OSA Foundation

Siegman International School on Lasers

Co-founded by IPG Photonics

HOST FOR 2015: MAX PLANCK INSTITUTE for the science of light

2 - 7 August 2015

Amberger Congress Centrum

Amberg, Germany







August 2015

Dear Participants,

It is our pleasure to welcome you to the Siegman International School on Lasers, co-founded by IPG Photonics. Each year, this school brings together the world's brightest graduate students to learn from academic and industry leaders. The school provides a valuable opportunity to present and exchange ideas from leading researchers in the field of optics and photonics.

Our thanks go to many people for helping make this conference happen. In particular I'd like to thank IPG Photonics, the staff of the Max Planck Institute for the Science of Light, the Siegman steering and program committees and—last but far from least—our donors.

We would also like to thank our distinguished line-up of speakers for accepting the invitation to teach at the school:

- Vahid Sandoghdar, Germany
- Marlan Scully, USA
- Jens Limpert, Germany
- Roel Baets, Belgium
- Clemens Kaminski, United Kingdom
- Franz Kärtner, Germany
- Anatoly Grudinin, United Kingdom
- Marie-Emmanuelle Couprie, France
- Eli Kapon, Switzerland
- Alexander Killi, Germany

We hope you will enjoy your week in Amberg. You are sure make many new friends and colleagues from all over the world and expand your knowledge of lasers and their applications.

Do not be shy about approaching any of the lecturers with questions or comments about the science—we'd like you all to participate actively in the school.

The Siegman staff and organizers will be very happy to help if you have any other non-scientific questions.

Best wishes,

Nicolas Joly, Co-Chair
Universität Erlangen-Nürnberg, Germany

Philip Russell, Co-Chair
Max Planck Institute, Germany

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The OSA Foundation would like to thank its contributors for their support of the Siegman International School on Lasers. Their generosity and vision has built a global resource for the next generation of optics and photonics scientists and engineers.

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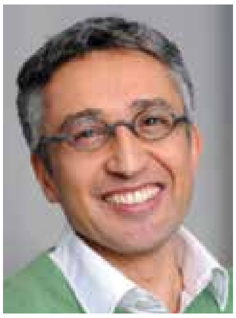
Speaker Bios & Abstracts



Vahid Sandoghdar obtained his B.S. in physics from the University of California at Davis in 1987 and Ph.D. in physics from Yale University in 1993. After a postdoctoral stay at the Ecole Normale Supérieure in Paris he moved to the University of Konstanz in Germany in 1995, where he started a new line of research to combine single molecule spectroscopy and scanning probe microscopy. In 2001 Vahid Sandoghdar accepted a chair at the Laboratory of Physical Chemistry at ETH in Zurich, Switzerland. In 2011 he became director at the newly founded Max Planck Institute for the Science of Light and Alexander-von-Humboldt Professor at the University of Erlangen-Nuremberg in Germany. Sandoghdar is one of the founders of the young field of Nano-Optics, which merges various methods and research areas to investigate fundamental issues in the interaction between light and matter at the nanometer scale. His current research spans a wide spectrum, ranging from quantum optics, plasmonics and ultrahigh resolution microscopy to nanobiophysics

Ultrasensitive Coherent Detection of Single Biomolecules and Quantum Emitters

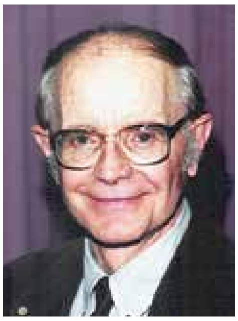
TIME: MONDAY, 09:30 AND TUESDAY, 09:00

Optical detection has played a central role in many areas of scientific research and has even reached single-atom and single-molecule sensitivity in the past three decades. However, these works have relied on the detection of fluorescence, which is an inherently incoherent process. Many schemes in quantum information processing rely on the preservation of coherence and phase information in the system. Furthermore, considering that fluorescence often suffers from photobleaching, there has been a large effort to explore other optical detection techniques. In this short course, I shall discuss recent advances in fluorescence-free coherent detection of quantum emitters, nanoparticles and biomolecules.

Several years ago, we showed theoretically that in the linear excitation regime, an atom can block a propagating light beam by up to 100%. In the first part of this course, I present an overview of our experimental work on the efficient interaction of light and single organic molecules at cryogenic temperatures in the near field or through strong focusing. We will see that such solid-state emitters can attenuate and phase shift a laser beam. Furthermore, I shall report on the direct long-distance communication of two quantum emitters, where single photons are funneled in and out of molecules using lenses of high numerical aperture. We will see that the key concept for efficient photon-atom interaction is mode matching and that optical antennas can be used to change the dipolar pattern of a quantum emitter. For example, we will examine the efficient coherent coupling of single molecules to a dielectric nanoguide.

In the second part of this presentation, I shall show that the same concepts discussed above can be exploited for the ultrasensitive and direct detection of single gold nanoparticles, viruses and proteins.

Speaker Bios & Abstracts



Marlan Scully (Baylor, Princeton, and Texas A&M) has worked on a variety of problems in laser physics and quantum optics including: the first quantum theory of the laser with Lamb, the laser phase transition analogy and its applications to the Bose condensate, experimental demonstrations of lasing without inversion, and ultraslow light in hot gases via quantum coherence.

His introduction of entanglement interferometry to quantum optics has shed light on the foundations of quantum mechanics, e.g., the quantum eraser. Recently he and his colleagues have applied quantum coherence to remote sensing of anthrax and probing through turbid medium such as skin, and plant tissue.

Scully is currently Distinguished University Professor at Texas A&M University and also holds positions at Princeton and Baylor Universities. He has been elected to the U.S. National Academy of Sciences and the Max Planck Society. He has recently been awarded the OSA Frederic Ives Medal / Quinn Prize and the DPG/OSA Herbert Walther Award.

The Photon Statistics of the Laser and Its Close Connection with the Atom Statistics in a Bose Condensate

TIME: MONDAY, 11:00 AND TUESDAY, 15:30

Bose Einstein condensation (BEC) in a trap has intriguing similarities with threshold behavior of a laser. But there are strong differences between the two systems and it is important to understand these differences. As we shall show, the effects of different interactions in the laser are easy to trace and relate to observable characteristics of the system such as gain, loss, and saturation nonlinearity. This is not the case in the BEC and it is important to separate out these different effects. For example, we find that the saturation nonlinearity in the laser is essential for laser coherence and naturally ask: "Is the corresponding nonlinearity in the BEC due to atom-atom scattering or is there a nonlinearity present even in a ideal Bose gas?" In these lectures we will show that the latter is the case.

In particular, we will develop a Master equation for the condensate of a dilute Bose gas and obtain the atom statistics in analogy with the photon statistics in a laser. One can show that in the canonical ensemble, the N atom constraint plays a role essentially similar to the saturation nonlinearity in the laser. Effects of atom-atom interactions will also be presented.

Speaker Bios & Abstracts

Jens Limpert received his M.S in 1999 and Ph.D. in Physics from the Friedrich Schiller University of Jena in 2003. His research interests include high power fiber lasers in the pulsed and continuous-wave regime, in the near-infrared and visible spectral range. After an one-year postdoc position at the University of Bordeaux, France, where he extended his research interests to high intensity lasers and nonlinear optics, he returned to Jena and is currently leading the Laser Development Group (including fiber- and waveguide lasers) at the Institute of Applied Physics. He is author or co-author of more than 240 peer-reviewed journal papers in the field of laser physics. His research activities have been awarded with the WLT-Award in 2006, an ERC starting grant in 2009 and an ERC consolidator grant in 2013. Jens Limpert is founder of the Active Fiber Systems GmbH a spin-off from the University Jena and the Fraunhofer-IOF Jena.

High Performance Ultrafast Fiber Lasers

TIME: MONDAY, 14:00

Fiber lasers enjoy an excellent reputation as power-scalable diode-pumped solid-state laser concept. Their immunity against thermo-optical issues is combined with efficiency and high performance in fiber based amplification. During the last decade, ultra-short pulse fiber laser systems have been developed in Jena's institutes. The laboratory results are ground-breaking; several world records in performance are held by those institutes. The mission of Active Fiber Systems GmbH (AFS) is to transfer experimental results to reliable laser systems suitable for scientific and industrial applications. Among the remarkable features of AFS's pulsed fiber lasers are their compact dimensions, considerably reduced production costs as well as flexible and outstanding laser parameters, which can be customized.

As mentioned, significant progress has been made in scaling the energy of the pulses as well as the average power of ultrafast lasers. However, different amplification schemes have been pushed to their specific limits, caused e.g. by detrimental nonlinear effects, by damage or by the occurrence of thermo-optical effects. New concepts have to be considered to address these issues and to enable new application fields. In that context, I will review the basics and achievements ultrafast fiber lasers and the coherent combination of fiber amplified femtosecond pulses, a concept which has already out-performed single aperture femtosecond laser systems and which allows for a scaling to unprecedented performance levels.

Speaker Bios & Abstracts

Roel Baets is full professor at Ghent University (UGent). He is also associated with IMEC. Roel Baets received an MSc degree in Electrical Engineering from Ghent University in 1980 and a second MSc degree from Stanford University in 1981. He received a PhD degree from Ghent University in 1984. From 1984 till 1989 he held a postdoctoral position at IMEC (with detachment to Ghent University). Since 1989 he has been a professor in the Engineering Faculty of UGent where he founded the Photonics Research Group. From 1990 till 1994 he has also been a part-time professor at the Technical University of Delft and from 2004 till 2008 at the Technical University of Eindhoven. Roel Baets has mainly worked in the field of integrated photonic components. He has made contributions to research on semiconductor laser diodes, guided wave and grating devices and to the design and fabrication of photonic ICs, both in III-V semiconductors and in silicon. In recent years his focus has shifted to life science applications of silicon photonics. As part of a team of 7 professors he leads the Photonics Research Group at UGent. With about 80 researchers this group is involved in numerous national and international research programs. The silicon photonics activities of the group are part of a joint research initiative with IMEC. Roel Baets is also director of the multidisciplinary Center for Nano- and Biophotonics (NB Photonics) at UGent, founded in 2010. . Roel Baets is a grant holder of the Methusalem programme of the Flemish government and of the European Research Council (ERC advanced grant). He is a Fellow of the IEEE.

