NextLite
Doktoranden-Workshop

Date and Time: **1.-2. October 2015 (Thursday-Friday)**

Location: **TU Wien, Photonics Institute**
Seminar Room E387-CBEG02, ground level,
Gußhausstraße 27-29, 1040 Vienna

Schedule & Speakers

Thursday, October 1st

11.00 - 11.15	Welcome
11.15 - 12.15	**Prof. Jan Wiersig** *Otto-von-Guericke-Universität Magdeburg* "Asymmetric backscattering in deformed or perturbed microcavities"
12.15 - 14.00	Lunch (together @Chang - www.chang.at)
14.00 - 15.00	**Prof. Jaime Gómez Rivas** *AMOLF - Philips Research Laboratories Eindhoven* "Collective plasmonic/photonic resonances coupled to luminescent molecules: from solid state lighting to plasmon exciton polaritons"
15.00 - 16.00	**Dr. Jean-Pierre van Helden** *Leibniz Institute for Plasma Science and Technology (INP Greifswald)* "Process Monitoring in Plasma Technology"
16.00 -	Coffee & Networking

Der Wissenschaftsfonds.

NEXT lite next generation light synthesis and interaction

Friday, October 2nd

09.00 - 10.00	**Dr. Florenta Costache** *Fraunhofer Institute for Photonic Microsystems (IPMS), Dresden* "Light control with liquid crystal waveguides integrated on a silicon backplane"
10.00 - 10.30	Coffee
10.30 - 11.30	**Prof. Gregor Weihs** *Universität Innsbruck and University of Waterloo* "Semiconductor photon sources for quantum communication"
11.30 - 12.30	**Prof. Maksym Kovalenko** *ETH Zürich and Empa-Swiss Federal Laboratories for Materials Science and Technology* "Colloidal Nanocrystals of Cesium Lead Trihalide Perovskites"
12.30 - 14.00	Lunch (together @Wieden Bräu - www.wieden-braeu.at)
14.00 - 14.30	**DI Wolfgang Ritter** *CEO QuantaRed Technologies, Vienna* "Mid-IR Quantum Cascade Lasers: An enabling technology for improved gas monitoring and liquid sensing"
14.30 -	**Labs**

For questions concerning the program please contact:
→ Moritz Wenclawiak (moritz.wenclawiak@tuwien.ac.at),
for questions concerning administration:
→ Ingrid Unger (ingrid.unger@tuwien.ac.at).

Abstracts

"Asymmetric backscattering in deformed or perturbed microcavities"

Jan Wiersig,
Otto-von-Guericke-Universität Magdeburg

In recent experiments it has been demonstrated that optical microcavities can exhibit so-called exceptional points in parameter space, which are degeneracies in open systems where at least two resonant frequencies and the corresponding eigenmodes coalesce. In this talk we show that in whispering-gallery cavities exceptional points can be related to asymmetric backscattering between clockwise and counterclockwise traveling waves.

We propose here to exploit these unconventional degeneracies for single-particle detection. Numerical and analytical calculations show that this has great potential for enhanced sensitivity provided that one is able to measure both the frequency splitting as well as the linewidth splitting. As another potential application we discuss an optical gyroscope based on asymmetric backscattering.

"Collective plasmonic/photonic resonances coupled to luminescent molecules: from solid state lighting to plasmon exciton polaritons"

Jaime Gómez Rivas,
AMOLF - Philips Research Laboratories Eindhoven

Surface plasmon polaritons (SPPs) are oscillations of the free charges at the surface of conductors, coherently driven by an electromagnetic field. The large local fields in subwavelength volumes associated to SPPs, has made plasmonic resonances an important instrument to enhance light-matter interactions at a nanoscale. SPPs can lead to an improved light absorption, to a strong modification of the emission of light sources, or to the sensitive detection of functionalized surfaces. By coupling localized surface plasmon resonances to diffracted orders in particle arrays or to guided modes in waveguides, collective plasmonic resonances can be excited. We will discuss how to improve the performance of white LEDs through the coupling of emitters to collective plasmonic resonances, which lead to a many-fold enhanced emission in defined directions. These collective resonances are also responsible of fascinating fundamental phenomena such as enhanced emission at frequencies in which the samples exhibit an induced transparency, their strong coupling to excitons forming plasmon exciton polaritons or the exciton-polariton scattering and thermalization.

