
Institute of
Applied Physics
Friedrich-Schiller-Universität Jena
Annual Report 2016

Imprint

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EDITORIAL
Dipl.-Ing. Ira Winkler M.Sc., Pat.-Ing.
Dr. Frank Schrempel

PHOTOS/GRAFICS
Institute of Applied Physics (IAP), Abbe Center of Photonics, Fraunhofer IOF and Friedrich Schiller University Jena [J.-P. Kasper]
p.62: aboutpixel.de/Lektüre©marshi
p.88/89: SPIE, PAF-FSU

Content

PREFACE

Dear colleagues,

In the last few years, application areas for light have become more and more apparent. Which was just a buzzword a few years ago, more and more utopias could be transformed into reality resulting in the demonstration of many application examples – and many came from us.

For example, I am thinking about the 3D visualization in free space by means of lasers, as it has been shown only in science fiction, but now realized with small pictures in the group "Ultrafast Optics" led by Stefan Nolte. Due to the high intensity of ultrashort fs laser pulses in their focus, air molecules can be stimulated by nonlinear ionization processes. If the laser focus is moved quickly through the room, three-dimensional, self-luminous structures can be generated. It will be very exciting to see which branch is first adopting this kind of representation - medical professionals, developers or architects.

"Beaming" is also one of the great dreams not only among the physicists. For the first time, researchers around Alexander Szameit could demonstrate that the concept of teleportation is not only existent in quantum teleportation, but also in our classical world. They illustrate that the information transmission works only locally but completely and immediately, without any time loss. This is highly interesting for applications such as telecommunications.

On a completely new concept of photonic components, so-called nanostructured films, which are produced by lithographic processes Isabelle Staude counts. Such films can produce complex light fields with clearly defined and especially tailor-made properties. In this way, different macroscopic optical systems such as lenses could be reproduced with the same precision but much easier and more flexible. In recognition of her contribution already made, she was awarded the Hertha Sponer Prize of the DPG and has started a collaborative project (Nano-Film) funded by the BMBF.

In the research group around Jens Limpert, a high-performance XUV laser (average power in mW range, $\lambda = 57$ nm) was developed in laboratory size, which can compete with particle accelerators or synchrotrons such as the XFEL in Hamburg. Laser pulses were focused into a nonlinear crystal, resulting in the frequency doubling of the originally infrared light. The laser pulses -now lying in the green wavelength range- are then again transformed by cascaded frequency conversion, resulting in even higher-frequency pulses in the XUV.

Thanks to this technology, the XUV sources can now also be used for practical applications, which will be pursued in the new junior research group of Jan Rothhardt - for example, for new imaging methods to make three-dimensional structures visible with a resolution of a few 10 nanometers. This will allow completely new insights into the nano world.

Beside this new research group, three further research groups from the BMBF-funded 3Dsensation project, led by Martin Steglich, Frank Setzpfand and Stefan Heist, have been established which address 3D sensors for various applications. Moreover, two of our young researchers received a call to renowned institutions. Since April Stefanie Kroker is working as a junior professor for metrology of functional nanosystems at the "Laboratory for Emerging Nanometrology (LENA)" at the Technical University Braunschweig and the Physikalisch-Technische Bundesanstalt (PTB). After a guest professorship in New Zealand, Alexander Szameit left us at the end of the year and is now a professor at the University of Rostock. Both of them remain connected with us through joint research projects.

Last but not least, with great political attention, the university photonics research building Abbe Center of Photonics (ACP) has opened up on 5th of July. This underlines the positive development of the photonics sector, which has been going on for years, and certainly is based recently on the joint strategy process of science and economy. This highly functional university center, which has been funded both by state and federal authorities, offers the structural framework to overcome boundaries: by bundling existing outstanding optics skills and collaboration with material and biosciences, further achievements in basic research on the field of optics and photonics will be made. Therewith a good tradition in Jena - founded by Carl Zeiss - is passed on and best honored, his 200th birthday was celebrated on 11th of September.

All these results show that we are on a forward-looking path and receive recognition for our work on many different levels. I would like to mention also the invitation of three of our scientists to the Lindau Nobel Laureate Meeting.

Only to your committed participation we were able to complete successfully such ground-breaking projects as the Wachstumskern "Freeform Optics plus fo+" and the ZIK ultra optics. At the same time you were deeply involved in teaching and incubated new research ideas. For this I would like to thank you for your dedication and for the support of our project partners and funding providers.

Yours sincerely,

Prof. Dr. Andreas Tünnermann

THE INSTITUTE

The Institute of Applied Physics (IAP) at the Friedrich Schiller University Jena (FSU Jena) has a long-standing tradition and competence in design, fabrication and application of active and passive optical and photonic elements for both optical and opto-electronical devices. Collaborative projects with companies ensure practical relevance and feasibility.

Research Profile

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

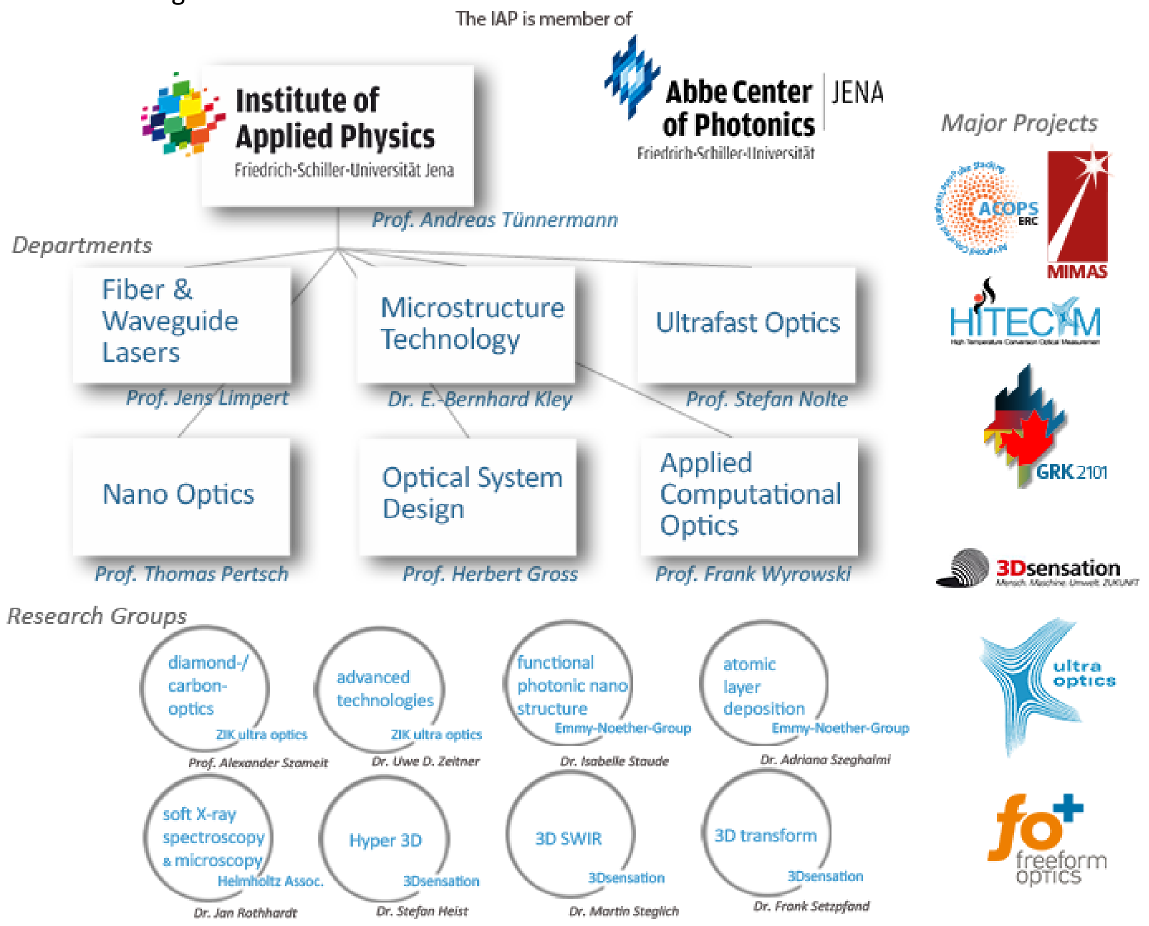
Our researcher develop novel optical materials, elements and concepts for information and communication technology, life science and medicine, security and mobility, environment and energy as well as process technology including material processing and optical measurement techniques.

Current research topics - investigated by over 120 scientists - concern design of optical systems, as well as function, design and production of micro- and nano-optical elements. Those are e.g. resonant grating structures, metallic and dielectric polarizers, all-optical switching processes in integrated photonic elements and effective media for reduced reflection losses of surfaces. Also light propagation and non-linear light-matter interaction in micro- and nano-structures, optical metamaterials and photonic crystals are investigated for their inherently novel fundamental physics. Further research fields are the application of femtosecond laser pulses, e.g. for material processing and micro- and nano-structuring, the development of new concepts for solid-state lasers such as fiber lasers, fiber-optical pulse shaping and the amplification of ultrashort laser pulses. Aim of other research efforts are the fundamental understanding of the propagation of optical waves in different systems, whose material parameter and structure are based on the different macroscopic manifestations of carbon. The usage of freeform optical key components due to their inherent advantages is also aim of the IAP. The design, fabrication and integration of such elements represent scientific and technological challenges, which our scientists accept.

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 partner companies, the IAP covers numerous parts of the innovation chain - from interdisciplinary fundamental research to thedemonstration of prototypes. This expertise offers remarkable contributions to solve issues in emerging fields like energy, environment, health and communication.

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), and moreover in 2015 the awarded ERC Advanced Grant for "Multi-dimensional interferometric amplification of ultrashort laser pulses — MIMAS" and 2014 the ERC Consolidator Grant for "Advanced Coherent Ultrafast Laser Pulse Stacking (ACOPS)", but also the BMBF Innovation Initative for the New Länder fo+ (Freeform Optics Plus, www.fo-plus.de), which combines fundamental and applied research in a unique way.

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



Research Facilities / Resources

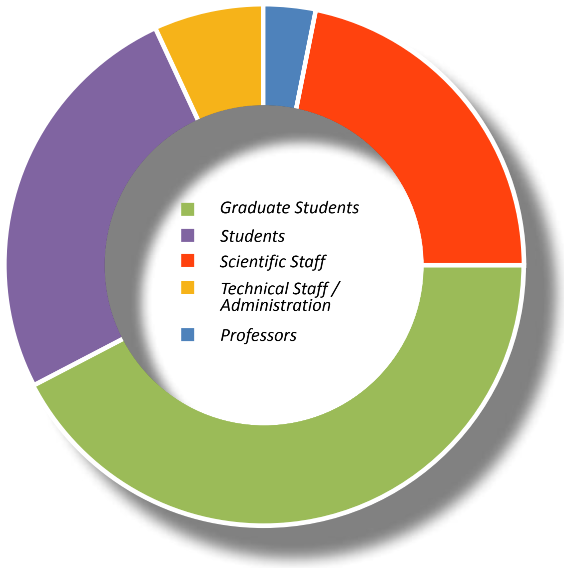
Excellence in research requires high quality equipment for experimental questions and analysis. The state-of-the-art technical infrastructure is driven constantly forward by acquired adaptions for scientific questions.

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 technology
- Rigorous optical simulation
- Field tracing techniques

Staff (status 12/2016)

6	university professors
31	research associates
16	technical & administrative staff members
89	PhD-students
60	students & trainees



ABBASIRAD Najmeh
ABBE Sylvia
ACKERMANN Roland
ARSLAN Dennis
ASOUBAR Daniel
BADAR Irfan
BALADRON ZORITA Olga
BAUER Toni
BECKER Nils
BEIER Franz
BEIER Matthias
BERGNER Klaus
BERLICH René
BETHKO Eduard
BINGEL Astrid
BLUMRÖDER Ulrike
BOHN Justus
BÖSEL Christoph
BOURGIN Yannick
BREITKOPF Sven
BRÖMEL Anika
BUCHER Tobias
BULDT Joachim
BURMEISTER Frank
CAI Danyun
DIENER Romina
DIETRICH Kay
DIETRICH Patrick
DREISOW Felix
EICHELKRAUT Toni
ENGELHARDT Hannes
ESCHEN Wilhelm
FALKNER Matthias
FASOLD Stefan
FELDE Nadja
FRANKE Christian
FRÖBEL Friedrich Georg
FUCHS Hans-Jörg
FÜßEL Daniel
GAIDA Christian
GEBHARDT Martin
GEIß Reinhard
GHAZARYAN Lilit
GIERSCHKE Philipp
GOEBEL Thorsten
GOTTSCHALL Thomas
GOY Matthias
GRÄF Waltraud
GRÄFE Markus
GROSS Herbert
GUZMAN-SILVA Diego
HÄDRICH Steffen
HAMBACH Ralf
HECK Maximilian
HEILMANN René
HEINRICH Matthias
HEIST Stefan
HELLER Lukas
HEUSINGER Martin
HILPERT Enrico
HOFFMANN Armin
JANUNTS Norik
JAUREGUI MISAS Cesar
JUNGHANNS Marcus
KADEN Lisa
KAISER Thomas
KAMMEL Robert
KÄMMER Helena
KÄSEBIER Thomas
KEMPER Falk
KERSTAN Marita
KIENEL Marco
KINAST Jan
KIRSCHE Alexander
KLAS Robert
KLENKE Arno
KLEY Ernst-Bernhard
KLUGE Anja
KOESTER Jan-Philipp
KRÄMER Ria
KREBS Manuel
KROKER Stefanie
KÜFFNER Erik
KÜHN Dominik
LANGE Nicolas
LIAKHOV Evgenii
LIMPERT Jens
LIU Chang
LÖCHNER Franz
LU XIANG
MA Chonghuai
MAC CIARNAÍN Rossá
MACZEWSKY Lucas
MAKOS Ioannis
MÁNKOWSKI Vojtech
MARTIN Bodo
MATTHÄUS Gabor
MATZDORF Christian
MENZEL Christoph
MERX Sebastian
MIDDENTS Wilko
MINARDI Stefano
MÖLLER Friedrich
MÜLLER Michael
MÜLLER Robert
MUSICK David
NARANTSATSRALT Bayarjargal
NATHANAEL Anne
NAUJOK Philipp
NIEDLICH Stefan
NOLTE Stefan
O'CONNELL Craig
OLESZKO Mateusz
ORNIGOTTI Marco
OTTO Christiane
OTTO Hans-Jürgen
PEREZ LEIJA Armando
PERTSCH Thomas
PFEIFER Kristin
PLEGUEZUELO Pol Ribes
PUFFKY Oliver
RAN Yang
REHFELDT Tim
RICHTER Daniel
RODRIGUEZ Asis Saad
ROCKSTROH Sabine
ROCKSTROH Werner
ROSENSTENGEL Diana
ROTHHARDT Carolin
ROTHHARDT Jan
SAHRAEI Negin
SARAVI Sina
SAYGIN Mikhail
SCHAARSCHMIDT Kay
SCHELLE Detlef
SCHMELZ David
SCHMIDT Holger
SCHMIDT Sören
SCHOEPPNER Tyler
SCHREMPEL Frank
SCHWINDE Stefan
SEKAM Jusuf
SERGEEV Natali
SETZPFANDT Frank
SEYFARTH Brian
SHESTAEV Evgeny
SHI Rui
SHU Zhe
SIEFKE Thomas
SIEMS Malte
SINGH Vikram
SIRMACI Yunus Denizhan
SPÄTHE Anna
SPERRHAKE Jan
SPIRA Susanne
STANICKI Jakob Badru
STARK Lars Henning
STAUDE Isabelle
STEGLICH Martin
STEINBERG Carola
STEINERT Michael
STIHLER Christoph
STOCK Carsten
STOCK Johannes
STÜTZER Simon
STUTZKI Fabian
SUKHORUKOV Andrey
SZAMEIT Alexander
SZEGHALMI Adriana
TADESSE Getnet Kassa
TISCHNER Katrin
TROST Marcus
TSCHERNAJEW Maxim
TÜNNERMANN Andreas
ULLSPERGER Tobias
VASKIN Aleksandr
VETTER Christian
VETTER Julia
VOIGT Daniel
VON LUKOWICZ Henrik
WANG Ziyao
WANG Zongzhao
WARZESCHKA Sandra
WEICHELT Tina
WEIMANN Steffen
WIDHOLZ Georg
WILDE Johannes
WINKLER Ira
WORKU Norman Girma
WUNDERLICH Stefano
WYROWSKI Frank
YANG Liangxin
ZEITNER Uwe
ZEUNER Julia
ZHANG Site
ZHANG Yueqian
ZHONG Huiying
ZHONG Minyi
ZHONG Yi
ZHOU Wenjia
ZILK Matthias
ZIMMERMANN Felix

Guests

Guests indicate the national and international visibility of research results and enrich the structures of the Institute of Applied Physics 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.

