FM 84: Poster: Quantum Networks

Time: Thursday 16:30–18:30 Location: Tents

FM 84.1 Thu 16:30 Tents

Stopped and stationary light at the single-photon level inside a hollow-core fiber — Thorsten Peters, Ta-Pang Wang, Antje Neumann, Lachezar S. Simeonov, •Alexander Bruns, and Thomas Halfmann — Institut für Angewandte Physik, Hochschulstrasse 6, 64289 Darmstadt, Germany

We report on light storage and retrieval as well as stationary light for weak coherent light pulses down to the single-photon level based on electromagnetically induced transparency. The experiments were carried out in an ensemble of laser-cooled atoms loaded into a hollow-core photonic crystal fiber to provide strong light-matter coupling, which is an essential requirement for a quantum information platform.

FM 84.2 Thu 16:30 Tents

Production of nanostructures in silicon carbide and their influence on single defect centres — •Timo Görlitz, Charles Babin, Rainer Stöhr, Roman Kolesov, Vadim Vorobev, Matthias Niethammer, Naoya Morioka, Roland Nagy, Florian Kaiser, and Jörg Wrachtrup — 3rd Institute of Physics, University of Stuttgart, Germany

Recently, it was shown that single silicon vacancy centres (V_{Si}) in 4H silicon carbide (SiC) are a promising platform for quantum information distribution [1]. The system combines unprecedented spin and spectral stability thanks to low spin-photon coupling and identical dipole moments in ground and excited state. The low photon count rates of the system represent the system's remaining bottleneck, especially when considering quantum communication tasks. To overcome this issue, nanophotonics structures can be used that boost emission rates via Purcell enhancement and, at the same time, improve light collection efficiency. Here, we will show that V_{Si} centres in SiC preserve excellent spin-optical properties in nanophotonics wave guide structures, which is a key requirement for any further advancements. We will then outline our advancements in our current research direction, i.e. the fabrication and characterization of V_{Si} centres in circular Bragg grating cavities. Those structures provide both Purcell enhancement and better collection efficiency [2], and we will compare our theoretical consideration to the experimentally obtained results.

[1] R. Nagy et al., *Nature Comm.* 10, 1954 (2019)
[2] J. Liu et al., *Nature Nano.* 14, 586 (2019)

FM 84.3 Thu 16:30 Tents

Quantum Memory with Optimal Control — •Stephan Trattnig[1,2], Edwar Xie[1,2,3], Frank Deppe[1,2,3,4], Qi-ming Chen[1,2], Michael Fischer[1,2,3], Michael Renger[1,2], Stefan Pogorzalek[1,2], Kirill G. Fedorov[1,2], Matti Partanen[1], Achim Marx[1], and Rudolf Gross[1,2,3,4] — [1]Walther- Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik Department, TU München, 85748 Garching, Germany — [3]Nanosystems Initiative Munich (NIM), 80799 München, Germany — [4]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 Munich, Germany

We realize a quantum memory by coupling a transmon qubit to a rectangular 3D cavity resonator [1]. Exploiting the multimode structure of the 3D cavity enables us to use a single resonator for storage and readout purposes, thereby significantly enhancing scalability. We accurately characterize the loss of quantum information during the storage and retrieval process by performing quantum process tomography on our memory system and find a corrected process fidelity of 88%. Finally, we employ optimal control with DRAG-like pulses in an attempt to suppress state leakage and, thus, improve our memory protocol.

We acknowledge support by the Germany's Excellence Strategy EXC-2111-390814868, Elite Network of Bavaria through the program ExQM, and the European Union via the Quantum Flagship project QMiCS (Grant No. 820505). [1] E. Xie *et al.*, Appl. Phys. Lett. **112**, 202601 (2018).

FM 84.4 Thu 16:30 Tents

Towards techniques for on-chip pump filtering of light sources — •Julian Brockmeier[1], Jan Philipp Höpker[1], Maximilian Protte[1], Harald Herrmann[2], Christof Eigner[2], Christine Silberhorn[2], and Tim Bartley[1] — [1]Mesoskopische Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Integrierte Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Integrated sources of quantum light are increasingly used in many quantum photonic technologies. Many of these sources are optically driven, based on a nonlinear process such as spontaneous parametric down-conversion (SPDC) or four-wave mixing (SFWM). It is also desirable to place detectors on the same chips as the sources, to reduce overall losses and latency of the photonic circuits. However, the strong pump must be separated from the single-photon level quantum light prior to detection. This is a challenging task due to the huge difference in relative power levels, as well as the requirement of low-loss on the quantum light. We present several schemes using titanium in-diffused lithium niobite waveguides which may offer progress towards the goal of on-chip pump filtering, based on both waveguide design, dispersion engineering and high-speed response of superconducting integrated detectors.