Silicon Photonics: Basics and Applications in ICT and Life Sciences

TIME: MONDAY, 16:00 AND THURSDAY, 9:00

Silicon photonics is an emerging technology that takes advantage of the technological maturity of CMOS fabs and also of the physical mechanisms enabled by high refractive index contrast to implement sophisticated photonic functions in a miniaturized chip. In part 1 of the lecture the basics of the field and its applications in high bandwidth data links will be covered. This will include basic passive devices, WDM functions, coupling to fiber, high speed modulators and detectors.

In the second part of the talk the options to integrate lasers on a silicon platform will be covered. Then the applications of silicon photonics in sensing, biosensing and spectroscopy will be addressed. In the latter context we will discuss how the field broadens from its conventional operation at telecom wavelengths to new wavelength bands, both in the mid IR as well as into the visible, that are relevant in life science applications.

Speaker Bios & Abstracts

Clemens Kaminski is Professor of Chemical Physics at the University of Cambridge, UK, and Director of the EPSRC Centre for Doctoral Training in Sensor Technologies and Applications. He obtained his PhD at the University of Oxford, UK, in 1995, held a Marie Curie post-doctoral fellowship and Associate-Professorship at the Lund Institute of Technology in Sweden before his appointment at the University of Cambridge in 2001. He pioneered ultrahigh speed imaging techniques for the study of chemistry both for gas phase reactions and, more recently, in biological systems. Currently his group focuses on the development of advanced microscopy techniques to unravel molecular mechanisms of disease. He is recipient of the Cyril Hinshelwood Prize 2004, Philip Leverhulme Prize in 2005, SAOT Research prize in optics, 2008, and the Morris Sugden award in 2013. Kaminski is co-founder and co-director of the Cambridge Advanced Imaging Center (CAIC) and director of CamBridgeSens, the strategic network to unite sensor research across the University of Cambridge. He is a Fellow of the Optical Society of America.

Principles and Applications of Superresolution Microscopy

TIME: MONDAY, 17:00 AND WEDNESDAY, 09:00

In this set of lectures I will introduce the principles of optical superresolution microscopy, which permit information to be retrieved on spatial scales much smaller than the wavelength of light. These 'diffraction unlimited' fluorescence methods work by modulating the fluorescence emission between on- and off-states. In stimulated emission depletion (STED) microscopy, this is achieved by depleting the excited states of fluorophores in the periphery of an excitation beam. In Structured illumination microscopy (SIM), a periodic intensity pattern is used to illuminate the sample fluorophores. This generates beat frequencies that shift high spatial frequency information into the pass band of the microscope imaging system. Finally, in single molecule localization microscopy techniques such as stochastic optical reconstruction microscopy, STORM, fluorophores in the sample are switched on and off sequentially in time, and only sparse subsets are sampled simultaneously, so that there is a negligible chance of overlap between the emission patterns from individual fluorophores. I shall discuss the physical principles of these techniques, their potential and limitations. Finally I will illustrate the use of these techniques with examples from our own research into the molecular mechanisms of neurodegeneration (1-5) and viral diseases (6).

1. Pinotsi D, et al. Nano Letters (2013), 14 (1), 339–345
2. Kaminski Schierle GS, et al. J. Am. Chem. Soc., 133 (33), pp 12902–12905 (2011)
3. Esbjörner, E.K., et al. Chemistry & Biology (2014).
4. Kaminski Schierle GS, et al. ChemPhysChem, 12(3), 673–680, (2011)
5. Michel CH, et al. J. Biol. Chem. (2014), 289: 956-967.
6. Laine R F. , et al. Nature Communications (2015), 6:5980

Speaker Bios & Abstracts

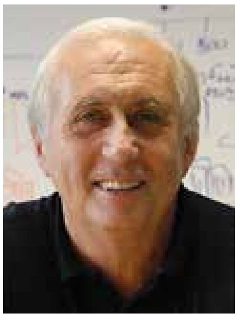
Franz Kärtner heads the Ultrafast Optics and X-rays Division at the Center for Free-Electron Laser Science (CFEL) at DESY, Hamburg, and is Professor of Physics at University of Hamburg and Adjunct Professor of Electrical Engineering at Massachusetts Institute of Technology (MIT). Prof. Kärtner received all his degrees in Electrical Engineering from Technical University in Munich, Germany. He held positions at ETH Zurich, Karlsruhe Institute of Technology and MIT. His research interests are in classical and quantum noise in electronic and photonic systems, ultrashort pulse generation, precision timing distribution, optical waveform synthesis, high energy THz generation and its applications to attosecond science and compact attosecond hard X-ray sources. He has authored or co-authored more than 280 peer-reviewed journal publications, four book chapters and holds or has applied for 26 patents. He is a fellow of the Optical Society of America and the Institute of Electrical and Electronics Engineers.

Low Jitter Femtosecond Lasers and Their Applications

TIME: TUESDAY, 11:00 AND FRIDAY, 14:00

The low noise properties of femtosecond lasers has lead to major technological revolutions over the last two decades: The femtosecond laser frequency comb for which the 2005 Physics Noble Prize was awarded, femtosecond level timing distribution systems for large scale science facilities and coherent synthesis of optical waveforms both at high and low pulse repetition rates. In a first lecture, we will elucidate how femtosecond pulses are generated, why femtosecond laser pulse trains have such low noise and especially low timing jitter and how to characterize this low timing jitter. In a second lecture we will apply it to femtosecond laser frequency combs, femtosecond level timing distribution systems for X-ray free-electron lasers, coherent pulse synthesis from femtosecond lasers as well as high energy optical waveform synthesis. As an outlook we discuss what integrated femtosecond laser technology can potentially do for next generation optical signal processing systems.

Speaker Bios & Abstracts



Anatoly Grudinin has started his work in the area of fiber optics in 1980 when he joined Physical Lebedev's Institute Russian Academy of Science (FIAN) after graduation from Moscow State Technical University. He was one of first researchers who studied nonlinear properties of silica fibers and nonlinear dynamics of picosecond and femtosecond pulse evolution in both passive and active single-mode optical fibers.

In 1992 Anatoly has joined Optoelectronics Research Centre at University of Southampton where his main areas of interest were in ultrafast fiber lasers, high power fiber laser and amplifiers. Over his scientific carrier Anatoly published over 200 papers and gave numerous invited talks at major international conferences (CLEO, OFC, ECOC, Photonics West).

In 2003 Anatoly left his professor's chair at the ORC and founded Fianium, a fiber laser company focused on development and volume manufacturing of ultrafast fiber lasers for bio-medical and industrial applications. A turning point in development of his company was a phone call in 2004 from a professor from University of Southampton with an enquiry if Fianium can make a supercontinuum fiber laser for his research project. At that time the laser did not exist. Since then Fianium have sold more than 1500 units of supercontinuum lasers

Ultrafast fiber lasers: the hunt for a killer application

TIME: TUESDAY, 14:00

In this talk we review latest developments and applications of picosecond and femtosecond fiber lasers. Considered for a long time as emerging technology with high scientific interest and tremendous potential, ultrafast fiber lasers are now widely used in a growing number of applications. Motivated by rapid improvement of performance and attractive features such as compactness and low ownership cost, ultrafast fiber lasers now challenge conventional DPSS ultrafast sources across numerous industrial sectors. Matured fiber laser technology also enables development of unique sources such as supercontinuum lasers capable of enabling scientific discovery as well as replacing incumbent illumination technologies within industrial instruments and systems. Results are being realized but the hunt continues.

Speaker Bios & Abstracts

Marie-Emmanuelle Couprie is graduated from École Normale Supérieure, PhD (1989), and she received her Habilitation at Orsay University in 1997. She has more than 25 years of experience in synchrotron radiation and Free Electron Laser (FEL). She first worked on storage ring FELs, ACO and Super-ACO (France) and demonstrated the first FEL applications in UV and two-colour applications with VUV synchrotron radiation. She has collaborations with Russia (VEPP3), Japan (UVSOR) and Italy (ELETTRA & SPARC). On SPARC, she demonstrated the first seeded FEL using high-harmonics generated in gas-jet.

At Synchrotron SOLEIL (france) she leads the "Magnetism & Insertion device" group and supervises the LUNEX5 project for the development of a compact FEL, for which she recently received an ERC grant. This project involves several R&D program across Europe.

Presently, she is a member of the Administration Council of French Physical Society and of the Accelerator Group of European Physical Society. She received the Aumale Prize (1993), the prize of the Interdivision of Accelerator and Associated Technologies / French Physical Society (2001) and the International FEL prize (2001). In 2002, she became a Chevalier of the order of Academic Palms.

An example of exotic laser system : free electron laser

TIME: WEDNESDAY, 11:00 AND FRIDAY, 09:00

More than 50 years after the lasers discovery and more than 30 years after the first Free Electron Laser (FEL), VUV-X light sources are actively developed around the word. Besides X-ray laser and High order Harmonic Generation in Gas or on solid targets, accelerator based light sources rely on synchrotron radiation generated from charged particles in bending magnets or undulators, creating a periodic permanent magnetic field. On storage ring based synchrotron radiation based facilities, a certain degree of transverse coherence is achieved. In FELs, the spontaneous emission comes from the synchrotron radiation from an undulator; the longitudinal coherence is achieved by setting in phase the electrons, thanks to an energy exchange between the electrons and a light wave resulting in bunching and gain for light wave amplification. FELs offer femtosecond intense tuneable light. First, the processes and properties of FEL will be described. Then, a panorama of existing facilities (such as LCLS and SACLA in the 1-0.1 nm spectral range, and in the VUV soft X-ray region FLASH and FERMI, first seeded FEL open for users) and development will be drawn.

Speaker Bios & Abstracts

Eli Kapon received his Ph.D. in physics from Tel Aviv University, Israel in 1982. He was a Chaim Weizmann Research Fellow at Caltech, Pasadena (1982-1984) and a member of technical staff and District Manager at Bellcore, New Jersey (1984-1993). Since 1993 he has been Professor at the Swiss Federal Institute of Technology in Lausanne (EPFL), where he heads the Laboratory of Physics of Nanostructures. In 1999-2000 he was a Sackler Scholar at Tel Aviv University, Israel, where he helped establishing the Tel Aviv University Center for Nanoscience and Nanotechnology, serving as its first Director till 2002. In 2001 he founded the start up BeamExpress, serving as its Chief Scientist. His research interests include quantum- and nano-photonics and vertical cavity semiconductor lasers. He is Fellow of the Optical Society of America, the Institute of Electrical and Electronics Engineers, and the American Physical Society of America, a recipient of a 2007 Humboldt Research Award, and a Photonics Society Distinguished Lecturer (2105-2016).