ALIKACEM Yasmine	Université Laval, Quebec, Canada
BERZINS Jonas	Center for Physical Sciences and Technology, Vilnius, Lithuania
BLUM Jürgen	TU Braunschweig, Germany
BRENER Igal	Sandia National Laboratories & CINT, Albuquerque, USA
BUSCH Kurt	Humboldt University Berlin, Germany
CAO Yubin	Harbin Institute of Technology, Harbin, China
CHEN Yen-Hung	National Central University, Taoyuan, Taiwan
CHOU Chun-Han	National Taiwan University of Science and Technology, Taipe, Taiwan
DATHE André	Leibniz Institute of Photonic Technology, Jena, Germany
DE STERKE Martijn	University of Sydney, Australia
FALCIONI Marco	University of Camerino (UNICAM), Italy
FITZGERALD Niamh	National University of Ireland, Galway, Ireland
HEYRAPETYAN Armen	Max Planck Institute for the Physics of Complex Systems, Dresden, Germany
HUANG Jer-Shing	National Tsing Hua University, Hsinchu, Taiwan
ISIC Goran	University of Belgrade, Serbia
JIN Chunqi	Changchun Institute of Optics, Fine Mechanics and Physics, Changchun, China
LINDEN Stefan	University Bonn, Germany
MA Libo	Institute for Integrative Nanoscience, Dresden, Germany
MORANDOTTI Roberto	Institut national de la recherche scientifique (INRS), Varennes, Canada
MORTENSEN Asger	Technical University of Denmark, Lyngby, Denmark
NIE Yunfeng	Vrije Universiteit Brussel, Belgium
OGATA Yoichi	Center for Advanced Photonics, Wako, Japan
PARTANEN Henri	University of Eastern Finland, Joensuu, Finnland
RALEVIC Uros	University of Belgrade, Serbia
RICHARDSON Martin	University of Central Florida, Orlando, USA
SAUTTER Jürgen	Karlsruhe Institute of Technology, Germany
SCHMITT Sebastian	Helmholtz-Zentrum Berlin & Max Planck Institute Erlangen, Germany
SCHUSTER Vittoria	Karlsruhe Institute of Technology, Germany
STALIUNAS Kestutis	Universitat Politècnica de Catalunya, Barcelona, Spain
TAUBNER Thomas	University of Aachen (RWTH), Germany
VAMOS Lenard	Max Planck Institute of Quantum Optics, Garching, Germany
VERHOEVEN Antonie	University of Eastern Finland, Joensuu, Finnland
WALTER Ramon	University of Stuttgart, Germany
WOLFF Christian	University of Technology Sydney, Australia
XIA Chunqiu	Changchun Institute of Optics and Fine Mechanics, Changchun, China

Research Stays

ARSLAN Dennis	University of Belgrade, Serbia
BOHN Justus	University of Sydney, Australia
FALKNER Matthias	University of Belgrade, Serbia
GEIß Reinhard	University of Belgrade, Serbia
GOEBEL Thorsten	Macquarie University, Sydney, Australia
HECK Maximilian	Université Laval, Québec, Canada
KLEY Ernst-Bernhard	Macquarie University, Sydney, Australia
	University of Sydney, Australia
PFEIFFER Kristin	VTT Technical Research Centre of Finland, Espoo, Finland
RICHTER Daniel	Macquarie University, Sydney, Australia
SAVARI Sina	University of Sydney, Australien
SPERRHAKE Jan	University of Belgrade, Serbia
STAUDE Isabelle	FOM Institut AMOLF, Amsterdam, The Netherlands
	Sandia National Laboratories, Albuquerque, USA
	University of Exeter, UK
	University of Paderborn, Germany
	Technical University of Kaiserslautern, Germany
STEGLICH Martin	Institut für Halbleitertechnik, Stuttgart, Germany
STIHLER Christoph	Université Laval, Québec, Canada
SZAMEIT Alexander	Massey University, Auckland, New Zealand
SZEGHALMI Adriana	Technical University of Eindhoven, The Netherlands
WYROWSKI Frank	Nanjing University of Science & Technology (NJUST), Nanjing, China
	Suzhou Institute of Biomedical Engineering and Technology, Suzhou, China
ZHANG Site	Changchun Institute of Optics, Fine Mechanics and Physics, Changchun, China

Cooperations

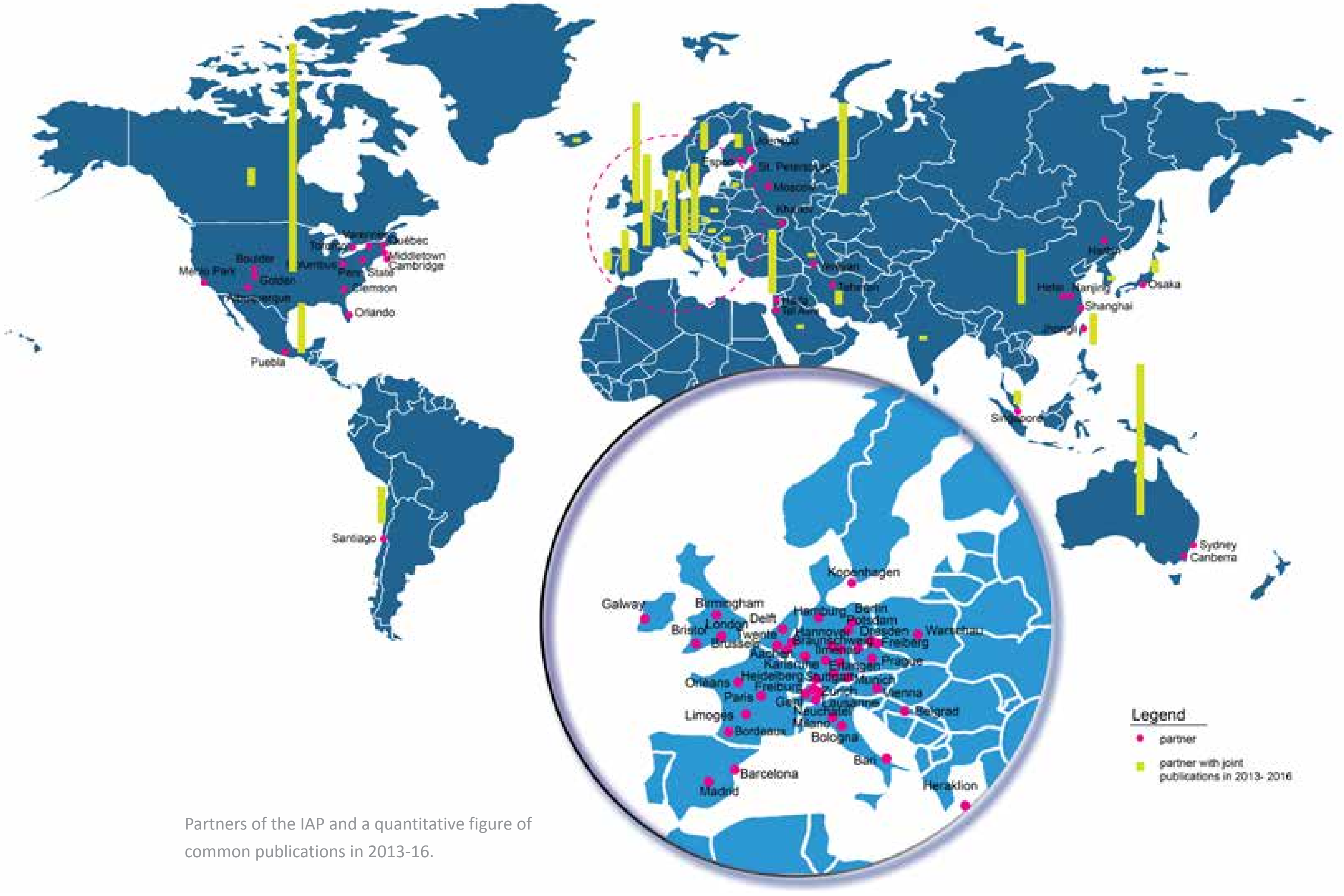
The IAP is cooperating with most of the departments of the Faculty of Physics and Astronomy at Friedrich Schiller University, 2016 in particular with the Institute of Optics and Quantum Electronics and the Otto Schott Institute of Materials Research.

In our work we are connected to many important research centers of Germany, like the Max-Planck-Institute of Quantum Optics (MPQ) and Extra-terrestrial Physics (MPE) in Garching as well as the Karlsruhe Institute of Technology and Institutes of the Leibniz Association - such as the Institute for Astrophysics Potsdam (AIP), the Institute of Photonic Technology Jena (IPHT) and the Institute for Innovative Microelectronics (IHP).

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 international center of excellence for micro- and nano-structured optics, optical systems and laser development and application. Therefore, the knowledge and equipment is used commonly, to face the research challenges and to assist also industrial partners in developing new products. Such a fruitful cooperation is the collaboration with eight leading Thuringian Photonics companies in the project “Freeform Optics Plus fo+”, mostly financed by the BMBF-Initiative “Unternehmen Region”. The Verbund-ZIK "HITECOM" connects our Institute with the TU Bergakademie Freiburg since years.

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) and the Australian National University, as well as the University of Toronto, the Vrije Universiteit Brussel, the University of Science and Technology China, Universities in Russia, Serbia, Israel, Great Britain and USA.

At the German-Canadian International Research Training Group GRK 2101 “Guided light, tightly packed” we are cooperating with the University of Toronto, Université Laval and the Institut National de la Recherche Scientifique (INRS) – the coordination lies in the hands of our partner Abbe School of Photonics here in Jena. In addition, efforts have been made to win the Chinese Changchun Institute of Optics Fine Mechanics and Physics (CIOMP) for a partnership in the training field.



Partners of the IAP and a quantitative figure of common publications in 2013-16.

Cooperations with Joint Research Topics *(Selection)*

Applied Optics
National University of Ireland
Galway, Ireland
Christopher Dainty

Applied Optics Group
Charles University Prague
Prague, Czech Republic
Antonín Mikš

Aston University
Birmingham, UK
Sergei Turitsyn

Brussels Photonics Team
Vrije Universiteit Brussel
Brussel, Belgium
Hugo Thienpont, Fabian Duerr

AT Technologies, Veldhoven, The Netherlands
Mikhail Loktev

Carl Zeiss AG, Oberkochen, Germany
Daniel Krähmer

Centre d'optique, photonique et laser
Université Laval, Québec, Canada
Réal Vallée

Centre of Ultrahigh bandwidth Devices for Optical Systems (CUDOS), MQ Photonics Research Centre, Department of Physics and Astronomy, Macquarie University
Sydney, Australia
Michael Withford, Alex Fuerbach

College of Optics and Photonics, CREOL & FPCE
University of Central Florida, Orlando, USA
Kathleen Richardson, Martin Richardson

Department of Electrical and Computer Engineering, University of Toronto
Toronto, Canada
Peter Herman

Department of Physics,
Colorado School of Mines, Golden, USA
Jeff Squier

Department of Physics and Mathematics
University of Eastern Finland, Joensuu, Finland
Jari Turunen

Énergie, Matériaux et Télécommunications Research Center
Institut national de la recherche scientifique
Varennes, Canada
Roberto Morandotti

Engineering Center OPTICA
State University of Information, Mechanics, and Optics (ITMO), St. Petersburg, Russia
Irina Livshits

Centre for Innovation Competence
ZIK innoFSPEC
Leibniz-Institut für Astrophysik Potsdam
Potsdam, Germany
Martin Roth

Institut de Chimie Moléculaire et des Matériaux d'Orsay (ICMMO), Laboratoire de Physico-Chimie de L'Etat Solide (LPCES)
Université de Paris Sud 11, Orsay, France
Matthieu Lancry

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

Institut für Geophysik und Extraterrestrische Physik, TU Braunschweig, Deutschland
Jürgen Blum

Institut für Halbleitertechnik (IHT)
Universität Stuttgart, Germany
Michael Oehme

Institute of Photonics and Optical Science (IPOS), ARC Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS),
University of Sydney, Australia
Benjamin Eggleton, Mike Smith

Institute of Physics, University of Belgrade
Belgrade, Serbia
Goran Isic

Institute of Quantum Electronics
ETH Zürich, Zürich, Switzerland
Florian Emaury

Laboratoire Ondes et Matière d'aquitaine (LOMA)
Université Bordeaux, France
Lionel Canioni

Laboratory of Nanophotonics & Metamaterials
Lomonosov Moscow State University
Moscow, Russia
Andrey Fedyanin

Metrologie funktionaler Nanosysteme
Technischen Universität Braunschweig,
Physikalisch-Technische Bundesanstalt
Braunschweig, Germany
Stefanie Kroker

National Accelerator Laboratory SLAC
Menlo Park, USA
Christian Roedel

National Synchrotron Radiation Laboratory
University of Science and Technology, Hefei, China
Ying Liu

Nonlinear Physics Center
Australian National University, Canberra, Australia
Dragomir Neshev

Optical Engineering Group (OEG)
Universidad Politecnico de Madrid (UPM)
Madrid, Spain
Pablo Benitez

Optical Sciences Center, National Central University
Jhongli, Taiwan
Wei-Kun Chang

Optics Research Group
Delft University of Technology, The Netherlands
Paul Urbach

OSRAM GmbH, Munich, Germany
Stephan Malkmus

Plasma & Materials Processing Group
Dept. of Applied Physics
Eindhoven Univ. of Technology, The Netherlands
Erwin Kessels

Pennsylvania State University, State College, USA
Mikael Rechtsman

Sandia National Laboratories, Albuquerque, USA
Igal Brener

School of Electronic and Optical Engineering
Nanjing University of Science & Technology
Nanjing, China
Jun Ma

Solid State Institute, Technion, Haifa, Israel
Mordechai Segev

Sydney Astrophotonics Instrumentation Laboratory (SAIL), University of Sydney, Australia
Sergio Leon-Saval

Technical University of Denmark
Lyngby, Denmark
Asger Mortensen

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, and running the International Research Training Group (GRK 2101) "Guided light, tightly packed: novel concepts, components and applications".

Lectures

Elective & Special Courses (Lectures & Seminars)

- Astrophotonics
- Atome und Moleküle II
- Computational Physics I
- Computational Photonics
- Diffractive Optics
- Design & Correction of Optical Systems
- Fundamentals of Quantum Optics
- Fundamentals of Microscopic Imaging
- Fundamentals of Modern Optics
- Grundlagen der Laserphysik
- Imaging and Aberration Theory
- Introduction to Applications of modern Optics and Photonics in Astronomy
- Introduction to Nanooptics
- Introduction to Optical Modeling
- Laser Physics
- Lens Design I & II
- Micro/Nanotechnology
- Optical Engineering
- Optical Metrology and Sensing
- Optical Modeling and Design I-III
- Physical Optics Design
- Physik der Materie III (AMQ Lehramt)
- Thin Film Optics
- Ultrafast Optics

Seminars of the Institute & Devisions

- Advanced Fabrication Technologies
- Applied Computational Optics
- Applied Physics
- ASP-Seminar Applied Photonics
- Atomic Layer Deposition
- Design of Optical Systems
- Diamond Optics
- Fiber Lasers
- Microstructure Technologies - Microoptics
- Nano Optics
- Ultrafast Optics

Practical Training

- ASP-Internship
- ASP-Experimental Optics
- Physikalisches Fortgeschrittenenpraktikum
- Physkalisches Grundpraktikum

Interior of the Auditorium at the Abbe Center of Photonics. The new students were wellcomed by our colleagues.

Master Theses

Xiang Lu
Monte Cralo simulation of light propagation in biological tissue

Chonghuai Ma
Tailored optics for Bragg grating writing systems

Ioannis Makos
Gas analysis using two beam ultra-broadband femtosecond Coherent Anti-Stokes Raman Scattering

David Musick
Investigation of desensitization methods for high-resolution endoscopes

Craig O´Connell
Arbitrary pattern generation for ultrashort pulse materials processing

Tim Rehfeld
Characterization methods of the emission and absoroption cross-sections of active optical fibers

Asis Rodriguez
Design of an objective lens for the tilted wave interferometer

Henning Stark
Electro-optically controlled divided-pulse amplification

Johannes Stock
Investigations on freeform surfaces under real conditions

Sandra Warzeschka
Entwicklung und Charakterisierung eines elektrolytischen Abscheide-prozesses zur Erzeugung von Goldnanostrukturen

Doctoral Theses

Daniel Asoubar
Simulation of continuous-wave solid-state laser resonators using field tracing and a fully vectorial Fox-Li algorithm

Martin Baumgartl
Ultrafast laser sources based on microstructured fibers

Astrid Bingel
Maßgeschneiderte TCO-Schichten und Schichtsysteme

Frank Burmeister
Hoch-NA-Fokussierung von ultrakurzen Laserpulsen für die Zwei-Photonen-Polymerisation

Reinhard Geiß
Micro and nanostructured Lithium niobate for integrated nonlinear optics

Arno Klenke
Performance scaling of laser amplifiers via coherent combination of ultrashort pulses

Dennis Lehr
Plasmonische Nanomaterialien auf Basis von Nanoringen

Constanze Pradarutti
Design und Entwicklung von optischen Messsystemen basierend auf bidirektionalen Sensorelementen

Martin Steglich
Black Silicon mittels ICP-RIE und seine Anwendungen in Optik und Optoelektronik

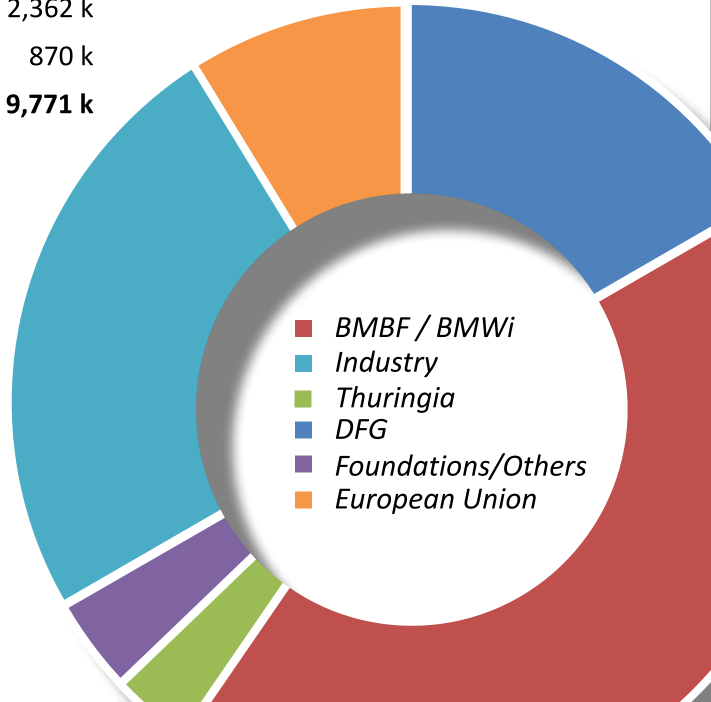
Anika Brömel in conversation about the results of the project Freeform Optics Plus fo+ at the workshop "Ultra Precision Manufacturing of Aspheres and Freeforms".

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 cooperations expanded. Thus, the IAP can continuously link the results at the value chain and transfer these results from basic research into innovative and novel demonstrators.

