridium ALD coat-ings are a promising alternative to the established metal mirrors of silver or gold at high tempera-tures or outdoor ambient conditions.

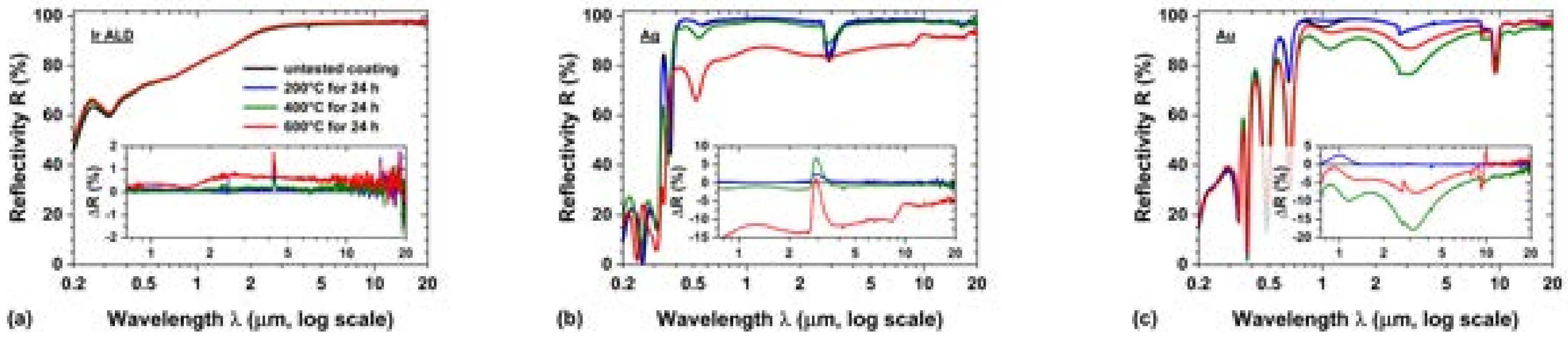


Figure 1:
Reflectivity of mirror coatings of (a) iridium, (b) protected silver, and (c) protected gold after thermal treatments up to 600°C.

/1/ P. Schmitt et al.: Optical, structural, and functional properties of highly reflective and sta-ble iridium mirror coatings for infrared applications, Opt. Mater. Express 12(2), 545-559, 2022.

Authors:
Gabor Matthäus, Qinfeng Li and Stefan Nolte

USP Laser Welding of Glass-Metal and Silicon-Metal

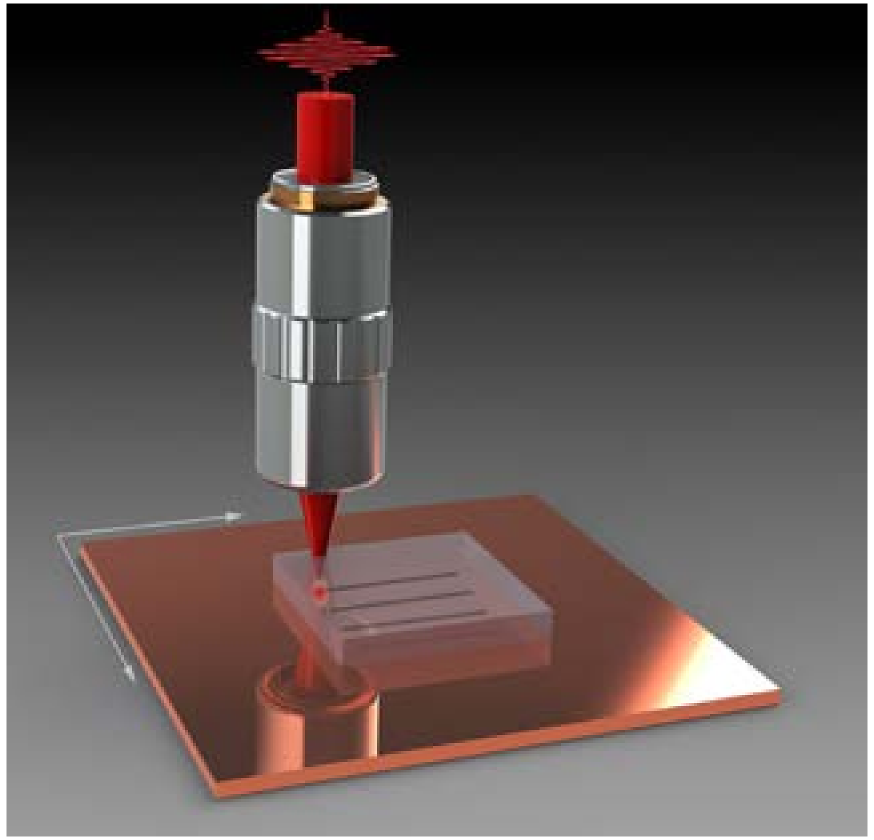


Figure 1:
Illustration of the laser welding process. The laser beam is focused through the volume of a material partner onto the contact surface. By moving the focus along the interface a weld seam is created.

The permanent joining of dissimilar materials is an essential work step for the manufacture of countless products. Various processes such as clamping, gluing, soldering or welding are available for this purpose. However, often, one would like to avoid the usage of additives such as adhesives or solder, e.g. if the connections are exposed to extreme environmental conditions. In this case, for example, chemical reactions, aging or outgassing must be avoided.

The ideal solution would often be direct welding without additives. However, extreme challenges are faced, especially when brittle materials are used. As welding requires high process temperatures, the induced thermal stresses usually lead to irreversible damage.

Laser welding using ultrashort laser pulses (USP) offers an alternative solution. Here, the laser radiation is focused into the area of the contact surface (Fig. 1). Due to the short interaction times (t<10-11 s) and reduced radiation energies of a few microjoules, the thermal loads are significantly lower than those of conventional laser welding processes. Consequently, strain can be reduced, and durable joints can be produced.

We were able to successfully weld different types of glass (borosilicate glass, quartz glass, Zerodur) onto metals such as copper, aluminum or molybdenum using this novel process. (Fig. 2a, /1/). The weld seams produced exhibit tensile strengths above 10 MPa, and significantly higher strengths can be expected when further optimization steps are taken into account in the future. Using long-wave laser radiation in the IR range, it was even possible for the first time to weld semiconductors such as silicon onto metals using this method (Fig. 2b, /2,3/).

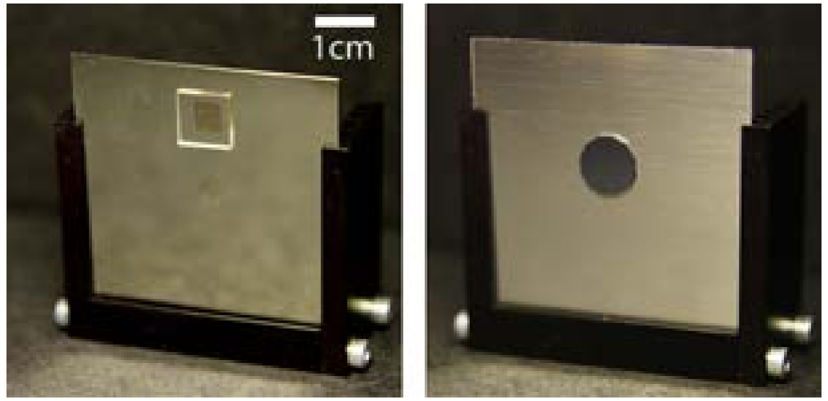


Figure 2:
Bonding of two dissimilar materials using USP laser welding. (a) Borosilicate glass on molybdenum, (b) silicon on aluminum.

/1/ Q. Li, G. Matthäus, et al.: Direct welding of glass and copper with a large gap by femtosecond laser pulse bursts. Laser in Manufacturing, Proc. 211, 2021.

/2/ M. Chambonneau, et al.: Taming ultrafast laser filaments for optimized semiconductor–metal welding. Laser & Photonics Reviews, 15(2), 2000433, 2021.

/3/ M. Chambonneau, et al.: Mastering micro-filamentation for semiconductor–metal ultrafast laser welding. Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC), pp. 1-1, 2021.

Authors:
Mohammadreza Younesi, Frank Setzpfandt and Thomas Pertsch

Micrometer-range periodic poling for integrated quantum circuits

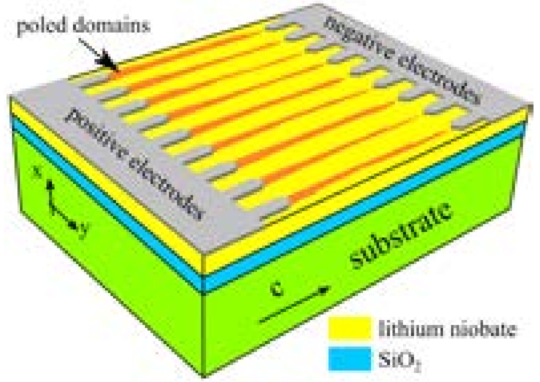


Figure 1:
Sketch of the electrode configuration for poling of LNOI.

Lithium Niobate is a favorable material for many applications in photonics due to its wide transparency window and high second-order nonlinearity. For nonlinear-optical processes such as second-harmonic generation (SHG) or photon-pair generation, momentum conservation between the fundamental and second-order photons should be realized. One of the main methods to do this is quasi-phase matching by inversion of the crystal direction periodically along the propagation direction. This inversion process, called poling, is triggered by applying a high-voltage electric field to the substrate through two electrodes, resulting in domain growth from positive to negative electrode. For the thin-film lithium niobate on insulator (LNOI) substrates used in integrated quantum photonics, the electric voltage is applied along the surface of the substrate using specific electrodes as sketched in Fig. 1. The main challenge in poling is to optimize the electric signal to obtain homogenous domains with defined domain width.

Using this technique, we could realize high-quality periodically poled LNOI substrates. We firstly deposit metallic electrodes on the LNOI surface with a lift-off process and then used the dedicated poling station shown in Fig. 2 to apply the poling field. Online monitoring of the poling current allows to analyze the poling process during the experiment. After poling, we use polarization contrast microscopy as a fast and non-destructive imaging method to investigate the poling quality, where an example image is shown in Fig. 3. To analyze the microscope images systematically, we developed a software which quantifies statistically the homogeneity and width of the domains. Using these instruments, we developed and optimized poling processes that enable repeatable poling of domains with widths down to 1 µm.

Figure 2:
Poling station for poling of LNOI.

The poled LNOI substrates were subsequently used to fabricate waveguides by electron-beam lithography and dry etching. The developed poling processes enable high-efficiency nonlinear frequency conversion with variable spectral properties in LNOI waveguides, in particular for photon-pair generation by spontaneous parametric down conversion. Thus, they are closing an important gap in our technological capabilities.

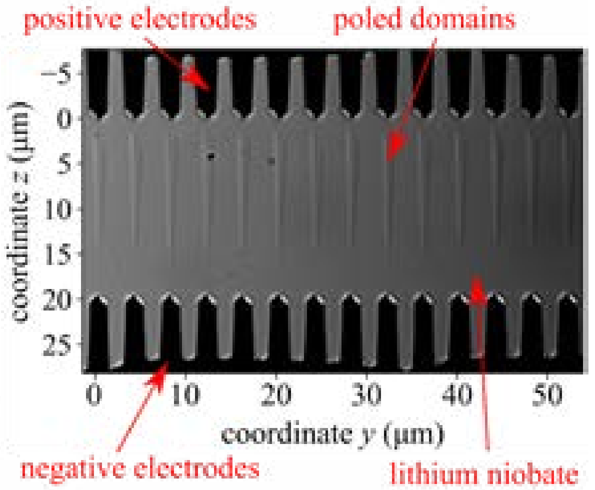


Figure 3:
Microscope image of poled LNOI substrate with poling period of 4 µm.