Semiconductor Lasers: Physics and Technology

TIME: THURSDAY, 11:00 AND FRIDAY, 11:00

Since the first observation of lasing in semiconductors in 1962 followed by the crucial development of heterostructure lasers in the 1970's, semiconductor lasers have become one of the most important laser sources in use. Their distinct characteristics include efficient conversion of electricity to light, wide spectral range and tunability of emission wavelength, direct current modulation, monolithic with other optoelectronic and electronic components, high reliability, and mass production leading to low manufacturing costs. These features have allowed a wide range of applications of diode lasers, from optical communications to optical spectroscopy, material processing, physical and chemical sensing, medical diagnosis and treatment, and more. These lectures will describe the structures, physical mechanisms and device characteristics involved in semiconductor lasers. The fundamentals of optical gain and lasing in semiconductors will be developed, and the major device categories and their fabrication technologies will be presented. Special designs yielding particular performance features such as low power consumption, high output power, high spatial coherence, high spectral purity, short pulse generation and large modulation bandwidths will be reviewed and discussed in the context of their applications.

Speaker Bios & Abstracts

Alexander Killi received the Diploma degree in electrical engineering from the University of Karlsruhe, Germany, in 2002 and the Ph.D. degree in physics from the Ruprecht-Karls-University, Heidelberg, Germany, in 2005. Since then he is with TRUMPF Laser GmbH, Schramberg, Germany, working on high power lasers and leading the disk laser development group from 2007. In 2010 he became head of the laser research department.

TRUMPF Solid State Lasers

TIME: THURSDAY, 14:00

TRUMPF is a leading manufacturer of solid state lasers for industrial material processing. Our product portfolio ranges from high power CW lasers for welding and cutting over ns-lasers with kW-average power to ultrafast lasers for micro applications. The technology base used for the products is covering the most important laser geometries: Disk lasers, fiber lasers, rod lasers and direct diode lasers. In this talk we will present an overview of the solid state laser technology development at TRUMPF and will show some of the latest advances. In especially we will highlight progress in high power disk laser technology enabling high performance laser cutting machines. Green CW and long pulsed disk lasers that are especially well suited for Cu-welding are introduced. Multi 100W average power UV disk lasers in the ns regime can be used for annealing and lift off processes, e.g in display manufacturing. Fiber and disk lasers in the ps and fs regime can be used to cut almost any material without significant heat generation and thus with extremely high quality.

Siegman International School on Lasers

General Information & Locations

Student Housing Check-In and Registration

AMBERGER CONGRESS CENTRUM (ACC) FOYER AREA

Students will receive program materials, Conference Center map, and information on Amberg, Germany.

Sessions

ACC LARGE LECTURE HALL

Poster Sessions

ACC FOYER AREA

Opening Reception

ACC FOYER AREA

Students are invited to join the Siegman School attendees for a welcome reception in the Foyer of the ACC. Attire is casual.

Breakfast

ARCADIA HOTEL AMBERG

Coffee Breaks, Lunch and Dinner (on Monday, Tuesday, Thursday and Friday)

ACC MAIN FOYER

Lunch (Wednesday)

Box lunches will provided for the bus ride to MPI

Dinner and Social Event (Wednesday)

ENTLA'S KELLER — A traditional experience with historic building tour

Farewell Banquet (Friday)

ACC MAIN FOYER AREA or outdoors on the patio (weather permitting)

Agenda

SUNDAY, 2 AUGUST

15:00 - 17:00	**Student Housing Check-In and Registration**
17:00 - 21:00	**Opening Reception**

MONDAY, 3 AUGUST

07:00 – 08:00	**Registration**
08:00 – 09:00	**Breakfast**
09:00 – 09:30	**Welcome Remarks**
09:30 – 10:30	**Vahid Sandoghdar** Ultrasensitive Coherent Detection of Single Biomolecules and Quantum Emitters
10:30 – 11:00	**Coffee Break**
11:00 – 12:00	**Marlan Scully** The Photon Statistics of the Laser and Its Close Connection with the Atom Statistics in a Bose Condensate
12:00 – 12:30	**Discussion**
12:30 – 14:00	**Lunch**
14:00 – 15:00	**Jens Limpert** High Performance Ultrafast Fiber Lasers
15:00 – 15:30	**Discussion**
15:30 – 16:00	**Coffee Break**
16:00 – 17:00	**Roel Baets** Silicon Photonics: Basics and Applications in ICT and Life Sciences
17:00 – 18:00	**Clemens Kaminski** Principles and Applications of Superresolution Microscopy

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Agenda

MONDAY, 3 AUGUST, CONTINUED

18:00 – 18:30	**Discussion**
18:30 – 19:30	**Poster Set-up**
19:30 – 21:00	**Dinner**

TUESDAY, 4 AUGUST

08:00 – 09:00	**Breakfast**
09:00 – 10:00	**Vahid Sandoghdar** Ultrasensitive Coherent Detection of Single Biomolecules and Quantum Emitters
10:00 – 10:30	**Discussion**
10:30 – 11:00	**Coffee Break**
11:00 – 12:00	**Franz Kärtner** Low Jitter Femtosecond Lasers and Their Applications
12:00 – 12:30	**Free Time**
12:30 – 14:00	**Lunch**
14:00 – 15:00	**Anatoly Grudinin** Ultrafast Fiber Lasers: The Hunt For a Killer Application
15:00 – 15:30	**Discussion**
15:30 – 16:30	**Marlan Scully** The Photon Statistics of the Laser and Its Close Connection with the Atom Statistics in a Bose Condensate
16:30 – 17:00	**Discussion**
17:00 – 18:30	**Poster Session #1 with Refreshments**
18:30 – 19:30	**Free Time**
19:30 – 21:00	**Dinner**

Agenda

WEDNESDAY, 5 AUGUST

08:00 – 09:00	**Breakfast**
09:00 – 10:00	**Clemens Kaminski** Principles and Applications of Superresolution Microscopy
10:00 – 10:30	**Discussion**
10:30 – 11:00	**Coffee Break**
11:00 – 12:00	**Marie-Emmanuelle Couprie** An Example of Exotic Laser System: Free Electron Laser
12:00 – 12:30	**Free time**
12:30 – 14:00	**Lunch and Travel to MPL**
14:00 – 17:00	**Lab Tours and Chapter Presentation at MPL**
17:00 – 18:00	**Travel to Social Event**
18:00 – 22:00	**Dinner and Social Event**

THURSDAY, 6 AUGUST

08:00 – 09:00	**Breakfast**
09:00 – 10:00	**Roel Baets** Silicon Photonics: Basics and Applications in ICT and Life Sciences
10:00 – 10:30	**Discussion**
10:30 – 11:00	**Coffee Break**
11:00 – 12:00	**Eli Kapon** Semiconductor Lasers: Physics and Technology
12:00 – 12:30	**Free time**

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Agenda

THURSDAY, 6 AUGUST, CONTINUED

12:30 – 14:00	**Lunch**
14:00 – 15:00	**Alexander Kili** TRUMPF Solid State Lasers
15:00 – 15:30	**Discussion**
15:30 – 16:00	**Coffee Break**
16:00 – 17:30	**Industry and Academia Career Panel Discussion**
17:30 – 19:30	**Poster Session #2 with Refreshments**
19:30 – 21:00	**Dinner**

FRIDAY, 7 AUGUST

08:00 – 09:00	**Breakfast**
09:00 – 10:00	**Marie-Emmanuelle Couprie** An Example of Exotic Laser System: Free Electron Laser
10:00 – 10:30	**Discussion**
10:30 – 11:00	**Coffee Break**
11:00 – 12:00	**Eli Kapon** Semiconductor Lasers: Physics and Technology
12:00 – 12:30	**Free time**
12:30 – 14:00	**Lunch**
14:00 – 15:00	**Franz Kärtner** Low Jitter Femtosecond Lasers and Their Applications
15:00 – 15:30	**Discussion**
15:30 – 16:00	**Closing Remarks**
18:00 – 21:00	**Farewell Banquet**

Poster Session 1

QI JIN

The Interactions Between THz and Plasma Studied by Time-resolved THz Radiation-Enhanced-Emission-of-Fluorescence

The interactions between THz and plasma studied by time-resolved THz radiation-enhanced-emission-of-fluorescence, Qi Jin. Terahertz (THz) science and technology are attracting more researchers and scientists for they have numerous applications in non-destructive testing, biomedical imaging and security scanning. However, there are still some important physical mechanisms which haven't been fully understood in THz field up to now. Here we applied THz radiation-enhanced-emission-of-fluorescence (REEF) to investigate the underlying physical mechanisms behind the interactions between THz waves and laser-induced plasma. A single cycle of free space THz radiation, generated from a lithium niobate prism using the tilted pulse front scheme. The time-resolved THz wave and THz-REEF is measured. An increasing of fluorescence is seen when the THz pulse starts to temporally overlap with the laser pulse. The saturation effect of REEF signal and the polarization dependency of laser pulse are studied.

KYUNGMOOK KWON

Metal-Dielectric-Metal (MDM) Based Photonic Devices for Future Integrated Circuit

Over the last decade, we have seen enormous increase in the information capacity of data communication. The expansion of such information bandwidth and related energy consumption is expected to continue in an unprecedented way for the foreseeable future. Electronics alone, however, is not enough to process this tremendous amount of information with reasonable power consumption and space constraints. Integrated photonic devices offer an exciting solution to this problem by utilizing faster and low power optical signals in conjunction with well-established semiconductor fabrication technologies. In this presentation, I will demonstrate metal-dielectric-metal (MDM) based light emitting and detecting devices, which are important component for integrated optical communications.

In the first part, I will present the subwavelength-scale metallodielectric light source. Cavity effects are observed when a semiconductor nano-block is on a metal substrate, and the bottom metal substrate significantly enhances a spontaneous emission rate. Introducing an upper metal layer allows the metallodielectric nano-cavity to reach lasing condition with subwavelength-scale effective mode volume (~0.0064 cubic wavelengths) and physical volume (~0.017 cubic wavelengths). I also investigate a thermal issue of small laser with considering temperature dependent characteristics of the metallodielectric nano-cavity.