FM 84.5 Thu 16:30 Tents

Polarization-preserving quantum frequency conversion for entanglement distribution in quantum networks — •Matthias Bock[1], Stephan Kucera[1], Robert Garthoff[2], Tim van Leent[2], Kai Redeker[2], Pascal Eich[1], Matthias Kreis[1], Wenjamin Rosenfeld[2,3], Tobias Bauer[1], Harald Weinfurter[2,3], Juergen Eschner[1], and Christoph Becher[1] — [1]Universität des Saarlandes, Campus E2.6, Saarbrücken, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

Entanglement between a stationary quantum system and a photonic flying qubit is an essential ingredient of a quantum-repeater network. Most stationary quantum bits, however, have transition wavelengths in the blue, red or near-infrared spectral regions, whereas long-range fiber-communication requires wavelengths in the low-loss telecom regime. A proven tool to interconnect flying qubits at visible/NIR wavelengths to the telecom bands is quantum frequency conversion. Here we will show an efficient and low-noise polarization-preserving frequency converter connecting 854 nm – a transition wavelength in a single trapped $^{40}Ca^{+}$-ion – to the Telecom O-band at 1310 nm. This enables the observation of ion-telecom-photon entanglement as well as an ion-to-telecom-photon state transfer. Moreover we will present a complete QFC system designed as telecom interface for an elementary Rubidium-atom based quantum network link. As a first result, the entanglement between a single Rb-atom and a telecom photon transmitted through an optical fiber of 10 km length is shown.

FM 84.6 Thu 16:30 Tents

Building Blocks for Practical Single-Photon QKD — •Lucas Rickert[1], Timm Kupko[1], Martin v. Helversen[1], Alexander Schlehahn[1], Sven Rodt[1], Christian Schneider[2], Sven Höfling[2,3], Stephan Reitzenstein[1], and Tobias Heindel[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [3]SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, United Kingdom

We will present our recent progress in the development of practical devices for quantum communication employing quantum light sources. The first device is a plug-and-play single-photon source (SPS) based on semiconductor quantum dots, integrated in a compact Stirling cryocooler for user-friendly operation. We address efficient direct coupling of electrically operable quantum light sources to optical single-mode fibers, representing one crucial step towards applications. The second device constitutes a receiver module designed for polarization-encoded QKD. We show that temporal filtering of single-photon pulses can be used for a performance optimization of QKD systems implemented with realistic quantum-light sources. Finally, we demonstrate real-time security monitoring using our receiver-module by evaluating $g^{(2)}(0)$ inside the quantum channel.

The results presented here are an important contribution towards the development of QKD-secured communication networks based on quantum-light sources suitable for practical applications.

FM 84.7 Thu 16:30 Tents

Polarization-Preserving Quantum Frequency Conversion of $^{40}Ca^+$-Resonant Photons to the Telecom C-Band — •Tobias Bauer, Matthias Bock, Stephan Kucera, Benjamin Kambs, Jan Arensközter, Jürgen Eschner, and Christoph Becher — Universität des Saarlandes, FR Physik, Campus E2.6, 66123 Saarbrücken

In quantum communication networks information is stored in internal states of quantum nodes, which can be realized e.g. in trapped ions like $^{40}Ca^+$. By transferring the states onto photons, it is possible to exchange information between these nodes over long distances via optical fiber links. In order to minimize attenuation in fibers, which is particularly high for typical transition frequencies of trapped ions, quantum frequency down-conversion of the transmitted photons to low-loss telecom bands is utilized [1].

We present a scheme for polarization-preserving quantum frequency conversion of $^{40}Ca^+$-resonant photons to the telecom C-band. It relies on the difference frequency generation process $854\,\mathrm{nm} - 1904\,\mathrm{nm} = 1550\,\mathrm{nm}$ [2] in a PPLN waveguide, which is arranged in a Sagnac configuration to achieve polarization preservation. We will present the characterization of the converter, in particular of its conversion efficiency and noise count rates.

[1] M. Bock, P. Eich et al., Nat. Commun. 9, 1998 (2018)
[2] V. Krutyanskiy et al., Appl. Phys. B 123:228 (2017).

