HL 56: Quantum Emitters in 3D Semiconductors

Time: Friday 11:15–12:30 Location: POT/0006

HL 56.1 Fri 11:15 POT/0006

Electrically driven single-photon sources for scalable quantum photonics operating at the telecommunication wavelengths — •Alessandro Puddu[1,2], Junchun Yang[2], Shengqiang Zhou[1], Artur Erbe[1,2], Ahmad Echresh[1], Kambiz Jamshidi[2], and Yonder Berencén[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstrasse 400, Dresden, 01328, Germany — [2]Technische Universität Dresden, Dresden, 01069, Germany

Silicon-based quantum technologies provide a scalable platform for photonics due to their CMOS compatibility and ease of integration. Single-photon sources operating at telecom wavelengths are key components for low-loss quantum communication networks and the emerging quantum internet. Integrating these emitters with reconfigurable photonic elements such as multiplexers, modulators, filters, etc. and on-chip single-photon detectors is essential for realizing scalable quantum hardware. Optical excitation methods, however, rely on complex and alignment-sensitive laser systems, limiting their integration potential. Electrically driven color centers offer a compact and fully integrable alternative. This paper is focused on achieving electrically driven single-photon emission from individual color centers embedded in a silicon PIN diode. Emission in the telecom O- and L-bands is particularly advantageous, as it aligns with low-loss and low-dispersion regions in standard optical fibers. To improve emission efficiency and on-demand single photon generation, a single-color center will be coupled to a CMOS-compatible optical cavity, enabling Purcell-enhanced emission and efficient integration into silicon photonic circuits.

HL 56.2 Fri 11:30 POT/0006

Liquid Metal Alloy Ion Sources for Quantum Emitters — •Nico Klingner[1], Lukas Prager[1], Gregor Hlawacek[1], Stefan Findeisen[1], Wolfgang Pilz[2], and Paul Mazarov[2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden - Rossendorf (HZDR), Bautzner Landstr. 400, 01328 Dresden, Germany — [2]Raith GmbH, Konrad-Adenauer-Allee 8, 44263 Dortmund, Germany

Liquid metal alloy ion sources (LMAIS) have evolved into powerful emitters for generating focused ion beams (FIBs) of a wide range of elemental species. In recent years, they have become a key enabling tools for quantum technologies, supporting applications such as deterministic single-ion implantation, the controlled creation of defect centers acting as single-photon sources, or for local isotopic purification of silicon for quantum-grade materials.

In this contribution, we present an overview of the LMAIS fabrication process, inluding eutectic alloy phase diagrams in selecting suitable compositions, the microfabrication and sharpening of emitter needles, and the challenges of alloy wetting and reservoir filling. As the alloy chemistry and emitter surface are highly susceptible to contamination, all steps are recently carried out under ultra-high-vacuum conditions to prevent oxidation and ensure reproducible operating characteristics.

Finaly we will show a summary and an outlook on single photon emitter production that benefit from the unique versatility of LMAIS-based ion beams.

HL 56.3 Fri 11:45 POT/0006

Defect-based quantum emitters in aluminum nitride — •Annkathrin Köhler, Jan Böhmer, and Carsten Ronning — Friedrich Schiller Universität, Jena, Deutschland

Aluminum nitride (AlN) has recently gained attention as a promising platform for integrated quantum photonic applications, where single-photon emitters (SPEs) play a key role in quantum communication and on-chip information processing. Its wide bandgap, CMOS compatibility, and established role in optoelectronic technologies make AlN an attractive host for stable, room-temperature SPEs. However, the microscopic origin and controllability of its defect-based emission remain insufficiently understood, challenging the implementation in scalable quantum photonic devices. Here, we investigated the defect-related luminescence in commercially available PVD-grown AlN thin films using micro-photoluminescence spectroscopy and second-order correlation measurements. By characterizing both intrinsic defects and extrinsic impurities introduced through controlled ion irradiation, we aim to identify routes toward reproducible and deterministic creation of optically active defect centers. Ion irradiation provides a tunable method for introducing specific defect types and spatially localized emitters, potentially enabling on-demand SPE fabrication. This study supports the development of AlN as a viable wide-bandgap host for quantum light sources and outlines directions for integrating AlN-based SPEs into future photonic architectures.

HL 56.4 Fri 12:00 POT/0006

Atomic force lithography positioned circular Bragg cavities for high performance quantum dot based quantum light sources. — •Abhishikth Dhurjati[1], Moritz Langer[1], Yared Zena[1], Ahmad Rahimi[1], Liesa Raith[1], Martin Bauer[1], Riccardo Bassoli[2], Frank Fitzek[3], and Caspar Hopfmann[2] — [1]Institute for Emerging Electronic Technologies, IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany — [2]Quantum Communication Networks research group, Deutsche Telekom Chair of Communication Networks, Dresden University of Technology, Germany — [3]Deutsche Telekom Chair of Communication Networks, Dresden University of Technology, Germany

Semiconductor quantum dots (QDs) are excellent quantum emitters, but their random spatial distribution hinders deterministic cavity integration. We present a room-temperature atomic force microscopy (AFM) assisted nano-oxidation technique enabling deterministic QD positioning with a radial displacement of 51(28) nm. Free-standing circular Bragg gratings fabricated around positioned GaAs QDs exhibit a 245-fold photoluminescence enhancement and fine-structure splitting comparable to bulk QDs. Polarization-resolved measurements and simulations show robust cavity-coupled emission for in-plane displacements up to 50 nm and devices with Stokes imbalance below 5 percent, confirming precise alignment and a scalable route toward high-performance quantum light sources.

HL 56.5 Fri 12:15 POT/0006

Bright quantum dot light sources using monolithic microlenses on gold back-reflectors — •Moritz Langer[1,2,3], Sai A Dhurjati[1], Yared Zena[1], Ahmad Rahimi[1], Mandira Pal[1], Liesa Raith[1], Sandra Nestler[1], Riccardo Bassoli[2,3], Frank H P Fitzek[3], Oliver G Schmidt[4], and Caspar Hopfmann[1,2,3] — [1]Institute for Emerging Electronic Technologies - IFW Dresden, Dresden, Germany — [2]Quantum Communication Networks Research Group, Dresden University of Technology, Germany — [3]Deutsche Telekom Chair of Communication Networks, Dresden University of Technology, Germany — [4]Research Center for Materials, Architectures and Integration of Nanomembranes (MAIN), Chemnitz University of Technology, Germany

We present a scalable approach for fabricating bright GaAs quantum-dot photon sources by integrating QDs into broadband monolithic AlGaAs microlens arrays on gold-coated GaAs substrates. Thermally reflowed photoresist templates are transferred into AlGaAs thin films using an optimized 3D reactive-ion etching process, enabling large-area arrays with highly uniform lens geometries. Photoluminescence statistics reveal brightness enhancements of up to *200, occurring in roughly 1 out of 200 lenses, in good agreement with our developed fabrication-yield model. Finite-difference time-domain simulations predict extraction efficiencies of up to 62% for free-space collection and 37% for fiber-coupling. These results highlight the strong potential of this platform for compact, scalable entangled-photon sources in future quantum networks.