In the second part, electrically-driven plasmonic source, detector, and links will be presented. To electrically drive the plasmon source, InGaAs based metal-dielectric-metal (MDM) structure is embedded in the metal-insulation-metal (MIM) waveguides, and thin insulator layers in MIM waveguide only support plasmonic mode. In the presentation, plasmonic source and detector will be characterized at first, and then on-chip scale plasmon signal links will be demonstrated for future on-chip scale integration.

GUANGHAO SHAO

Nonlinear Frequency Conversion with Optical Vortices Using PPLN

The nonlinear frequency conversion of optical vortices is investigated through quasi-phase-matched (QPM) using periodically poled lithium niobate (PPLN). The orbital angular momentum (OAM) states are represented by Laguerre-Gaussian (LG) modes, characterized with the azimuthal and radial indices. Coupling wave equations are used to study the typical three-wave nonlinear interactions among the involved OAM modes. We find that both of the azimuthal and radial indices of the OAM states stay constant in most of the cases, just the same as energy and quasi-momentum conservations in normal QPM process. However, abnormal change of the radial index is observed when there is asynchronous nonlinear conversion in different parts of the beams. The QPM technique avoids the undesired walk-off effect in traditional birefringent phase matching, which could reserve high-quality LG modes. We believe the QPM is an effective way to convert, amplify, and switch OAM states in various optical vortex related applications.

Poster Session 1

MADHURA SOMAYAJI

Size Dependent Patterns in Depolarization Maps from Turbid Medium and Tissue

"There is a continued research interest in the use of polarization characteristics of the scattered light for optical characterization of tissue as well as for imaging through turbid medium. The polarization characteristics of any optical medium are quantified in terms of three polarization parameters viz. retardance (change in relative phase of the two orthogonal linear or circular polarizations), diattenuation (differential attenuation of the two orthogonal linear or circular polarizations) and depolarization (randomization of the polarization state of light). Since the concentration or the macroscopic arrangement of some of the constituents of the biological tissue such as collagen, glucose etc. gets altered in a number of diseases like cancer, diabetes, liver fibrosis etc., measurement of the polarization parameters of tissue can provide valuable diagnostic information. Similarly, morphological alterations such as changes in size shape and refractive index of tissue constituents resulting from diseases also lead to changes in the polarization properties which can also be used for imaging and diagnosis.

Mueller matrix measurements on turbid media can be used to quantify its polarization properties in terms of retardance, diattenuation and depolarization. In particular the depolarizing ability of such media, which is represented by the depolarization index, has been shown to be a useful diagnostic parameter. However, being a single valued metric, its dependence on host of tissue optical parameters makes it difficult to interpret. In this paper we show that a map of depolarization as a function of input polarization state parameters can be used to infer information about size of scatterer and order of birefringent and depolarizing layers in turbid medium. The experiments carried out on different mice organ tissues indicate that the depolarization characteristics of tissue is closely represented by depolarization properties of intralipid. We also observed that these maps do not vary in presence of absorption.

YU LIU

Innovative Fiber Probe for Laser Ablation of Tumor Cells

Minimally invasive treatments like laser ablation have now proved to be effective in curing early-stage malignant solid tumors. However, despite the significant advantages – fully compatibility with MRI, fast processing time, low costs and simplified implementation, laser ablation is still hampered mainly by the limited area that can be treated and the necessity of strict temperature control due to the variability of laser absorption and the cooling effect of blood vessels. To address these issues, we have recently developed an all-optical probe for laser ablation with simultaneous temperature sensing capabilities. Based on double-cladding fiber, the probe integrates FBGs for temperature sensing with the delivery of the ablation beam from laser diodes; moreover, the tip surface is properly micro-structured to shape the beam diffusion area and thus to adapt it to different tumor geometries and sizes. The combination of tailored beam delivery and real-time temperature monitoring have already proved in agar phantoms and porcine livers.

JIN-HUI CHEN

Platform for Enhanced Light –Graphene Interaction and Miniaturizing Microfiber Stereo Devices

The Dirac massless fermions nature of graphene has attracted much attentions since its first discovery in 2004. By utilizing properties of graphene such linear optical absorption, saturable absorption, and the tunable chemical potential through doping or electrical gating, various broadband applications, such as modulators, photo-detectors, polarizers and mode-locked fiber lasers have been realized. To achieve enough light-graphene interaction, most practical applications require graphene to be integrated with waveguide structure. Subwavelength-diameter microfibers (MF) with a strong evanescent field are attractive for graphene integration in fiber optics system, which can be realized by covering or wrapping a graphene sheet on a straight and thin MF. However, it is challenging to handle such a thin MF and graphene for sufficient length and strength of interaction. Using an MF-based lab-on-a-rod technique, we present a platform for ultra-long light–graphene interaction and design graphene-integrated helical MF devices. We have demonstrated an in-line fiber polarizer and single polarization high-Q fiber resonator based on graphene-MF hybrid structure. Further, we also achieve a state variable pulse fiber laser and an all optical switch based on the saturagle absorption of graphene. Our study may provide a path to the optoelectronic applications of graphene.

YUE PAN

Detuned Grating Single-mode Laser with High Immunity to External Optical Feedback

We propose a novel single-mode laser with high immunity to external optical feedback following the principle of active-filter tuned oscillator. Within the conventional Fabry-Pérot (FP) cavity, two tilted gratings with detuned Bragg wavelengths are embedded, which acts as a high-Q band pass filter. The simulations from the large signal dynamic model show that a stable single-mode operation can be achieved for the proposed device. Moreover, compared with the conventional index-coupled distributed feedback (DFB) lasers, the proposed device exhibits a much higher immunity to external optical feedback and its single-mode yield is also less sensitive to random changes of the effective phases at the end facets caused by cleaving.

AJANTA BARH

Design of Application Specific Microstructured Optical Fibers for Functional Mid-IR and THz Domain

In recent years, eye safe mid-infrared (mid-IR) spectral domain (2 ~ 10 μm) have become remarkably important owing to emerging potential applications in latest non-destructive medical treatments (like soft/hard tissue ablation, laser surgery for brain, nerve, eye, skin, etc.), monitoring of combustion gas flows, semiconductor processing, sensing, thermal imaging and a wide range of defense applications. Furthermore, this mid-IR window is also known as molecular fingerprint regime due to strong absorptions exhibited by a variety of organic/inorganic molecules (like As-H, O-H, HCHO, CH3COOH, CH3, CCl4, various hydrocarbons, hydrochlorides and commonly used solvents). Therefore it has become strategically important to develop efficient light sources, high power distortion free light guiding waveguides, and various guided wave components for this wavelength regime. Our primary research work is based on the theoretical design of various all-fiber components suitable for this functional spectral range. We have explored chalcogenide glass (S-Se-Te) based microstructured optical fibers (MOFs) for numerically designing high power light sources and waveguides for distortion free light guidance at mid-IR. The As2S3 and As2Se3 based MOFs are designed to produce discrete (~4.36 μm, 6.45 μm) as well as broad-band (3 – 4.2 μm, 5 – 6.3 μm) sources by exploiting nonlinear parametric process through proper tailoring of fiber dispersion and nonlinearity. Our result reveals that conversion efficiency of 20 - 40% is possible for different cases in a just meter length of fiber. Fiber nonlinearity in taper structures has been also explored to generate temporal parabolic pulse from a Gaussian laser pulse to enhance its power carrying capacity by reducing its tendency towards nonlinear optical wave breaking. For high power light guidance, we have also proposed a design of ultra-large mode area fiber, whose effective area can go up to almost 70,000 μm2.

More recently, we have started work on fiber based terahertz (THz) applications (under a trilateral collaborative project, funded by British Council). The frequency of THz radiation extends from 0.1 to 10 THz and only over the last 10 – 15 years, a tremendous interest has grown towards the THz-based active applications, ranging from medical tomography to security/defense applications. We have explored polymer (mainly Teflon) based MOFs to design THz sources and waveguides for high power transmission and achieved some exciting results quite recently.

BIENVENU NDAGANO

Propagation of Cylindrical Vector Beams Through Fibres

Light carrying orbital angular momentum (OAM) has been investigated for the past 20 years. The optical field of beams carrying OAM has been shown to be quantized; defining an infinite dimensional Hilbert space. As such there is an infinite amount of information that can be encoded onto such beams. We demonstrate

Poster Session 1

techniques to generate OAM carrying beams using spatial light modulators (SLMs), where the phase and amplitude are modulated. We also make use of an SLM to detect the amount of OAM present in a beam by spatial correlation filtering, also known as mode decomposition. Lastly, we investigated the effect of propagating these OAM modes through an optical fibre. Fibres have the advantage of being efficient for long distance communication and are not susceptible to atmospheric turbulence, which impedes the propagation of OAM beams. Optical Fibres possess intrinsic modes, known as the cylindrical vector (CV) modes. These modes display azimuthal symmetry in both field distribution and polarisation. We show that the polarisation and OAM density of the CV modes is preserved through the fibre and that the OAM and polarisation are non-separable before and after the fibre.

SERHII POLISHCHUK

The Influence of Dye and Scattering Centers Concentrations on Random Lasing Threshold

Random laser (RL) unlike other types of lasers uses highly disordered gain medium without optical cavity. That becomes possible due to multiple scattering which substitutes the positive feedback of a cavity. This type of a laser would potentially have small gain volume of arbitrary shape. The influence of dye and scattering centers concentrations on random lasing threshold is investigated. Sets of vesicular films with wide range of desired characteristics are the objects of investigation. The results provide understanding of optimal properties of RL gain media.

DAVID FERNANDO ORTEGA TAMAYO

Spatial Shock Wave Formation by Diffraction Effect in a Photorefractive Medium

We show experimental results for the propagation of a diffracted beam by a straight edge like initial condition in a photorefractive crystal under drift nonlinearity. We have observed that the diffracted pattern and propagation is enhanced in the form of multiple waveguides.

RIC JOHN OMBID

Analysis of Radiation Force Arising from Kerr Nanoparticle - Pulsed Gaussian Beam Interaction

Pulsed laser beam have more advantages compared to its counterpart, a continuous-wave laser. It has, in particular, emerged as a useful tool in optical trapping due to its minimal average power but with a high impulsive peak power. Other than that, radiation force does not depend on the pulse duration but on the relaxation time between consecutive pulses. With this, the nonlinear optical effects was produced in the trapped particles, which shows that the focal center is no longer single spot but instead it split into two equivalent position that is called "trap split." This nonlinear optical effects is considered to be the result of the two-photon induced luminescence. This shows that the nonlinear optical forces is greatly dependent on the relaxation time of the pulsed beam. When the beam died out between the relaxation time, it is the time that it induced nonlinear optical effects. However, during the turn-on time within the pulse width, the nonlinear effects dissipated.

