SYPC 2: From Atoms to Photonic Circuits: Integrating Quantum Optics and Optical Communication 2

Time: Thursday 14:00–16:00 Location: V47.01

Invited Talk SYPC 2.1 Thu 14:00 V47.01
Coherent population trapping in quantum dot molecules — Katharina Weiss, Jeroen Elzerman, and •Atac Imamoglu — ETH, Zurich, Switzerland

Low-frequency atomic transitions that are insensitive to magnetic fields play a fundamental role in precision measurements and metrology. In contrast, most solid-state quantum systems are subject to either strong electric or magnetic field fluctuations that severely limit their T2*coherence time. In this talk, we will describe experiments where we demonstrate that by adjusting the applied bias voltage and the magnetic field, spin singlet and triplet ground states of an optically active quantum dot molecule can be rendered insensitive to both electric and magnetic field fluctuations. By using coherent population trapping on transitions to a common optically excited state, we show that the singlet-triplet T2* time can exceed 100 nanoseconds. The rich optical spectrum of this quantum system exhibiting recycling transitions for spin measurements and indirect excitons for spin-state dependent long-range dipole-dipole interactions, potentially allow for applications in quantum information processing.

Invited Talk SYPC 2.2 Thu 14:30 V47.01
Nanophotonic Interconnection Networks for Performance-Energy Optimized Computing — •Keren Bergman — Department of Electrical Engineering, Columbia University, New York, NY

As chip multiprocessors (CMPs) scale to increasing numbers of cores and greater on-chip computational power, the gap between the available off-chip bandwidth and that which is required to appropriately feed the processors continues to widen under current memory access architectures. For many high-performance computing applications, the bandwidth available for both on- and off-chip communications can play a vital role in efficient execution due to the use of data-parallel or data-centric algorithms. Electronic interconnected systems are increasingly bound by their communications infrastructure and the associated power dissipation of high-bandwidth data movement. Recent advances in chip-scale silicon photonic technologies have created the potential for developing optical interconnection networks that can offer highly energy efficient communications and significantly improve computing performance-per-Watt. This talk will examine the design and performance of photonic networks-on-chip architectures that support both on-chip communication and off-chip memory access in an energy efficient manner.

SYPC 2.3 Thu 15:00 V47.01
Controlled coupling of single solid-state quantum emitters to optical antennas — •Markus Pfeiffer[1,2], Klas Lindfors[1,2], Paola Atkinson[3], Armando Rastelli[3], Oliver Schmidt[3], Harald Giessen[2], and Markus Lippitz[1,2] — [1]Max Planck Institute for Solid State Research, Stuttgart, Germany — [2]University of Stuttgart, Stuttgart, Germany — [3]IFW Dresden, Dresden, Germany

Plasmonic structures combined with stable solid-state quantum emitters are a promising approach to integrated photonic circuits and quantum optics applications. One of the main challenges in realizing such structures is the controlled positioning of single plasmonic structures next to a single emitter. To address this challenge, we have developed an electron-beam lithography based technique that enables fabrication of nanostructures aligned with respect to single self-assembled semiconductor quantum dots with nanometer precision.

We have applied our fabrication method to couple excitons in single quantum dots with plasmons in rod-shaped optical antennas. The plasmon-exciton coupling is manifested as a significant change in the polarization state of the photoluminescence. We investigate the strength of the coupling as a function of the position of the quantum dot with respect to the antenna. We observe large variations in the polarization properties of the luminescence as the quantum dot is placed at different positions in the vicinity of an antenna.

SYPC 2.4 Thu 15:15 V47.01
Telecom wavelength semiconductor-superconductor based quantum emitters — •Claus Hermannstädter[1,2], Hirotaka Sasakura[1], Nahid A. Jahan[1], Jae-Hoon Huh[1], and Ikuo Suemune[1] — [1]Hokkaido University, Sapporo, Japan — [2]JSPS

Practical integrated single and entangled photon-pair sources in the telecommunication band are attracting plenteous attention for on-chip and fiber-based technologies. We use semiconductor quantum dot (QD) and light emitting diode (LED) structures grown on InP substrates as quantum emitters in the spectral range between 1.3 and 1.6 μm.