Photonic Quantum Information

Authors:
Meritxell Cabrejo Ponce, Carlos A. Sevilla, Luis J. González, Robert Leitel and Fabian Steinlechner

High-dimensional quantum entanglement in space and time

Entangled photons are a vital resource for quantum-enhancements in many technologies. They act as low-noise probes in quantum imaging and sensing, as versatile information carriers in quantum information processing and quantum networks, or as tamper-proof padlocks in cryptography. The ability to engineer the spatiotemporal mode structure of light as well as methods for generating, manipulating, and processing entangled quantum information are key technologies for practical applications.

A promising approach here could be to increase the dimensionality of quantum entanglement.

State-of-the-art quantum information protocols encode information in two-level systems, so-called qubits. In general, polarization or two-level time-bin coding is used, which means that each photon can transmit at most one qubit. However, other properties such as frequency, temporal or spatial modes can also be used to transmit information. Extending quantum protocols to high-dimensional degrees of freedom thereby realizing high-dimensionally entangled (HDE) states holds immense potential in terms of bandwidth and efficiency of quantum photonics.

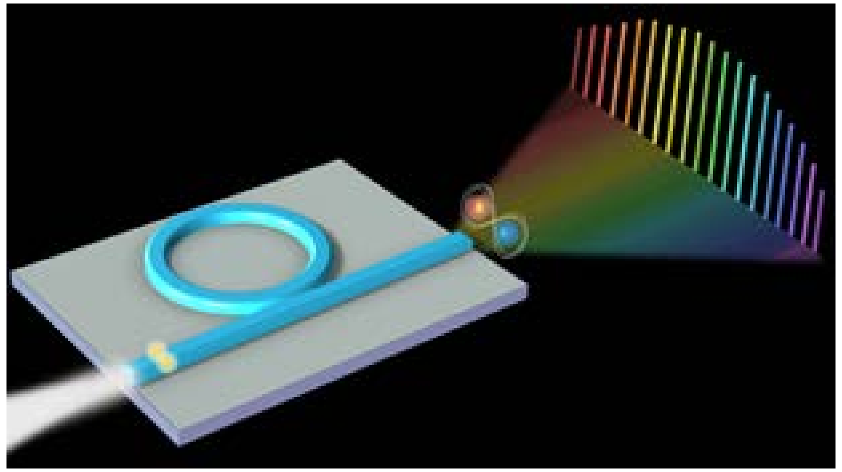


Figure 1:
Illustration of the generation of frequency entangled states on an integrated microring resonator.

To this end, Fraunhofer IOF implements various schemes for achieving HDE sources. From theory to experiment we are leveraging Fraunhofer IOF applied optics and photonics manufacturing capabilities to harness such correlations to attain HDE photon pairs in time-, frequency, and space.

Within the Attract project, we have developed approaches to harness the carrier frequency of photons to encode vast amounts of quantum information. Figure 1 depicts a microring resonator that was used to generate quantum frequency combs with massive entanglement dimensionality. We are currently working with photon pairs of 100x100 frequency modes, which corresponds to a possible information capacity of more than 6 qubits per photon. Similarly, we have developed phase-stabilization techniques for unbalanced interferometers which enable the analysis of quantum states encoded in discrete time-bin superposition states.

Within the BMBF-Funded Quantum Photonics Labs (QPL), we are developing new techniques to control and manipulate the complex wavefront of photons. Employing "Multi-Plane Light Conversion" (Figure 2) we have realized a spatial mode sorter for up to 7 Hermite-Gauss modes that uses custom phase elements developed in collaboration with the nano and micro-optics department at IOF. A current project employing entanglement in space is QSource, which aims to develop a bright and stable modular HDE source in orbital angular momentum with scalable dimensionality.

Figure 2:
Phase elements fabricated at IOF for efficient demultiplexing of higher order Hermite-Gaussian modes using multi-plane light conversion.

PUBLICATIONS

Aim of applied research is the implementation of the results and thus to make contributions to overcome certain problems of the future. For this reason, the research actually not only ends in itself, but their results must be discussed and adjusted with further findings. In the end again, new ideas and scientific approaches can be developed.

Journals

A. Anwar, C. Perumangatt, F. Steinlechner, T. Jennewein, A. Ling, Entangled photon-pair sources based on three-wave mixing in bulk crystals, Review of Scientific Instruments 92 (4), 29 (2021).

A. Barreda, S. Hell, M. A. Weissflog, A. Minovich, T. Pertsch, I. Staude, Metal, dielectric and hybrid nanoantennas for enhancing the emission of single quantum dots: A comparative study, Journal of Quantitative Spectroscopy & Radiative Transfer 276, 107900 (2021).

A. Fedotova, M. Younesi, J. Sautter, A. Vaskin, F. J. F. Loechner, M. Steinert, R. Geiss, T. Pertsch, I. Staude, F. Setzpfandt, Correction to "Second-Harmonic Generation in Resonant Nonlinear Metasurfaces Based on Lithium Niobate", Nano Letters 21 (1), 888-888 (2021).

A. V. Pakhomov, M. Hammerschmidt, S. Burger, T. Pertsch, F. Setzpfandt, Modeling of surface-induced second-harmonic generation from multilayer structures by the transfer matrix method, Optics Express 29 (6), 9098-9122 (2021).

A. Vaskin, S. Liu, S. Addamane, P. P. Vabishchevich, Y. M. Yang, G. Balarishnan, M. B. Sinclair, T. Pertsch, I. Brener, I. Staude, Manipulation of quantum dot emission with semiconductor metasurfaces exhibiting magnetic quadrupole resonances, Optics Express 29 (4), 5567-5579 (2021).

A. Vega, T. Pertsch, F. Setzpfandt, A. A. Sukhorukov, Metasurface-Assisted Quantum Ghost Discrimination of Polarization Objects, Physical Review Applied 16, 064032 (2021).

B. Baghdasaryan, F. Steinlechner, S. Fritzsche, Justifying the thin-crystal approximation in spontaneous parametric down-conversion for collinear phase matching, Physical Review A 103 (6), 5 (2021).

B. Tugchin, N. Janunts, M. Steinert, S. Fasold, T. Pertsch, Experimental observation of the short-range surface plasmon polariton mode and its longitudinal adiabatic compression in a metallic wedge, Optics Express 29 (23), 37161-37174 (2021).

C. Gaida, M. Gebhardt, T. Heuermann, Z. Y. Wang, C. Jauregui, J. Limpert, Transverse mode instability and thermal effects in thulium-doped fiber amplifiers under high thermal loads, Optics Express 29 (10), 14963-14973 (2021).

C. Gaudiuso, P. N. Terekhin, A. Volpe, S. Nolte, B. Rethfeld, A. Ancona, Laser ablation of silicon with THz bursts of femtosecond pulses, Scientific Reports 11 (1), 11 (2021).

C. Jauregui, C. Stihler, S. Kholaif, Y. Tu, J. Limpert, Control and stabilization of the modal content of fiber amplifiers using traveling waves, Optics Express 29 (21), 34452-34464 (2021).

C. P. Jisha, S. Nolte, A. Alberucci, Geometric Phase in Optics: From Wavefront Manipulation to Waveguiding, Laser & Photonics Reviews 15, 2100003 (2021).

C. Zou, C. Amaya, S. Fasold, A. A. Muravsky, A. A. Murauski, T. Pertsch, I. Staude, Multiresponsive Dielectric Metasurfaces, Acs Photonics 8 (6), 1775-1783 (2021).

D. Arslan, A. Rahimzadegan, S. Fasold, M. Falkner, W. Zhou, M. Kroychuk, C. Rockstuhl, T. Pertsch, I. Staude, Toward Perfect Optical Diffusers: Dielectric Huygens' Metasurfaces with Critical Positional Disorder, Advanced Materials 2105868, 1-18 (2021).

D. Cai, H. Gross, Generalized chromatic aberrations in non-rotationally symmetric optical systems-Part I: mathematical approach, Applied Optics 60 (21), 6313-6321 (2021).

D. Cai, H. Gross, Generalized chromatic aberrations in non-rotationally symmetric optical systems-Part II: applications, Applied Optics 60 (21), 6322-6330 (2021).

D. Liu, B. Yürekli, T. Ullsperger, G. Matthäus, L. Schade, S. Nolte, M. Rettenmayr, Microstructural aspects of additive manufacturing of Al-Li alloys with high Li content, Materials & Design 198, 109323 (2021).

E. Najafidehaghani, Z. Y. Gan, A. George, T. Lehnert, G. Q. Ngo, C. Neumann, T. Bucher, I. Staude, D. Kaiser, T. Vogl, U. Hübner, U. Kaiser, F. Eilenberger, A. Turchanin, 1D p-n Junction Electronic and Optoelectronic Devices from Transition Metal Dichalcogenide Lateral Heterostructures Grown by One-Pot Chemical Vapor Deposition Synthesis, Advanced Functional Materials 31 (27), 9 (2021).

F. An, F. Klister, R. Ackermann, S. Guhl, A. Richter, Heat and mass transfer analysis of a high-pressure TGA with defined gas flow for single-particle studies, Chemical Engineering Journal 411, 11 (2021).

F. Löchner, A. George, K. Koshelev, T. Bucher, E. Najafidehaghani, A. Fedotova, D. Y. Choi, T. Pertsch, I. Staude, Y. Kivshar, A. Turchanin, F. Setzpfandt, Hybrid Dielectric Metasurfaces for Enhancing Second-Harmonic Generation in Chemical Vapor Deposition Grown MoS_2 Monolayers, Acs Photonics 8 (1), 218-227 (2021).

H. Shan, L. Lackner, B. Han, E. Sedov, C. Rupprecht, H. Knopf, F. Eilenberger, J. Beierlein, N. Kunte, M. Esmann, K. Yumigeta, K. Watanabe, T. Taniguchi, S. Klembt, S. Hoefling, A. V. Kavokin, S. Tongay, C. Schneider, C. Anton-Solanas, Spatial coherence of room-temperature monolayer WSe2 exciton-polaritons in a trap, Nature Communications 12, 6406 (2021).

H. Stark, J. Buldt, M. Müller, A. Klenke, J. Limpert, 1 kW, 10 mJ, 120 fs coherently combined fiber CPA laser system, Optics Letters 46 (5), 969-972 (2021).

I. Badar, C. Hellmann, F. Wyrowski, Wavefront phase representation by Zernike and spline models: a comparison, Journal of the Optical Society of America a-Optics Image Science and Vision 38 (8), 1178-1186 (2021).

I. Badar, L. X. Yang, C. Hellmann, F. Wyrowski, Antiderivative of gradient data by spline model integration, Journal of the Optical Society of America a-Optics Image Science and Vision 38 (8), 1187-1193 (2021).

I. Badar, L. Yang, C. Hellmann, F. Wyrowski, Freeform surface for light shaping by iterative design via Fourier domain, Optics Express 29 (20), 31270-31282 (2021).

J. Buldt, H. Stark, M. Müller, C. Grebing, C. Jauregui, J. Limpert, Gas-plasma-based generation of broadband terahertz radiation with 640 mW average power, Optics Letters 46 (20), 5256-5259 (2021).

J. Sperrhake, M. Falkner, M. Steinert, S. Fasold, T. Pertsch, Experimental validation of the fundamental mode approximation for stacked metasurfaces and its application to the treatment of arbitrary period ratios, Apl Photonics 6 (9), 12 (2021).

J. White, S. C. Wang, W. Eschen, J. Rothhardt, Real-time phase-retrieval and wavefront sensing enabled by an artificial neural network, Optics Express 29 (6), 9283-9293 (2021).

K. Schaarschmidt, J. Kobelke, S. Nolte, T. Meyer, M. A. Schmidt, Ultrafast intermodal third harmonic generation in a liquid core step-index fiber filled with C2Cl4 erratum (vol 28, pg 25037, 2020), Optics Express 29 (2), 1890-1891 (2021).