KONSTANTIN TSAPENKO

As2S3–Silica Double-Nanospike Waveguide for Mid-Infrared Supercontinuum Generation

Chalcogenide glasses are promising materials for realizing compact devices in the infrared (IR) and mid-IR regions due to their high linear refractive index, high optical nonlinearity, and long-wavelength transparency.

Here we report an As2S3–silica hybrid double-nanospike waveguide in purpose of efficient mid-IR supercontinuum generation. The waveguide contains inverse nanotapers at both ends. The total length from tip to tip is 3 mm. The first nanospike is used to adiabatically convert the input beam to the fundamental mode of the waveguide with 1 µm core diameter. The output nanospike is used to reduce the output beam divergence as well as endface Fresnel reflection. By introducing the double-nanospikes, the total transmission of the waveguide can be as high as ~ 60%.

By pumping the waveguide using an Er-doped fiber laser at 1550 nm (60 fs), an over one-octave supercontinuum spectrum (from 0.9 um to 2.5 um) is measured. The required pump energy is only 38 pJ.

Poster Session 1

ANDREA ANNONI

Silicon Photonic Circuit Reconfiguration and Light Tracking by Means of Non-invasive Optical Probes

Complex reconfigurable integrated architectures is one of the next frontiers of photonic technologies but when component count is large, temperature and functional drifts as well as fabrication tolerances become critical and must be counteracted through local feedback control by tapping light from the circuit. This is not likely to be a viable route to large scale integration; we have demonstrated the possibility to monitor the light propagating in Silicon waveguides non-invasively by means of Contactless Integrated Photonic Probe (CLIPPs). Here we demonstrate the reconfiguration of a complex SiP circuit assisted by CLIPP monitors. Optical signals are routed through an 8×8 switch fabric by sequentially tuning feedback-controlled 2×2 switches monitored by 24 CLIPPs, simultaneously interrogated by an integrated CMOS ASIC bridged to the photonic chip, that enable to track the light path in each waveguide of the circuit.

SHAIMAA MONEM

Study of the Optical Properties of Solid Tissue Phantoms Using Single and Double Integrating Sphere Systems

Tissue simulators, the so called tissue phantoms, have been used to mimic human tissue for spectroscopic applications. Phantoms design depends on patterning the optical properties, namely absorption and scattering coefficients which characterize light propagation inside tissues. Two calibration models based on measurements adopting integrating sphere systems have been used to determine the optical properties of the studied solid phantoms. Integrating spheres measurements results were fed into the calibration models using the multiple polynomial regression method and Newton-Raphson algorithm. The third order polynomials have been used for optical properties predictions. Good agreement between the two models has been obtained. Role of solid phantoms' components, namely titanium dioxide as a scatterer and black carbon as an absorber, has been discussed. Both scatterer and absorber showed observable effects on the absorption and scattering of light propagating through the phantoms.

PREETI RANI

Slow Light with Ultra-flattened Dispersion in Slotted Photonic Crystal Waveguide

We propose a design of slotted PhC considering alternate arrangement of elliptical and circular air holes on SOI substrate exhibiting slow light with ultra-flat dispersion. The air hole radius of the basic structure has been chosen as 0.3a where 'a' is the lattice constant. The final parameters of the structure have been taken as 'A=0.41a' (semi major axis) and 'B=0.25a' (semi minor axis) of the elliptical air holes with slot width's = 0.3a'. The proposed structure has high group index and low group velocity dispersion with wide normalized bandwidth range which leads to the slow light effect. The proposed structure have constant group index of 75.5, 103.4 and 135.4 for the flat bandwidth of 3.5, 2.3 and 1.2nm around the wavelength of 1550nm with GVD of the order of 104 ps2/km. Hence,the proposed structure can be used as an optical buffer.

LEI LIAO

Evidence of Tm Influence on Photobleaching and Photodarkening Phenomenon in Ytterbium-doped Silica Double-clad Fiber

Abstract: We demonstrated a measurement technique to study the photodarkening phenomenon and photobleaching phenomenon pumped by 915nm and 793nm respectively. The recovery procedure became slow after the 793nm diode laser was replaced by 808nm. It suggests that the reversion of color centers during photobleaching is related to the absorption of the Tm^{3+} impurities in the Yb-doped fiber. Further, an experiment with Yb/Tm co-doped fiber also testified that Tm^{3+} should be responsible for the defect creation process as photodarkening.

NATASHA TOMM

Tremor Analysis using Speckle-Imaging Technique

The current method for detection of the tremors in the human muscles involves pain and great time. By introducing a method using Speckle Pattern Analysis, those disadvantages are overcome and exact frequency and amplitude of movements are determined.

Poster Session 1

ENKELEDA BALLIU

Passively Q-switched, Single Frequency, 20 µm core Yb-doped Fiber Amplifier

We demostrate a single frequency, nanosecond pulsed, single stage amplifier operating at 1064 nm by using an overall fiber core/cladding diameter of 20/125µm. The key component is a custom made, compact, passively Q-switched, single frequency, ring-cavity solid state laser (SSL) at 1064 nm used as a seed source. The single frequency Q-switched seed laser, has an ultra-low noise, low timing jitter and an excellent beam quality. Pulse durations between 9 and 30 ns and repetitions rates from 10 – 50 kHz have been evaluated in this work- The nanosecond pulses are amplified in a single amplification stage by using a short and highly Yb-doped polarization maintaining fiber. The non-linear effect of Stimulated Brillouin Scattering (SBS) is mitigated by applying a strain distribution technique to the active fiber, improving the final results by 4-5 times, resulting in average output powers up to 10W and pulse energies up to 337µJ.

ZACH MITCHELL

Energy Transfers in Photosynthetic Systems Studied via Ultrafast Transient Absorption Spectroscopy

Photosynthesis is a beautiful and complicated process that fuels a significant fraction of life on Earth. Despite playing such a critical role in sustaining life on this planet, the most fundamental details of its physical workings are still not fully understood. Key steps in the photosynthetic process occur between tightly packed molecules in the photosynthetic reaction center on timescales ranging from femtoseconds to microseconds. We observe these electron transfer and energy transfer processes via ultrafast transient absorption spectroscopy. Data extracted from the spectra give insight into the functions and roles of the molecules in the reaction center. However, photosynthesis takes place inside large protein complexes containing thousands of molecules, often making samples too spectrally congested for current techniques. A project involving the use of mutant reaction centers to alleviate this concern is discussed.

MARKUS WAHLE

Electrically Tunable Group Velocity Dispersion in Liquid Crystal Infiltrated Photonic Crystal Fibers

Infiltrating photonic crystal fibers with liquid crystals allows for electrical control over the waveguiding properties. This can be used for nonlinear optical effects like four wave mixing (FWM) because the dispersion of the waveguide can be influenced in order to realize a tunable FWM source.

MARIANNA KOVALOVA

Generation-recombination Processes in InGaAs/GaAs Heterostructures with Nanowires

Structures with one-dimensional quantum objects in intermediate band are promising for their application in solar cells and photodetectors. We present analysis of dark current-voltage characteristics, photo-voltage decay and photo-voltage spectra for this structures in comparison with reference GaAs based structures. It has been shown that InGaAs quantum wires make a significant influence on J-V dependences and photo-voltage spectra. InGaAs QWRS are additional recombination centers and transitions between them dominated over by Shockley-Read-Hall recombination at low bias. The InGaAs/GaAs sample shows a significantly higher photo-voltage in the spectral range of 1.25-1.37 eV, as compared to a reference GaAs p-n junction, due to intermediate band transitions in the quantum wires.

JULIEN POUYSEGUR

Generation of Sub-100 fs Pulses in a Yb:CALGO Regenerative Amplifier

Ultra short pulse down to 100 fs has been obtained in a regenerative amplifier using Yb doped CALGO crystals. By employment of nonlinearity we succeed to overcome gain narrowing limitation.

Poster Session 1

GEORG EPPLE

Rydberg Atoms Inside a HC-PCF

The exceptionally large polarizability of highly excited Rydberg atoms uniquely enables long-range interactions between atoms, such as the Rydberg blockade. These properties make them of great interest for sensitive electric field sensors or for optical non-linearities down to the single photon level. A promising way to realize technically feasible, miniaturized devices that operate at room temperature, is the excitation of Rydberg atoms inside a HC-PCF. Recently, we demonstrated coherent three-photon Rydberg excitation in a caesium vapour confined in different kagomé structured HC-PCF. Our current work focuses on understanding and minimizing the interactions between these highly sensitive Rydberg atoms and the confining fibre.

KAROLINA DOROZYNSKA

Designing an Experiment to Investigate Slow Light Effects in Whispering Gallery Mode Resonators

"Slow light and Whispering Gallery Mode Resonators (WGMRs) are two interesting and useful fields with applications in, e.g. optical sensing. By combining the two fields an attempt to achieve ultra-high Quality (Q) Factors and ultra-narrow resonance linewidths is made.

Using a Rare-Earth-Ion doped crystal, formed into a disc shaped WGMR, the intention is to spectrally hole burn the crystal in order to create slow light structures in it. The aim of this work is to design and test a setup where Spectral Hole Burning (SHB) and efficient WGMR coupling can be achieved. Results, at room temperature, were taken for wavelengths between 593.1-610.4nm to investigate the effect of the ions wavelength dependent absorbance, on the losses. The coupling efficiency was observed to try and understand the effects of various parameters on it. Future measurements will look for any changes in the Q-Factor value at cryogenic temperatures after SHB, which can be attributed to slow light effects alone."

SEYEDREZA HOSSEINI

Fundamental Performance Tradeoffs for Reverse Biased Free Carrier Plasma Dispersion Effect Based Silicon Optical Modulators

Design rules for optimizing reverse biased free carrier plasma dispersion effect based modulators are investigated using an analytical approach to model modulation efficiency, bandwidth, and insertion loss coefficient of modulators.

Simple RC model, which only considered PN junction capacitance and series resistor, and complete circuit model considering parasitic capacitances of a carrier depletion based optical modulators are studied. Modulation efficiency and bandwidth of the modulators are investigated using analytical models and numerical simulations respectively.