We present one approach to realize a source of single photons and polarization entangled photon-pairs by isolating a small number of QDs inside InGaAlAs nano-mesas of around 150 nm diameter. For enhanced photon extraction, the nano-mesas are embedded in metal and the InP substrate is removed [Jpn. J. Appl. Phys. 50, 06GG02 (2011); New. J. Phys., submitted (2011)]. Another approach for the realization of entangled photon-pairs is the concept of Cooper-pair (Josephson) LEDs [PRL 103, 187001 (2009); PRL 107, 157403 (2011)]. InGaAs LEDs are processed with superconducting Niobium electrodes for the injection of electron Cooper-pairs. The presence of these Cooper-pairs at the p-n-junction leads to their radiative recombination with two normal holes and thus the simultaneous generation of entangled photon-pairs. Both demonstrated approaches have the potential to be combined to "Cooper-pair QD-LEDs" and allow for integration on semiconductor chips as parts of larger devices. Moreover, the target wavelength of 1.55 μm for application in silica fiber networks is successfully covered.

SYPC 2.5 Thu 15:30 V47.01
Si-based light emitters in integrated photonic circuits for smart biosensor applications — •Susette Germer — Institute of Ion-Beam Physics and Materials Research (FWI), Helmholtz-Centre Dresden-Rossendorf (HZDR), Dresden, Germany

In this report we present our recent developments for utilizing the Si-based light emitter consisting of a MOS structure for the detection of organic pollutants. In the latest approach the light emitters are intended to serve as light sources in smart biosensors. Now we discuss our concept of an integrated light emitter and a receiver in a dielectric waveguide structure below the bioactive layer for the detection of harmful substances, like synthetic estrogens or plasticizer in drinking water. Optical properties of waveguides, e.g. the transmission, are very sensitive to changes of the effective refraction index, which might be induced by the immobilization of biomolecules on the waveguide surface or in cavity structures, e.g. photonic crystals. The guiding of the light depends on the geometry and material composition of the waveguide. First waveguides were fabricated through plasma enhanced chemical vapor deposition (PECVD) and optical photolithography with following etching steps. Afterwards the layer thicknesses were analyzed by ellipsometry and the surface roughness via scanning electron microscopy (SEM). However, the investigation of the different waveguides will be allowed through finite element method (FEM) simulations (COMSOL) and experimentally through a setup for the optical transmission measurement. In summary, this lab-on-a-chip system provides fast light transmission and achieves further portability and miniaturization.

SYPC 2.6 Thu 15:45 V47.01
Arrayed waveguide grating based interrogator for fiber Bragg grating sensors: measurement and simulation — •Jan Koch[1,2], Martin Angelmahr[1], and Wolfgang Schade[1,2] — [1]Fraunhofer Heinrich Hertz Institute, Am Stollen 19B, 38640 Goslar, Germany — [2]Clausthal University of Technology, Am Stollen 19B, 38640 Goslar, Germany

Fiber Bragg grating (FBG) strain sensors offer great potential. Compared to strain gauges they are small and lightweight, can easily be multiplexed, and are immune to electromagnetic disturbance. In addition the new femtosecond laser processed FBG sensors are very robust and easy to handle. However, the main disadvantage of those fiber-optical measurement systems lies within the applied FBG interrogator, which usually consists of expensive and fragile components.

In this work a FBG interrogator based on an arrayed waveguide grating (AWG) chip, known as cost efficient and very stable multi-/demultiplexer module in the telecommunication industry, is presented. In order to achieve high wavelength resolution, the interpretation of the response signal of the FBG strain sensors has to be done very carefully. Hence, the required evaluation algorithm is examined in detail. The corresponding calibration parameters are determined by calibration measurements and by simulations. The system simulation provides additional information for the error estimation of the measurand.