L. Ghazaryan, S. Handa, P. Schmitt, V. Beladiya, V. Roddatis, A. Tünnermann, A. Szeghalmi, Structural, optical, and mechanical properties of TiO2 nanolaminates, Nanotechnology 32, 095709 (2021).

L. Lackner, M. Dusel, O. A. Egorov, B. Han, H. Knopf, F. Eilenberger, S. Schröder, K. Watanabe, T. Taniguchi, S. Tongay, C. Anton-Solanas, S. Hofling, C. Schneider, Tunable exciton-polaritons emerging from WS2 monolayer excitons in a photonic lattice at room temperature, Nature Communications 12 (1), 6 (2021).

L. Yang, I. Badar, C. Hellmann, F. Wyrowski, Integrable solution for light shaping based on a Fourier-pair mapping, Journal of the European Optical Society-Rapid Publications 17 (1), 10 (2021).

PUBLICATIONS

L. Yang, I. Badar, C. Hellmann, F. Wyrowski, Light-shaping design by a fourier pair synthesis: the homeomorphic case, Optics Express 29 (3), 3621-3630 (2021).

M. Braasch, V. F. Gili, T. Pertsch, F. Setzpfandt, Classical Ghost Imaging: A Comparative Study of Algorithmic Performances for Image Reconstruction in Prospect of Plenoptic Imaging, Ieee Photonics Journal 13 (3), 15 (2021).

M. Chambonneau, D. Grojo, O. Tokel, F. Ö. Ilday, S. Tzortzakis, S. Nolte, In-Volume Laser Direct Writing of Silicon-Challenges and Opportunities, Laser & Photonics Reviews 15, 2100140 (2021).

M. Chambonneau, M. Blothe, Q. Li, V. Yu. Fedorov, T. Heuermann, M. Gebhardt, C. Gaida, S. Tertelmann, F. Sotier, J. Limpert, S. Tzortzakis, S. Nolte, Transverse ultrafast laser inscription in bulk silicon, Physical Review Research 3, 043037 (2021).

M. Chambonneau, Q. Li, V. Yu. Fedorov, M. Blothe, K. Schaarschmidt, M. Lorenz, S. Tzortzakis, S. Nolte, Taming Ultrafast Laser Filaments for Optimized Semiconductor-Metal Welding, Laser & Photonics Reviews 15 (2), 2000433 (2021).

M. Gebhardt, E. B. Amuah, R. Klas, H. Stark, J. Buldt, A. Steinkopff, J. Limpert, Investigation of spatiotemporal output beam profile instabilities from differentially pumped capillaries, Optics Express 29 (5), 6957-6966 (2021).

M. Gebhardt, T. Heuermann, R. Klas, C. Liu, A. Kirsche, M. Lenski, Z. Wang, C. Gaida, J. E. Antonio-Lopez, A. Schulzgen, R. Amezcua-Correa, J. Rothhardt, J. Limpert, Bright, high-repetition-rate water window soft X-ray source enabled by nonlinear pulse self-compression in an antiresonant hollow-core fibre, Light, science & applications 10 (1), 36-36 (2021).

M. Gilaberte Basset, A. Hochrainer, S. Töpfer, F. Riexinger, P. Bickert, J. R. Leon-Torres, F. Steinlechner, M. Gräfe, Video-Rate Imaging with Undetected Photons, Laser & Photonics Reviews 15 (6), 6 (2021).

M. Heinzig, G. Palma-Vega, B. Yildiz, T. Walbaum, T. Schreiber, A. Tünnermann, Continuous-wave cascaded second Stokes diamond Raman laser at 1477 nm, Optics Letters 46 (5), 1133-1136 (2021).

M. Kumar, P. Kumar, A. Vega, M. A. Weissflog, T. Pertsch, F. Setzpfandt, Mid-infrared photon pair generation in AgGaS2, Applied Physics Letters 119, 244001 (2021).

M. Landmann, H. Speck, P. Dietrich, S. Heist, P. Kühmstedt, A. Tünnermann, G. Notni, High-resolution sequential thermal fringe projection technique for fast and accurate 3D shape measurement of transparent objects, Applied Optics 60 (8), 2362-2371 (2021).

M. Lapteva, V. Beladiya, S. Riese, P. Hanke, F. Otto, T. Fritz, P. Schmitt, O. Stenzel, A. Tünnermann, A. Szeghalmi, Influence of temperature and plasma parameters on the properties of PEALD HfO_2, Optical Materials Express 11 (7), 1918-1942 (2021).

M. Müller, C. Aleshire, J. Buldt, H. Stark, C. Grebing, A. Klenke, J. Limpert, Scaling potential of beam-splitter-based coherent beam combination, Optics Express 29 (17), 27900-27911 (2021).

M. Müller, J. Buldt, H. Stark, C. Grebing, J. Limpert, Multipass cell for high-power few-cycle compression, Optics Letters 46 (11), 2678-2681 (2021).

M. Peysokhan, S. Rostami, E. Mobini, A. R. Albrecht, S. Kuhn, S. Hein, C. Hupel, J. Nold, N. Haarlammert, T. Schreiber, R. Eberhardt, A. Flores, A. Tünnermann, M. Sheik-Bahae, A. Mafi, Implementation of Laser-Induced Anti-Stokes Fluorescence Power Cooling of Ytterbium-Doped Silica Glass, Acs Omega 6 (12), 8376-8381 (2021).

M. Younesi, R. Geiss, S. Rajaee, F. Setzpfandt, Y. H. Chen, T. Pertsch, Periodic poling with a micrometer-range period in thin-film lithium niobate on insulator, Journal of the Optical Society of America B-Optical Physics 38 (3), 685-691 (2021).

N. Abbasirad, A. Barreda, D. Arslan, M. Steinert, S. Fasold, C. Rockstuhl, I. Staude, F. Setzpfandt, T. Pertsch, Investigation of dipole emission near a dielectric metasurface using a dual-tip scanning near-field optical microscope, Nanophotonics 10 (18), 4511-4522 (2021).

P. Birckigt, K. Grabowski, G. Leibeling, T. Fluegel-Paul, M. Heusinger, H. Ouslimani, S. Risse, Effects of static load and residual stress on fused silica direct bonding interface properties, Applied Physics a-Materials Science & Processing 127, 938 (2021).

P. Böttner, A. Brady, C. Reinlein, R. Eberhardt, S. Nolte, Design routine and characterisation of a biconic deformable metal mirror for focus shifting, Optics Express 29 (3), 2971-2983 (2021).

P. Hönicke, Y. Kayser, K. V. Nikolaev, V. Soltwisch, J. E. Scheerder, C. Fleischmann, T. Siefke, A. Andrle, G. Gwalt, F.Siewert, J. Davis, M. Huth, A. Veloso, R. Loo, D. Skroblin, M. Steinert, A. Undisz, M. Rettenmayr, B. Beckhoff , Analytical Characterization of Ordered Nanostructures, Small 18 (6), 2105776 (2021).

P. Paul, M. G. Hafiz, P. Schmitt, C. Patzig, F. Otto, T. Fritz, A. Tünnermann, A. Szeghalmi, Optical bandgap control in Al2O3/TiO2 heterostructures by plasma enhanced atomic layer deposition: Toward quantizing structures and tailored binary oxides, Spectrochimica acta. Part A, Molecular and biomolecular spectroscopy 252, 119508 (2021).

P. Schmitt, S. Stempfhuber, N. Felde, A. V. Szeghalmi, N. Kaiser, A. Tünnermann, S. Schwinde, Influence of seed layers on the reflectance of sputtered aluminum thin films, Optics Express 29 (13), 19472-19485 (2021).

P. Schmitt, V. Beladiya, N. Felde, P. Paul, F. Otto, T. Fritz, A. Tünnermann, A. V. Szeghalmi, Influence of Substrate Materials on Nucleation and Properties of Iridium Thin Films Grown by ALD, Coatings 11 (2), 23 (2021).

Q. Li, M. Chambonneau, M. Blothe, H. Gross, S. Nolte, Flexible, fast, and benchmarked vectorial model for focused laser beams, Applied Optics 60 (13), 3954-3963 (2021).

R. Camphausen, A. Cuevas, L. Duempelmann, R. A. Terborg, E. Wajs, S. Tisa, A. Ruggeri, I. Cusini, F. Steinlechner, V. Pruneri, A quantum-enhanced wide-field phase imager, Science Advances 7 (47), eabj2155 (2021).

R. Klas, A. Kirsche, M. Gebhardt, J. Buldt, H. Stark, S. Hädrich, J. Rothhardt, J. Limpert, Ultra-short-pulse high-average-power Megahertz-repetition-rate coherent extreme-ultraviolet light source, PhotoniX 2, 4 (2021).

R. Shi, Z. Z. Wang, S. T. Hung, C. Hellmann, F. Wyrowski, Numerical analysis of tiny-focal-spot generation by focusing linearly, circularly, and radially polarized beams through a micro/nanoparticle, Optics Express 29 (2), 2332-2347 (2021).

S. Ecker, B. Liu, J. Handsteiner, M. Fink, D. Rauch, F. Steinlechner, T. Scheidl, A. Zeilinger, R. Ursin, Strategies for achieving high key rates in satellite-based QKD, Npj Quantum Information 7 (1), 7 (2021).

S. Linss, D. Michaelis, U. D. Zeitner, Macroscopic wave-optical simulation of dielectric metasurfaces, Optics Express 29 (7), 10879-10892 (2021).

S. Saravi, T. Pertsch, F. Setzpfandt, Lithium Niobate on Insulator: An Emerging Platform for Integrated Quantum Photonics, Advanced Optical Materials 9 (22), 2100789 (2021).

S. Skruszewicz, A. Przystawik, D. Schwickert, M. Sumfleth, M. Namboodiri, V. Hilbert, R. Klas, P. Gierschke, V. Schuster, A. Vorobiov, C. Haunhorst, D. Kip, J. Limpert, J. Rothhardt, T. Laarmann, Table-top interferometry on extreme time and wavelength scales, Optics Express 29 (24), 40333-40344 (2021).

T. Goebel, J. Nold, C. Hupel, S. Kuhn, N. Haarlammert, T. Schreiber, C. Matzdorf, T. O. Imogore, R. G. Kramer, D. Richter, A. Tünnermann, S. Nolte, Ultrashort pulse written fiber Bragg gratings as narrowband filters in multicore fibers, Applied Optics 60 (19), D43-D51 (2021).

T. Gottschall, T. Meyer-Zedler, M. Schmitt, R. Huber, J. Popp, A. Tünnermann, J. Limpert, Ultra-compact tunable fiber laser for coherent anti-Stokes Raman imaging, Journal of Raman Spectroscopy 52 (9), 1561-1568 (2021).

T. Santiago-Cruz, A. Fedotova, V. Sultanov, M. A. Weissflog, D. Arslan, M. Younesi, T. Pertsch, I. Staude, F. Setzpfandt, M. Chekhova, Photon Pairs from Resonant Metasurfaces, Nano Letters 21 (10), 4423-4429 (2021).

T. Ullsperger, D. Liu, B. Yürekli, G. Matthäus, L. Schade, B. Seyfarth, H. Kohl, R. Ramm, M. Rettenmayr, S. Nolte, Ultra-short pulsed laser powder bed fusion of Al-Si alloys: Impact of pulse duration and energy in comparison to continuous wave excitation, Additive Manufacturing 46, 102085 (2021).

T. Ullsperger, Y. L. Wencke, B. Yürekli, G. Matthäus, M. Rettenmayr, G. A. Luinstra, S. Nolte, Laser powder bed fusion of ultra-high molecular weight polyethylene (UHMWPE) using near-infrared ultrashort laser pulses, Materials & Design 210, 110048 (2021).

T. Vogl, H. Knopf, M. Weissflog, P. K. Lam, F. Eilenberger, Sensitive single-photon test of extended quantum theory with two-dimensional hexagonal boron nitride, Physical Review Research 3 (1), 10 (2021).