External funding

DFG (German Research Society)	€	1,634 k
BMBF/BMWI (Federal Ministries)	€	4,182 k
State of Thuringia	€	322 k
Foundations	€	401 k
Contract Research	€	2,362 k
European Union	€	870 k
Total:	**€**	**9,771 k**



BMBF/ BMWI

Federal Ministry of Education and Research/Federal Ministry for Economic Affairs and Energy

ZIK Ultra Optics 2015

- Forschergruppe Fertigungstechnologien für hoch entwickelte Mikro- und Nano-Optiken
- Nachwuchsgruppe Design und Realisierung komplexer mikro- u. nanostrukturierter photonischer Systeme basierend auf Diamant- u. Kohlenstoffoptiken

Verbund-ZIK Hitecom II - Spektroskopische Untersuchungen zur Vergasung von Kokspartikeln unter Hochdruck- und Hochtemperaturbedingungen

Verbund-ZIK astrOOptics - Astrooptic components

Wachstumskern fo+ - Untersuchung ultrapräziser Freiformsysteme

Program "Zwangzig20" - Project "3Dsensation":

- 3D SWIR - Augensichere 3D-Bildgebung im SWIR
- Hochdynamische 3D-Sensorik in erweiterten Spektralbereichen
- FastDetect - Methoden zur ultraschnellen dreidimensionalen Detektion zeitveränderlicher Lichtfelder
- Untersuchungen zur Visualisierung von 3D-Objekten im freien Raum mittels Laser
- 3D-NanoVisual - Dreidimensionale Visualisierungssysteme auf der Basis photonischer Nanomaterialien
- OMNIdetect - Redundanzfreie omnimodale 3D-Detektionstechnologie
- 3Dtransform - Transformationsoptik für multidimensionale Dektoren

ALSI - Advanced Laser-writing for Stellar Interferometry

Design optischer Komponenten zur flexiblen Lichtformung mit Anwendungen für Weißlicht LEDs

HoruS - Hochrobuste ultrakurzpulsgeschriebene Fasersensorarrays

Integriert-optische Module durch neue Bondtechnologien

MonOCrom - Moderne optische Technologien zur Crosstalk-Minimierung in Silizium-Photomultipliern

Nano-Aktiv - Aktiv modulierbare dielektrische photonische Nano-Filme mit integrierter Lichtquelle

NanoInt - Verbundprojekt Integrierte Nanooptik

NASIKA - Nachtsichtkamera für Automotiv-Anwendungen

NUKLEUS - Grundlegende Untersuchung zur Performanceskalierung von Thulium-dotierten Ultrakurzpulsfaserverstärkern

SCULPT - Scaling Ultrafast Laser Productive Precision Processing Technology

SITARA - Selbstadaptierende intelligente Multiaperturkamera-Module

SolarNano - Nanostructured plasmonic reflectors for efficient thin film solar cells

TEHFA II - Erforschung thermo-optischer Wellenleitereffekte in monolithischen Hochleistungs-laserfasern, Moden und hochleistungsstabile Komponenten für Faserlaser

T4nPV - Tailored for next PV, UKP-Laserstrukturierung von dünnen Schichten für PV-Anwendungen

Ultrakurzpulslaser-Bearbeitung von Gläsern mit biologisch aktiven Oberflächen; Ultrakurzpulslaser-Bearbeitung von Glassubstraten

Verbund APPA R&D: Licht-Materie-Wechselwirkung mit hochgeladenen Ionen

European Union

ERC Advanced Grant MIMAS - Multi-dimensional interferometric amplification of ultrashort laser pulses

ERC Consolidator Grant ACOPS - Program „Ideas“,; Advanced coherent ultrafast laser pulse stacking

ADOPSYS - Advanced Optical System Design

BRI 5 - Fundamental Fiber Laser Science for High Powers

Marie Curie Initial Training Network PICQUE - Photonic Integrated Compound Quantum Encoding

QuILMI - Quantum Integrated Light Matter Interface

DFG - German Research Foundation

Research Training Group

- International Research Training Group GRK 2101 "Guided light, tightly packed: novel concepts, components and applications"

Emmy Noether-Programm

- Optische Beschichtung mittels ALD - Beschichtung nanostrukturierter Substrate und Adsorption von Flüssigkristallen an dünnen Schichten
- Hochbrechende dielektrische Nanopartikel als neue Plattform für die Nanophotonik

MetaLiquid - Metamaterialien in flüssiger Phase

ALDBIAS - Einfluss des elektrischen Feldes auf die Materialeinegschaften mittels Atomlagenabscheidung hergestellter Oxid-Dünnschichten: Experimentelles und rechnergestütztes Design

Investigation on near-plane varied-line-spacing gratings made by electron beam lithography and near field holography

PhoToMaD - Photonische Topologische Materialien mit Umordung

Multipfad-Interferenztests der Quantenmechanik

Quantum simulators: from photonic to atomic

Nanoguide - Nonlinear optics plasmonic nanoantennas from Lithium Niobate

Disorder - Kontrolle der Streufeldwechselwirkung in ungeordneten zweidimensionalen Anordnungen von Silizium-Nanopartikeln

E-GRAS - Emulation der Graphenstruktur mittels Photonik

NearFieldHolo - Investigation on near-plane varied-line-spacing gratings made by electron beam lithography and near field holography

Laserbasierte Simulation von Hochgeschwindigkeitskollissionen und strukturelle Zustände des Staubs in Trümmerscheiben

Contract Research

The IAP runs a very dense network of industry partners. Contract research have been made - very often in common with the Fraunhofer IOF - both with medium size regional and large size international companies, such as ORAFOL Fresnel Optics GmbH, Layertec GmbH, Carl Zeiss AG, TRUMPF GmbH + Co. KG or the European Space Agency (ESA).

Foundations/Other Sources

Stiftungsprofessur Theorie optischer Systeme (endowed professorship)

InfectoOptics - Leibniz Society

6x Carl-Zeiss-Scholarships

1x TRUMPF-Scholarship

DAAD exchange programs (Australia, Taiwan, Serbia)

State of Thuringia

Thuringian Ministry of Economy, Science and Digital Society

ACP-FIB - Fokussierte Ionen- und Elektronenstrahlanlage zur Nanostrukturierung und -charakterisierung

ACP-Mesolab - Labor für die Präparation und Charakterisierung mesoskopischer Hybridsysteme am ACP

KoMIMAS - Koordinierung ERC-"Advanced Grant"

Parallas - Grundlegende Betrachtung zu parallelisierten Ultrakurzpulsverstärkern

FaserForLaser - Mikrostrukturtechnologie zur Überwindung von Leistungsgrenzen faserbasierter Lasersysteme

GRINeMotion - Systemdesign und Simulation von Endomikroskopen

DIADEM - 3D-Bildaufnahme und -Verarbeitung mit höchstem kontinuierlichem Datendurchsatz für die Mensch-Maschine Interaktion und adaptive Fertigung

ProExz., ACP Explore - Intelligentes Laserskalpell für die Diagnose und Therapie von Tumoren

ProExz., ACP Explore - Einzelmolekülfalle (ABEL trap) zum ultrasensitiven Nachweis löslicher Marker und Wirkstoffe gegen Autoimmunerkrankungen

ProExz., ACP-Explore - Enlightening New States of Matter

ProExz., ACP-Explore - ITechnologien zur Realisierung von einkristallinen Gold-Nanostrukturen

ProExz., ACP2020 - Agenda für exzellente Photonik

More than simply fans: Marco Ornigotti (left) and Alexander Szameit (right) have demonstrated in 2016 experimentally for the first time that the concept of teleportation not only lasts in the world of tiny quantum particles, but also in our classical world.

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.

Fiber & Waveguide Lasers

Prof. Dr. Jens Limpert
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This research group is working on the development of new concepts for solid-state lasers with focus on fiber laser technology.

Scientific focus lies on:

- Fiber optical amplification of ultra-short laser pulses
- Ultra-short pulse oscillators, few-cycle pulse generation and amplification
- Conception of novel large core diameter fibers
- Simulation of non-linear effects and amplification dynamics in active fibers
- Fiber optical frequency conversion
- Mid-IR laser sources
- High Harmonic Generation and applications in imaging and spectroscopy

Robert Klas tunes an experimental setup that allows XUV pulses to be produced in practically every optics laboratory., here in the new Abbe Center of Photonics lab.

Authors:
Cesar Jauregui Misas, Christoph Stihler and Jens Limpert

Mitigation of mode instabilities in high-power fiber laser systems

The output power of fiber laser and amplifier systems has exponentially increased over the last 20 years /1/. However, in 2010 the first reports of a new phenomenon /2/, transverse mode instabilities (TMI), promptly announced the stagnation of this trend. TMI is an effect that limits the average power of fiber laser systems with diffraction-limited beam quality. This alone sets TMI apart from any other known effect happening in a fiber laser system.

TMI refers to the sudden degradation of the quality and stability of the beam emitted by a fiber laser system observed once that a certain average power threshold is reached (Figure 1). TMI are caused because the interference of two transverse modes in a few-mode fiber creates, via the thermo-optic effect, a long period grating which can potentially lead to an energy exchange between the interfering modes.

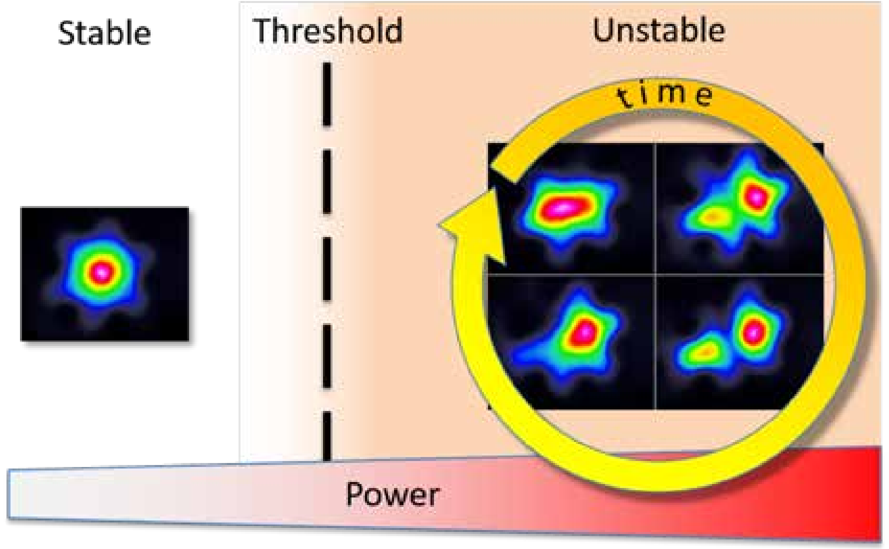

Figure 1:
Schematic representation of the onset of TMI.

Recently we have revealed that photodarkening (PD) in Yb-doped fiber laser systems results in a significant reduction of the TMI threshold /3/. Consequently, a long-term mitigation strategy for TMI is to look for better optical materials devoid of PD.

In a recent development a new mitigation of TMI has been demonstrated, which allows stabilizing the beam above the TMI threshold by modulating the pump power with frequencies around 1kHz. This modulation washes out the thermally-induced index grating and weakens the energy transfer (Figure 2). With this technique an increase of the TMI threshold by a factor of 3 has already been achieved. Such mitigation strategies make the future of fiber laser technology look bright again.

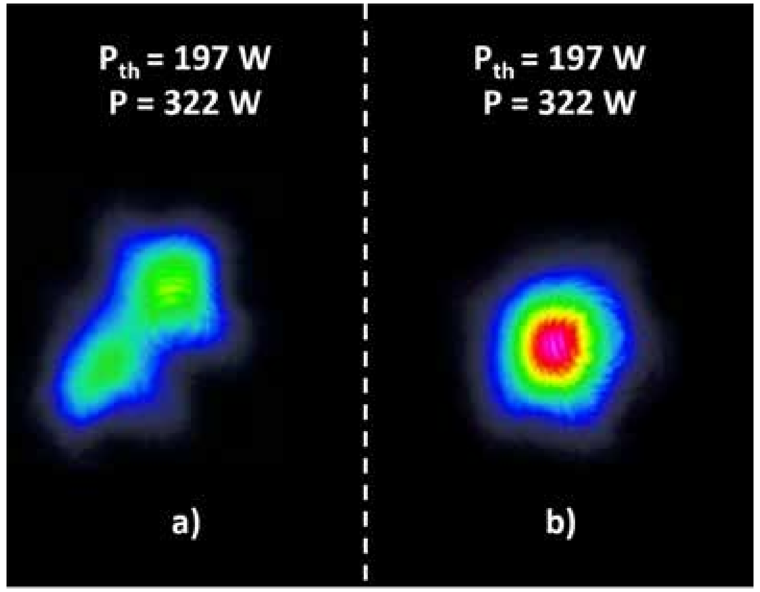

Figure 2:
TMI without pump modulation (a) and stabilized with pump modulation (b).

/1/ C. Jauregui, J. Limpert, A. Tünnermann, High-power fibre lasers," Nat. Photonics 7, 861–867 (2013).

/2/ T. Eidam et al., Experimental observations of the threshold-like onset of mode instabilities in high power fiber amplifiers, Opt. Express 19, 13218–13224 (2011).

/3/ H.-J. Otto, N. Modsching, C. Jauregui, J. Limpert, A. Tünnermann, Impact of photodarkening on the mode instability threshold, Opt. Express 23, 15265 (2015).

Authors:
Getnet K. Tadesse, I. Wahyutama, R. Klas, S. Demmler, M. Tschernajew, J. Limpert and J. Rothhardt

Soft X-ray Spectroscopy and Microscopy Group

The research group, led by Dr. Rothhardt, investigates matter on smallest spatial and temporal scales by using modern laser-based XUV and soft x-ray sources. There are strong cooperations between the Helmholtz-Institute Jena and our Institute, depended on the common research interests, like:

- laser-based short wavelength sources
- nanometer scale imaging techniques
- ultrafast spectroscopy
- XUV spectroscopy of highly-charged ions

Research methods

The group utilizes a variety of modern imaging and spectroscopy techniques including:

- coherent diffraction imaging and holographic techniques
- XUV Laser spectroscopy
- pump-probe spectroscopy

The group utilizes modern experimental equipment including:

- high average power femtosecond lasers
- high photon flux table-top XUV and soft x-ray sources
- XUV and soft x-ray spectrometers and detectors

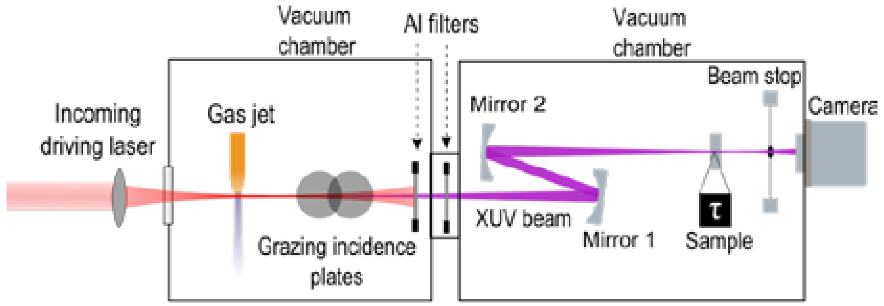

Figure 1:
Experimental setup of the table-top XUV Nanoscope. XUV light is generated by focusing femtosecond pulses from an infrared fiber laser into an argon gas jet. It is then refocused onto the sample and a CCD-Camera records the diffraction pattern behind the sample.

Table-top Nanoscale imaging with XUV light

Coherent diffractive imaging is nowadays a well-established technique at synchrotron light sources and allows nano-scale imaging with only a few-nanometers resolution. Since only the diffraction pattern is detected and the object exit wave is reconstructed by iterative computer algorithms, no imaging optics are required. Hence, the resolution is solely determined by the wavelength and the maximum scattering angle which can be detected with sufficient signal-to-noise ratio.

We developed a table-top implementation of this technique by utilizing high harmonics generated by focusing an infrared femtosecond fiber laser into an argon gas jet (Figure 1). The generated XUV radiation (18 nm wavelength) is separated from the fundamental infrared light and refocused onto the sample by using two concave multilayer mirrors. A typical diffraction pattern of a test structure, recorded by an XUV-CCD, is shown in Figure 2(a).

Due to the record high photon flux of our table-top XUV source /1/, as well as the excellent beam quality and spatial coherence, the diffraction pattern (Figure 2(a)) has been detected with a numerical aperture as high as 0.7. Figure 2(b) and (c) display the reconstructed amplitude and phase of the light wave exiting the employed sample. The achieved spatial resolution is better than 15 nm (Abbe-limit: 12 nm) and represents a new record for table-top XUV and X-ray microscopes. Moreover, a single 3 s acquisition is sufficient to achieve ~25 nm resolution, which will allow scanning on extended samples and 3D tomography on the nanoscale in the near future. Further advances in femtosecond fiber laser technology and high harmonic generation will ultimately enable few-nanometer resolution imaging of 3D nanostructures e.g. modern nano-optical and nano-electronic devices.

/1/ J. Rothhardt,et al., High-repetition-rate and high-photon-flux 70 eV high-harmonic source for coincidence ion imaging of gas-phase molecules, Opt. Express 24, 18133–18147 (2016).

/2/ G. Tadesse, et al., High Speed and High Resolution Table-Top Nanoscale Imaging, Opt. Lett. 41, 5170-5173 (2016).

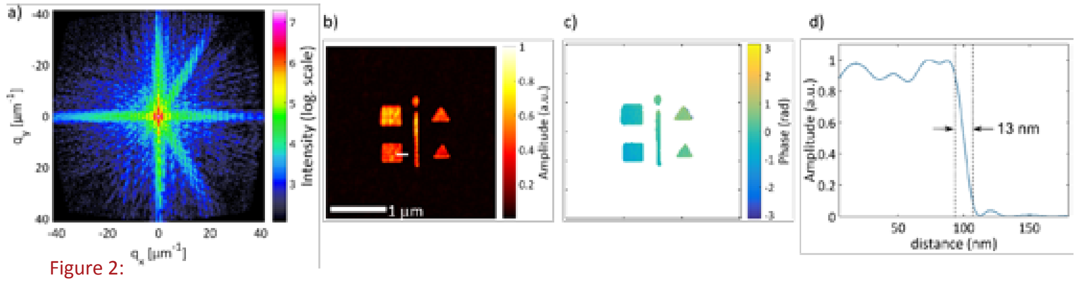

Figure 2:
(a) Measured diffraction pattern, (b) Reconstructed amplitude, (c) reconstructed phase. The achieved resolution is ~13 nm, (d) cross-section at an edge of the sample.

Microstructure Technology & Microoptics

Dr. Ernst-Bernhard Kley
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In the new facility of the Abbe Center of Photonics (ACP), Michael Steinert presents metallic nanorings, filled with lithium niobate.