Several limitations of optical modulators designing have been studied. There are two general output features which should be properly designed in order to get best performance: operational bandwidth and modulation efficiency. These two characteristics are dependent to many parameters such as bias voltage, impurity doping level and modulator's shape.

TOBIAS STEINLE

All-optical Modulation by Period Multiplication in a Synchronously-pumped Optical Parametric Oscillator

We present the first observation of period multiplication in a synchronously-pumped OPO, enabling all-optical modulation for ultrafast pulses at 20.5 MHz. The modulation is driven by nonlinear effects, mainly self-phase-modulation in an intracavity feedback-fiber. By varying the output coupling ratio and pump power, a rich variety of nonlinear dynamics including limit cycles, period multiplication, chaos, and optical bistability can be explored. Up to 400 mW signal power are extracted in the period-2-state with an amplitude modulation depth close to 50%.

Pump-probe spectroscopy without external modulator is shown in a stimulated Raman scattering (SRS) experiment. The frequency-doubled OPO signal (750 – 820 nm) is employed as SRS-pump, while the Yb:KGW pump laser (1033 nm) serves as SRS-Stokes. We demonstrate broadband tuning (2500 – 3500 cm-1) by the acquisition

Poster Session 1

of the SRS-spectrum of acetone and stable long-term operation over 45 min by taking an SRS image of PM-MA-beads.

EVELYN STRUNK

Coherent Revivals of Nonlinear Refractive Index Changes in Carbon Disulfide Vapors

Carbon Disulfide (CS2) has been studied in nonlinear optics (NLO) for many years but typically in liquid form. The experiments I am performing study CS2 in vapor form. I am utilizing the beam deflection technique which is an extremely sensitive technique shown to be sensitive to one 20 thousandth of a wavelength. This same experiment has been performed and revivals of the refractive index were observed in the components of air, nitrogen and oxygen, using femtosecond excitation. When the molecules are excited with the femtosecond excitation beam (essentially giving the impulse response function of the molecules), liquid molecules rotate but are restricted by the surrounding molecules; however, in vapor form, the molecules are able to make many complete revolutions. We are able to see the nonlinear refractive response of the carbon disulfide vapors for many 10's of picoseconds. I will present analyses of these results.

GABRIELA SALAMU

Efficient Laser Emission from Waveguides Inscribed in Nd-doped Media by Femtosecond-Laser Writing Technique

In this work we report on the realization of depressed cladding waveguides in Nd-doped laser media by direct writing with a fs-laser beam.The first waveguides were fabricated by a classical step-by-step translation technique. Using the pump at 808 nm with a fiber-coupled diode laser we have obtained efficient laser emission at 1.06 and 1.3 microns from circular waveguides inscribed in Nd:YAG. Further, we have developed a novel technique in which the laser medium is moved on a helical trajectory during the writing process. We applied this arrangement to inscribe, in Nd:YAG ceramics, cylindrical waveguides with improved laser performances than those of similar waveguides realized by the classical method. Circular depressed cladding waveguides were also inscribed in Nd:YVO4. These results show that depressed cladding waveguides inscribed by fs-laser writing techniques can be a solution for realizing of diode-pumped compact lasers.

STEPHEN WOLF

2um Degenerate OPO's for Dielectric Particle Accelerators

We present the work our group is doing in order to power scale 2um degenerate optical parametric oscillators (OPOs). Such devices are methods of taking a frequency locked pump (1um in our devices) and transferring the frequency comb properties to wavelengths deeper in the infrared. The current use of these devices will also be discussed, where we use the ultrafast 2um radiation (around 50fs) to drive a dielectric particle accelerator.

JOHNSTON K. KALWE

Exploiting Cellophane Birefringence to Generate Radially and Azimuthally Polarized Vector Beams

We exploit the birefringence of cellophane to convert a linearly polarised Gaussian beam into either a radially or azimuthally polarised beam. For that, we fabricated a low-cost polarisation mask consisting of four segments of cellophane. The fast axis of each segment is oriented appropriately in order to rotate the polarisation of the incident linearly polarised beam as desired. To ensure the correct operation of the polarisation mask, we tested the polarisation state of the generated beam by measuring the spatial distribution of the Stokes parameters. Such a device is very cost efficient and allows for the generation of cylindrical vector beams of high quality.

Poster Session 1

A. A. RIFAT

Flat Fiber Based Surface Plasmon Resonance Sensor

A simple liquid analyte filled multi-core flat fiber (MCFF) based Surface Plasmon Resonance (SPR) refractive index sensor is proposed. Chemically stable gold (Au) and titanium dioxide (TiO2) layers are used outside the fiber structure to realize a simpler detection mechanism. Guiding properties and sensing performance are numerically investigated by Finite Element Method (FEM). Proposed sensor shown the average wavelength interrogation sensitivity of 9,600 nm/RIU (Refractive Index Unit) and highest sensitivity of 23,000 nm/RIU in the sensing range of 1.46-1.485 and 1.47-1.475, respectively. Moreover, refractive index resolution of 4.35×10-6 is demonstrated. Additionally, maximum amplitude interrogation sensitivity of 820 RIU-1 with the sensor resolution 1.22×10-5 RIU are obtained. The proposed MCFF SPR sensor allows real time sensing and monitoring, ultimately enabling inexpensive and accurate chemical and biochemical analytes detection.

MAITREYI UPADHYAY

Electromagnetic Wave Interaction with One Dimensional Photonic Crystal: An Analytical Approach

The propagation of electromagnetic waves in two-layer structure is investigated. The systematic dependence of the reflection coefficient on the parameters characterizing the structure is studied in detail. Using results of this theoretical analysis we investigate the influence of variation of the structure parameters on the reflection coefficients. As an example we considering one dimensional (1D) superconductor dielectric photonic crystal (SDPC), we consider the changes in the structure parameters under changing temperature of superconductor material. We show that under theoretical conditions the reflection of the electromagnetic wave can be changed by creating a changing refractive index inside the structure. This study also provides some insight into the design of new kind of thermally tunable optical devices which have potential applications in modern communication systems.

AURA HIGUERA R.

Densely Integrated Nano-beam Lasers for Optical Interconnects

Dense laser integration is an increasing necessity for communication systems. However, while dense small lasers bring advantages as smaller footprints and threshold currents, it raises challenges due to the shortening of the gain section, which in turn raises the series resistance, requires very efficient mirrors and tight fabrication control. Consequently, high density deployment in an on-chip scheme is not limited by the device footprint but by the high serial resistance of micro-nano-scale-lasers.

During our research we have designed III-V semiconductor nano-beam lasers at 1550 nm. The devices comprise 1D photonic crystal holes and few microns of cavity length. Based on 3D FDTD simulations, Q factors around 1200 and optical differential efficiencies up to 80% are possible for 5μm length cavities."

JAKUB BOGUSLAWSKI

Sub-200 fs Dissipative Soliton Er-doped Fiber Laser Mode-locked by Sb_2Te_3 Topological Insulator

Saturable absorber (SA) is responsible for ultrashort pulse generation in passively mode-locked lasers. Up to date, the most widespread solution is based on semiconductor materials in the role of SA. However, the technology is very complicated and expensive. Narrow operation bandwidth is yet another limitation. Here we applied the topological insulator (TI) in the role of a SA for fiber laser. We demonstrated the dissipative soliton generation in 1.55 μm spectral range in Er-doped fiber laser mode-locked by antimony telluride (Sb2Te3) TI SA. Topological insulators are characterized by broadband saturable absorption. The use of TI makes the device simpler, cost-effective and versatile. The Sb2Te3 was deposited on a side-polished fiber (D-shaped). This design enables the interaction of deposited layers with evanescent field of propagating beam, which enhances the damage threshold. Pulses as short as 197 fs with 32.5 nm FWHM optical bandwidth are generated in near-zero dispersion regime.

Poster Session 2

NARESH KUMAR THIPPARAPU

Progress Towards Development of Efficient Bi-doped Fiber Lasers and Amplifiers

Development of lasers and amplifiers in new wavelength regions have been the research interest for decades. Bi-doped fibers paved the way to develop lasers and amplifiers in 1150-1500nm wavelength range owing to its broad luminescence characteristics. Bi-doped aluminosilicate, phosphosilicate and germanosilicate fibers have shown luminescence around 1150nm, 1300nm and 1450nm respectively (I. A. Bufetov, et al., 2014) . Here, we present the fabrication of Bi-doped fibers with aluminosilicate and phosphosilicate hosts by the MCVD-solution doping technique. These fibers were characterised for absorption and unsaturable loss. The obtained results were used to select appropriate pump wavelength for laser and amplifier development. A Bi-doped aluminosilicate fiber amplifier has been demonstrated with a maximum gain of 8dB at 1180nm. In addition, a 22mW Bi-doped phosphosilicate fiber laser operating at 1360nm has been reported with a laser efficiency of 11% by direct diode pumping at 1267nm.

PRINCE SUNIL THOMAS

Concentration Dependent Thermal Diffusivity Measurement of Green Synthesized Silver Nanoparticles using Dual Beam Thermal Lens Technique

A dual beam thermal lens technique is used to probe the thermal diffusivity of silver nanofluids prepared via green synthesis of hibiscus leaves. It is found that the thermal diffusivity of silver nanofluid increases with increase in concentration.

Keywords : Thermal lens; Thermal diffusivity ; Green synthesis

PAUL DUMONT

Low-noise dual-frequency Laser at 852 nm for CPT Atomic Clocks

We report the dual-frequency and dual-polarization emission of an optically-pumped vertical external-cavity semiconductor laser (OP-VECSEL). Our laser source provides a high-purity optically-carried RF signal tunable in the GHz range, and is specifically designed for the coherent population trapping (CPT) of Cs atoms in compact atomic clocks. The laser spectrum is stabilized onto a Cs atomic transition at 852.1 nm, and the frequency difference is locked to a local oscillator at 9.2 GHz. Special attention has been paid to the evaluation of the frequency, intensity and phase noise properties. A maximum phase noise of -90 dBrad²/Hz has been measured. Finally, we estimate the contribution of the laser noise on the short-term frequency stability of a CPT atomic clock, and predict that a value below 3 × 10-13 over one second is a realistic target.