V. Distler, F. Möller, B. Yildiz, M. Plotner, C. Jauregui, T. Walbaum, T. Schreiber, Experimental analysis of Raman-induced transverse mode instability in a core-pumped Raman fiber amplifier, Optics Express 29 (11), 16175-16181 (2021).

V. Hanus, V. Csajbok, Z. Papa, J. Budai, Z. Marton, G. Z. Kiss, P. Sandor, P. Paul, A. Szeghalmi, Z. L. Wang, B. Bergues, M. F. Kling, G. Molnar, J. Volk, P. Dombi, Light-field-driven current control in solids with pJ-level laser pulses at 80 MHz repetition rate, Optica 8 (4), 570-576 (2021).

V. Schuster, C. Liu, R. Klas, P. Dominguez, J. Rothhardt, J. Limpert, B. Bernhardt, Ultraviolet dual comb spectroscopy: a roadmap, Optics Express 29 (14), 21859-21875 (2021).

V. Schuster, V. Hilbert, R. Klas, C. Liu, M. Tschernajew, B. Bernhardt, J. Rothhardt, J. Limpert, Agile spectral tuning of high order harmonics by interference of two driving pulses, Optics Express 29 (14), 22117-22126 (2021).

W. Eschen, S. C. Wang, C. Liu, R. Klas, M. Steinert, S. Yulin, H. Meissner, M. Bussmann, T. Pertsch, J. Limpert, J. Rothhardt, Towards attosecond imaging at the nanoscale using broadband holography-assisted coherent imaging in the extreme ultraviolet, Communications Physics 4 (1), 7 (2021).

X. Lu, H. Gross, Wigner function-based modeling and propagation of partially coherent light in optical systems with scattering surfaces, Optics Express 29 (10), 14985-15000 (2021).

Y. Chen, S. Ecker, L. Chen, F. Steinlechner, M. Huber, R. Ursin, Temporal distinguishability in Hong-Ou-Mandel interference for harnessing high-dimensional frequency entanglement, Npj Quantum Information 7, 167 (2021).

Y. Lin, M. Younesi, H. P. Chung, H. K. Chiu, R. Geiss, Q. H. Tseng, F. Setzpfandt, T. Pertsch, Y. H. Chen, Ultra-compact, broadband adiabatic passage optical couplers in thin-film lithium niobate on insulator waveguides, Optics Express 29 (17), 27362-27372 (2021).

Y. Ran, A. Boden, F. Küster, F. An, A. Richter, S. Guhl, S. Nolte, R. Ackermann, In situ investigation of carbon gasification using ultrabroadband coherent anti-Stokes Raman scattering, Applied Physics Letters 119 (24), 243905 (2021).

Z. Tang, H. Gross, Extended aberration analysis in symmetry-free optical systems - part I: method of calculation, Optics Express 29 (24), 39967-39982 (2021).

Z. Tang, H. Gross, Extended aberration analysis in symmetry-free optical systems - part II: evaluation and application, Optics Express 29 (25), 42020-42036 (2021).

Z. Tang, H. Gross, Improved correction by freeform surfaces in prism spectrometer concepts, Applied Optics 60 (2), 333-341 (2021).

PUBLICATIONS

Z. Wang, O. Baladron-Zorita, C. Hellmann, F. Wyrowski, Generalized far-field integral, Optics Express 29 (2), 1774-1787 (2021).

D. Werdehausen, X.G. Santiago, S. Burger, I. Staude, T. Pertsch, C. Rockstuhl, M. Decker, Modeling Optical Materials at the Single Scatterer Level: The Transition from Homogeneous to Heterogeneous Materials, Advanced Theory and Simulations 2000192 (2020).

D. Werdehausen, S. Burger, I. Staude, T. Pertsch, M. Decker, General design formalism for highly efficient flat optics for broadband applications, Optics Express 28 (5), 6452-6468 (2020).

N. Worku, H. Gross, Application of Gaussian pulsed beam decomposition in modeling optical systems with diffraction grating, Journal of the Optical Society of America A-Optics Image Science and Vision 37 (5), 797-806 (2020).

N. Worku, H. Gross, Gaussian pulsed beam decomposition for propagation of ultra-short pulses through optical systems, Journal of the Optical Society of America A-Optics Image Science and Vision 37 (1), 98-107 (2020).

N. Worku, H. Gross, Spatially truncated Gaussian pulsed beam and its application in modeling diffraction of ultrashort pulses from hard apertures , Journal of the Optical Society of America A-Optics Image Science and Vision 37 (2), 317-326 (2020).

L. Yang, I. Badar, C. Hellmann, F. Wyrowski, Light shaping by freeform surface from a physical-optics point of view, Optics Express 28, 16202-16210 (2020).

X.D. Zhao, S. Nolte, R. Ackermann, Lasing of N-2(+) induced by filamentation in air as a probe for femtosecond coherent anti-Stokes Raman scattering, Optics Letters 45 (13), 3661-3664 (2020).

H. Zhong, S. Zhang, O. Baladron-Zorita, R. Shi, C. Hellmann, F. Wyrowski, k-domain method for the fast calculation of electromagnetic fields propagating in graded-index media, Optics Express 28 (8), 11074-11084 (2020).

Y. Zhong, Z. Tang, H. Gross, Correction of 2D-telecentric scan systems with freeform surfaces, Optics Express 28 (3), 3041-3056 (2020).

Conference Contributions

Invited Contributions

Alberucci, A.; Frontiers in ultrafast optics, Two Week International Faculty Development Programme on Advanced Computational and Experimental Research in Physics, Ramapuram SRM Institute of Science and Technology, online.

Brambila Tamayo, E., F. Steinlechner, M. Gräfe; Enhanced Quantum Imaging And Development of Entangled Sources, Max-Planck-of-Photonics Autum School, online.

Chambonneau, M., Q. Li, V. Yu. Fedorov, M. Blothe, S. Tzortzakis, S. Nolte; Mastering micro-filamentation for semiconductor–metal ultrafast laser welding, LiM - Lasers in Manufacturing, online.

Chambonneau, M.; In-Volume Laser-Silicon Interaction – Limitations, Solutions, Applications, International Conference on Hierarchically Structured Materials (ICHSM), online.

Chambonneau, M.; In-volume laser-silicon interaction, Two Week International Faculty Development Programme on Advanced Computational and Experimental Research in Physics, Ramapuram SRM Institute of Science and Technology, online.

Chambonneau, M.; Understanding ultrashort laser-induced filamentation in bulk silicon for optical functionalization, welding and dicing applications, Procédés Laser pour l'Industrie (PLI) Conference, online.

Eilenberger, F., F. Steinlechner; Alice und Bob im Quantenwunderland, MINT Festival Jena, online.

Eilenberger, F.; Quantum Computing: An Introduction, Doctoral Students' Conference for the Discussion of Optical Concepts DoKDoK, Jena, Germany.

Eilenberger, F.; Quantum Communications: Fundamentals, Visions, and Applications, Max Planck School of Photonics - Photonics Days, online.

Eilenberger, F.; Integration of two-dimensional materials in optical systems: towards nanolasers, nonlinear fibers, and integrated quantum light sources, 2DMatMet Workshop, online.

Eilenberger, F.; Photonics in 2D-Materials, 2nd European Quantum Technologies Virtual Conference (EQTC), online.

Eilenberger, F.; Photonics in 2D-Materials, Max Planck School of Photonics - Lecture Series, online.

Eilenberger, F.; Towards Nonlinear Optics with Graphen &Transition Metal Dichalcogenides: Materials and Guided Waves, NOA Lecture Series, online.

Eilenberger, F.; Towards Nonlinear Optics with Graphen &Transition Metal Dichalcogenides: Materials and Guided Waves, Max Planck School of Photonics - Photonics Days, online.

Gräfe, M.; Quantum imaging and sensing – From fundamentals towards biomedical applications, Huawei Optical Innovation Summit, online.

Gräfe, M.; Quantum imaging and sensing, VDI/VDE-GMA Fachbeirat Optische Technologien, online.

Gräfe, M.; Sensing with photon pairs, Photonic Days Berlin-Brandenburg, online.

Jisha, C.; A gentle introduction to physics informed neural network., International e-Conference on Recent Advances in Physical Science (ICRAPS), online.

Ngo, Q. G., A. George, A. Tuniz, E. Najafidehaghani, Z. Gan, T. Bucher, H. Knopf, S. Saravi, T. Lühder, S. Warren-Smith, H. Ebendorff-Heidepriem, A. Turchanin, M. Schmidt, F. Eilenberger; Functionalization of Exposed-Core Fibers with CVD-Grown Monolayer Transition Metal Dichalcogenides: Photolumiescence and Nonlinearity, International Conference on Advances in Functional Materials AAAFM-UCLA, online.

Ngo, Q. G., A. George, A. Tuniz, E. Najafidehaghani, Z. Gan, T. Bucher, H. Knopf, S. Saravi, T. Lühder, S. Warren-Smith, H. Ebendorff-Heidepriem, A. Turchanin, M. Schmidt, F. Eilenberger; Scalable Functionalization of Exposed-Core Fibers with CVD-Grown Monolayer Transition Metal Dichalcogenides, Materials Science 2021, online.

Paul, P., V. Beladiya, D. Kästner, M. Burkhardt, U. Schulz, A. Szeghalmi; Conformal antireflection coating on polycarbonate domes, SPIE Optical Systems Design, online.

Nolte, S.; Bulk Processing of Silicon Using IR Ultrashort Laser Pulses, Laser Congress, online, USA.

Pertsch, T.; Quantum state generation in dielectric metasurfaces, Conference on Smart Nanomaterials (SNAIA 2021), online.

Pertsch, T.; Quantum state generation in dielectric metasurfaces, International Congress on Optics, Electronics, and Optoelectronics 2021 (ICOEO-2021), online.

Pertsch, T.; Photon-pair generation by spontaneous parametric down-conversion in nonlinear metasurfaces, 15th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials, online.

Pertsch, T.; Nonlinear dielectric metasurfaces for photonic quantum state generation, 13th International Symposium on Modern Optics and Its Applications, online.

Setzpfandt, F.; Lithium niobate nonlinear nanophotonics, DPG Fall Meeting, online.

Setzpfandt, F.; Parametric frequency conversion in nanostructured lithium niobate, Optics & Photonics Taiwan International Conference (OPTIC 2021), online.

Setzpfandt, F.; Parametric frequency conversion in lithium niobate metasurfaces, Smart NanoMaterials, online.

Szeghalmi, A.; Optical Properties of SiO2:HfO2 PEALD Composites for Functional Coatings, 317. PTB-Seminar VUV and EUV Metrology, Berlin, Germany.

Szeghalmi, A.; Conformal Coatings for Laser Applications, Laser, Optics & Photonics, online.

Tünnermann, A.; Wie definiert man wissenschaftlichen Erfolg?, 2. NWA Herzchirurgie, Jena, Germany.

Tünnermann, A.; Center of Excellence Photonics, Baden-Badener Unternehmergespräche, Jena, Germany.

Tünnermann, A.; The laser - enabler of innovations for more than 50 years, Laser Symposium & International Symposium Additive Manufacturing (ISAM), Jena, Germany.

Tünnermann, A.; High-power fiber lasers: challenges and perspectives in power scaling, Laserkonferenz Mittweida, Mittweida, Germany.

Tünnermann, A.; Kommerzialisierung der Quantentechnologien in Deutschland – Chancen und Herausforderungen, Spectaris-Branchentag, online, Germany.

Wyrowski, L. Yang, I. Badar, C. Hellmann, Light shaping from a physical-optics perspective, EOS Annual Meeting (EOSAM), Rome, Italy.

Talks & Posters

Alberucci, A.; C.P. Jisha, S. Nolte; Optical waveguides based upon a gauge field, European Quantum Electronics Conference (OSA), online, Germany.