"Process Monitoring in Plasma Technology"

Jean-Pierre van Helden,
Fraunhofer Institute for Photonic Microsystems (IPMS), Dresden

Many industrial processes in the materials processing technology, such as the deposition and etching of thin films, involve the application of molecular plasmas due to their favourable properties. While offering a wide field of potential applications, however, the properties of these plasmas are far from being fully understood for this type of plasma. This situation concerns plasmas generated under low-pressure conditions, in particular, with growing numbers of applications involving gas discharges at atmospheric pressures, including phenomena of plasma-surface interactions. To improve the efficiency of these processes, more insight into the plasma chemistry is required. Therefore, the detection and quantitative measurement of stable and transient species is a major challenge in industrial plasma applications.

From the middle of the last decade a variety of phenomena in molecular non-equilibrium plasmas in which many short-lived and stable species are produced have been successfully studied with tunable diode laser absorption spectroscopy (TDLAS) and quantum cascade laser absorption spectroscopy (QCLAS) in the mid-infrared spectral range (3 to 20 µm). In the meantime mid-infrared laser absorption spectroscopy (MIR-LAS) has been established as a powerful in-situ diagnostic tool for molecular plasmas. Nowadays, the commercial availability of different types of QCLs along with their convenient operating conditions and performance has led to the rapid development of MIR-LAS from a niche position to a standard diagnostic technique in fundamental research and in industrial process monitoring. We will discuss examples of industrial relevant plasma monitoring in varying types of plasmas applying laser-based diagnostics in the mid-infrared using quantum cascade lasers.

Light control with liquid crystal waveguides integrated on a silicon backplane

Dr. Florenta Costache,
Fraunhofer Institute for Photonic Microsystems (IPMS), Dresden

The presentation will address innovative technologies for light manipulation and control, currently under research and development at the Fraunhofer IPMS, which, by making use of smart organic materials and wafer level fabrication, provide on-chip tunable micro-optical devices with new or improved parameters for specific market needs.

Details will be given on devices based on a unique concept of integrated field-induced liquid crystal waveguides, which are able to rapidly and precisely control the optical power transmitted from one fiber to another. Specifically developed nematic liquid crystal blends were used in these devices. These blends possess unique properties such as large electro-optic Kerr constants, low optical loss and sub-microsecond response time. The waveguides are fabricated on silicon wafers by means of bulk micro-machining processes. It will be shown that based on these waveguides – with an appropriate electrode design configuration – a variety of variable optical functions such as switching, attenuation or power splitting could be demonstrated.

The developed waveguide technology enables a dynamic, continuously voltage controlled adjustment of the light waves transmitted in fiber optic networks and finds applications in optical telecommunication but also in fiber optic sensor networks and laser systems.
Additionally, other tunable micro-optic devices with smart organic materials will be addressed, in particular their concept design, wafer level fabrication and characteristics tailored for specific applications involving light control.

"Semiconductor photon sources for quantum communication"

Gregor Weihs,
Universität Innsbruck and University of Waterloo

For fundamental tests of quantum physics as well as for quantum communications non-classical states of light are an important tool. In our research we focus on developing semiconductor-based and integrated sources of single photons and entangled photon pairs. In this talk I will present our work on with single InAs quantum dots and with AlGaAs waveguides.

In our quantum dot work, for the highest degree of quantum control we use resonant two-photon excitation to deterministically trigger a biexciton-exciton cascade. We demonstrate Rabi oscillations, Ramsey interference and all-optical coherent control of the quantum dot resulting in single and paired photons with a high degree of indistinguishability leading to high-quality single photons and time-bin entangled photon pairs.

Most III-V semiconductors exhibit a large second-order optical nonlinearity. Phase matching the nonlinear interaction is, however, notoriously difficult. We have shown that Bragg-reflection waveguides allow efficient creation of photon pairs through spontaneous parametric down-conversion. They have the potential to be integrated with a pump laser on the chip for a miniaturized room-temperature entangled photon pair source.
This work was supported by the European Research Council (ERC), the Canadian Institute for Advanced Research (CIFAR), and the Austrian Science Fund FWF.