This research group concentrates fundamentally on function and design of micro- and nano-optical elements as well as applications and technology developments for micro structuring.

The following research priorities have been treated:

- Plasmonic resonant nanometric structures
- Resonant reflective monolithic gratings
- Transmissive, reflective and diffractive elements based on effective media
- Metallic and dielectric polarizers from IR to DUV range
- 3D nano-structuring of crystals with ion beam
- Optical and opto-electronic applications of antireflective fused silica and silicon surfaces
- Microoptical light-trapping in optoelectronic devices
- Material-scientific aspects

Authors:
Kay Dietrich and Ernst-Bernhard Kley

Voluminous Metamaterial

Optical materials are essential to the performance of optical elements and systems. Very high expectations exist in so-called metamaterials, an artificial collection of structures with dimensions in the range of a few nm up to some 100 nm. The geometry and the substance of nanostructures determine the optical properties of metamaterials. A realization is accomplished by chemical (bottom-up) or lithographic processes (top-down), where the latter provide the greatest freedom within design. Metamaterials offer spectacular features such as negative refraction, sub-wavelength resolution or cloaking /1/.

The production of voluminous metamaterial requires an extremely high number of nanostructures. Simultaneously a defined or stochastic distribution in a 3-dimensional matrix is requested. Within the frame of a DFG project, lithographic technologies are developed at the IAP to allow for a production of a huge amount of nanostructures and transfer- and embeddable into a voluminous material.

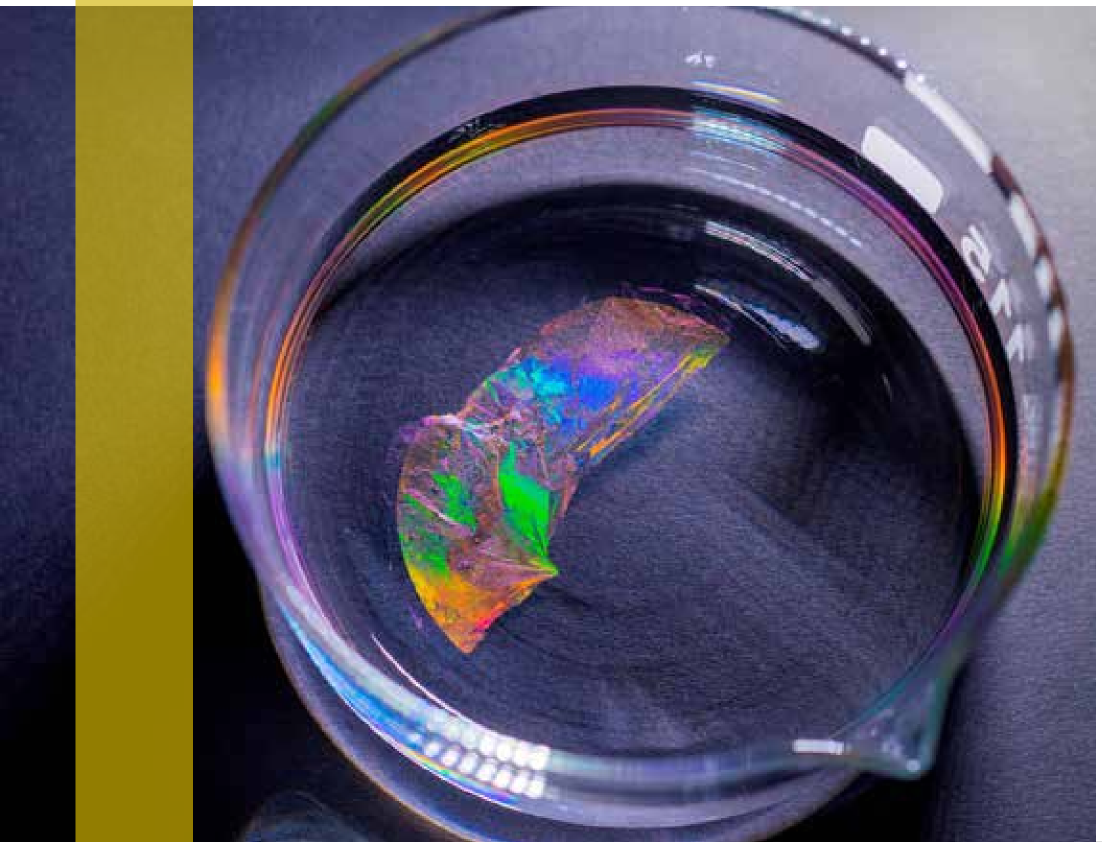

Figure 1:
Floating membrane in acetone-containing solution. The iridescence stems from the embedded nanostructures.

At present we develop this process for discus-shaped nanostructures, consisting of an Au-SiO_2-Au stack. This design is ideal to realize a negative index of refraction /2/. After lithographic definition the nanostructures are clenched by a membrane and peeled-off the substrate (Figure 1). The optical functionality remains intact even after releasing the membrane (Figure 2). Still supported by the membrane, the nanostructures will be clustered and embedded into a transparent medium. During transfer the nanostructure orientation becomes random resulting in three-dimensional isotropic metamaterial.

The pronounced flexibility and elasticity of the membrane, might enable usage as “Wearable Technology". Clothing with optical signaling devices or integrated monitoring of health aspects and environmental impacts would be possible. In addition, the ultra-flexible membrane allows for a transfer of optical nanostructures onto any surface. Elements and components are difficult to process with lithography could ideally laminated with the membrane and their optical functionality.

We acknowledge financial support by Deutsche Forschungsgemeinschaft – DFG (project KL1199/6-1).

/1/ N. Fang, H. Lee, C. Sun, X. Zhang, Sub–diffraction-limited optical imaging with a silver superlens, Science 308 (5721) 534-537 (2005).

/2/ V. Shalaev, W. Cai, U. Chettiar, H. Yuan, A. Sarychev, V. Drachev, A. Kildishev, Negative index of refraction in optical metamaterials, Opt. Lett. 30(24) 3356-3358 (2005).

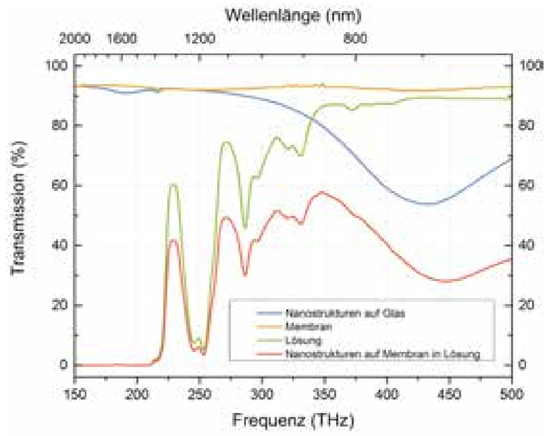

Figure 2:
Optical transmittance spectra of: nanostructures on glass (blue), membrane (yellow), acetone-containing solution (green) and nanostructures on membrane in solution (red).

Authors:
Tina Weichelt and Uwe D. Zeitner

ZIK ultra optics: Manufacturing Technologies for Advanced Micro-and Nano-Optics

Mask aligner lithography with laser illumination

Mask aligner lithography is an established manufacturing process for micro-optical devices. However, the underlying principle of shadow printing limits the achievable resolution, i.e. the smallest feasible pattern size. In order to overcome this limitation, mask aligner lithography has been further developed in the last years. The illumination system was optimized with regard to homogeneity /1/ or special diffractive photomasks were designed /2-4/. This allows the fabrication of various sophisticated micro- and nanostructures, e.g. pulse compression gratings or wire-grid polarizers.

By exchanging the conventional illumination source, the mercury arc lamp, with a solid-state laser, the mask aligner system additionally gains flexibility in the choice of the illumination angles. This is achieved by the use of a galvano scanner. At the same time, the power output of the laser ensures that the exposure times are shortened, irrespective of the selected angular spectrum of the mask illumination. In the conventional mask aligner set-up, the latter was defined by placing a metallic aperture into the light path. For small illumination angles, this means a decrease in the irradiation intensity of the mask.

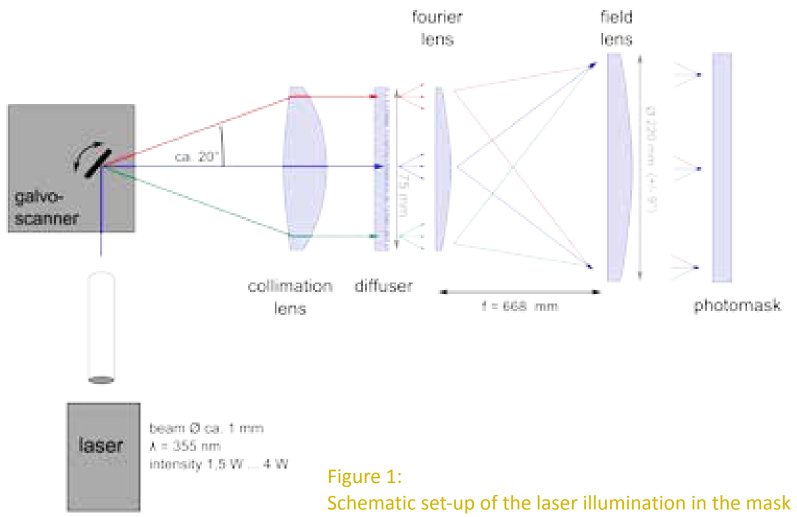

Figure 1:
Schematic set-up of the laser illumination in the mask aligner.

For the integration of the laser as an illumination source, the illumination optic was newly developed. In addition to the galvano scanner, the system features an eccentrically rotating diffuser for speckle reduction and various aspheric lenses. The diffuser consists of a large number of different holograms whose superimposed far-field intensity distribution ensures a homogeneous and speckle-free illumination of the photomask. Hence, exposures of wafers up to 8 inch diameter are possible. The schematic set-up of the laser illumination is shown in Figure 1.

The new laser illumination unit has been successfully tested by the generation of 2D structures and various continuous surface profiles. The structures in Figure 2 are examples of micro-optical elements realized with the new system.

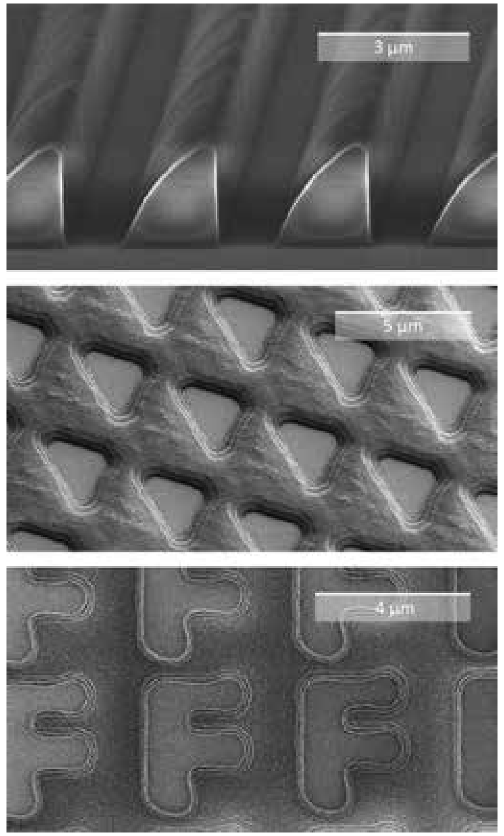

Figure 2:
Examplary photoresist pattern.

/1/ R. Voelkel et al., Advanced mask aligner lithography: new illumination system, Opt. Express 18 (20) (2010).

/2/ T. Weichelt et al., Resolution enhancement for advanced mask aligner lithography using phase-shifting photomasks, Opt. Express 22 (13) (2014).

/3/ T. Weichelt et al., Optimized lithography process for through-silicon vias-fabrication using a double-sided (structured) photomask for mask aligner lithography, J. Micro/ Nanolith. MEMS MOEMS 14(3) (2015).

/4/ L. Stuerzebecher et al., Pulse compression grating fabrication by diffractive proximity photolithography, Opt. Lett. 39 (4) (2014).

Authors:
Lilit Ghazaryan, Ernst-Bernhard Kley and Adriana Szeghalmi

Junior Research Group: Atomic Layer Deposition - Emmy Noether Group

Atomic layer deposition (ALD) is a thin film coating technology based on self-limiting surface reactions. The thickness of ALD films is controlled with sub-nanometer precision by the number of ALD cycles. The films manifest high uniformity and low roughness. The decisive advantage of ALD over other established coating techniques is its ability of conformal coating on curved and high aspect ratio substrates. A wide range of materials, including oxides, nitrides, fluorides, sulfides, metals and hybrid organic-inorganic composites, can be deposited via the ALD and molecular layer deposition (MLD) techniques. Additionally, composite materials with tailored composition and material properties are possible. The above-mentioned materials find numerous applications in the fields of photovoltaics, electronics, catalysis, biotechnology, display technology, and photonics.

We aim to establish this technology for the development of novel and improved optical elements. We currently focus on developing atomic layer deposited coatings for:

- low and high refractive index materials
- porous materials
- advanced nanostructuring technologies
- interference coatings
- functional coatings for diffractive optical elements
- space & laser technology, spectrometry, UV-VIS, DUV, EUV, BEUV, x-ray optics
- understanding chemical reactions during nucleation and film growth.

Research methods

The ALD facility led by Dr. Szeghalmi has two plasma-enhanced atomic layer deposition reactors at hand. Both are located in a clean room environment and are equipped with in situ monitoring techniques for experimental characterization by means of spectroscopic ellipsometry in the 245…1700 nm spectral range. The equipment comprises:

- OpAL PEALD, Oxford Plasma Technologies
- Sunale R200, Picosun Oy
- J. A. Woollam spectroscopic ellipsometer.

Funding

DFG Emmy Noether Program, Friedrich Schiller University ProChance Program, Carl Zeiss Stiftung, TMBWK, European Space Agency, Fraunhofer Gesellschaft Attract Program

Conformal nanoporous SiO_2 films with adjustable refractive index

Nanoporous SiO_2 thin films attracted intensive research interest for optical applications since they have a refractive index lower than glass. Such artificial low refractive index materials are essential for antireflection coatings. In case of a single layer antireflection coating (SLAR), the refractive index of the coating is equal to the square root of the refractive index of the substrate material ($n_c = \sqrt{n_s}$). For fused silica and glass substrates, the thin film should have an n_c in the range of 1.20 to 1.30. Even lower refractive index coatings are required for more complex broadband antireflection coatings. Hence, various methods have been developed to deposit nanoporous SiO_2 thin films such as sol-gel, glancing angle deposition, deposition of mesoporous silica nanoparticles, etc.

The precise control of the refractive index and film thickness, and the conformal coating of highly curved 3D shaped substrates such as lenses, cones and cylinders, etc. remain challenging. In contrast to other coating technologies, atomic layer deposition (ALD) enables conformal coatings with precise composition and thickness control independent of the geometrical shape of the substrate. We have developed a new synthetic route for nanoporous SiO_2 thin films by atomically mixing SiO_2 and Al_2O_3 followed by selective removal of the alumina constituent. In comparison to other deposition methods the best results were obtained using ALD which allows to precisely and reproducibly controlling the Al_2O_3:SiO_2 ratio in the composites. In general, two ALD-cycles of SiO_2 corresponding to approximately 2 Å and two to four ALD-cycles of Al_2O_3 corresponding to 2 to 4 Å build the basic sequence of the composite materials. The final thickness is achieved by repeating the Al_2O_3:SiO_2 sequence until the desired thickness is reached /1/. With increasing the ratio of Al_2O_3 in the basic sequence, the final SiO_2 film porosity has been tailored from 10 % to 63 %, which in turn has resulted in a decrease of the refractive index from 1.40 to 1.15 at 632.8 nm wavelength (Figures 1 and 2).

The nanoporous SiO_2 films were applied as antireflection coatings on various glass substrates. A single layer antireflection (SLAR) coating for the UV spectral range around 256 nm wavelength was demonstrated using an Al_2O_3:SiO_2 composite with the ALD-cycle ratio 3:2. The control of the film thickness led to the minimum reflectance R at the required wavelength (an example for UV range is shown in Figure 3). The 4:2 composite on the other hand is a highly suitable top layer for a broadband antireflection coating.

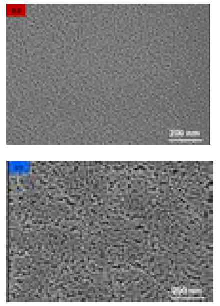

Figure 1:
Top-view SEM images of nanoporous SiO_2 made by ALD.

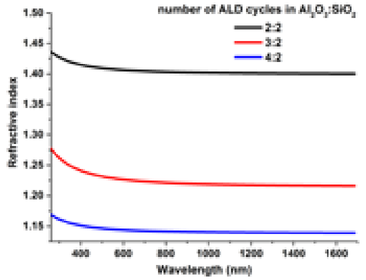

Figure 2:
Dispersion of the nanoporous SiO_2 thin films derived from composites with the unit cell of 2:2, 3:2 and 4:2 of Al_2O_3: SiO_2 cycles, after etching in H_3PO_4 at 50°C.

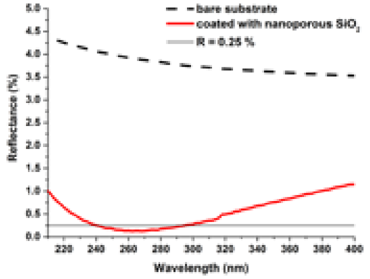

Figure 3:
SLAR coating on fused silica with $R_{min} < 0.2$ % from 245 nm to 290 nm wavelength.

/1/ L. Ghazaryan, E. B. Kley, A. Tünnermann, A. Szeghalmi, Nanotechnology 27, 255603, (2016).