Alberucci, A.; N. Alasgarzade, M. Blothe, M. Chambonneau, C.P. Jisha, S. Nolte; Analysis of laser-inscription of waveguides in bulk silicon via ultrashort pulses., European Quantum Electronics Conference (OSA), online, Germany.

Berner, A.; H. Gross; New surface contributions for higher order color aberrations and chromatical variation of Seidel aberrations, EOSAM 2021, TOM 3-246, Optical System Design, Tolerancing, Manufacturing, online.

Fedotova, A.; T. Santiago-Cruz, v. Sultanov, M. Weissflog, M. Younesi, I. Staude, T. Pertsch, F. Setzpfandt, M. V. Chekhova; Spontaneous Parametric Down-Conversion in Nonlinear Metasurfaces, Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference, online.

Fedotova, A.; T. Santiago-Cruz, V. Sultanov, M. Weissflog, M. Younesi, I. Staude, T. Pertsch, F. Setzpfandt, M. V. Chekhova; Enhancement of Spontaneous Parametric Down-Conversion in Nonlinear Metasurfaces, Conference on Lasers and Electro-Optics, online.

Kirsche, A.; R. Klas, M. Gebhardt, L. Eisenbach, W. Eschen, J. Buldt, H. Stark, J. Rothhardt, J. Limpert; Continuously tunable high photon flux high harmonic source at 50 – 70 eV, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Kirsche, A.; R. Klas, M. Gebhardt, L. Eisenbach, W. Eschen, J. Buldt, H. Stark, J. Rothhardt, J. Limpert; Continuously tunable high photon flux high harmonic source at 50-70 eV, The European Conference on Lasers and Electro-Optics, online, Germany.

Klenke, A.; A. Steinkopff, C. Aleshire, C. Jauregui, S. Kuhn, J. Nold, C. Hupel,S. Hein, S. Schulze, N. Haarlammert, T. Schreiber, A. Tünnermann, J. Limpert; Coherently combined high power 16 core rod-type multicore amplifier, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Klenke, A.; A. Steinkopff, C. Aleshire, M.Müller, C. Jauregui, S. Kuhn, J. Nold, N. Haarlammert, T. Schreiber, A. Tünnermann, J. Limpert; Coherent beam combination of pulses emitted by a 16-core Ytterbium doped fiber, The European Conference on Lasers and Electro-Optics, online, Germany.

Sansa Perna, A.; M. Gräfe, F. Steinlechner; Visible-wavelength Entangled Photon Source for Quantum Communication and Quantum Imaging, CLEO/ QELS conference, online.

Steinkopff, A.; C. Aleshire, C. Jauregui, A. Klenke, J. Limpert; Optimizing rod-type multicore fiber amplifiers in coherently-combined laser systems, The European Conference on Lasers and Electro-Optics, Munich, Germany.

Steinkopff, A.; C. Aleshire, C. Jauregui, A. Klenke, J. Limpert; Optimizing the design of coherently-combined multicore fiber amplifiers, SPIE Photonics West, online, USA.

Szeghalmi, A.; V. Beladiya, P. Paul, D. Kästner, L. Ghazaryan, M. Lapteva, A. S. Munser, S. Schröder, C. Mühlig, S. Riese; High Performance Functional Coatings for Challenging Substrate Geometries, European Optical Society Annual Meeting (EOSAM), online.

Seyfarth, B.; T. Ullsperger, G. Matthäus, H. Kohl, B. Yürekli, L. Schade, N. Heidler, E. Hilpert, S. Kuhn, S. Nolte; Additive Manufacturing of Fused Silica Glass Using a CO2 Laser, ASP DoKDoK-lite, Jena.

PUBLICATIONS

Aleshire, C.; A. Steinkopff, M. Karst, A. Klenke, C. Jauregui, S. Kuhn, J. Nold, N. Haarlammert, T. Schreiber, J. Limpert; Q-Switched Rod-Type Multicore Fibre Laser Delivering 3.1 mJ Pulses, The European Conference on Lasers and Electro-Optics, Munich, Germany.

Aleshire, C.; A. Steinkopff, M. Karst, A. Klenke, C. Jauregui, S. Kuhn, J. Nold, N. Haarlammert, T. Schreiber, J. Limpert; High Energy Pulsed Operation of a Tapered Rod-Type Multicore Fiber Amplifier, OSA Laser Congress, online, USA.

Jauregui, C.; C. Stihler, S. Kholaif, Y. Tu, J. Limpert; Transverse Mode Instability in High-Power Fiber Laser Systems: a "Hot Topic, The European Conference on Lasers and Electro-Optics, Munich, Germany.

Jauregui, C.; C. Stihler, S. Kholaif, Y. Tu, J. Limpert; Mitigation of transverse mode instability in polarization maintaining, high-power fiber amplifiers, SPIE Photonics West, online, USA.

Stihler, C.; C. Jauregui, S.E. Kholaif, Y. Tu, J. Limpert; Mitigation of transverse mode instability through a dynamic modification of the inversion in high-power fiber amplifiers, SPIE Photonics West, online, USA.

Jisha, C.; J. Beeckman, N. Nolte, A. Alberucci; Interplay between geometric and dynamic phase in liquid crystals, European Quantum Electronics Conference (OSA), online, Germany

Beckert. E.; C. Wächter, B. Höfer, U. Zeitner; Laser-based manipulation and readout for multi-ion traps in quantum computing, SPIE Photonics West: Quantum Computing, Communication, and Simulation, San Francisco, UAS.

Santos, E.; S. Saravi, A. Vega, T. Pertsch, F. Setzpfandt; Sub-Diffraction Near-Field Imaging with Undetected Photons using Thin Sources of Photon Pairs, Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference, online.

Shestaev, E.; S. Hädrich, M. Tschernajew, N. Walther, T. Eidam, A. Klenke, I. Seres, Z. Várallyay, P. Jójárt, Á. Börzsönyi, J. Limpert; Improving the CEP stability of high-power few-cycle ytterbium-doped fiber lasers to a sub-300 mrad level, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Abtahi, F.; P. Paul, A. Szeghalimi, F. Eilenberger; Surface Nonlinearities in Dielectric Nanofilm, Doctoral Students' Conference for the Discussion of Optical Concepts DoKDoK, Jena, Germany.

Abtahi, F.; P. Paul, A. Szeghalmi, F. Eilenberger; Surface Nonlinearities in Dielectric Nanofilm, ASP DokDok-lite, Jena, Germany.

Klauck, F.; M. Gräfe, M. Heinrich, A. Szameit; Correlations of indistinguishable photons in quantum walks under broken PT-symmetry, META 2021 conference, online.

Ngo, G.; A. George, A. Tuniz, E. Najafidehaghani, Z. Gan, T. Bucher, H. Knopf, S. Saravi, T. Lühder, S. Warren-Smith, H. Ebendorff-Heidepriem, A.Turchanin, M. Schmidt, F. Eilenberger; Scalable Integrated Waveguide with CVD-Grown MoS_2 and WS_2 Monolayers on Exposed-Core Fibers, Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, online.

Ngo, G.; E. Najafidehaghani, Z. Gan, S. Khazaee, A. George, H. Ebendorff-Heideprim, T. Pertsch, A. Tuniz, M. Schmidt, U. Peschel, A.Turchanin, F. Eilenberger; Monolayer TMDs Functionalized Exposed Core Fibers, Doctoral Students' Conference for the Discussion of Optical Concepts DoKDoK, Jena, Germany.

Ngo, G.; E. Najafidehaghani, Z. Gan, S. Khazaee, A. George, U.Peschel, A. Tuniz, H. Ebendorff-Heidepriem, M. Schmidt, A. Turchanin, F. Eilenberger; Second-Harmonic Generation in Directly-Grown MoS_2 Monolayers on Exposed-Core Fibers, Frontiers in Optics (FiO), online.

Q. Ngo, G.; R. Schock, A. George, E. Najafidehaghani, T. Bucher, H. Knopf, C. Neumann, T. Lühder, H. Ebendorff-Heideprim, A.Turchanin, M. Schmidt, F. Eilenberger; Direct Growth of 2D-Materials on Optical Fibers:a Novel and Scalable Route to Integrated Photonics with 2D-Materials, 2D Materials for Photonic Quantum Technologies (716. WE-Heraeus-Seminar), online.

Knopf, H.; M. Zilk, S.Bernet, G. Q. Ngo, F. A. Abtahi, A. George, E. Najafidehaghani, Z. Gan, M. Weissflog, T. Vogl, A. Turchanin, U.Schulz, S.Schröder, F. Eilenberger; Second Harmonic Generation in monolayer WS_2 with double resonant Bragg-Cavities , Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, online.

Kohl, H.; L. Schade, G. Matthäus, T. Ullsperger, B. Yürekli, B. Seyfarth, B. Braun, S. Nolte; 3D printing of high-density copper parts using common NIR CW laser systems at moderate powers, Lasers in Manufacturing LIM 2021, online, Germany.

Kohl, H.; L. Schade, G. Matthäus, T. Ullsperger, B. Yürekli, B. Seyfarth, S. Nolte; Additive Fertigung von reinem Kupfer: Von der numerischen Simulation zur experimentellen Realisierung, 12. Jenaer Lasertagung, online, Germany.

Kohl, H.; L. Schade, G. Matthäus, T. Ullsperger, B. Yürekli, B. Seyfarth, S. Nolte; Additive manufacturing of pure copper: from numerical simulations to experimental results, SPIE Photonics West, online, USA.

Kohl, H.; L. Schade, G. Matthäus, T. Ullsperger, B. Yürekli, B. Seyfarth, S. Nolte; Lasergestützte Additive Fertigung reiner Kupferbauteile unter Einsatz von Laserstrahlung im NIR-Spektral-bereich, Kupfer-Symposium, online, Germany.

Stark, H.; J. Buldt, M. Müller, A. Klenke, J. Limpert; 100 fs pulses directly from a kW-class mJ-level ytterbium-doped fiber CPA laser system, SPIE Photonics West, online, USA.

Stark, H.; J. Buldt, M. Müller, C. Grebing, A. Klenke, J. Limpert; Divided-pulse nonlinear compression in a multipass cell, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

nopf, H.; M. Zilk, S. Bernet, G. Q. Ngo, F. Abtahi, A. George, E. Najafidehaghani, Z. Gan, M. Weissflog, T. Vogl, A. Turchanin, U. Schulz, S. Schröder, F. Eilenberger; Second Harmonic Generation in monolayer WS2 with double resonant Bragg-Cavities, Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC), online.

linger, Ho; R.; Harshitha, N.; Korolev, V.; Gan, Z.; George, A.; Shumakova, V.; Zürch, M.; Vogl, T.; Pugžlys, A.; Baltuška, A.; Eilenberger, F.; Spielmann, C.; Turchanin, A. & Kartashov, D.; Ellipticity controlled high-order harmonic generation in 2D materials, Conference on Lasers and Electro-Optics, Conference on Lasers and Electro-Optics, online.

Buldt, J.; H. Stark, M. Müller, A. Klenke, J. Limpert; Broadband Ytterbium fiber CPA-system delivering 120fs, 10 mJ pulses at 1 kW average power, SPIE Photonics West, online, USA.

Buldt, J.; M. Müller, H. Stark, C. Grebing, C. Jauregui, J. Limpert; Average-Power Scaling of Gas-Plasma Generated THz Radiation, Infrared, Millimeter, and Terahertz Waves - IRMMW-THz, Chengdu, China.

Buldt, J.; M. Müller, H. Stark, C. Grebing, C. Jauregui, J. Limpert; Fiber-laser driven gas-plasma based generation of high-power THz radiation, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Grundmann, J.; D. Bergmann, T. Siefke, S. Kroker, B. Bodermann; Applicability simulations of inverted plasmonic lenses, SPIE Optical Metrology, Munich, Germany.