GUILLAUME SCHIMMEL

Coherent Combining of Two High-brightness Laser Diodes Phase-locked by a Michelson-type External Cavity

We describe a new coherent beam combining architecture based on passive phase-locking of emitters in an external cavity on their rear facet, and their coherent combination on the front facet. Two high-brightness high-power tapered laser diodes have been coherently combined as a proof-of-principle, using a Michelson-based cavity – the combining efficiency is above 80% and results in an output power of more than 6 W. The phase-locking range, and the resistance of the external cavity to perturbations have been thoroughly investigated. Thus, the combined power has been stabilized with an automatic adjustment of the driving currents. We believe that this new configuration combines the simplicity of passive self-organizing architectures with the optical efficiency of master-oscillator power-amplifier ones.

Poster Session 2

MARIAFERNANDA VILERA

Longitudinal Multimode Instabilities in Master Oscillator Power Amplifier: Experiments and Theory

This research work focus on the experimental characterization and theoretical modelling of high-brightness semiconductors lasers, especially on integrated Master Oscillator Power Amplifier (MOPA) devices. The MOPA architecture is a promising candidate for applications requiring high power and good spectral purity such as LIDAR and free space optical communications. Nevertheless, the usefulness of MOPA devices can be jeopardized by several spectral instabilities even in CW operation regime. The objective of this work is to ascertain the origin of these instabilities, how they affect the device performance under modulation and in pulsed regime and how can they be avoided.

CHUNSHENG LI

A Novel Planar Waveguide Super-Multiple-Channel Optical Power Splitter

In this paper, we have proposed a novel planar waveguide optical power splitter design with a large number of splitting channels. The design uses the wavefront lateral interference in light propagation in a slab waveguide, with its cladding properly adjusted in different areas for achieving different effective indices for the required phase delays. Therefore, the whole structure is equivalent to a non-blocking all-pass filter, hence suffers very small insertion loss. Another unique advantage of this structure lies in its almost constant length irrespective of the number of splitting channels, although its lateral size has to be scaled up as the channel number increases, as opposed to conventional splitters with both of its length and lateral size scaled up with increasing channel numbers.

YANGJIE LIU

Infinite Maxwell Fisheye as a Complement for an Imaging Device

This poster proposes a new imaging medium via isotropic refractive index of heterogeneous medium. We exploit conformal-map to transfers the full Maxwell fisheye into a mapped profile within a unit circle. The imaging resolution of this new profile can be maintained as good as the mirrored Maxwell fisheye profile or its conformally-mapped counterpart in previous literature.

The aim of this work is to removal the mapped mirror in a conformally-mapped profile of imaging to compare their resolution. The result shows that the removal keeps the resolution to a fifth of wavelength.

DHIRENDRA KUMAR

Phase-only Computer-generated Fresnel Hologram Synthesis Using a Symmetrical Three Dimensional GS Algorithm

A method for synthesizing phase-only computer-generated Fresnel hologram (PCGFH) of multi-plane object has been discussed. Modified Gerchberg Saxton (GS) algorithm has been used to extract phase in the Fresnel domain. In this scheme, a random phase is taken as the input which is Fresnel transformed. The object in first plane is substituted in the Fresnel diffracted random phase, which is then inverse Fresnel transformed. The same process is repeated for the second plane to complete the first iteration. The obtained PCGFH is reconstructed to obtain the desired objects in respective planes. It can be seen that with the discussed symmetrical three dimensional GS algorithm, distortion in image is eliminated and the image quality also improves. Diffraction efficiency and root mean square error is calculate to evaluated the performance of the reconstructed image.

Poster Session 2

SHAMPY MANSHA

Design of Random Quantum Cascade Lasers

Random Lasers (RL) are lasers which confine light through multiple scattering in a random optical medium, rather than a well-defined cavity. Due to their low spatial coherence they can have potential applications in imaging and sensing. Though RL have been extensively studied in the visible & UV spectrum, the first mid-infrared RL has only been demonstrated recently using a quantum cascade (QC) wafer with etched air holes acting as scatterers. However the device suffers from low Q-factors and lacks the multimode emission behavior which is desired for applications. QC lasers can support only TM modes and we show that system with air holes is unfeasible for high-Q TM modes. Through full-wave simulations we show that designs in which dielectric rods are connected by veins can support high-Q TM modes- enhancement by two orders of magnitude -,as these systems have pseudo band gaps. These designs can be used as the basis for multimode QC RL operating at mid-infrared or terahertz frequencies.

PAVEL KOŠKA

Mode Field Adapter for Low-loss Fiber-bundle Pump and Signal Combines and Optimization of Pump Absorption in Double Clad Rare Earth Doped Fibers

In the first part of our contribution we present a new type of mode field adapter for a signal branch of fiber-bundle signal and pump combiners. Proposed combiner allows optimization of signal-mode matching between input signal fiber and output double-clad fiber core with different profiles of fundamental mode. We used advanced optimization technique to optimize our theoretical design and achieved signal loss of 0.16 dB. Second part of our contribution is focused on numerical analysis of pump absorption efficiency in double clad active fibers. We show that absorption tends to ideal limit under the conditions of simultaneously twisted and coiled fiber with a broken circular symmetry.

PERRY VAN SCHAIJK

Design of Feedback Insensitive InP Ring Laser

It is well known that semiconductor lasers are highly susceptible to optical feedback. Normally this is solved by using an optical isolator. Good optical isolators cannot be integrated on a photonic integrated circuit however. In order to solve this problem we propose to fabricate a feedback insensitive laser. Analysis of the rate equations show that such a device can be realized by employing a ring laser in which the clockwise and counterclockwise modes are not optically coupled except by the feedback. To achieve unidirectional lasing, this work proposes to use a device that acts as a frequency modulator if light travels in one direction, and is transparent if it travels in the other. When combining this device with an optical filter, a differential roundtrip gain can be achieved. Simulations show that up to 3% of intensity feedback can be tolerated without any distinguishable effect on the laser light. More feedback mainly reduces the amount of output power.

STEFANIE DIERMEIER

Structure-related Force Deficit Predicted by Quantitative Multiphoton Microscopy of Single Muscle Fibres from an Animal Model of Human Desminopathy

Degenerative muscle diseases result in progressive weakness, but it is not clear if the force deficit is induced by structural remodeling. We examined structural changes in a myopathy using force-predicting optical parameters. The myosin architecture of our R349P mouse model for the human R350P desminopathy was imaged by Second Harmonic Generation microscopy. Structural changes of single muscle fibres were quantified by a measure for sarcomere lattice disruptions called 'vernier density' and a descriptor of myofibrillar misalignment called 'cosine angle sum'. We found a deranged myofibrillar architecture and an age-dependent progression in R349P mice, which corresponds to the late phenotype of the human disease. Therefore, our data suggest a high influence of the structural changes on the force-deficit in human desminopathy. The authors gratefully acknowledge funding of the Erlangen Graduate School in Advanced Optical Technologies in the framework of the German excellence initiative.

Poster Session 2

MEDHANIE TESFAY GEBREKIDAN

Shifted-Excitation Raman Difference Spectroscopy (SERDS) for Biological Tissue Analysis

Raman signals provide objective spectroscopic information which is molecule-specific and unique to the nature of the specimen under investigation. Thus, when any pathological process changes the native biochemistry of biological tissues, this leads to a change in the Raman spectrum, which provides the potential of identifying diseases. However, often the raw spectrum is severely affected by fluorescence interference. In order to apply Raman spectroscopy for biochemical characterization of pathologies in biological tissue, two principles of fluorescence interference rejection are combined. In this study, we combined the shifting excitation technique for physical fluorescence suppression with mathematical fluorescence suppression approaches and found that the combination of both approaches assured the most efficient fluorescence suppression and best reconstruction quality of the Raman spectra.

NICHOLAS WONG

Modal Characterization of Hollow-core Photonic Bandgap Fibers in the Time-domain

We present a collection of modal characterization techniques based on time-of-flight, that are applicable to multimode fibers for data transmission, with particular focus on hollow-core photonic bandgap fibers.

OUADGHIRI IDRISSI ISMAIL

Attenuation of Nonlinear Instabilities with Shaped Bessel Beams

Ultrashort Bessel pulses may exhibit significant oscillations in the nonlinear regime. Due to Kerr effect, new spatial frequency components may be generated. The interference between the conical wave and Kerr-generated waves may lead to intensity modulation. We introduce a novel method to attenuate these instabilities using longitudinal beam shaping. Our approach consists in designing an on-axis intensity profile which takes into account the nonlinear intensity oscillations. Firstly, we study the nonlinear propagation of a Bessel beam. In case this latter exhibits intensity modulation, we devise an on-axis intensity profile with the exact opposite intensity modulation. This way, any increase/decrease in intensity will be partially compensated thanks to the localized intensity decrease/increase included in the initial design of the on-axis intensity. Numerical simulations show that this modified Bessel beam exhibits significant decrease in the nonlinear oscillation depth.

YAUHEN BARAVETS

Widely Tunable Narrow-band CW Mid-IR Generator Based on the Difference Frequency Generation in KTA Crystal

Mid-infrared (mid-IR) range is of particular interest for many applications, especially for high-resolution absorption spectroscopy of trace gases. Absorption bands of many molecules fall within the mid-IR range that allows high-sensitive and selective detection of trace gases. In our laboratory we developed a narrow-band continuous-wave mid-IR generator based on the quasi-phase matched difference frequency generation in periodically poled potassium titanyl arsenate (PPKTA) crystal. The nonlinear crystal was used to mix the beams from tunable high power master-oscillator power-amplifier fiber laser sources working in the spectral range of 1040-1089 nm and 1540-1589 nm, respectively. The PPKTA crystal had a length of 16.5 mm and thick of 1 mm. The maximum tuning range achieved with the poling period of 39.8 μm was 3100-3620 nm. We also compared mid-IR generators based on PPKTA and periodically poled potassium titanyl phosphate crystal. The prototype device was built at our institute.

Poster Session 2

DERREK WILSON

Development of Strong Field Light Sources Using a Wavelength Tunable, Carrier Envelope Phase Stabilized Laser

We demonstrate an 800 nm, Ti:Sapph laser with 20 mJ, 26 fs pulses at a 1kHz repetition rate. The system includes carrier envelope phase (CEP) stabilization with an impressive single shot error of 300 mrad spanning 9 hours. This laser is equipped with a high-energy white-light-seeded optical parametric amplifier (OPA) that can be pumped with 18 mJ to produce a total of 6 mJ signal and idler in the near infrared. We plan to use this system in the development of two novel light sources. The first is a multi-octave pulse across the NIR window. In this project we plan to utilize the properties of our OPA to generate a continuous spectrum across the NIR window and synthesize a single pulse capable of sub-carrier cycle duration. The second development is a strong field light source in the far infrared (5-10 µm wavelength) capable of reaching intensities high enough for strong field physics (>1013 W/m2). We will also discuss the experimental advantages of these light sources.