"Colloidal Nanocrystals of Cesium Lead Trihalide Perovskites"

Maksym V. Kovalenko,
ETH Zürich and Empa-Swiss Federal Laboratories for Materials Science and Technology

Chemically synthesized inorganic nanocrystals (NCs) are considered to be promising building blocks for a broad spectrum of applications including electronic, thermoelectric, and photovoltaic devices. We have synthesized monodisperse colloidal nanocubes (4-15 nm edge lengths) of fully inorganic cesium lead halide perovskites (CsPbX3, X=Cl, Br, and I or mixed halide systems Cl/Br and Br/I) using inexpensive commercial precursors [1]. Their bandgap energies and emission spectra are readily tunable over the entire visible spectral region of 410-700 nm. The photoluminescence of CsPbX3 NCs is characterized by narrow emission line-widths of 12-42 nm, wide color gamut covering up to 140% of the NTSC color standard, high quantum yields of up to 90% and radiative lifetimes in the range of 4-29 ns.

Post-synthestic chemical transformations of colloidal NCs, such as ion-exchange reactions, provide an avenue to compositional fine tuning or to otherwise inaccessible materials and morphologies. While cation-exchange is facile and commonplace, anion-exchange reactions have not received substantial deployment. Here we present fast, low-temperature, deliberately partial or complete anion-exchange in CsPbX3 NCs. By adjusting the halide ratios in the colloidal NC solution, the bright photoluminescence can be tuned over the entire visible spectral region (410-700 nm). Furthermore, fast inter-NC anion-exchange is demonstrated as well, leading to uniform CsPb(Cl/Br)3 or CsPb(Br/I)3 compositions simply by mixing CsPbCl3, CsPbBr3 and CsPbI3 NCs in appropriate ratios.

We also present low-threshold amplified spontaneous emission and lasing from CsPbX3 NCs [3]. We find that room-temperature optical amplification can be obtained in the entire visible spectral range (440-700 nm) with low pump thresholds down to 5±1 µJ cm-2 and high values of modal net gain of at least 450±30 cm-1. Two kinds of lasing modes are successfully realized: whispering gallery mode lasing using silica microspheres as high-finesse resonators, conformally coated with CsPbX3 NCs, and random lasing in films of CsPbX3 NCs.

1. L. Protesescu *et al*. Nano Letters **2015**, *15*, 3692–3696
2. G. Nedelcu *et al.* Nano Letters, **2015**, 15, 5635–5640.
3. S. Yakunin *et al.* Nature Communications, **2015**, 9, 8056.

Mid-IR Quantum Cascade Lasers:
An enabling technology for improved gas monitoring and liquid sensing

Wolfgang Ritter,
QuantaRed Technologies, Vienna

Mid-IR quantum cascade lasers (QCLs) hold promise to revolutionize the way mid-IR spectroscopy is employed in analytical chemistry. Due to their highly attractive properties which include high spectral power densities (>100mW/cm-1), small size (e.g. TO8), room temperature operation and recently also increased tunability, a range of new measurement concepts can be envisioned and realized.

For the analysis of liquids the company QuantaRed Technologies has successfully defined a new standard (ASTM D7678) for the measurement of oil-in-water, which meanwhile is used in more than 35 countries. In the field of gas analysis on-going research activities are carried out in cooperation with the Vienna University of Technology with the aim to develop prototypes for rapid and sensitive detection of several analytes by in-line or on-line measurements for process monitoring.

In this presentation we plan to review the current state of the art of Quantum Cascade Lasers technology including their spectroscopic properties as revealed by step-scan FTIR spectroscopy. Furthermore, the working principle of the new oil-in-water method will be introduced and results obtained at challenging applications (oil-rigs) reported. Concerning in-line stack gas monitoring, results on simultaneous measurement of NO/NO2 will be presented and compared to standard extractive measurement technologies. Finally applications of multi wavelength devices (Ring-QCLs, DFB Arrays) will be introduced.