Grundmann, J.; S. Teichert, T. Siefke, S. Kroker, B. Bodermann; Ellipsometric characterizations of individual nanoform structures, OPTM - Optical Technology and Measurement for Industrial Applications, Japan.

Grundmann, J.; T. Siefke, S. Kroker, B. Bodermann; Einzelstrukturcharakterisierung mittels abbildender Müller-Matrix-Ellipsometrie, DGaO Jahrestagung, Bremen, Germany.

Grundmann, J.; T. Siefke, S. Kroker, B. Bodermann; Mueller Matrix Imaging Simulations with Inverted Plasmonic Lenses, 11th Workshop Ellipsometry (WSE 11), Steyr, Germany.

Grundmann, J.; T. Siefke, S. Kroker, B. Bodermann; Enhanced nanoform metrology by imaging Mueller matrix ellipsometry combined with plasmonic support structures, SPIE Modeling Aspects in Optical Metrology VIII, Strasbourg, Belgium.

Carter, J.; P. Birckigt, O. Gerberding, Q. Li, T. Ullsperger, S. M. Koehlenbeck; An experiment to test the mechanical losses of different bonding techniques in fused silica, American Society for Precision Engineering (ASPE) 36th Annual Meeting, online, USA.

Krause, J.; G. Corrielli, M. Mishuk, F. Eilenberger, T. Vogl; Coupling of Quantum Emitters and 2D Materials to Laser-written Waveguides, Doctoral Students' Conference for the Discussion of Optical Concepts DoKDoK, Jena, Germany.

Kretzschmar, J.; S. Ritter, T. Vogl, F. Eilenberger; Photonic Quantum Experiments for Everyone with DIY Components, Web Services, and VR endpoints, 2nd European Quantum Technologies Virtual Conference (EQTC), online.

Léon Torres, J.; T.B. Gäbler, N. Jain, P. Hendra, M. Gräfe; On the way to Entangled 2-Photon microscopy, ASP DoKDoK-lite, online.

Dietrich, K.; M. Zilk, M. Steglich, T. Siefke, U. Hübner, A. Tünnermann, E.-B. Kley, C. Rockstuhl,T. Pertsch; Combining top-down and bottom-up techniques to fabricate metamaterials, META2021, online.

Lammers, K.; A. Alberucci, A. Szameit, S. Nolte; Using liquid crystals as tuneable waveplates in femtosecond laser direct written waveguides., The European Conference on Lasers and Electro-Optics (OSA), online, Germany.

Tanaka, K.; D. Arslan, M. Weißflog, N. Geib, F. Eilenberger, A. Minovich, T. Pertsch, I. Staude; Femtosecond pulse shaping with semiconductor Huygens' metasurfaces, Doctoral Students' Conference for the Discussion of Optical Concepts DoKDoK, Jena, Germany.

Lackner, L.; M. Dusel, C. Anton-Solanas, H. Knopf, F. Eilenberger, O. Egorov, S. Schröder, S.Höfling, C. Schneider; Fully tuneable Bloch-Band polaritons emerging from WS_2 monolayer excitons in an optical lattice at room temperature, Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, online.

Lötgering, L.; T. Aidukas, M. Du, D. Boonzajer Flaes, D.Penagos, M. Rose, A. Pelekanidis, A. De Beurs, W. Eschen, J. Hess, T. Wilhein, R. Heintzmann, J. Rothhardt, S. Witte; ptyLab: a cross-platform inverse modeling toolbox for conventional and Fourier ptychography, OSA Computational Optical Sensing and Imaging - OSA COSI, Washington, USA.

Lötgering, L.; W. Eschen, V. Schuster, R. Klas, M. Steinert, T. Pertsch, J. Limpert, J. Rothhardt; The PST beamline: a laboratory-scale setup for extreme ultraviolet ptychography in the silicon transparency window, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Lötgering, L.; W. Eschen, V. Schuster, R. Klas, M. Steinert, T. Pertsch, J. Limpert, J. Rothhardt; The PST beamline: a laboratory-scale setup for extreme ultraviolet ptychography in the silicon transparency window, European Optical Society Annual Meeting, EOSAM 2021, online.

Schade, L.; G. Matthäus, H. Kohl, R. Ramm, B. Yürekli, T. Ullsperger, B. Seyfarth, S. Nolte; Comparison of different density measurement techniques for laser assisted powder bed fusion, Lasers in Manufacturing LIM, online, Germany.

Weissflog, M.; S. Saravi, C. Gigli, G. Marino, A. Borne, G. Leo, T. Pertsch, F. Setzpfandt; Describing SPDC at the Nanoscale: A Quasinormal Mode Approach, Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference, online.

Blothe, M.; M. Chambonneau, T. Heuermann, M. Gebhardt, J. Limpert, S. Nolte; Silizium Trennprozess mit picosekunden Laserstrahlung bei 2 µm Wellenlänge, 12. Jenaer Lasertagung, online, Germany.

Blothe, M.; M. Chambonneau, T. Heuermann, M. Gebhardt, J. Limpert, S. Nolte; Silicon laser dicing with picosecond pulses at 2-µm wavelength, SPIE Photonics West, online, USA.

Blothe, M.; M. Chambonneau, T. Heuermann, M. Gebhardt, J. Limpert, S. Nolte; Laying the foundations of ultrafast stealth dicing of silicon with picosecond laser pulses at 2-µm wavelength, Conference on Lasers and Electro-Optics (CLEO®/Europe-EQEC), online, Germany.

Chambonneau, M.; Q. Li, V. Yu. Fedorov, M. Blothe, S. Tzortzakis, S. Nolte; Semiconductor-metal ultrafast laser welding with relocated filaments, SPIE Photonics West, online.

Chambonneau, M.; Q. Li, V. Yu. Fedorov, M. Blothe, S. Tzortzakis, S. Nolte; Relocating micro-filaments for semiconductor-metal ultrafast laser welding, European Materials Research Society (E-MRS) - Spring meeting, online.

Chambonneau, M.; Q. Li, V. Yu. Fedorov, M. Blothe, S. Tzortzakis, S. Nolte; Mastering micro-filamentation for semiconductor–metal ultrafast laser welding, Conference on Lasers and Electro-Optics (CLEO®/Europe-EQEC), online.

Gebhardt, M.; T. Heuermann, R. Klas, C. Liu, A. Kirsche, Z. Wang, M. Lenski, C. Gaida, J. Antonio-Lopez, A. Schülzgen, R. Amezcua-Correa, J. Rothhardt, J. Limpert; 100 kHz water window soft X-ray high-order harmonic generation through pulse self-compression in an antiresonant hollow-core fiber, The European Conference on Lasers and Electro-Optics, Munich, Germany.

Gebhardt, M.; T. Heuermann, R. Klas, C. Liu, A. Kirsche, Z. Wang, M. Lenski, C. Gaida, J. Antonio-Lopez, A. Schülzgen, R. Amezcua-Correa, J. Rothhardt, J. Limpert; High repetition rate high-order harmonic generation up to the carbon K-edge in an antiresonant hollow-core fiber, SPIE Photonics West, online, USA.

Gebhardt, M.; T. Heuermann, R. Klas, C. Liu, A. Kirsche, Z. Wang, M. Lenski, C. Gaida, J. Antonio-Lopez, A. Schülzgen, R. Amezcua-Correa, J. Rothhardt, J. Limpert; Fiber-integrated, high-repetition-rate water window soft X-ray source, MML Workshop, online.

Gilaberte Basset, M.; J. Fuenzalida, T.B. Gäbler, M. Gräfe; High-speed resolution-enhanced quantum imaging of living organisms, SPIE Photonics West, online.

Gilaberte Basset, M.; S. Töpfer, J.P. Torres, J. Fuenzalida, F. Steinlechner, M. Gräfe; Holography of a Photon Without its Detection, CLEO/QELS conference, online.

PUBLICATIONS

Gilaberte Basset, M.; S. Töpfer, J.P. Torres, J. Fuenzalida, F. Steinlechner, M. Gräfe; Single photon holography with undetected light, CLEO/Europe-EQEC Conference, online.

Gilaberte Basset, M.; S. Töpfer, J.R. León Torres, J. Fuenzalida, F. Steinlechner, M. Gräfe; Holography of an object without its detection, ASP DoKDoK-lite, online.

Gilaberte Basset, M.; S. Töpfer, J.R. León Torres, J. Fuenzalida, M. Gräfe; Quantum Sensing With Undetected Light, 751. Heraeus-Seminar on "Optical Information Processing – from Quantum Computing to Artificial Intelligence, online.

Gilaberte Basset, M.; S. Töpfer, J.R. León Torres, J. Fuenzalida, M. Gräfe; Quantum Holography With Undetected Light, 754. Heraeus-Seminar on "Sensing with Quantum Light", online.

Kumar, M.; T. Pertsch, F. Setzpfandt; Photon-Pair Generation in the Mid-Infrared using $AgGaS_2$ Crystals, Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference, online.

Kumar, M.; T. Pertsch, F. Setzpfandt; Mid-Infrared Photon-Pair Generation in AgGaS2 crystals, Conference on Lasers and Electro-Optics, online.

Mohaupt, M.; U. Zeitner, G. Harnisch, T. Bolz, S. Risse, A. Gebhardt, H.v. Lukowicz, T. Peschel, U. Hübner, Y. Gerome, M. Erhard, G. Huber; The high precision double slit device of the slit assembly for the FLEX instrument, ICSO - International Conference on Space Optics, online.

Jain, N.; T.B. Gäbler, J.R. León Torres, P. Hendra, M. Gräfe; Entangled 2-Photon Absorption in Commercial Fluorophores, PicoQuant Single Molecule Workshop, Berlin, Germany.

Jain, N.; T.B. Gäbler, J.R. León Torres, P. Hendra, M. Gräfe; Entangled Two-Photon Absorption in Commercial Fluorophores, European Light Microscopy Initiative (ELMI), online.

Hendra, P.; J.R. León Torres, M. Gräfe; Ultra-bright Photon-pair Source by a Non-linear Waveguide Crystal, IONS Ireland, online.

Kumar, P.; M. Younesi, S. Saravi, T. Pertsch, F. Setzpfandt; Dispersion engineered sum-frequency generation in a periodically poled thin-film $LiNbO_3$ nanowaveguide, Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference, online.

Paul, P.; Md. G. Hafiz, P. Schmitt, C. Patzig, F. Otto, T. Fritz, A. Tünnermann, A. Szeghalmi; Optical Quantizing Structures in Al2O3/TiO2 Heterostructures by Plasma Enhanced Atomic Layer Deposition, AVS ALD/ALE, online.

Paul, P.; V. Beladiya, D. Kästner, M. Burkhardt, A. Szeghalmi; Conformal Coating of Polymer Domes: Antireflection and Mirror Multilayer Systems made by PEALD, V2021 – Vakuum & Plasma, Dresden, Germany.

Li, Q.; G. Matthäus, S. Nolte; Glass to copper direct welding with a rough surface by femtosecond laser pulse bursts, Lasers in Manufacturing LIM, online, Germany.

Li, Q.; M. Chambonneau, M. Blothe, H. Gross, S. Nolte; A benchmarked vectorial model and flexible software-tool for in-bulk laser processing, Conference on Lasers and Electro-Optics (CLEO®/Europe-EQEC), online, Germany.

Klas, R.; A. Kirsche, J. Buldt, H. Stark, S. Hädrich, J. Rothhardt, J. Limpert; 12.9 mW high harmonic generation at 26.5 eV enabled by a sub-20 fs visible laser, The European Conference on Lasers and Electro-Optics, online, Germany.

Klas, R.; A. Kirsche, M. Gebhardt, J. Buldt, H. Stark, S. Hädrich, J. Rothhardt, J. Limpert; 13 mW average power ultrafast HHG source, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Fray, S.; M. Lippa, E. Semmler, W. Posselt, Ph. Giaccari, C. A. Mastrandrea, U.D. Zeitner, Th. Fluegel-Paul, S. Sadlowski, T. Käsebier, Ch. Monte, M. Kehrt; FORUM payload study for phase A/B1 by a consortium led by OHB System AG and TAS-UK, ICSO - International Conference on Space Optics, online.

