HL 36: Focus Session: Integrated Quantum Photonics II

The huge impact of semiconductor-based technologies on modern society has resulted from the ability to integrate small functional units or building blocks into integrated circuits with macroscopic functionality. In a similar way, integrated nanophotonic quantum circuits are believed to enable real-world quantum technologies with applications in secure communication, information processing, metrology and sensing.

Organizers: Kai Müller (TU Munich) and Tobias Heindel (TU Berlin)

Time: Tuesday 14:00–15:45 Location: POT 51

Invited Talk HL 36.1 Tue 14:00 POT 51

Towards One-way Quantum Repeaters with Spin Qubits in Nanophotonic Interfaces — •Tim Schröder — Institut für Physik, Humboldt-Universität zu Berlin — Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik

We show progress on theoretical concepts and experimental implementation of *One-Way* Quantum Repeaters. While to date *one-way* quantum repeater proposals rely on a relatively large number of resources, we introduce a scheme that requires only one single photon emitter and two ancilla qubits per communication node. We analyse achievable quantum communication rates and propose a physical implementation that is accessible with today*s technology [arXiv:1907.05101]. On the experimental side, we demonstrate coherent control of single InAs quantum dot electron spins in nanobeam waveguides and show that coherence times reach those of spins in bulk. We furthermore demonstrate nanobeam to fibre coupling efficiencies of 92%; together with waveguide*photon coupling of up to 0.95 this enables highly efficient photonic systems for the generation of multi-photon cluster states. Towards improving waveguide*photon coupling efficiencies beyond 0.95 we introduce a novel waveguide-integrated nanocavity and demonstrate a 30-fold quantum dot lifetime reduction. Finally, we demonstrate that quantum dot spin-photon interfaces in nanobeams are well suited for the demonstration of two-qubit gates, an important requirement for the generation of photonic cluster states. Towards this goal we show that a single waveguide-coupled quantum dot enables spin-state dependent transmission of single photon states.

HL 36.2 Tue 14:30 POT 51

Applications of a Wannier-Stark modulator in waveguide configuration for optical signal regeneration, memory operation and computing in the telecom wavelength range — •Heinz-Christoph Neitzert — Dept. of Industrial Engineering (DIIn), Salerno University, Via Giovanni Paolo II 132, 84084 Fisciano (SA), Italy

Based on an InGaAs/InP superlattice, a Wannier-Stark type EA-modulator has been operated around 1550 nm. A large transmission contrast with low applied voltage changes has been observed. Operating the modulator in a resistor based self-electrooptic effect configuration, a large tunability of the optical transfer function has been achieved by varying the electrical bias voltage and the feedback resistor value. As an example just the functionality of optical thresholding for the noise suppression in a digital optical transmission system and signal frequency multiplication will be shown. Simulation results demonstrate the feasibility to use this type of device for the realization of logic gate operations, like NOR and NAND. Due to the functional completeness theorem this means that in principal every logic functionality can be achieved. The critical parameters during optical computing operations are the optical bias stability and high frequency limitations due to the low-pass filter in the electrical feedback circuit. The waveguiding configuration ensures, however, a good stability and operation at low optical powers.

HL 36.3 Tue 14:45 POT 51

Deterministic integration of single quantum dots into on-chip waveguide devices using in-situ electron beam lithography — •Johannes Schall[1], Peter Schnauber[1], Samir Bounouar[1], Theresa Höhne[2], Anshuman Singh[3], Suk In Park[4], Geun-Hwan Ryu[4], Tobias Heindel[1], Sven Burger[2], Jin-Dong Song[4], Kartik Srinivasan[3], Sven Rodt[1], Marcelo Davanco[3], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, TU Berlin, Berlin, Germany — [2]Zuse Institut Berlin, FU Berlin, Berlin, Germany — [3]NIST, Gaithersburg, United States — [4]KIST, Seoul, Korea

The deterministic integration of quantum emitters into on-chip photonic elements is crucial for the implementation of scalable integrated quantum circuits. We report on the single step deterministic integration of QDs into on-chip WGs using in-situ EBL. We realize multimode interference (MMI) splitters acting as 50/50 coupling elements and demonstrate the functionality by μPL spectroscopy and photon cross-correlation [1]. Furthermore, we integrate InAs QDs as single-photon sources in SiN WGs. Our deterministic fabrication approach guarantees the precise alignment of InAs QDs in the center of a GaAs Tapers, injecting photons in the SiN WGs underneath. In quasi-resonant p-shell excitation, we demonstrate the generation of indistinguishable photons from a single InAs QD in a hybrid quantum photonic device with a post-selected Hong-Ou-Mandel visibility of 0.89 [2].

[1] Schnauber et al., Nano Letters 18 (4), 2336 (2018)
[2] Schnauber et al., Nano Letters 19 (10), 7164 (2019)

HL 36.4 Tue 15:00 POT 51

Voltage dependent photoluminescence of GaAs/AlGaAs quantum dots — •Nandlal Sharma, Robert Keil, Caspar Hopfmann, and Oliver G. Schmidt — Institute for Integrative Nanosciences, Leibniz Institute for Solid State and Material Research (IFW), Helmholtzstraße 20, 01069 Dresden, Germany

The semiconductor quantum dots (QDs) are promising candidate for high quality photon sources and the biexciton cascade decay in such dots is most advanced technique for the generation of entangled photon pairs. In this work the GaAs/AlGaAs QDs are grown by droplet epitaxy in a n-i Schottky diode structure. The back contact is prepared by thermal diffusion and top contacts is prepared by deposition of semi-transparent 2 nm/4 nm Cr/Au metals. The optical emission (photoluminescence) from different charging state of a GaAs QDs is controlled by application of external bias. The voltage dependent photoluminescence spectrum is recorded at 4K. The effect of external bias on the fine structure splitting and coherence time is studied.

Invited Talk HL 36.5 Tue 15:15 POT 51

Classical computing with quantum states of light — •Stefanie Barz — University of Stuttgart, Germany

Secure delegated computing is a key task for both classical and quantum networks. There exist both classical and quantum protocols for performing secure (quantum) computations in networks.

In this talk, I will show how to use quantum states of light for computing in such networks.

Here, each party in the network has limited computational resources; quantum states increase the computational power of the individual parties. As particular examples, I will show how single qubits and XOR gates allow for universal classical computation. Further, I will demonstrate how quantum resources and linear classical processing enable non-linear computation.

Finally, I will show proof-of-concept implementations using photonic qubits. Thus, this work highlights how minimal quantum and classical resources can be combined and exploited for classical computing.