Ultrafast Optics

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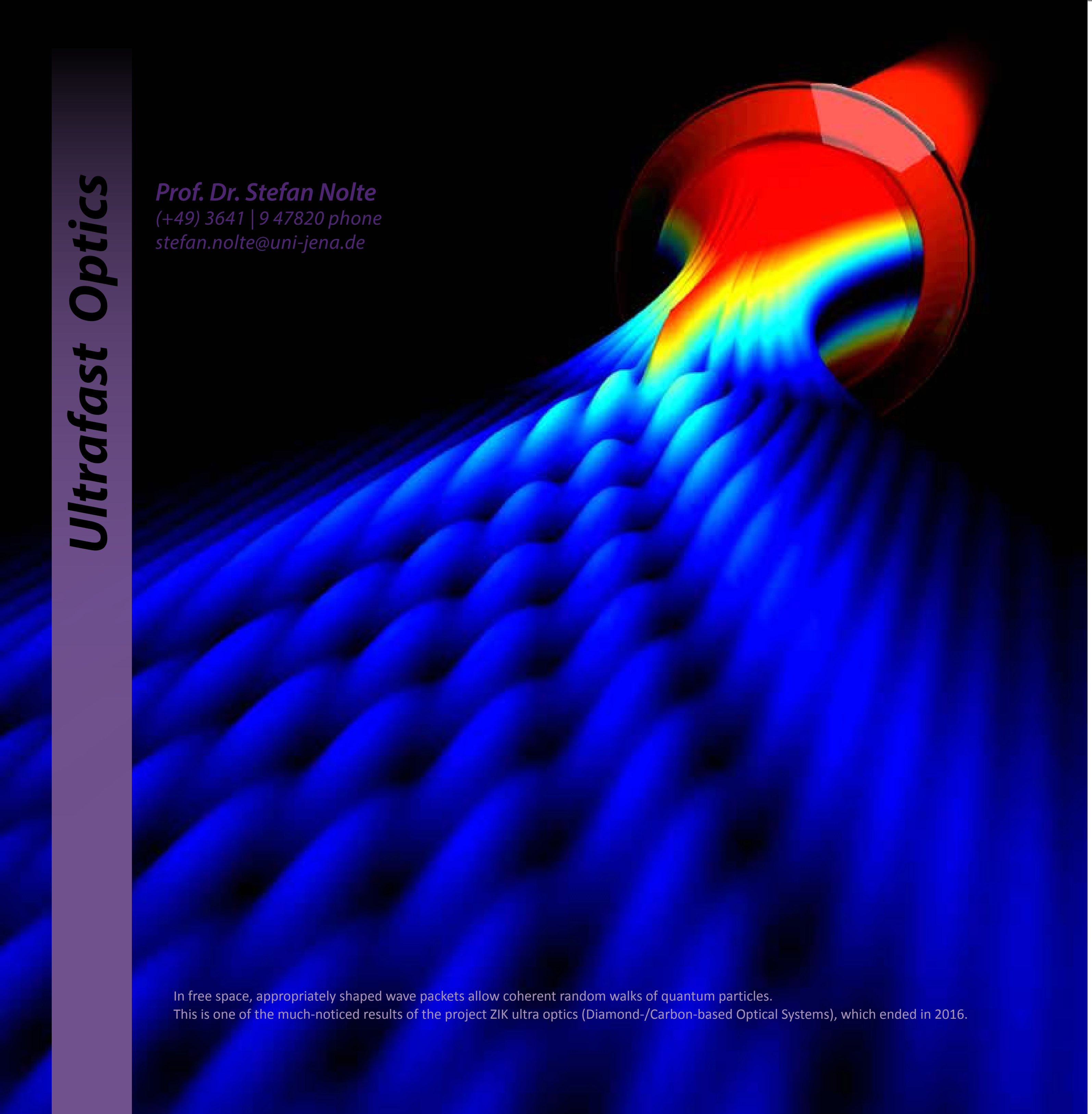


In free space, appropriately shaped wave packets allow coherent random walks of quantum particles.
This is one of the much-noticed results of the project ZIK ultra optics (Diamond-/Carbon-based Optical Systems), which ended in 2016.

The group Ultrafast Optics works on applications of femtosecond laser pulses, such as materials processing and micro/nano structuring of optical materials.

The scientific topics are:

- Linear and nonlinear interaction processes between light and matter
- Micro- and nanostructuring with ultrashort laser pulses
- Additive manufacturing using ultrashort laser pulses
- Sub-wavelengths structuring
- Fiber Bragg Gratings (FBG), Volume Bragg Gratings (VBG)
- Linear and nonlinear optics in discrete systems
- Medical laser applications
- THz technology
- Spectroscopic methods for gas analysis

In 2016, some outstanding results were:

• demonstration of additive manufacturing of Cu and non-eutectic alloys using fs laser radiation • minimizing thermal effects in fs-written VBGs in fused silica • inscription of FBGs in active and passive fibers with tailored optical properties • cutting of hardened and unhardened glass • ultrastable welding of glass • structural analysis of laser induced nanogratings in different glasses • temporal resolved microscopy of transient effects in glass after fs-pulse irradiation • fabrication of CGHs using ultrashort laser pulses • gas spectroscopy by fs CARS • quantum optics in fs written lattices

Authors:
Roland Ackermann, Stefan Nolte and Andreas Tünnermann

Femtosecond-CARS for gas analysis

The efficient use of fossil fuels is a major challenge for our society, as the development of new oil, gas or coal fields will more and more require cost-intensive techniques, such as the highly controversial 'fracking'. Nevertheless, the use of fossil fuels will be indispensable in the foreseeable future. Thus, there is an increasing demand for improving the efficiency of conversion processes of fossil fuels. An essential prerequisite for this task is to acquire a better understanding of the involved processes. However, experimental access to these processes is limited, as the technical gasification of coal, for example, takes place under extreme ambient conditions (≤1400 °C, ≤40 bar). Therefore, the preferential research method is currently the thermogravimetric analysis (TGA), for which the decrease in weight is the only accessible parameter. In the scope of the joint-project HITECOM ('High Temperature Conversion Optical Measurement'), which is founded by the BMBF (grant-IDs: 03Z1H532, 03Z1H533), new spectroscopic techniques are being developed for the use under these extreme ambient conditions.

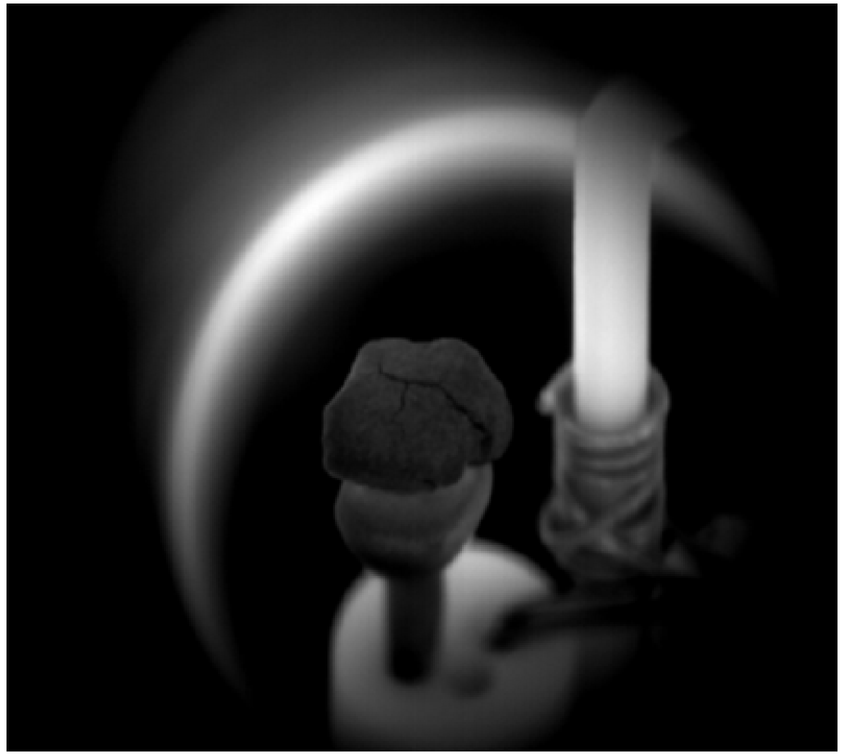


Figure 1:
Coal particle with holder in high pressure/high temperature oven during gasification.

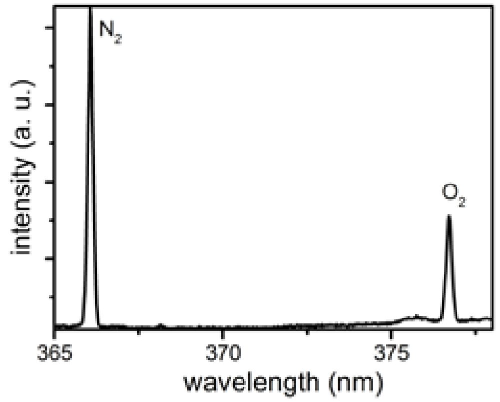


Figure 2:
Fs-CARS spectrum of air using a ~ 7fs pulse as excitation.

In collaboration with the TU Bergakademie Freiberg, a high pressure/high temperature oven was implemented, providing optical access by means of four sapphire windows (Figure 1) /1/.

A promising spectroscopic approach for the process analysis is the coherent anti-Stokes Raman scattering using femtosecond laser pulses ('fs-CARS'). The short pulse durations enable the excitation of molecular states of a gas, before detrimental molecular collisions take place. This feature makes fs-CARS ideally suited for thermometry and gas concentration measurements under high temperature and high pressure conditions /2/. Usually, the required energy difference for the Raman transition is provided by a femtosecond laser and an optical parametric amplifier. Using a fiber-based optical parametric amplifier (OPCPA), we have successfully shown that a ~7 fs pulse may excite the Raman transitions of all gas species which are relevant for coal gasification /3/. Figure 2 shows exemplarily a fs-CARS spectrum of air with the Raman signals of nitrogen and oxygen, respectively. In a next step, a technique is being developed which allows the simultaneous determination of the gas temperature and concentration by means of a single fs-CARS spectrum.

/1/ F. Küster, P. Nikrityuk, M. Junghanns, S. Nolte, A. Tünnermann, R. Ackermann, S. Guhl, A. Richter, L. Kampioni, B. Meyer, In situ investigation of single particle gasification in a defined gas flow applying TGA with optical measurements, Fuel 194, 544-556 (2017).

/2/ R. P. Lucht, S. Roy, T. R. Meyer, J. R. Gord, Femtosecond coherent anti-Stokes Raman scattering measurement of gas temperatures from frequency-spread dephasing, Appl. Phys. Lett. 89, 251112 (2006).

/3/ G. Matthäus S. Demmler, M. LeBugle, F. Küster, J. Limpert, A. Tünnermann, S. Nolte, R. Ackermann, Ultrabroadband two beam CARS using femtosecond laser pulses, Vib. Spectrosc. 85, 128-133 (2016).

Author:
Alexander Szameit

ZIK ultra optics: Diamond-/Carbon-based Optical Systems

In 2016, the project ZIK ultra optics was completed. During the funding period (01.07.2011 – 30.06.2016) many outstanding results were achieved. Two of them from 2016 will be presented here.

Topologically protected bound states in photonic parity-time-symmetric crystals

Parity-time (PT)-symmetric crystals are a class of non-Hermitian systems that allow, for example, the existence of modes with real propagation constants, for self-orthogonality of propagating modes, and for uni-directional invisibility at defects. Photonic PT-symmetric systems that also support topological states could be useful for shaping and routing light waves. However, it is currently debated whether topological interface states can exist at all in PT-symmetric systems.

In 2016, together with colleagues from the Technion in Haifa/Israel, the Crete Center for Quantum Complexity and Nanotechnology, the Vienna University of Technology and the Pennsylvania State University we could show theoretically and demonstrate experimentally the existence of such states: states that are localized at the interface between two topologically distinct PT-symmetric photonic lattices. We found analytical closed form solutions of topological PT-symmetric interface states, and observed them through fluorescence microscopy in a passive PT-symmetric dimerized photonic lattice. Our results are relevant towards approaches to localize light on the interface between non-Hermitian crystals /4/.

Demonstration of local teleportation using classical entanglement

This year, the research team has demonstrated experimentally for the first time that the concept of teleportation not only last in the world of tiny quantum particles, but also in our classical world /A/. For this purpose, a particular form of laser beams has been used, where the properties of light beams are entangled to each other. "Entanglement" refers to a type of coding, in which the information to be transmitted is linked with a particular property of the light.

In this specific case, the information has been encoded in a particular direction of polarization of the laser light and transmitted via teleportation on the shape of the laser beam. In this form of teleportation, not any distance can be skipped - the classical teleportation only works locally. But just as in quantum teleportation, the information is transmitted completely and immediately, without any loss of time. This fact makes such a transfer of information highly interesting for potential applications such as telecommunication.

The nomination of Markus Gräfe and Matthias Heinrich as participants for the 66th Meeting of Nobel Laureates in Lindau was outstanding in 2016, too.

/A/ D. Guzman-Silva et al., Demonstration of local teleportation using classical entanglement, Laser Photon. Rev. (2016).

Publication of results

The results were published in a total of 115 publications in refereed international scientific journals, 22 in journals of the Nature Publishing Group and 28 in the Physical Review Letters. The members of the working group were invited to take part in 97 international scientific meetings to present the results of the project. In addition, the scientific results were presented by 168 contributions at international conferences. The work group leader reported at 39 invited colloquia in universities around the world. Two patents were granted.

Most important publications

/1/ M. C. Rechtsman et. al., Photonic Floquet Topological Insulators, Nature 496(7444), 196-200 (2013).

/2/ M. Gräfe et al., On-Chip Generation of High-Order Single-Photon W-States, Nat. Photonics 8(10), 791-795 (2014).

/3/ M. C. Rechtsman et al., Strain-induced pseudo-magnetic field and Landau levels in photonic structures, Nat. Photonics 7(2), 153-158 (2013).

/4/ S. Weimann, et al., Topologically protected bound states in photonic PT-symmetric crystals, Nat. Mat.(2016).

/5/ L. J. Maczewsky et al., Observation of photonic anomalous Floquet Topological Insulators, Nat. Commun. 8, 13756 (2017) .

/6/ S. Weimann et al., Implementation of Quantum and Classical Discrete Fractional Fourier Transforms, Nat. Commun. 7, 11027 (2016).

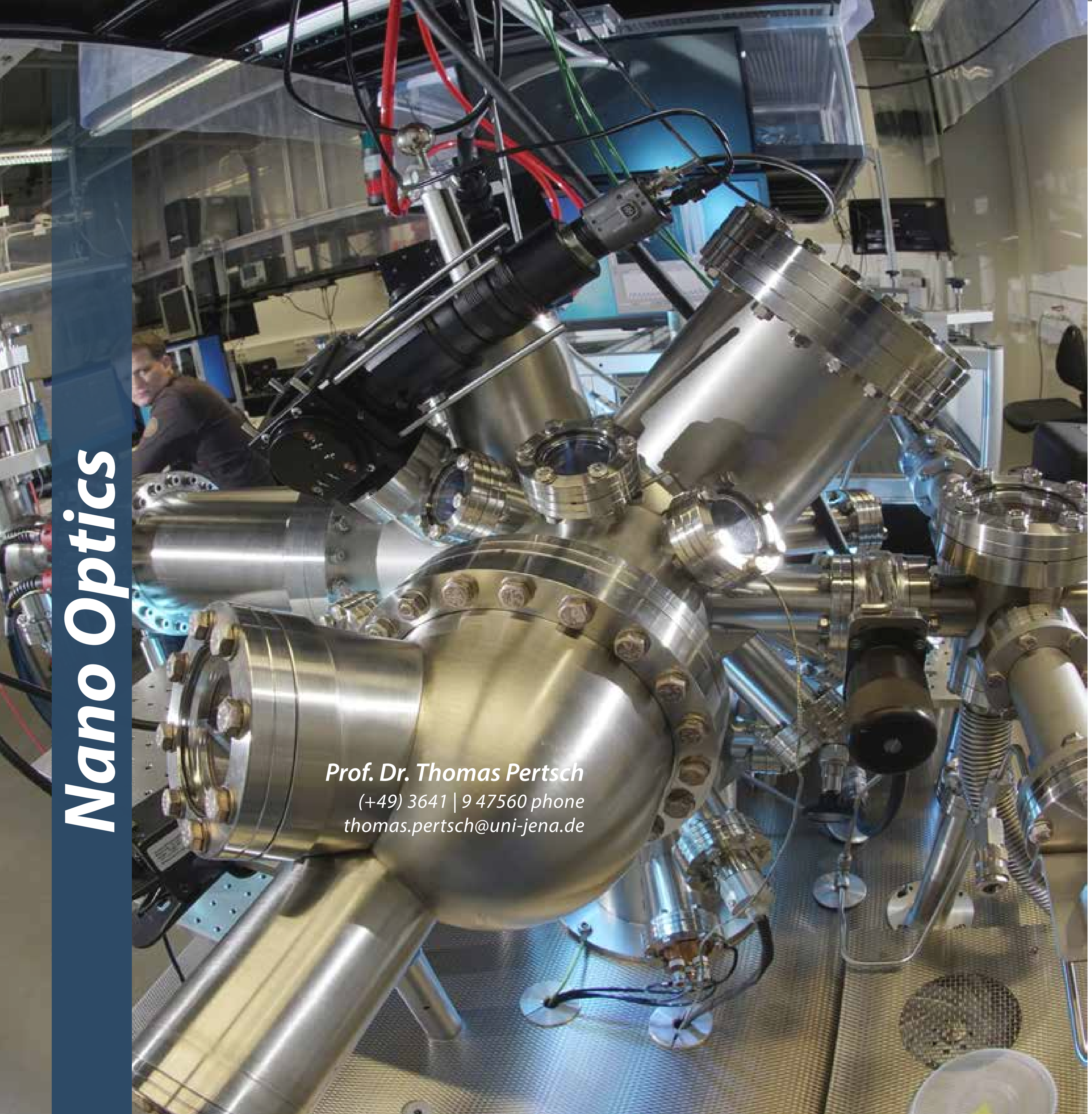
/7/ M. Lebugle et al., Experimental Observation of N00N state Bloch oscillations, Nat. Commun. 6, 8273 (2015).

/8/ M. Tillmann et al., Experimental Boson Sampling, Nat. Photonics 7(7), 540-544 (2013).

/9/ R. Keil et al., The random mass Dirac model and long-range correlations on an integrated optical platform, Nat. Commun. 4, 1368 (2013).

/10/ T. Eichelkraut et al., Mobility transition from ballistic to diffusive transport in non-Hermitian lattices, Nat. Commun. 4, 2533 (2013).