Kholaif, S.; Y. Tu, C. Stihler, C. Jauregui, J. Limpert; Characterization of transverse mode instability in Fiber-Laser systems using a position-sensitive detector, SPIE Photonics West, online, USA.

Ritter, S.; J. Kretzschmar, T. Kaiser, R. Geiss, T. Vogl, F. Eilenberger; Photonic Quantum Experiments for Everyone with DIY Components, Web Services, and VR endpoints, Education and Training in Optics \& Photonics Conference 2021, online.

Wang, S.; W. Eschen, C. Liu, M. Steinert, T. Pertsch, J. Limpert a Jan Rothhardt; Towards Nanoscale imaging with Attosecond Pulses: Holography-enhanced broadband lensless imaging in the XUV, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Heuermann, T.; Z. Wang, M. Lenski, M. Gebhardt, C. Gaida, A. Klenke, M. Müller, C. Grebing, J. Limpert; 130 W, 1.3 mJ coherently combined ultrafast Tm-doped fiber laser system operating at 1.9 µm wavelength, European Optical Society Annual Meeting - EOSAM, Rom, Italy.

Heuermann, T.; Z. Wang, M. Lenski, M. Gebhardt, C. Gaida, A. Klenke, M. Müller, C. Grebing, J. Limpert; Four-channel coherently combined Tm-doped fiber chirped-pulse amplification system delivering 1 mJ-pulses at 98 kHz repetition rate, The European Conference on Lasers and Electro-Optics, online, Germany.

Käseberg, T.; J. Grundmann, T. Siefke, S. Kroker, B. Bodermann; Optical Nanoform Characterization by Imaging Mueller Matrix Ellipsometry, SPIE Optical Systems Design, Madrid, Spain.

Matthes, T.; A. Klein, U.D. Zeitner, F. Eilenberger, T. Vogl; Laser Annealing of Quantum Emitters in hBN, Doctoral Students' Conference for the Discussion of Optical Concepts DoKDoK, Jena, Germany.

Pertsch, T.; F. Setzpfandt; Lithium niobate on insulator as a versatile quantum photonics platform, First International Symposium on Lithium Niobate Optoelectronics (ISLNO 2021), online.

Santiago-Cruz, T.; A. Fedotova, V. Sultanov, M. A. Weissflog, D. Arslan, M. Younesi, T. Pertsch, I. Staude, F. Setzpfandt, M. V. Chekhova; Spontaneous photon pair generation in nonlinear metasurfaces, EOS Annual Meeting, Rome, Italy.

Santiago-Cruz, T.; A. Fedotova, V. Sultanov, M. Weissflog, M. Younesi, I. Staude, T. Pertsch, F. Setzpfandt, M. V. Chekhova; Mie Resonances in the Spectrum of Spontaneous Parametric Down-Conversion, Conference on Lasers and Electro-Optics, online.

Ullsperger, T.; Y. Wencke, B. Yürekli, G. Matthäus, G. Luinstra, S. Nolte; Powder bed fusion of ultra-high molecular weight polyethylene using ultra-short laser pulses, Lasers in Manufacturing LIM, online, Germany

Gäbler, T.; N. Jain, J.R. León Torres, P. Hendra, M. Gräfe; Entangled Two-Photon Absorption in Commercial Fluorophores, CLEO/QELS conference, online.

Gäbler, T.; N. Jain, J.R. León Torres, P. Hendra, M. Gräfe; Entangled Two-Photon Absorption in Commercial Fluorophores, CLEO/Europe-EQEC Conference, online.

Schulz, U.; K. Pfeiffer, F. Rickelt, A. Szeghalmi; ALD/PVD - hybrid coating for antireflection of 3D surfaces, SVC Society of Vacuum Coaters, online.

Besaga, V.; A. Vega, V. Gili, F. P´qez Larios, E.C. Brambilla Tamayo, T. Pertsch, M. Gräfe, F. Setzpfandt; Development and characterization of highly non-degenerate polarization-entangled Sagnac photon pair source, 754. Heraeus-Seminar on "Sensing with Quantum Light", online.

Eschen, W.; L. Loetgering, V. Schuster, R. Klas, J. Limpert, J. Rothhardt; Table-top highresolution ptychographic EUV imaging, OSA Imaging and Applied Optics Conference, online, USA.

Eschen, W.; V. Schuster, S. Wang, L. Loetgering, C. Liu, R. Klas, J. Limpert, J. Rothhardt; Ultrafast nanoscale XUV table-top coherent diffractive imaging, SPIE Photonics West, online, USA.

Zhao, X.; M. Baudisch, M. Beutler, T. Gabler, S. Nolte, R. Ackermann; Picosecond Optical Parametric Amplifier Pumped by A Thin-disk Laser at 1 µm for Coherent Anti-Stokes Raman Scattering, 19th European Conference On Non-Linear Optical Spectroscopy (ECONOS), Karlsruhe, Germany.

Zhao, X.; M. Baudisch, M. Beutler, T. Gabler, S. Nolte, R. Ackermann; Tunable femtosecond optical parametric amplifier pumped by 1 kHz ultrafast thin-disk laser pulses for coherent anti-Stokes Raman scattering, Conference on Lasers and Electro-Optics (CLEO®/Europe-EQEC), online, Germany.

Lin, Y.; C. Lee, H. Chung, M. Younesi, P. Kumar, K. Wang, O. Bernard, C. Shirpurkar, W. Su, R. Geiss, T. Pertsch, A. Sukhorukov, F. Setzpfandt, Y. Chen; Integrated Photonic Sources and Circuits in Lithium Niobate Platform, 26th Optoelectronics and Communications Conference, online.

Lin, Y.; M. Younesi, H. Chung, H. Chiu, R. Geiss, Q. Tseng, F. Setzpfandt, T. Pertsch, Y. Chen; Broadband Adiabatic Couplers in Thin-Film Lithium Niobate On Insulator, Conference on Lasers and Electro-Optics, online.

Ran, Y.; A. Boden, F. Küster, S. Guhl, A. Richter, S. Nolte, R. Ackermann; A Study on Carbon Gasification Dynamics using Ultrabroadband Coherent Anti-Stokes Raman Scattering, 19th European Conference On Non-Linear Optical Spectroscopy (ECONOS), Karlsruhe, Germany.

Tang, Z.; H. Gross; Higher order aberration analysis in symmetry-free optical systems, SPIE Optical Systems Design, online.

Colloquia

U.D. Zeitner, Novel Avenues in Micro-Structured Optical Components - from Consumer Market to Space-Applications, IOF, Photonics Manager, Jena, Germany (2021).

U.D. Zeitner, S. Risse, Tailored Optics for Space Applications, IOF, Photonics Days, Jena, Germany (2021).

H. Gross, Von der sphärischen Linse zur Freiform, Universität Lübeck, online, Germany (2021).

S. Nolte, Ultrashort pulse laser processing – from precise modification to welding dissimilar materials, 2021 Workshop on Novel Photonics Technologies, Bordeaux, France (2021).

Granted Patents

A. Brahm, A. Willms, G. Notni, S. Nolte, S. Döring
Verfahren und Vorrichtung zum Entspiegeln eines optischen Elements

DE102014200742B4

C. Stihler, C. Jauregui Misas, J. Limpert, H.-J. Otto, A. Tünnermann
Aktivstabilisierung von Modeninstabilität in einem Lichwellenleiter

EP3270473B1

D. Nodop, J. Limpert, A. Tünnermann
Faserverstärkersystem

EP2647090B1

J. Petschulat, M. Rahm, M. Dichtl, M. Heim, T. Pertsch, E.-B. Kley, T. Kämpfe
Sicherheitselement

EP2225110B1

J. Popp, M. Schmitt, T. Meyer, S. Nolte, R. Ackermann, J. Limpert
Lasermikroskop mit Ablationsfunktion

EP3458841B1

M. Goy, C. Reinlein, N. Leonhard, M. Appelfelder
Verfahren zur Formgebung und /oder Formkorrektur mindestens eines optischen Elements

DE102015106184B4

M. Müller, M. Kienel, A. Klenke, A. Tünnermann, J. Limpert
Optical arrangement

US11,043,783B2

M. Steglich, M. Zilk, K. Füchsel, A. Tünnermann, E.-B. Kley
Strahlungsdetektierendes Halbleiterbauelement

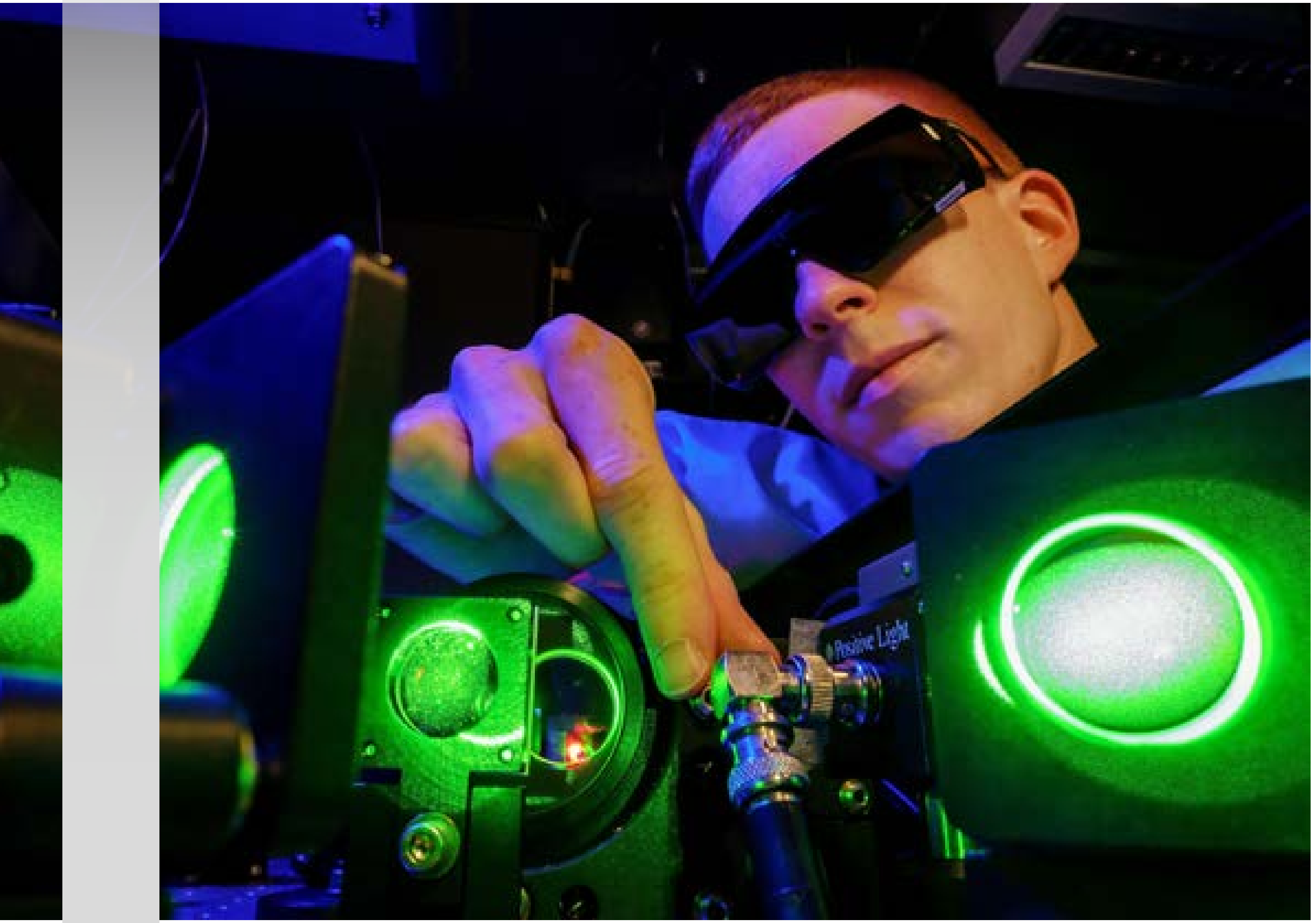
DE102012109243B4

S. Schröder, N. Felde, L. Coriand, M. Trost, G. Notni
Kontaminationsabweisender Spiegel und Verfahren zu dessen Herstellung

DE102018110251B4

S. Schröder, N. Felde, L. Coriand, M. Trost, G. Notni
Antifouling mirror and method for producing the same

JP6896785B2



Thorsten Goebel adjusts experimental equipment on an optical setup.

