HL 30: Focus Session: On-Chip Quantum Photonics I

Organizers: Simone Portalupi and Peter Michler (Universität Stuttgart)

Time: Tuesday 11:00–13:15 Location: H16

Invited Talk HL 30.1 Tue 11:00 H16
On-chip quantum photonics with integrated quantum dot emitters — •Mark Fox — Department of Physics & Astronomy, University of Sheffield, Sheffield S3 7RH, U.K.

On-chip quantum photonics relies on the integration of efficient single-photon sources with advanced quantum-optical circuits. In this presentation I will review progress at the University of Sheffield on a chip-compatible III-V semiconductor platform in which quantum-dot (QD) single-photon sources are integrated into GaAs photonic circuits. I will first describe work demonstrating a monolithic on-chip Hanbury Brown-Twiss interferometer, a resonantly-excited QD source emitting high coherence single photons into a single-mode waveguide, and an on-chip single-photon router [1]. I will then discuss experiments investigating the coupling of the spin of single QD excitons to circularly-polarized photonic modes on chip [2], focusing on very recent results demonstrating chiral emission from quantum dots embedded in nano-photonic waveguides [3]. These results lay the foundations for more complex photonic integration, opening the route to multi-qubit circuits with advanced quantum-optical functionality.

[1] N. Prtljaga et al., Appl. Phys. Lett. 23, 231107 (2014); M.N. Makhonin, et al. Nano Letters, 14, 6997-7002 (2014); C. Bentham, et al. Appl. Phys. Lett., 106, 221101 (2015)

[2] I.J. Luxmoore, et al. Phys. Rev. Lett., 110, 037402 (2013); R.J. Coles, et al., Optics Express, 22, 2376-2385 (2014)

[3] R. J. Coles et al., arXiv:1506.02266

Invited Talk HL 30.2 Tue 11:30 H16
Quantum photonics with quantum dot single photons in silicon oxynitride waveguide circuits — •Anthony Bennett[1], James Lee[1,2], David Ellis[1], Eoin Murray[1,3], Frederik Floether[1,3], Jonathon Griffiths[3], Thomas Meany[1], Ian Farrer[3], David Ritchie[3], and Andrew Shields[1] — [1]Toshiba Research Europe Limited, Cambridge Research Laboratory, 208 Science Park, Milton Road, Cambridge, CB4 OGZ, United Kingdom. — [2]Engineering Department, University of Cambridge, 9 J. J. Thomson Avenue, Cambridge, CB3 0FA,United Kingdom. — [3]Cavendish Laboratory, Cambridge University, J. J. Thomson Avenue, Cambridge, CB3 0HE, United Kingdom.

The interferometric stability and scalability of silicon oxynitride circuits makes them well suited to quantum optics experiments. Waveguides, phase shifters and couplers can be combined with a semiconductor light source to create an attractive and compact source of few-photon quantum states.

We report our experiments where resonant pi-pulse excitation of quantum dots in micro-pillars creates highly indistinguishable photons. We overlap these photons in a SiON circuit to create a two-photon N00N state, and show its phase super-resolving ability (A. J. Bennett et al, arxiv.org/abs/1508.01637 (2015)). We also report a device where the semiconductor light source is directly bonded to the end facet of the SiON circuit. The photonic circuit is then used to measure the quantum nature of the emitted light and create path-encoded qubits (E. Murray et al, Appl. Phys. Lett. 107, 171108 (2015)).

15 min. Coffee break

Invited Talk HL 30.3 Tue 12:15 H16
GaAs integrated quantum photonics — •S. Höfling[1], C. P. Dietrich[1], A. Fiore[2], M. Thompson[3], and M. Kamp[1] — [1]Technische Physik, Würzburg University, Germany — [2]TU Eindhoven, The Netherlands — [3]University of Bristol, UK

Quantum information processing is a rapidly developing research field. The exploitation of quantum bits instead of classical bits offers key advantages for future technologies including secure communication and ultra-fast computation. Lab-size experiments on quantum information processes have already proven the validity of its concepts. However, any wide spread utilization will require dense integration of functionalities. This requires the realization of semiconductor integrated quantum photonic circuits on a single semiconductor chip with embedded sources, photon processing units and detectors on the single photon level. Among the different material platforms currently being investigated, direct-bandgap semiconductors and particularly gallium arsenide (GaAs) offer the widest range of functionalities, including single- and entangled-photon generation by radiative recombination, low-loss routing, electro-optic modulation and single-photon detection. We review recent achievements in quantum integrated photonic components and circuits based on the GaAs technology platform. All key functionalities, including single-photon sources and single-photon detectors, integrated auto-correlators and tuneable Mach-Zehnder interferometers have been realized and tested. These results lay the foundation for a fully-functional and densely integrated quantum photonic technology based on GaAs components.

Invited Talk HL 30.4 Tue 12:45 H16
Photonic integrated circuits with on-chip single-photon emitters based on III-V semiconductors — •Mario Schwartz, Ulrich Rengstl, Thomas Herzog, Matthias Paul, Jan Kettler, Simone Luca Portalupi, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Research Center SCoPE and IQST, University of Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

In quantum photonics the full on-chip integration of major optical components, like beamsplitters, single-photon sources and detectors are currently one of the main goals. Here, we present our progress on the implementation of InAs quantum dots as single photon sources in on-chip rib GaAs/AlGaAs waveguide structures. An on-chip evanescent field coupler is shown to act as a 50:50 beamsplitter for single photons, generated by pumping an integrated quantum dot quasi-resonantly and resonantly in order to improve the coherent properties of the emitted photons. The purity of the single photon emission is verified under quasi-resonant and resonant continues wave excitation, by directly measuring the photon correlations at the output arms of the on-chip beamsplitter. Especially for pulsed resonant excitation, we demonstrate that the hurdle of strong laser stray light can be overcome by carefully adjusted laser excitation pulses enabling nearly background free, triggered single-photon emission. This manifests in the observation of clear Rabi oscillations over two periods of the quantum dot emission as a function of laser excitation power. The present results open exciting new perspectives for fully integrated quantum circuits.