Nano Optics



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The research group Nano Optics deals with light propagation and nonlinear ultrafast light-matter interaction microstructured and nanostructured matter, as e.g. photonic nanomaterials, including metamaterials, photonic crystals, as well as effective media and high-Q nonlinear optical microresonators.

The scientific emphasis lies on:

- Plasmonics, near field optics
- Nonlinear spatio-temporal dynamics, quantum phenomena and integrated quantum optics, opto-optical processes in integrated optics, all-optical signal processing
- Multi-tip scanning optical nearfield microscopy (SNOM), photoemission electron microscopy (PEEM)
- Application of photonic nanomaterials for multi-functional diffractive optical elements
- Application of optical nanostructures for efficiency enhancement of photovoltaic elements
- Application of advanced photonic concepts for astronomical instruments

Matthias Falkner operates the vacuum chamber in one of the newly arised photonics laboratories at the Abbe Center of Photonics.

Authors:
Reinhard Geiss, Sina Saravi, Séverine Diziain, Frank Schrempel and Thomas Pertsch

Integrated nonlinear optics with lithium niobate thin films

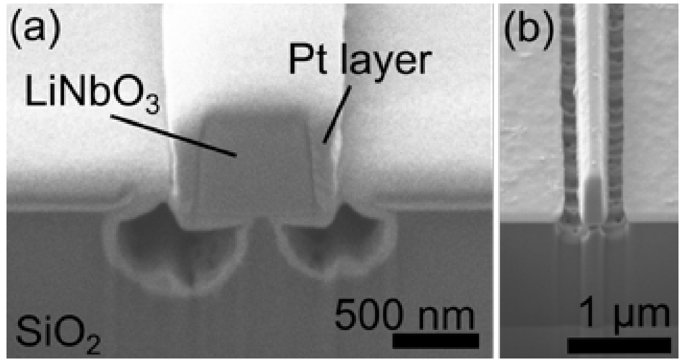


Figure 1:
Scanning electron microscope images of LNOI ridge waveguides. The waveguides have a height of 530 nm and widths of (a) 570 nm and (b) 220 nm. The platinum layer is merely used for edge protection during the preparation of the cross section.

Microstructured lithium niobate (LN) becomes increasingly important for applications in nonlinear integrated optics. Miniaturized optical devices enable the interaction of light in very small volumes which increases the efficiency of nonlinear optical effects. The required concentration of optical fields can be achieved through different micropatterned waveguides and resonators. As a substrate material for the experimental realization LNOI (lithium niobate on insulator) is a novel and promising technological basis. LNOI mainly consists of a crystalline LN thin film (530 nm) and a layer of SiO_2 (2 µm) underneath. The LN thin film acts as a planar waveguide that can be patterned by electron beam lithography and subsequent ion beam enhanced etching. In this way, millimeter long ridge waveguides with a width down to few hundred nanometers were realized /1/.

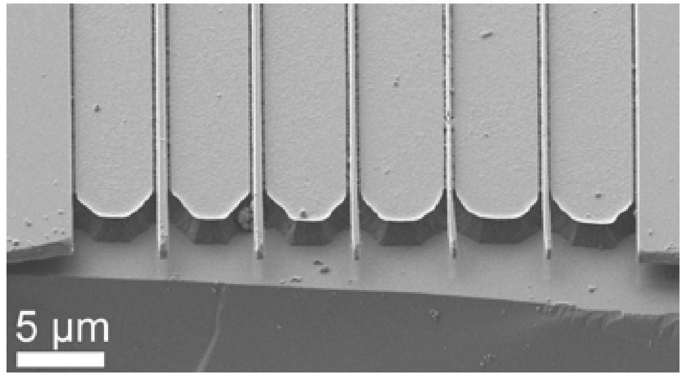


Figure 2:
Scanning electron microscope image of a group of waveguides located at the sample front facet.

In order to achieve modally phase matched second harmonic generation (SHG) at a pump wavelength of 1400 nm a waveguide width of 1.2 µm was calculated. The optical characterization of this waveguide finally showed strong SHG with an efficiency of 6.9%$W^{-1}cm^{-2}$. Furthermore, LNOI can be directly patterned with a focused ion beam (FIB).
Using this technique microdisk resonators with high quality factors and photonic crystal resonators for resonant SHG were realized /2/.

/1/ R. Geiss, S. Saravi, A. Sergeyev, S. Diziain, F. Setzpfandt, F. Schrempel, R. Grange, E.-B. Kley, A. Tünnermann, T. Pertsch, Fabrication of nanoscale lithium niobate waveguides for second-harmonic generation, Opt. Lett., 40 (12), 2715–2718 (2015).

/2/ S. Diziain, R. Geiss, M. Steinert, C. Schmidt, W.-K. Chang, S. Fasold, D. Füßel, Y.-H. Chen, T. Pertsch, Self-suspended micro-resonators patterned in Z-cut lithium niobate membranes, Opt. Mater. Express, 5 (9), 2081 (2015).

Author:
Isabelle Staude

Junior Research Group: Functional Photonic Nanostructures
Emmy Noether Group

The research focuses lies on the use of designed photonic nanostructures which are to control the emission, absorption, and propagation of light at the nanoscale level. The research topics include:

- nanophotonics, -plasmonics, and –antennas
- high-index dielectric nanoparticles
- hybrid quantum systems and quantum emitters
- nanofabrication technology
- subwavelength optics
- metamaterials and photonic crystals

Research methods

For the experimental realization and study of functional photonic nanostructures, the junior research group Functional Photonic Nanostructures employs a range of state-of-the-art nanotechnology and optical characterization techniques, including:

- electron-beam lithography based nanofabrication
- linear and nonlinear optical spectroscopy
- time-resolved photoluminescence spectroscopy
- back focal plane imaging
- assembly of hybrid nanostructures via dry transfer
- assembly of hybrid quantum systems by selective surface functionalization

Recent Research Results

Resonant nanoparticles and their assemblies can show complex and often surprising interactions with light, giving rise to phenomena such as „magnetic light“, directional scattering, Fano resonances, and strong near-field enhancements. Using the capabilities of modern nanotechnology, these interactions can be tailored by the size, shape, material composition, and arrangement of the nanoparticles. Resonant nanoparticle structures are a versatile research platform for investigating fundamental light-matter interactions and nanoscale coupling phenomena /1/. Furthermore, they provide unique optical functionalities, opening new opportunities for applications like next-generation (quantum) light sources, optical communications, and truly flat optical components. In our research, we combine top-down and bottom-up nanofabrication approaches to realize composite photonic systems. These systems are able to control the emission, propagation, and absorption of light - and all of its properties at the nanoscale.

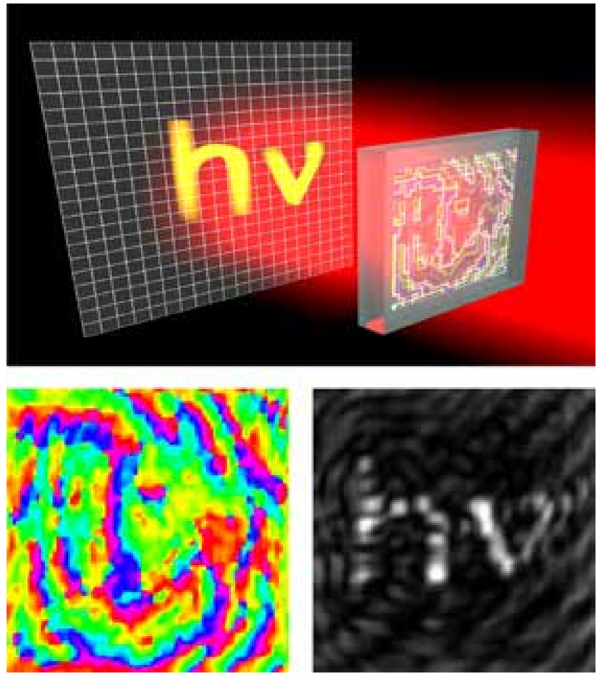


Figure 1:
Schematic of the holographic Huygens’ metasurface (top), measured phase distribution in the sample plane (bottom left) and generated holographic image (bottom right) /2/.

Recently we have focused on dielectric metasurfaces – planar arrangements of highly transparent, high-refractive-index nanoresonators, which can provide local control of the phase of a light wave thereby enabling functionalities like focussing, beam shaping and holographic imaging. While conventional optical components providing these functionalities are often bulky, such metasurfaces allow for wavefront shaping using just a sheet of nanoscale thickness.

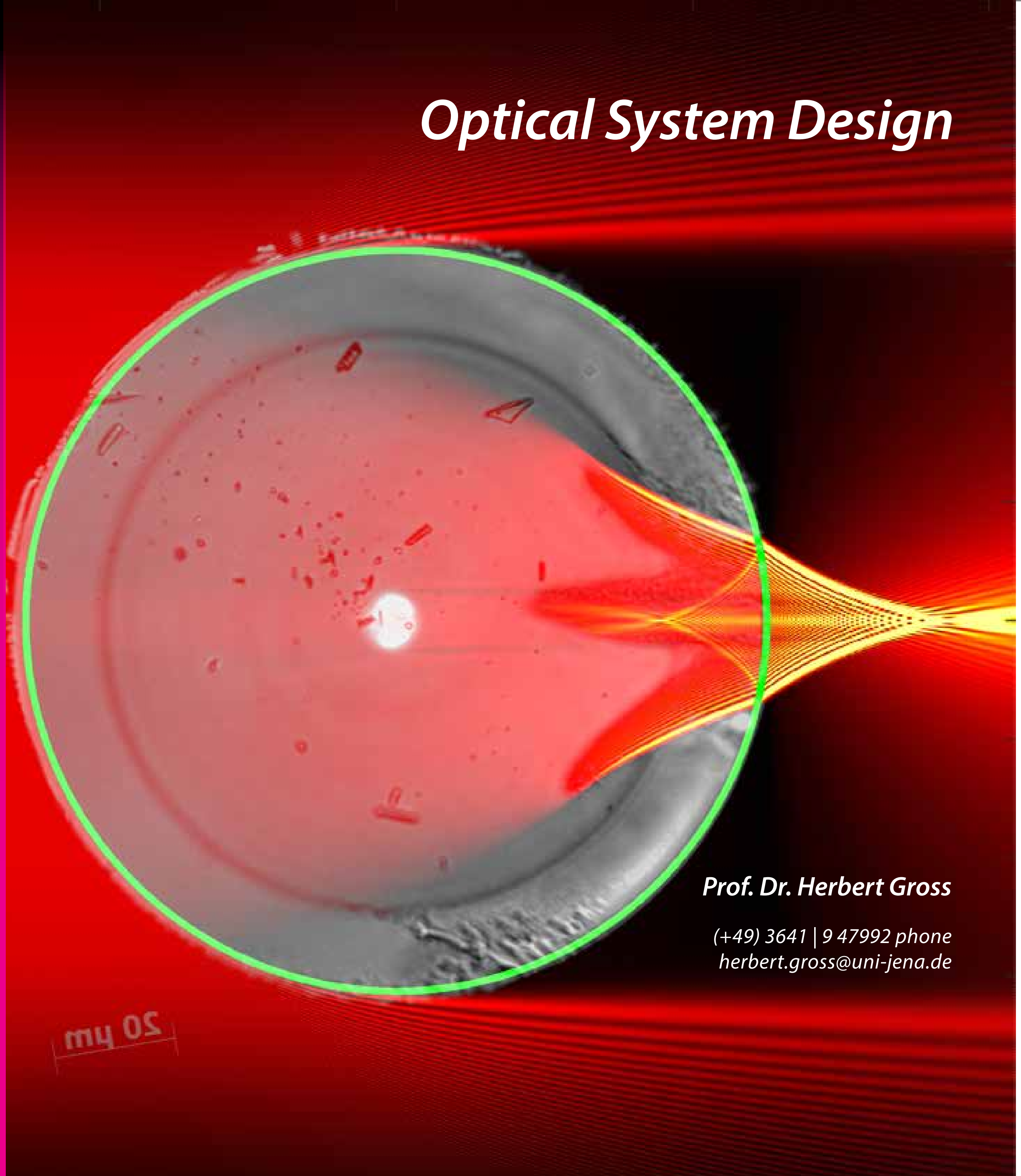
In the last year in collaboration with groups from the Australian National University and Sandia National Laboratories, we have demonstrated complex wavefront control using a new type of metasurface, which can shape the wavefront of a light field with close-to-unity efficiency. We use metasurfaces consisting of disk-shaped silicon nano-resonators carefully designed to exhibit overlapping electric and induced magnetic Mie-type resonances.

Our results for a holographic metasurface /2/ producing an image of the letters hv are summarized in Figure 1. The device has a high transparency at resonance and works for any input polarization.

/1/ M. Decker and I. Staude, J. Opt. 18, 103001 (2016).

/2/ K. E. Chong et al., ACS Photonics 3, 514-519 (2016).

Optical System Design



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The research priorities of this working group can be divided into two main areas. In classical optics design, especially the following topics will be addressed:

- Design of modern optical system
- Aberration theory
- Quality evaluation of optical systems
- Measurement of the performance of optical systems
- Design of laser and delivery systems
- Design and evaluation of freeform optical systems for imaging and illumination
- Optimization methods in optical design
- Tolerancing of optical systems.

In somewhat more general physical issues relating to optical systems, in particular the following topics of interest are:

- Simulation of diffraction effects
- Microscopic image formation
- Calculation algorithms of wave propagation
- Straylight and scattering in optical systems
- Modelling of illuminations systems
- Partial coherent imaging and beam propagation
- Point spread function engineering and Fourier optics.

The endowed professorship Theory of Optical Systems aims to support optical companies in their development and training. Amongst others, this could be reached in the project "Freeform Optics Plus (fo+)", which combines research on the brand new technology field of freeforms in optics but also in education and training.

Simulated field distribution of a side-illuminated optical fiber overlayed with a microscopic image of the optical fiber after an fiber bragg grating inscription process. The simulations were used to explain glass matrix distortions after the inscription process.

Authors:
Sören Schmidt, Tobias Tieß & Siegmund Schröter (Leibniz IPHT) and Herbert Gross

In-line holographic measurements for the metrology of optical fibers

Optical fibers are one of the most important building blocks in modern photonic industries. Increasing demands on their functionality requires the realization of complex, micro-structured optical fibers. The metrological characterization of these fibers during the drawing-process is of fundamental importance to ensure their quality and therewith their optical functionality.

One very versatile tool to characterize optical fibers is in-line holography. The optical fiber under investigation is side-illuminated by a coherent, monochromatic beam with a large diameter. Part of the beam is diffracted by the fiber and creates a characteristic fringe pattern at the position of a distant detector due to interference with the unperturbed part of the incoming beam. Analyzing the detected signal and comparing it against numerical simulations of the entire structure allows us to retrieve structural parameters of the optical fiber.

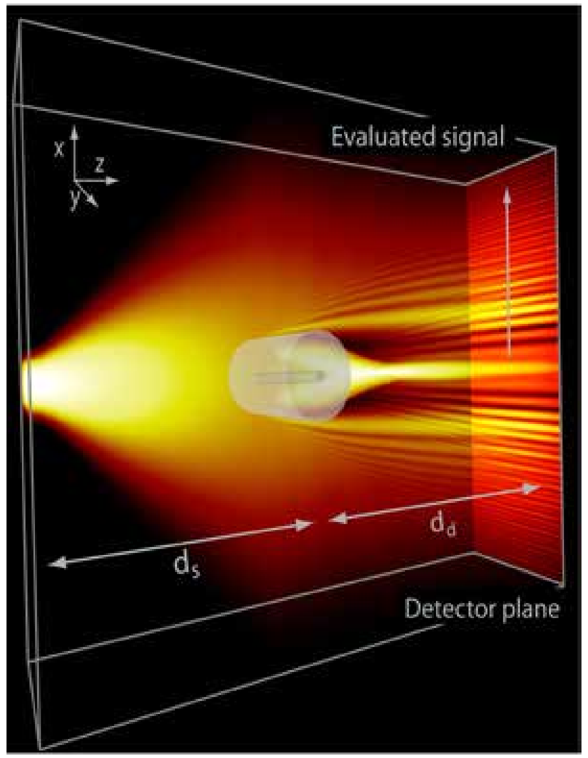


Figure 1:
Illustrative sketch of the measurement configuration.

Exemplary, the proposed method is used to analyze capillary fibers, which are specified by a cladding made out of Fused-Silica and an hollow air-core which is arranged concentrically.

