HL 48: Quantum Dots and Wires: Growth

Time: Thursday 15:00–16:30 Location: EW 202

HL 48.1 Thu 15:00 EW 202

Doping of GaAs/AlGaAs core-shell nanowires by ion implantation — •Yuxuan Sun[1,2], Donovan Hilliard[1,2], Emmanouil Dimakis[1], Shengqiang Zhou[1], Manfred Helm[1,2], and Slawomir Prucnal[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany; — [2]Technische Universität Dresden, 01062 Dresden, Germany

III-V semiconductor core-shell nanowires are promising for high electron mobility transistors and one-dimensional electron transport, which can be integrated on a nanoscale platform. Core-shell heterostructures are typically designed so that electrons are confined inside the thin core, which is surrounded by a relatively thick undoped shell with wider bandgap. This makes it challenging to form ohmic contacts for the measurement of the electrical properties of the core or the fabrication of devices. Here, we present the contact engineering to GaAs:Si/AlxGa1-xAs core-shell nanowires using selective area ion-implantation of Sulphur. The properly chosen energy of the ion-implantation and selective area implantation allow precise control of the carrier concentration just below the metal contact. Such an approach provides electrical connection to the core nanowire without degrading the crystal structure of the entire nanowire. For electrical activation of implanted impurities we have used ms-range Flash lamp annealing and rapid thermal annealing. Detailed structure, optical and electrical characterization of the nanowires will be presented.

HL 48.2 Thu 15:15 EW 202

Influence of InAl deposition amount and annealing time on nanohole formation by local droplet etching on $In_{0.52}Al_{0.48}As$ layers — •Dennis Deutsch[1], Christopher Buchholz[1], Viktoryia Zolatanosha[1,2], Klaus D. Jöns[1,2], and Dirk Reuter[1,2] — [1]Department of Physics, Paderborn University, Paderborn, Germany — [2]Institute for Photonic Quantum Systems (PhoQS), Paderborn University, Paderborn, Germany

Semiconductor quantum dots are excellent candidates for on-demand generation of entangled photon pairs. Especially $GaAs/Al_xGa_{1-x}As$ quantum dots grown via the local droplet etching approach have been proven to be very promising sources, due to their low strain and excellent in-plane symmetry. However, for the $GaAs/Al_xGa_{1-x}As$ system one is limited to photon emission around 780 nm and ideally photons would be generated in the optical C-band (1530 - 1565 nm) to utilize established fiber networks. One solution is to transfer the local droplet etching technique to the $InP/In_yAl_{1-y}As/In_xGa_{1-x}As$ system. In this contribution we report on the etching of nanoholes into $In_{0.52}Al_{0.48}As$ layers by depositing InAl droplets. We show how the amount of deposited material influences the size, shape and density of the drilled nanoholes. We further display the effect of varying the annealing time after the initial droplet droplet deposition step. Finally, we present that the filled nanoholes emit light when embedded in an $In_{0.52}Al_{0.48}As$ matrix and that we can create quantum dots that show emission up into the optical C-band.

HL 48.3 Thu 15:30 EW 202

High-quality single InGaAs/GaAs quantum dots grown on a CMOS-compatible silicon substrate for quantum photonic applications — •Imad Limame[1], Peter Ludewig[2], Ching-Wen Shih[1], Marcel Hohn[1], Chirag C. Palekar[1], Wolfgang Stolz[2], and Stephan Reitzenstein[1] — [1]ISSP, Technical Univ. of Berlin, DE — [2]NAsP III/V GmbH, Philipps-Univ. of Marburg, DE

Despite significant advances in silicon photonics employing classical light sources, advancements in silicon-compatible quantum photonics have been hindered by the challenge of achieving direct and high-quality growth of single quantum dots (QDs) on the silicon platform. While there have been advancements in post-growth QD integration on silicon, the intricacies of the process restrict scalability and cost-effectiveness. Silicon quantum photonics seeks to harness the unique properties of quantum systems-such as superposition, entanglement, and photon indistinguishability-to facilitate a cost-effective integration of cutting-edge silicon electronics and advanced quantum photonics.

We report on the direct growth of InGaAs QDs with excellent quantum optical properties on a CMOS-compatible silicon substrate [1]. The heteroepitaxy of GaAs heterostructures on silicon is accomplished through a GaP buffer layer. Under non-resonance excitation, we measure high multi-photon suppression of 0.037, and good photon indistinguishability of 0.66. Furthermore, we achieve an extraction efficiency of up to 18.35% for the as-grown QDs with a backside distributed Bragg mirror, showcasing the significant potential of the developed approach.