ACTIVITIES

A key feature of the IAP is the active and engaged exchange of its employees within the scientific community. This commitment can be measured in both the participation at conferences and at cooperation in projects with other institutions. Such community projects are the fruits of compulsory networking and strengthen the reputation of the institute within the research society and industrial associations. Appreciation of these efforts are also the call-ups of particular scientists in committees and editorial positions of academically approved journals.

Awards

Fatemeh Abtahi
2nd. Place Poster Session, DoKDoK-lite
Surface Nonlinearities in Dielectric Nanofilm

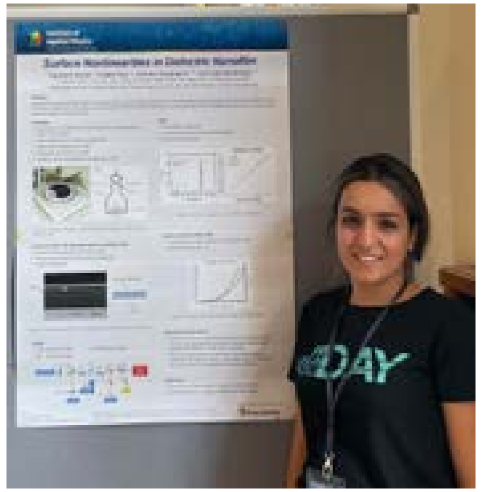
Marta Gilaberte Basset
Zeiss Dissertation Award in Modern Optics
Quantenbildgebung mit nicht-detektiertem Licht

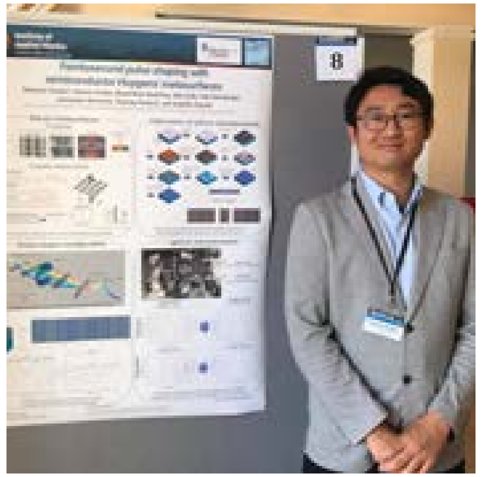
Robert Klas
SPARC PhD-Prize
Efficiency Scaling of High Harmonic Generation using Ultrashort Fiber Lasers

Thomas Siefke
Dr.-Ing. Siegfried Werth Award,
Best Dissertation in
Optical Metrology Technology
Entwicklung von Drahtgitterpolarisatoren für Anwendungen im ultravioletten bis in den vakuumultravioletten Spektralbereich

Lars-Henning Stark
1st Place Best Student Paper
Photonics West sub-conference "Fiber Lasers XVIII: Technology and Systems"
100 fs pulses directly from a kW-class mJ-level ytterbium-doped fiber CPA laser system

Albrecht Steinkopff
3rd Place Best Student Paper
Photonics West sub-conference
"Fiber Lasers XVIII: Technology and Systems"
Optimizing the design of coherently combined multicore fiber amplifiers





Fatemeh Abtahi (above) and Katsuya Tanaka at the students Conference DoKDoK-lite next to their at the awarded posters.

Christoph Stihler
Applied Photonics Award: Jury award for special application potential
Transverse mode instability - Insights into modal energy transfer in high-power fiber lasers

Katsuya Tanaka
1st Place Poster Session, DoKDoK-lite
Femtosecond pulse shaping with semiconductor Huygens' metasurfaces

Tobias Vogl
Innovationspreis „INNOspace“
Project „QuVeKS – Quantenprozessoren für verschlüsselte Kommunikation mit Satelliten"

Maximilian Weißflog
Best Talk, DoKDoK-lite
Describing SPDC in Nanoresonators Using Quasinormal Mode Expansions

Daniel Werdehausen
Friedrich-Hund-Dissertation Award
Nanocomposites as Next- generation Optical Materials: Fundamental Properties and Potential

Daniel Werdehausen during the award ceremony at the "PAF Alumni Tag", 2021.

Organizing Activities

Falk Eilenberger

Fellow of the Max-Planck-School of Photonics

Referee for Optica, Annalen der Physik, Opt. Comm.

Herbert Gross

Member of the program committee conference „European Optical Society Annual Meeting"

Referee as an expert for the Dutch Research Council NOW

Referee of several scientific journals

Jens Limpert

Member of Deutsche Physikalische Gesellschaft (DPG)

Member of the Optical Society of America (OSA)

Referee for several scientific journals

Stefan Nolte

Deputy Director of the Institute for Applied Optics and Precision Engineering IOF

Fellow of the Max Planck School of Photonics

Member of the Abbe School of Photonics

Chair of the Faculty´s Budget Commission and member of the Budget Board of the Senate

Scientific Coordinator for International Graduate Research School GRK 2101 (DFG)

Member of jury "Jugend forscht"

Member of several scientific committees (e.g. Phot. West, CLEO, ICALEO, LANE, Lasers in Manufacturing LiM, Lasertagung Jena)

Fellow of the Optical Society of America (OSA)

Fellow of the International Society for Optics and Photonics SPIE

Member of Deutsche Physikalische Gesellschaft (DPG)

Referee for several scientific journals and funding organizations

Thomas Pertsch

Member of the board of directors of the Abbe Center of Photonics at the Friedrich Schiller University Jena

Spokesman of the Abbe School of Photonics at the Friedrich Schiller University Jena

Member of the board of trustees of the Center of Excellence in Photonics ("Leistungszentrum Photonik") of the Fraunhofer Society

Member of the board of directors of the Thuringian Innovation Center for Quantum Optics and Sensing

Associate Investigator of the ARC Centre of Excellence for Transformative Meta-Optical Systems

Associate Investigator of the Cluster of Excellence Balance of the Microverse

Fellow of the Max Planck School of Photonics

Fellow of the Optical Society of America (OSA, Optica)

Referee for several international journals

Member of the Undergrad Committee of the Faculty of Physics and Astronomy at the Friedrich Schiller University Jena

Study program director for "Master of Science in Photonics" at the Friedrich Schiller University Jena – also responsible for accreditation

Advisor of the Student Chapter Jena of the Optical Society of America

Jan Rothhardt

Member of the extended directory board of the Helmholtz Institute Jena

Member of the Program committee for EOSAM conference 2021

Member Optical Society of America (OSA)

Referee for Nature Photonics, Nature Communications, Optics Letters, Optics Express, J Phys B, Appl. Phys B, Applied Optics, European Physical Journal D

Frank Setzpfandt

Journal-Referee for: ANano Letters, Nature Communications, Physical Review Letters, Physical Review A, APL Photonics

Managing Director of the „Thüringer Innovationszentrums für Quantenoptik und Sensorik"

ACTIVITIES

Markus Gräfe

- Journal-Referee for: Nature Photonics, Optics Letters, APL Photonics, Physical Review Letters, Physical Review A, Optics Communication, Advanced Photonics Research, Laser & Photonics Reviews, Journal of Microscopy
- Member of Deutsche Physikalische Gesellschaft (DPG)
- Member of the ACP

Fabian Steinlechner

- Referee for Physical Review Letters, Nature Physics, Optica, and other international journals
- Reviewer for DFG
- Sprecher für Quanten Hub Thüringen Qi1 - Quantenkommunikation

Adriana Szeghalmi

- Member of Deutsche Physikalische Gesellschaft (DPG)
- Senior Member of the Optical Society of America (OSA)
- Reviewer for several scientific journals

Andreas Tünnermann

- Member of the BMBF Research Cluster "infectooptics"
- Spokesman of the BMBF Center for Innovation Competence ZIK "ultra optics"
- Spokesman of the BMBF Program Zwanzig20 "3Dsensation" & BMBF Program QuNET
- Spokesman of DFG Research Training Group GRK2101
- Council member of the excellence cluster "Balance of the microverse"
- Director Fraunhofer IOF
- Chairman of the Technical Council Fraunhofer-Gesellschaft
- Spokesman of the Fraunhofer Innovation Cluster "Leitprojekt Quilt"
- Co-Spokesman of the Fraunhofer Cluster of Excellence "Advanced photon source"
- Spokesman of the Thuringian Innovation Center of "Quantum optics and sensors"
- Board of Directors Helmholtz Institute, Jena
- Supervisory board member Jenoptik AG
- Board of Trustees MPA, Heidelberg
- Spokesman of the "Max-Planck-School of Photonics"
- Surveyor BMBF, DFG, EU, AIF, MF, VF Projektträger Euronorm (BMWI)
- Alexander von Humboldt Stiftung - Selection Committee Alexander-von-Humboldt Professur
- Jury member STIFT - Thüringer Innovationspreis
- Stakeholder Photonics 21-Platform
- Member of Program Committee "Quantensysteme", BMBF
- Member of the Strategic Advisory Board for the Quantum Technologies Flagship (SAB), EU
- Member of the Expert Council "Quantumcomputing" of the Federal Gouvernment
- Member of Technological Sovereignty Council, BMBF
- Council Member of the TU Bergakademie Freiberg
- Council Member of the Faculty PAF at FSU
- Member of the Excecutive Board of the Abbe Center of Photonics at the Friedrich Schiller University Jena
- Spokesman of the Fraunhofer Innovation Cluster "Leistungszentrum Photonik" & Fraunhofer Graduate College "Fraunhofer Graduate Research School Photonics"
- Member Wissenschaftliche Gesellschaft Lasertechnik e .V. - Chairman "AG Naturwissenschaften"
- Member of acatech "Deutsche Akademie der Technikwissenschaften"
- Fellow Opical Sociaty of America (OSA) & SPIE
- Member of Deutsche Physikalische Gesellschaft (DPG)
- Spokesman Thuringian Quantum Hub
- Member of „Rat für technischen Souveränität RAT4TS", BMBF
- Representative of „Fraunhofer-Gesellschaft im QVLS | Quantum Valley Lower Saxony"

Frank Wyrowski

- Visiting Professor at the Chinese Academy of Science, China
- Visiting Professor at the Institute of Technology (HIT), China
- Conference Co-Chair: SPIE Workshop on Light Shaping
- Conference Co-Chair: SPIE Meeting on Computational Optics
- Conference Co-Chair: EOS Topical Meeting on Diffractive Optics
- Member of the Technical Program Committee SPIE Conference on Optics and Photonics for Information Processing
- Member of the Technical Program Committee SPIE Conference on Digital Optics for Immersive Displays
- Member of the Technical Program Committee OSA Conference on Digital Holography and 3D Imaging
- President of the LightTrans GmbH
- President of Wyrowski Photonics GmbH

Uwe D. Zeitner

- Member of the Program Committee for SPIE Advanced Lithography: Optical Microlithography XXXIV
- Member of the Program Committee for Microoptics Conference MOC2021
- Referee for several scientific journals

LOCATION

Institute of Applied Physics
Albert-Einstein-Straße 6 & 15
Campus Beutenberg
07745 Jena
Germany