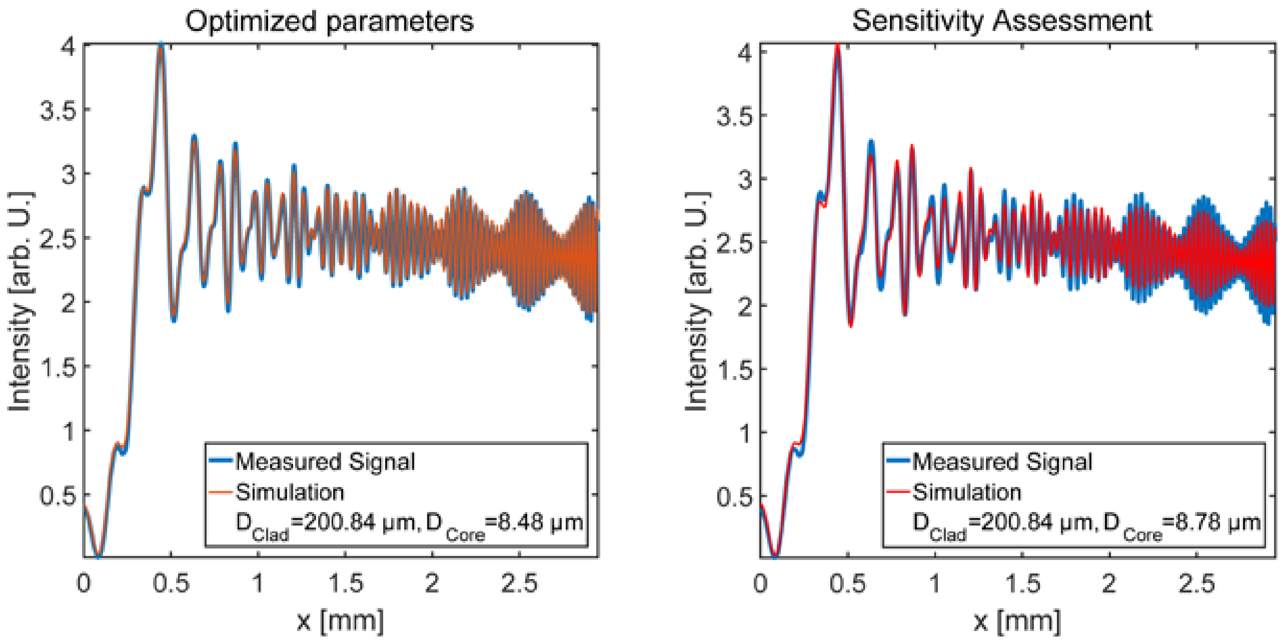


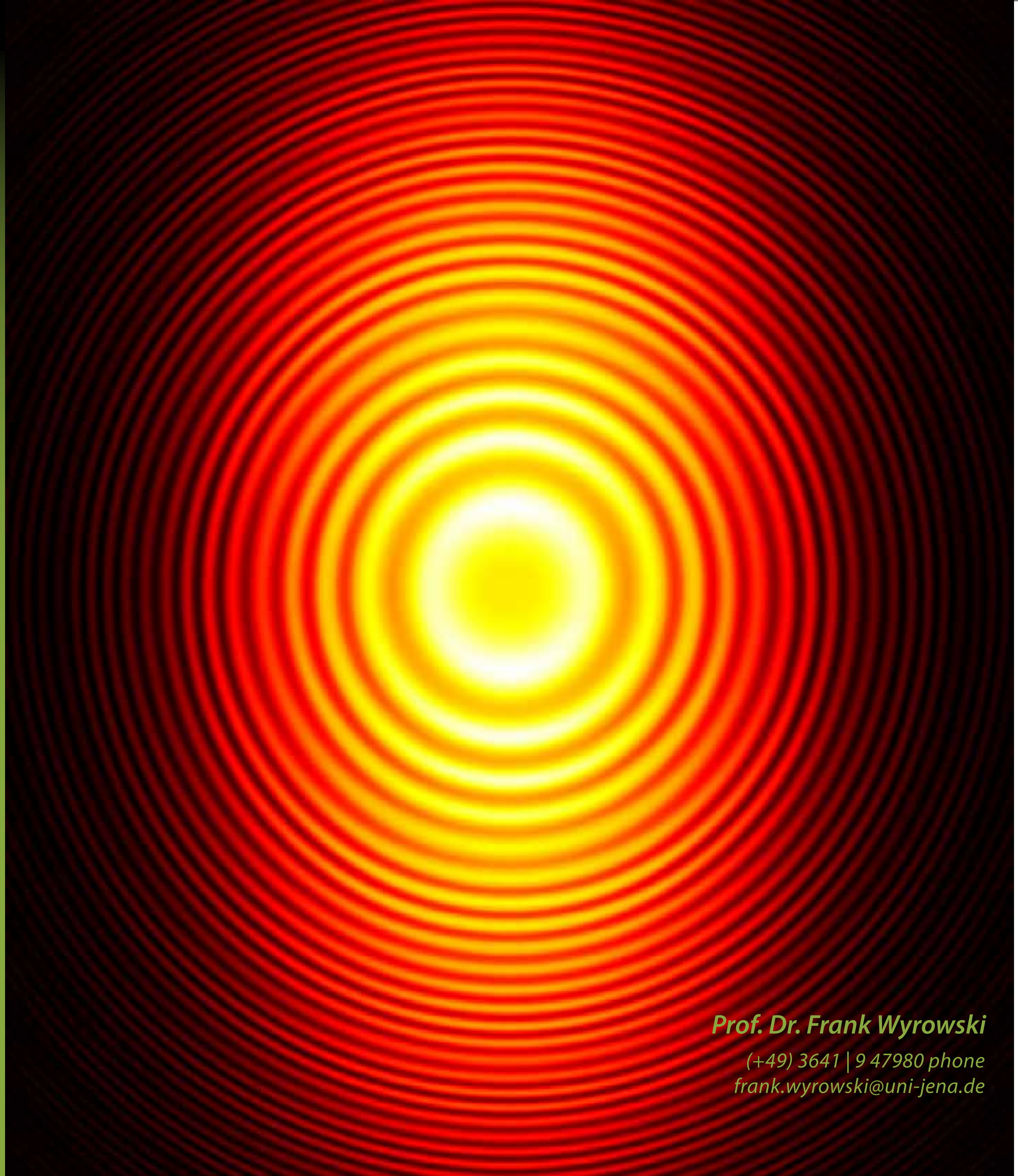
Figure 2:
Comparison of measured and simulated signals. The origin of the diagram corresponds to the optical axis: a) Comparison to the numerically optimized Cladding and Core diameter. b) Comparison of the measured signal to a slight deviation of the ideally matching parameters.

The diameter of this capillary hole can be adjusted during the drawing process by controlling an overpressure in the hollow core. The ability to monitor this core diameter on-line is of special importance. It can enable a feedback mechanism to accurately control the resulting diameter of the hollow air core.

To determine the core diameter, we compare the in-line holographic measurement of the capillary fiber to simulations of the entire structure. By optimizing the outer cladding and inner core diameter D_{Clad}, D_{Core} an optimal match between simulation and measurement is examined. This approach allowed us to retrieve the diameters with an accuracy of $\Delta D_{Clad,\ Core} < 0.3\ \mu m$.

/1/ S. Schmidt et al.: Wave-optical modeling beyond the thin-element-approximation, Opt. Express 24(26), 30188-30200 (2016)

Applied Computational Optics



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The Applied Computational Optics Group steadily works on developing a physical optics concept which includes a geometric theory of electromagnetic fields. As a practical benefit, that enables the development of fast solvers of Maxwell's equations.

In 2016 we investigated the following research and development (R&D) topics, among others:

- Maxwell solver in the k-domain
- Fast Fourier transform algorithms with minimized sampling effort
- Spline interpolation of smooth functions in physical optics modeling
- Parametrization of electromagnetic fields
- Gouy phase shift
- Multiple aperture diffraction
- Geometric bidirectional operators
- Bidirectional scattering distribution function (BSDF)
- Use of ray data from LED measurements in physical optics modeling
- Partial coherence and partial polarization modeling
- Spatio-temporal simulation of ultrashort pulses
- Fast electromagnetic modeling of light propagation through crystals and graded-index media
- Modeling and design of freeform surfaces
- Design of light-shaping elements by mesh concepts
- Non-sequential physical optics modeling for virtual and mixed reality devices

Several topics have been developed in cooperation with LightTrans GmbH and Wyrowski Photonics UG using the optics software VirtualLab Fusion.

Figure 1:
Intensity of an asymmetric Gaussian beam after interacting with an etalon.

Author:
Frank Wyrowski

Fast physical optics modeling and design

We have taken it upon ourselves to bridge the vast rift which, for historical reasons, exists in optics between its geometrical and physical branches. Commonly understood to be two completely independent research fields, experimentally the truth is that geometric and diffractive behaviors often co-exist within the very same optical system. Light is a single physical entity, and as such oblivious to the artificial separation in descriptions which has been foisted upon it. Therefore, rather than two self-contained fields barely interacting with each other, geometric and physical models ought to be considered as two different levels of approximation. A modern optical modeling theory should combine these concepts and results in a physical optics theory which inherently applies geometric and diffractive models in a well-defined, cogent way. Algorithms which are based on such a theoretical concept minimize the numerical effort in physical optics modeling. We refer to such algorithms as fast physical optics algorithms.

Virtual and Mixed Reality Devices

An important and typical example of the need for such fast physical optics techniques is the modeling and design of near-eye displays for virtual and mixed reality.

The modeling of such a device must include energy and wavefront propagation, polarization, partial coherence and interference. Therefore, it requires physical optics modeling. Hundreds or even thousands of different imaging channels must be evaluated fast, to enable an optimization of the system. In 2016 we have developed, together with the company Wyrowski Photonics, a suitable non-sequential fast physical optics algorithm to solve this task. This algorithm consists of two major steps:
(1) Non-sequential analysis of all light paths by ray tracing.
(2) Fast physical optics modeling of each light path.
This is done by solving Maxwell’s equations in the k-domain and switching into the x-domain when apertures and curved surfaces must be included. The technique enables the evaluation of the uniformity in the eye box of the device, as well as its MTF (which is dependent on the object point and the eye position in the eye box). The MTF calculation includes multiple aperture effects as well as partial temporal coherence.

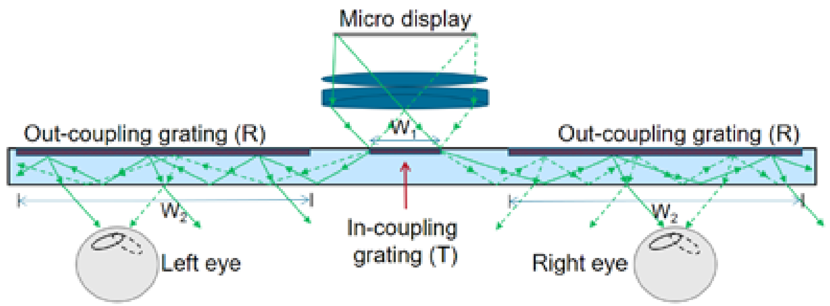

Figure 2:
Illustration of the concept of va near-eye display with a waveguide plate in combination with gratings for in- and out-coupling as well as exit-pupil extension.

Figure 3:
Microsoft HoloLens is an example of mixed reality glasses which uses a waveguide plate for exit-pupil extension [source: microsoft].

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

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Conference Contributions

Invited Contributions

A. Klenke, M. Kienel, M. Müller, T. Gottschall, S. Breitkopf, E. Shestaev, C. Jauregui, J. Rothhard, T. Eidam, S. Hädrich, J. Limpert, A. Tünnermann: Coherent combination of fiber lasers, 7th International Conference on Ultrahigh Intensity Lasers - ICUIL, Montebello, Canada, 2016.

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R. Keil, C. Poli, M. Heinrich, J. Arkinstall, G. Weihs, H. Schomerus, A. Szameit: Universal sign-control of coupling in tight-binding lattices, Quantum Optics 2016 conference, Obergurgl, Austria, 2016.

R. Klas, S. Demmler, M. Tschernajew, S. Hädrich, J. Rothhardt, J. Limpert, A. Tünnermann: Milliwatt Class Narrowband High Harmonic Source Based on Cascaded Frequency Conversion, 7th EPS-QEOD Europhoton Conference, Vienna, Austria, 2016.

R. Klas, S. Hädrich, J. Rothhardt, J. Limpert, A. Tünnermann, M. Aeschlimann, M. Barkowski, S. Sadashivaiah, J. Urbancic, S. Mathias: High Photon Flux 70 eV HHG Source for Ultrafast Dynamics, International Conference on Ultrafast Phenomena, Santa Fe, USA, 2016.

R. Müller, S. Yulin, P. Naujok, N. Kaiser, A. Tünnermann: Optical properties and oxidation resistance of coatings for EUV applications ,39th International Conference on Vacuum Ultraviolet and X-ray (VUVX), Zurich, Switzerland, 2016.

S. Böhme, S. Fabian, A. Kamm, T. Peschel, E. Beckert, A. Tünnermann, K. Nicklaus, M. Dehne: High reproducible CO_2 laser spliced fiber-collimator for a space borne laser system, International Conference on Space Optics (ICSO), Biarritz, France, 2016.

S. Breitkopf, S. Wunderlich, T. Eidam, E. Shestaev, T. Gottschall, H. Carstens, S. Holzberger, A. Tünnermann, I. Pupeza, J. Limpert: Extraction of enhanced, ultrashort laser pulses from a passive 10-MHz stack-and-dump cavity, 7th EPS-QEOD Europhoton Conference, Vienna, Austria, 2016.

S. Breitkopf, S. Wunderlich, T. Eidam, E. Shestaev, T. Gottschall, H. Carstens, S. Holzberger, I. Pupeza, J. Limpert, A. Tünnermann: Investigation of a 10 MHz, non-steady state cavity for pulse energy enhancement of ultrafast fiber lasers, SPIE Photonics West, San Francisco, USA, 2016.

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S. Hädrich, M. Kienel, M. Müller, A. Klenke, J. Rothhardt, R. Klas, T. Gottschall, T. Eidam, A. Drozdy, P. Jojart, Z. Varallyay, E. Cormier, K. Osvay, A. Tünnermann, J. Limpert: Utilizing fiber lasers to obtain 220W average power energetic sub 2-cycle pulses, 7th EPS-QEOD Europhoton Conference, Vienna, Austria, 2016.

S. Kuhn, S. Hein, C. Hupel, F. Beier, J. Nold, B. Sattler, N. Haarlammert, T. Schreiber, E. Eberhardt, A. Tünnermann, Towards monolithic single-mode Yb-doped fiber amplifiers with >4 kW average power, Lasers Congress 2016 (ASSL, LSC, LAC), Boston, USA, 2016.

S. Saravi, F. Setzpfandt, T. Pertsch: Counterpropagating Spatially Entangled Bell-states Generation in Photonic Crystal Waveguides, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

S. Saravi, F. Setzpfandt, T. Pertsch: Periodic Wave-guides for Generation of Engineered Photon-pair States, Photonics and Fiber Technology 2016 (ACOFT, BGPP, NP), Sydney, Australia, 2016.

S. Saravi, R. Quintero-Bermudez, F. Setzpfandt, N. A. Mortensen, T. Pertsch: Effect of Loss on Slow-light-enhanced Second Harmonic Generation in Periodic Nanostructures, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

S. Saravi, R. Quintero-Bermudez, F. Setzpfandt, N. A. Mortensen, T. Pertsch: How Useful Is Slow Light in Enhancing Nonlinear Interactions in Lossy Periodic Nanostructures?, Photonics and Fiber Technology 2016 (ACOFT, BGPP, NP), Sydney, Australia, 2016.

S. Schmidt, T. Tiess, S. Schröter, H. Gross: Numerical and experimental evaluation of inline holographic measurements for the metrology of optical fibers, European Optical Society Annual Meeting (EOSAM), Berlin, Germany, 2016.

S. Schwinde, M. Schürmann, N., Kaiser, A. Tünner-mann: Investigation of SiO_2-Al_2O_3-nanolaminates for protection of silver reflectors, Optical Interference Coatings (OIC), Tuscon, USA, 2016.

S. Stützer, A. Solntsev, S. Nolte, A.A. Sukhorukov, A. Szameit: Observation of Bloch oscillations with a threshold, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

S. Stützer, R. Keil, C. Noh, A. Rai, S. Nolte, D.G. Angelakis, A. Szameit: Optical simulation of unphysical Majorana dynamics, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

S. Weimann, L. Morales-Inostrosa, B. Real, C. Cantillano, A. Szameit, R.A. Vicencio: Bulk and edge transport in Sawtooth lattices, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

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S. Zhang, H. Zhong, F. Wyrowski: Modelling and design of modified Wollaston prisms and the application in differential interference contrast microscopy, SPIE Photonics West, San Francisco, USA, 2016.

S. Zhang, Z. Wang, F. Wyrowski: Generation of complex light using uniaxial and biaxial crystals: an efficient and accurate vectorial simulation technique, SPIE Photonics West, San Francisco, USA, 2016.

S. Zhang, Z. Wang, F. Wyrowski: Generation of complex light using uniaxial and biaxial crystals: an efficient and accurate vectorial simulation technique, SPIE Photonics West, San Francisco, USA, 2016.

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T. Burkhardt, M. Mohaupt, B. Zaage, E. Beckert, R. Eberhardt, A. Tünnermann: Solderjet bumping - Laser soldering for high precision system integration, International Conference and Exhibition on Integration Issues of Miniaturized Systems (SSI), Munich, Germany, 2016.

T. A. Goebel, C. Voigtländer, R. G. Krämer, D. Richter, M. Heck, E. Lindner, S. Nolte: Fs inscription of high strain resistant fiber Bragg gratings for sensor applications, DokDok Conference, Oppurg, Germany, 2016.

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T. Eichelkraut, S. Weimann, J. M. Zeuner, A. Szameit: Managing Radiation Loss in Photonic Waveguides for Applications in PT-Symmetric Systems, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

T. Siefke, E.-B. Kley, A. Tünnermann: Design and fabrication of titanium dioxide wire grid polarizer for the far ultraviolet spectral range, SPIE Optics + Photonics, San Diego, USA, 2016.

T. Siefke, S. Kroker: Materials for wire grid polarizer in the far ultraviolet spectral range, International workshop on optical characterization of thin solid films, Brno, Czech Republic, 2016.

T. Ullsperger, G. Matthäus, M. Rettenmayr, S. Risse, A. Tünnermann, S. Nolte: Femtosecond laser pulse induced rapid melting and resolidification of aluminum silicon powder for additive manufacturing, SPIE Photonics West, San Francisco, USA, 2016.

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T. Weichelt, Y. Bourgin, M. Banasch, U.D. Zeitner: Advanced photomask fabrication by e-beam lithography for mask aligner applications, Mask and Lithography Conference (EMLC), Dresden, Germany, 2016.

T. Weichelt, Y. Bourgin, U.D. Zeitner: Flexible pattern generation with laser illumination for mask aligner lithography, SPIE Photonics Europe, Brüssel, Belgium, 2016.

T. Weichelt, Y. Bourgin, U.D. Zeitner: Flexible pattern generation with laser illumination for mask aligner lithography, Fraunhofer IISB Lithoworkshop, Pommelsbrunn (Hersbruck), Germany, 2016.

U. Blumröder, H. Angermann, C. Kloß, S. Nolte: Influence of doping concentration and surface preparation on THz emission from silicon, 41st International Conference on Infrared, Millimeter and Terahertz Waves (IRMMW), Copenhagen, Denmark, 2016.

Y. Chen, H. Chung, K. Huang, S. Yang, W. Chang, C. W. Wu, F. Setzpfandt, T. Pertsch, D. N. Neshev: Ultra-Broadband Adiabatic Light Transfer in Titanium Diffused Lithium Niobate Waveguides, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

Y. Lumer, M.A. Bandres, H. Herzig-Sheinfux, Y. Plotnik, M. Heinrich, A. Szameit, M. Segev: Experimental Demonstration of Waveguiding by Artificial Gauge Field, Conference on Lasers and Electro-Optics (CLEO US), San José, USA, 2016.