[1] Limame, I. et al., Preprint at arXiv:2311.14849 (2023)

HL 48.4 Thu 15:45 EW 202

Droplet-etched GaAs quantum dots integrated in AlGaAs photonic circuits as a source of highly indistinguishable photons — •Ulrich Pfister[1], Florian Hornung[1], Stephanie Bauer[1], Dee Rocking Cyrlyson's[2], Ponraj Vijayan[1], Ailton J. Garcia Jr[2], Saimon Filipe Covre da Silva[2], Michael Jetter[1], Simone L. Portalupi[1], Armando Rastelli[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen (IHFG), Center for Integrated Quantum Science and Technology (IQST) and SCoPE, University of Stuttgart, Allmandring 3, Germany — [2]Institute of Semiconductor and Solid State Physics, Johannes Kepler University Linz, 4040 Linz, Austria

Droplet-etched GaAs quantum dots (QDs) are a promising source of single and highly indistinguishable photons. Their optical properties like narrow wavelength distribution, short decay times, linewidths near to the Fourier limit and the resulting highly indistinguishable photons make them highly appealing for several quantum technologies [1]. We demonstrate the first integration of these QDs in photonic integrated circuits consisting of single-mode waveguides and multi-mode interference splitters [2].Under pulsed resonant excitation we achieved high single photon purities of up to $1 - g^{(2)}(0) = 0.929 \pm 0.009$ and two-photon interference visibilities of consecutively emitted photons of 0.939 ± 0.009.

[1] S. F. C. da Silva, *et al.*, Applied Physics Letters, **119**,12 (2021)
[2] Florian Hornung, *et al.*, arXiv:2310.11899 (2023)

HL 48.5 Thu 16:00 EW 202

Separating nucleation and growth during the synthesis of perovskite quantum dots — •David Ederle, Jochen Feldmann, and Quinten A. Akkerman — Chair for Photonics and Optoelectronics, Department of Physics, Nano-Institute Munich, Ludwig-Maximilians-Universität (LMU), Königinstr. 10, 80539 Munich, Germany

Due to their unique optoelectronic properties, colloidal lead halide perovskite quantum dots (LHP QDs) have received much attention in recent years.[1] With a near-unity photoluminescence (PL) quantum yield and highly tuneable PL with a narrow emission, this group of materials is of interest for research and applications such as light-emitting devices and photovoltaics. As the properties of the QDs strongly depend on their size and shape, complete control over their synthesis is crucial. Nonetheless, the search for suitable reaction conditions to synthesize LHP QDs of a certain size remains challenging.

Here, we present a synthesis protocol which allows to temporally separate the nucleation and growth, facilitating the synthesis of monodisperse QDs of a specific size.[2] In this process, in-situ absorption spectroscopy provides a suitable tool for live monitoring the kinetics of the nucleation and growth. This allows us to gain a better understanding of what drives the challenging synthesis of LHP QDs and how to control it.

[1] A. Dey et al., *ACS Nano* **15**, 10775-10981 (2021).
[2] Q. A. Akkerman et al., *Science* **377**, 1406-1412 (2022).

HL 48.6 Thu 16:15 EW 202

Wafer-Scale Emission Energy Modulation of Indium Flushed Quantum Dots — •Nikolai Spitzer, Nikolai Bart, Hans-Georg Babin, Marcel Schmidt, Andreas D. Wieck, and Arne Ludwig — Ruhr-Universität Bochum, Lehrstuhl für Angewandte Festkörperphysik, Universitätsstraße 150, 44801 Bochum, Germany

We explore a novel approach for fine-tuning the emission wavelength of quantum dots (QDs) by building upon the indium flush growth method: Submonolayer variations in the capping thickness reveal a non-monotonic progression, where the emission energy can decrease even though the capping thickness decreases. Indium flush, a well-known technique for inducing blue shifts in quantum dot emissions, involves the partial capping of QDs with GaAs followed by a temperature ramp-up. However, our findings reveal that the capping layer

roughness, stemming from fractional monolayers during overgrowth, plays a pivotal role in modulating the emission energy of these QDs. We propose increased indium interdiffusion between the QDs and the surrounding GaAs capping layer for a rough surface surrounding the QD as the driving mechanism. This interdiffusion alters the indium content within the QDs, resulting in an additional emission energy shift, counterintuitive to the capping layers thickness increase. We utilize photoluminescence spectroscopy to generate wafer maps depicting the emission spectrum of the QDs. Using thickness gradients, we produce systematic variations in the capping layer thickness on 3-inch wafers, resulting in modulations of the emission energy of up to 26 meV.