PARYA SAMADIAN

Homogenization of Nanostructure Waveguides in the Non-resonant and Resonant Regimes.

A recent break-through in the domain of photonic integration is the use of sub-wavelength waveguide grating structures (SWG) to engineer the refractive index of integrated components. Current tools for component simulation require sub-wavelength computational meshes that can only be applied to regions a few wavelengths in extent. Modeling at larger scales requires an abstraction of the properties of the nanostructure, which summarizes its properties pertinent to the larger scale and smoothes over the detail at the smaller scale.

To illustrate the methods, the homogenization of two example structures is considered. The first example is a slab waveguide structure in the absence of any resonance and the second example is a corrugated ridge waveguide where the vacuum wavelength used is close to the band edge where resonant Bragg scattering is prominent.

In both cases comparison with experimental and simulation results show good.

JORGE FERNANDEZ HERRERA

Lensed Fibers for Coupling to Photonic Waveguide

The edge coupling is one the most interesting options to coupling fiber to photonic waveguide.

In this sense the conical lensed fibers are used to perform this work to focus the fiber fundamental mode diameter to dimensions according to chip's waveguide. So the lensed fibers made in the fiber tip are fundamental for the coupling efficiency level. For that, the control over the process manufacturing and a suitable optical characterization of the produced lenses are important steps to high efficiency lens production. In this work are presented relevant aspects of the manufacturing process using polishing-based technique and its effects over the coupling efficiency with optical waveguides.

POUYAN NASR

The Effect of Varying the Length and Spacing of Layers on Maker Fringe Measurements in Poled Multi-layer Silica Structures

In this presentation the impact of the discrete nature of the non-linearity in multi-layer structures is investigated. Spacing and number of layers are shown to have a significant impact on both the overall magnitude and structure of Maker Fringe measurements of the second order non-linearity in multilayer thin-film doped silica structures. A Beam Propagation Method (BPM) model is developed for SHG in multi-layer structures and compared to Maker fringe data.

The structure is built of Ge-doped and bulk silica layers alternatingly which results in several concatenated non-linear regions.

The SHG rose as we increased the layer separation. The SHG measurement drops rapidly as the layer spacing increases then recovers when the layer spacing approaches the coherence length. The reason for this is because of the constructive and destructive interferences that occurs every time the length of the layers and spacing between them is varied.

Poster Session 2

BADRINATH VADAKKAPATTU CANTHADAI

Pest Damage Assessment in Fruits and Vegetables using Thermal Imaging

In some fruits and vegetables, it is difficult to visually identify the ones which are pest infested. This particular aspect is important for quarantine and commercial operations. In this article, we propose to present the results of a novel technique using thermal imaging camera to detect the nature and extent of pest damage in fruits and vegetables, besides indicating the level of maturity and often the presence of the pest. Our key idea relies on the fact that there is a difference in the heat capacity of normal and damaged ones and also observed the change in surface temperature over time that is slower in damaged ones. This paper presents the concept of non- destructive evaluation using thermal imaging technique for identifying pest damage levels of fruits and vegetables based on investigations carried out on random samples collected from a local market.

MARTIN VANEK

Design, Fabrication and Testing of Polarization Insensitive (independent) Diffraction Grating for High Power Fiber Laser Application at 2 um Wavelength

The polarization insensitive diffraction grating is designed (simulated) using numerical RCWA – Rigorous coupled wave analysis code. Diffraction to -1st reflected order is maximized for both TE and TM polarization in presented design. Diffraction grating structure is chosen to be binary with period of 1.01 um to suppress higher orders. Grating is fabricated on fused quartz window using reactive ion etching. Etching mask is created using two beam interferometry. SEM – scanning electron microscopy is used for preliminary imaging, investigation and measurements of fabricated diffraction grating. Up to 20 W thulium fiber laser is used for measurement of diffraction grating characteristics.

MACIEJ KOWALCZYK

Microstructured Gradient-index Antireflective Coating Fabricated on a Fiber Tip with Direct Laser Writing

We present a simple broadband gradient-index antireflective coating, fabricated directly on a single mode telecom fiber tip. A regular array of hemi-ellipsoidal protrusions significantly reduce the Fresnel reflection from the glass-air interface. The parameters of the structure were optimized with numerical simulation for the best performance at and around 1550 nm and the coating was fabricated with Direct Laser Writing. The measured reflectance decreased by a factor of 30 at 1550 nm and was below 0.28% for the 100 nm spectral band around the central wavelength. Compared to quarter wavelength antireflective coatings the demonstrated approach offers significantly reduced technological challenges, in particular processing of a single optical material with low sensitivity to imperfections in the fabrication process.

JONAS BERZINŠ

Scribing of sapphire wafers is an area where the use of laser technologies can be effective. With the increasing demand of light emitting diodes (LEDs) the requirements to the efficiency appear. New method has been developed - stealth dicing.

Poster Session 2

TINA PARSONAGE

Pulsed Laser Deposition of Rare-Earth-Doped Sesquioxides for use as Planar Waveguide Lasers

Rare-earth-doped sesquioxides have been identified as promising host materials for high power lasers, due to their excellent thermomechanical properties. However, these materials are challenging to grow from the melt as they have high melting points of around 2500°C. Pulsed laser deposition avoids the requirement to reach such high temperatures and is therefore employed to fabricate thin films of rare-earth-doped sesquioxides to be used as planar waveguide lasers. This geometry allows for effective thermal management, which is important for efficient, high power lasers. We aim to optimise deposition conditions to decrease losses in our waveguides and move towards more efficient, high output power lasers. Here we focus on Yb-doped Lutetia waveguides, including material analysis and our best laser output power results to date.

FABIEN LESPARRE

High Power Single Crystal Fiber Amplifiers for Linearly and Cylindrically Polarized Picosecond Lasers

We demonstrate a three-stage diode-pumped Yb:YAG single-crystal-fiber amplifier to generate femtosecond pulses at high average powers with linear or cylindrical (i.e. radial or azimuthal) polarization. At a repetition rate of 20MHz, 750fs pulses were obtained at an average power of 85W in cylindrical polarization and at 100W in linear polarization. The report includes investigations on the use of Yb:YAG single-crystal-fibers with different length/doping ratio and the zero-phonon pumping at a wavelength of 969nm in order to optimize the performance.

SUNDAY ATUBA

Generation of a Train of Ultrashort Pulses using Periodic Waves in Tapered Photonic Crystal Fibers

We consider a light wave propagation in tapered photonic crystal fibers (PCFs) wherein the wave propa-gation is governed by the variable coefficient nonlinear Schrödinger equation (NLSE). We solve it directly by means of the theta function identities and Hirota bilinear method and obtain the exact periodic waves of sn, cn and dn types. These chirped periodic waves demand the exponentially varying dispersion and nonlinearity. Besides, we analytically demonstrate the generation of a train of ultrashort pulses using the periodic waves by exploiting the exponentially varying optical properties of the tapered PCFs. As a special case, we also discuss the chirped solitary pulses under long wave limit of these periodic waves. In addition, we derive these types of periodic waves using the self-similar analysis and compare the results.

JAKUB CAJZL

Thulium Doped Fibers with Enhanced Fluorescence Lifetime

Thulium-doped optical fibers operating in the region around 2 µm are used primarily in the so-called „eye safe" applications, e.g., the biological imaging, atmospheric transmission, etc. High quantum conversion efficiency (QE) is required in devices such as ASE (Amplified Spontaneous Emission) sources and optical fiber lasers and amplifiers. In my work I report on the thulium-doped silica-based optical fibers with increased fluorescence lifetime and QE thanks to the modification by high content of alumina. Tm-doped optical fibers were fabricated by the conventional solution-doping and alumina nanoparticles dispersion-doping. The error of the lifetime determination caused by ASE was eliminated by extrapolation method. We measured the fluorescence lifetimes increase of a factor of two for optical fiber samples prepared by co-doping with alumina nanoparticles, when compared to the conventional thulium-doped fibers.

Poster Session 2

ZHANNA RODNOVA

Stable Mode-locking in All-fiber Er-doped Ring Lasers for Frequency Metrology

In the last decade, ultra-short pulse (USP) fiber lasers have become one of the most important instruments in frequency metrology. In this work we compared two mechanisms of passive mode-locking (ML) such as Kerr ML and hybrid ML.

We demonstrated a passive ML based on Nonlinear Polarization Evolution in a ring cavity formed by an active erbium-doped fiber, a highly nonlinear germanosilicate fiber with positive GVD, and an SMF-28 fiber with negative GVD at 1550 nm.

We demonstrated hybrid mode-locking using two different ML mechanisms – a slow saturable absorber such as single-walled carbon nanotubes and a fast nonlinear polarization evolution. In this case we obtained a similariton generation.

We studied the stability of generated USPs using two ML mechanisms. The obtained results make it highly promising for further development of the stabilized comb.

Our current efforts are currently focused on demonstrating comb-stabilization for further generation of low-noise microwaves.

PORNAPA ARTSANG

Experimental Study in Fourier Transform Infrared Spectroscopy for Combining with Tuning Fork Based Atomic Force Microscopy

Nano-materials are very interesting and this research is about the use of optical techniques as a tool to manipulate and characterize them. The research is aimed to combine the FTIR spectroscopy with and Near-field scanning atomic force microscopy as a tool to characterize nano-materials. My research project currently focuses on studying and developing both an optical setup and processing algorithms of the FTIR system in laboratory.

HAITHAM OMRAN

MEMS Based Swept Laser Source for Optical Coherence Tomography Applications

In this thesis we report a wide tuning range MEMS-based swept laser source using Deep Reactive Ion Etching (DRIE) on SOI substrate and present a new multimode rate equation model accessing the instantaneous spectral width of swept laser source. The instantaneous spectral width of the laser during sweeping is calculated through wavelength and time dependent cavity loss model. For the MEMS based swept laser source a MEMS Fabry-Perot filter with a free-spectral range larger than 130 nm and a tuning range wider than 125 nm is presented. This filter is used to construct a swept laser source with 100 nm tuning range. These results represent the widest tuning range reported in literature for an in-plane SOI-MEMS based swept laser source using deeply-etched free-standing distributed-Bragg-reflection mirrors.

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