Z. Shu, O. Pabst, E. Beckert, R. Eberhardt, A. Tünnermann: Fully solution-processed organic light-emitting electrochemical cells (OLEC) with inkjet-printed micro-lenses for disposable lab-on-chip applications at ambient conditions, SPIE Photonics West, San Francisco, USA, 2016.

Colloquia

A. Szameit: Topological Photonics, Technische Universität Ilmenau, Germany, 2016.

A. Szameit: Topological Photonics, Universität Bayreuth, Germany, 2016.

A. Szameit: Topological Photonics, Humboldt-Universität Berlin, Germany, 2016.

A. Szeghalmi: Overview of ALD, Workshop: Optical Coatings for Laser Applications, Buchs, Switzerland, 2016.

A. Tünnermann: Advanced micro- and nanooptics for next generation high power lasers, Lawrence Livermore national laboratory, Lawrence, USA, 2016.

A. Tünnermann: Facet vision – insects inspired imaging system, Kolloquium Universität Innsbruck, Austria, 2016.

A. Tünnermann: Optics Valley Jena – Trend-setter in Optics in the past, present and future, Celebration 10 years of optical excellence, Jena, Germany, 2016.

A. Tünnermann: The next big thing: Mensch-Maschine-Interaktion – Herausforderungen und Chancen für die Photonik, PTB Festkolloquium, Braunschweig, Germany, 2016.

A. Tünnermann: Photonische Lösungen für die Mensch-Maschine-Interaktion in der digitalen Produktion, JET – Jenaer Lasertagung, Jena, Germany, 2016.

A. Tünnermann: Optics and Photonics – Key technology and enabler, Deutsch-Brasilianische Wirtschaftstage, Weimar, Germany, 2016.

A. Tünnermann: Photonic Technologies in Human-Machine-Interaction, Leibniz talk, New York, USA, 2016.

A. Tünnermann: Industrie 4.0 – Herausforderungen und Chancen für die optische Industrie, 22. Industriegespräche, Chemnitz/Jena, Jena, Germany, 2016.

A. Tünnermann: Industry 4.0 – Challenges in Men-Machine-Interaction, Hamamatsu photonics, Hamamatsu, Japan, 2016.

A. Tünnermann: Industry 4.0 – Challenges in Men-Machine-Interaction, Toyota CDRL, Tokyo, Japan, 2016.

A. Tünnermann: Licht, Laser, Sensor: Innovationen für die Industrie 4.0, Industrie 4.0 Thüringen: Erfolge mit digital vernetzter Produktion, Zurich, Switzerland, 2016.

H. Gross: Optikdesign von abbildenden Freiformsystemen, Workshop Simulationen in der Photonik, Hannover, Germany, 2016.

H. Gross: Optische Systeme mit Freiformflächen, Carl-Zeiss Optikkolloquium, Jena, Germany, 2016.

H. Gross, A. Brömel, J. Stock: Optical systems with freeform surfaces - challenges in simulation and realization, Workshop IOSB FhG Erlangen, Germany, 2016.

I. Staude: Wavefront Control with Dielectric Huygens' Metasurfaces, Technical University of Kaiserslautern, Germany, 2016.

I. Staude: Tailoring Light Fields with Dielectric Huygens' Metasurfaces, University of Exeter, GB, 2016.

I. Staude: Tailoring Light Fields with Silicon Huygens' Metasurfaces, Sandia National Laboratories, Albuquerque, USA, 2016.

I. Staude: Tailoring Light Fields with All-Dielectric Huygens' Metasurfaces, FOM Institute AMOLF, Amsterdam,
The Netherlands, 2016.

I. Staude: Tailoring Light Fields with Silicon Huygens' Metasurfaces, Friedrich-Schiller-University Jena, Germany, 2016.

I. Staude: Mie-resonant dielectric nanostructures as a platform for functional nanophotonics, University of Paderborn,
Germany, 2016.

T. Siefke, S. Kroker: Auswirkung der Kantenrauheit auf die optischen Eigenschaften von Drahtgitterpolarisatoren, Physikalisch-Technische Bundesanstalt PTB, Braunschweig, Germany, 2016.

Patents

Published Patent

H.-J. Otto, A. Klenke, A. Tünnermann, J. Limpert
Optische Anordung mit Strahlaufteilung
EP 3103167A1

M. Goy, C. Reinlein, N. Leonhard, M. Appelfelder
Verfahren zur Formgebung und /oder Formkorrektur mindestens eines optischen Elements
WO 2016 170043 A1

T. Gottschall, M. Baumgartl, A. Tünnermann, J. Limpert
Vorrichtung und Verfahren zur Erzeugung von kurzen Strahlungspulsen
EP 3063590A1

T. Gottschall, M. Baumgartl, A. Tünnermann, J. Limpert
Vorrichtung und Verfahren zur Erzeugung von kurzen Strahlungspulsen
US 20160320687A1

Granted Patents

E. Beckert, O. Pabst
Mikropumpe
DE 10 2011 107 046 B4

E. Beckert, C. Damm, T. Burkhardt
Mounted optical component, method for the production thereof and use of same
US 9,233,430B2

L. Ghazaryan, A. Szeghalmi, E.-B. Kley
Verfahren zur Herstellung optisch wirksamer Elemente
DE 10 2015 203 307 B3

A. Klenke, A. Tünnermann, E. Seise, J. Limpert
Optical amplifier arrangement
US 9,484,709B2

J. Limpert, A. Tünnermann, C. Jauregui, C. Jocher
Generation of azimuthally or radially polariezed radiation in optical waveguides
US 9,459,403 B2

J. Limpert, F. Röser, T. Eidam, C. Jauregui, A. Tünnermann
Single-mode propagation in microstructured optical fibers
US 9,448,359B2

S. Scheiding, S. Risse, A. Gebhardt, C. Damm, T. Peschel, R. Steinkopf
Method for producing an optical assembly having at least two optical functional surfaces, an optical device and unit for carring out the method
US 9,296,161B2

U. Schulz, I. Wendling, P. Munzert, N. Kaiser
Method for producing an optical element having a reflection-reducing anti-fog layer
EP 2 118 691 B1

A. Tünnermann, J. Limpert, F. Jansen, T. Eidam, C. Jauregui, H.-J. Otto, F. Stutzki
Method and device for reducing mode instability in an optical waveguide
US 9,235,106 B2

C. Voigtländer, J. U. Thomas, S. Nolte, A. Tünnermann, R. Williams
Mode filter with refractive index modification
US 9,360,617B2

Interesting themes and exciting conversation with reasearchers of the Australian Centre of Excellence of Ultrahigh Bandwidth Devides for Optical Systems (CUDOS). CUDUS-ACP workshop was embedded in DokDok program. The main theme of the Australian contributors was the aspired future implementation of optomechanic interaction schemes into photonic-phononic integrated chips.

CARL ZEISS (1816 – 1888)
200. GEBURTSTAG

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.

Beside this involvement, more and more it is a concern to involve the public in the work we do. We want to attract people for our topics to show them the significance of research for daily life but also reach the interest of young persons to encourage young scientific talents.

In 2016 Jena celebrated the 200th anniversary of Carl Zeiss, not only the founder of the well-known company but also - together with Ernst Abbe - the groundbreaker of modern optics and enabler of many sciences, such as microbiology - because of his high expectations of quality on his own products.

2016 - The year of Carl Zeiss

Lots of activities around physics and our Institute

In addition to our focus on research and teaching, there are many annual events in which the IAP is involved.

Therefore, it is self-evident that we were participating in the faculty`s “Tag der Physik” (18.03.), which had its focus this year on space science. In addition, our PhD students were very committed to the annual organization and realization of the doctoral conference DoKDoK, which was also attended by international researchers at the Oppburg Castle (25.-29.09.) to exchange ideas and experiences.

In addition to the prestigious international conferences the colleagues visited, highly interesting events took place at our campus, such as the “Laser Display and Lighting Conference” (04.-08.07.) and the workshop "Ultra Precision Manufacturing of Aspheres and Freeforms" which also served to presented the latest results of the project "Freeform Optics Plus fo +" (21.-22.09.).

Exceptional lots of fun is to interest the youngest for natural sciences, especially physics. We have done this again in various ways this year. In addition to children's lectures (Physik Arena 08.04.), we also went to schools to complement the curriculum: at the school project days, we were invited to the Friedensschule in Hermsdorf and worked intensively on optical phenomena and magnetism. We were supported by pedagogy students. In spite of the unusual task, it was really fun! We were also invited to attend the GalileoNacht at the Gesamtschule in Winzerla, where, together with the FhG-IOF, we answered questions from pupils and their parents.

Extending beyond, the 200th birthday of Carl Zeiss was celebrated on 11.09. We were part of a great science festival in the inner city of Jena with over 50,000 visitors! A further milestone in 2016 was the inauguration ceremony of the office and laboratory building of the Abbe Center of Photonics (ACP) with celebrities from science and politics, such as Bodo Ramelow and Hans-Peter Hiepe on July 5th.

Events in 2016 (right): 1) Alumni Day for IAP and FhG-IOF fellows 2) Amongst other, C. Stock and T. Weichelt inspire young and grown-up guests of the 200th anniversary of Carl Zeiss, 3) At the Goethe Gallery the IAP could present how the findings of Zeiss and Abbe still influence our work today 4, 5) The so-called Physik Arena attracted many classes of Jena and periphery. A. Szameit and F. Schrempel explain physical phenomena in an exciting story. 6) For the so-called Galileo Nacht, the IAP supported the Galileo Gesamtschule in Winzerla with experiments and the popular laser marker (with C. Matzdorf). 7) For the CUDOS-ACP workshop on nano-optical systems exploiting nonlinear effects, austalian guests visited Jena and took also part on the annual DokDok conference. 8) At the inauguration ceremony for the ACP building A. Tünnermann welcomes the celebraties. 9) U. Zeitner and A. Szameit conclude the second funding round of the Centre for Innovation Competence (ZIK) ultra optics with a status seminar. 10 - 12) During three days, the IAP supported young researchers in their discoveries on the topics of optics and magnetism at the Friedensschule in Hermsdorf.


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Awards

Sven Breitkopf
3rd Place Best Student Presentation, Photonics West,
„Fiber Lasers: Technology, Systems, and Applications"
SPIE - The International Society for Optics and Photonics
„Investigation of a non-steady state cavity for pulse energy enhancement of ultrafast fiber lasers"

Nadja Felde
EMASST Award on Surface Science for the Best Scientific Work - EMASST Association
„Advanced Roughness Analysis of Functional Nanostructures for Optical Applications"

Martin Gebhardt
Carl Zeiss PhD Award in Modern Optics - Carl Zeiss AG
„High-power, ultrafast mid-IR laser sources"

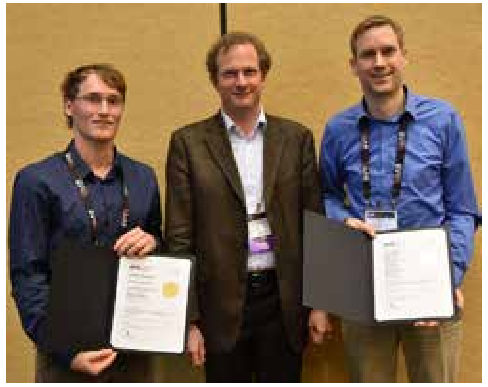
Martin Gebhardt
Outstanding Oral Presentation Award, Advanced Solid State Lasers Conference (ASSL) in Boston, USA
Optical Society of America (OSA)
„High-power nonlinear compression stage delivering sub-50 fs, 0.25 mJ pulses, 15 W at 2 µm wavelength for HHG"

Thorsten Goebel
Transferpreis
Bundesverband mittelständige Wirtschaft & Wirtschaftsförderungsgesellschaft Jena
„Hochrobuste ultrakurzpulsgeschriebene Fasersensorarrays"

Thomas Gottschall
Jenlab Young Investigator Award, Photonics West, „BIOS - Multiphoton Microscopy in the Biomedical Sciences XVI"
SPIE - The International Society for Optics and Photonics
„Four-wave mixing based light source for real-world bio-medical applications of coherent Raman microscopy"


Thorsten Goebel (right) proudly presents his first scientific award.


Angela Klein received her award at the Alumni-Day of the faculty.


Martin Heusinger (right) together with Prof. Dr. Georg von Freymann (TU Kaiserslautern, center).

Martin Heusinger
Best Student Paper Award, Photonics West, "Advanced Fabrication Technologies for Micro/Nano Optics and Photonics IX"
SPIE - The International Society for Optics and Photonics
„Investigation and optimization of Rowland ghosts in high efficiency spectrometer gratings fabricated by e-beam lithography"

Helena Kämmer
3rd Place Best Student Presentation, Photonics West,
„SPIE LASE Frontiers in Ultrafast Optics conference"
SPIE - The International Society for Optics and Photonics
„Analysis of the hole shape evolution in fs-pulse percussion drilling with bursts"

Robert Keil (Alumnus)
Carl Zeiss Awards for Young Researchers
Ernst-Abbe-Stiftung
„The random mass Dirac model and long-range correlations on an integrated optical platform"

Marco Kienel
Outstanding Oral Presentation Award, Advanced Solid State Lasers Conference (ASSL) in Boston, USA - Optical Society of America (OSA)
"12 mJ and 1 kW Ultrafast Fiber-Laser System using Spatial and Temporal Coherent Pulse Addition"

Angela Klein
Preis der Dr.-Ing. Siegfried Werth Stiftung
Faculty of Physics and Astronomy (PAF) of the FSU Jena
„Scanning near-field optical microscopy: from single-tip to dual-tip operation"

Stefan Nolte
Fellow of the Optical Society of America (OSA)

Getnet Tadesse
Best Poster Award at the International Conference "Coherence 2016" - Soleil Synchrotron
„High-resolution nanoscope with spatial resolution of 13 nm"

Marcus Trost
STIFT Sonderpreis Thüringen (Dissertartion)
Stiftung für Technologie, Innovation und Forschung Thüringen (STIFT)
„Light scattering and roughness properties of optical components for 13.5 nm"


Dr. Hans-Jörg Fuchs celebrated 40 years of employment at the university.


Helena Kämmer (left) at Photonics West award ceremony.


Martin Gebhardt is pleased with his Carl-Zeiss PhD- Award.


Marco Kienel (center) presents the certificate at the ASSL.

Organizing Activities

Herbert Gross

Referee of several scientific journals

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

Member in the expert committee of the Baden-Würtemberg foundation of Optical Technologies

E.-Bernhard Kley

Member of the GMM-Technical Committee meeting
FA 4.7 Micro-Nano Integration

Referee for several scientific journals

Jens Limpert

Member of the Program Committee SPIE Photonics West Conference "LASE 2016"

Referee for several scientific journals

Stefan Nolte

Coordinator & Spokesman of the BMBF Association "Ultrashort Pulse Laser for High Precision Machining"

Conference Chair of the SPIE Photonics West Conference "Frontiers in Ultrafast Optics: Biomedical, Scientific and Industrial Applications (LASE)"

Member of Scientific Committee OSA conference "Bragg Gratings, Photosensitivity and Poling in Glass Waveguides (BGPP)

Member of jury "Jugend forscht"

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)

Fellow of the Optical Society of America (OSA)

Member of SPIE

Member of Deutsche Physikalische Gesellschaft (DPG)

Referee for several scientific journals

Thomas Pertsch

Vice Dean of the Faculty of Physics and Astronomy

Spokesman 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 High Performance Center for Photonics of the Fraunhofer Society

Spokesman of the research initiative "Photonic Nanomaterials PhoNa"

Member of the committee for the Esther Hoffman Beller Medal of the Optical Society of America

Coordinator of the study program "Master of Science in Photonics"

Local coordinator of Erasmus Mundus Program – NANOPHI – Nonlinear Nanophotonics

Fellow of the Optical Society of America (OSA)

Referee for several international journals

Member of conference program committees: ETOP - Education and Training in Optics & Photonics, Hangzhou, China

Jan Rothhardt

Member of the extended directory board of the Helmholtz Institute Jena

Program committee for CLEO Europe conference

Program committee for IEEE photonics conference

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

Lecture on "LASERS" for high school students at the Gymnasium Leinefelde

Frank Schrempel

Coordinaton of the IAP at the Beutenberg Campus e.V

Member of the Faculty Board

Referee for several scientific journals

ACTIVITIES

Isabelle Staude

Session Chair at ICONO-2016 (Minsk)

Reviewer for several scientific journals including Nature Materials, Nature Photonics, ACS Nano, Advanced Materials and Optica.

Member of Deutsche Physikalische Gesellschaft (DPG)

Member of the Optical Society of America (OSA)

Coordinator of the research association “Nano-Film” within the funding program “Photonik Plus” of the German Federal Ministry for Education and Research (BMBF)

Early career women in photonics special recognition by the European Optical Society (EOS)

Alexander Szameit

Program committee for CLEO/QELS conference FS5: Nonlinear optics and novel phenomena

Member Optical Society of America (OSA)

Member of Deutsche Physikalische Gesellschaft (DPG)

Referee for several scientific journals, including Nature, Nature Photonics, and Nature Physics

Adriana Szeghalmi

Member of Deutsche Physikalische Gesellschaft (DPG)

Member of the Optical Society of America (OSA)

Reviewer of Chemical Physics Letters, IEEE Photonics, Journal of Vacuum Science and Technology

Andreas Tünnermann

Council member of the Faculty

Council member of the TU Bergakademie Freiberg

Member of program committee "Optische Technologien", BMBF

Chairman of the Technical Council Fraunhofer-Gesellschaft

Member of the steering committee Fraunhofer-Gesellschaft

Member of the VDI / VDE-GMA Advisory Board FB 8 "Optical Technologies of the Society for Measurement and Automation"

Board of Trustees MPA, Heidelberg

Board of Trustees IOM, Leipzig

Board of Trustees MPQ, Garching

Chairman "AG Naturwissenschaften", Wissenschaftliche Gesellschaft Lasertechnik e.V.

Member of acatech "Deutsche Akademie der Technikwissenschaften"

Member of Honor SPIE International Society of Optics and Photonics

Stakeholder Photonics 21-Platform

Director of the Abbe Center of Photonics at the Friedrich Schiller University Jena

Spokesman of the DFG International Research Training Group GRK2101 "Guided light, tightly packed: novel concepts, components and applications"

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