FM 84.8 Thu 16:30 Tents

Quantum repeater implementation based on a nitrogen-vacancy center in diamond — •Javid Javadzade, Florian Kaiser, Amlan Mukherjee, Erik Hesselmeier, Ilja Gerhardt, and Jörg Wrachtrup — 3rd Institute of Physics, University of Stuttgart and Institute for Quantum Science and Technology IQST, Stuttgart, Germany

Distribution of entanglement over large distances is a prerequisite for implementation of high-level quantum information tasks, e.g. quantum cryptography. While there are already commercial solutions for short distance point-to-point quantum links, a scalable approach towards long-distance quantum key distribution (QKD) calls for a quantum repeater based network architecture. By dividing the quantum communication channel in multiple nodes, channel losses are overcome and error correction can be implemented. Here, we outline our research strategy towards implementing an elementary quantum repeater node as a part of the Q.Link.X project, funded through the German BMBF. The repeater node will utilize a single nitrogen-vacancy center in diamond coupled to a nearby 13C nuclear spin, acting as quantum memory [1]. Our protocol is based on entanglement between solid-state spins and photonic time-bin modes. We will present the estimated entanglement rates and discuss further extensions and improvements.

[1] D. Luong et al. Appl. Phys. B, 122, 96 (2016)

FM 84.9 Thu 16:30 Tents

Towards hybrid waveguides in lithium niobate for quantum optical applications — •Maxmilian Protte[1], Lena Ebers[2], Jan Philipp Höpker[1], Basudeb Sain[1], Julian Brockmeier[1], Raimund Ricken[1], Manfred Hammer[2], Christof Eigner[1], Jens Förstner[2], Christine Silberhorn[1], and Tim Bartley[1] — [1]Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Department Elektrotechnik und Informationstechnik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

In recent years there has been a great number of optical devices realized in titanium in-diffused lithium niobate waveguides. One great advantage is the on-chip coupling efficiency ($\geq 80\%$) which results from the good overlap between the fiber mode and the waveguide mode. A significant challenge is efficiently coupling between titanium in-diffused waveguides and material systems with much smaller optical mode dimensions, such as semiconductor waveguides or superconducting detectors. One approach is the use of tapers consisting of a high refractive index material such as silicon, and vertical evanescent coupling between the two waveguide structures. We theoretically and experimentally investigate this approach to increase the detection efficiency of superconducting integrated detectors, which would further increase the versatility of an already promising platform for integrated photonics.

FM 84.10 Thu 16:30 Tents

Characterization and Readout of Multi-Element Superconducting Single Photon Detectors — •Timon Schapeler[1], Johannes Tiedau[2], Vikas Anant[3], Helmut Fedder[4], Christine Silberhorn[2], and Tim Bartley[1] — [1]Mesoskopische Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Integrierte Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [3]Photon Spot, Inc. 142 W Olive Ave, Monrovia, CA 91016, USA — [4]Swabian Instruments GmbH, Frankenstr. 39, 71701 Schwieberdingen, Germany

The detection of single photons is the basis of many applications in quantum photonics. Increasingly, superconducting nanowire single-photon detectors (SNSPDs) are used, due to their high efficiency, low dark count rate and their high repetition rate up to the gigahertz regime. In addition, some photon-number information can be extracted using multi-element devices. We demonstrate one way to characterize the photon statistics arising from four-element SNSPDs in terms of their detection efficiency. By a comparison of experimental data and a theoretical model of a commercial four-pixel device, we were able to account for the individual detection efficiencies of each pixel. Furthermore, we demonstrate a multi-element single-channel readout scheme, based on measuring pulse length of the output of the four-pixel device with each element connected in series. This simplifies the electronic data acquisition of such devices, as well as reduces the electronic heat-load in the cryostat.

FM 84.11 Thu 16:30 Tents

Linear and Nonlinear Characterisation of Cryogenic Waveguides in Lithium Niobate — •Nina Amelie Lange[1], Moritz Bartnick[1], Jan Philipp Höpker[1], Frederik Thiele[1], Raimund Ricken[2], Viktor Quiring[2], Christof Eigner[2], Harald Herrmann[2], Christine Silberhorn[2], and Tim Bartley[1] — [1]Mesoskopische Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Integrierte Quantenoptik, Department Physik, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Lithium niobate is a promising platform for integrated quantum photonics. In particular, the outstanding electro-optic properties and the high second-order nonlinearity allow for high-speed modulation, polarisation conversion and sources of quantum light. These properties are well examined at room temperatures. However, many quantum optic devices, especially superconducting detectors, can only operate at cryogenic temperatures. Therefore, the properties of waveguides in lithium niobate must be investigated at temperatures of a few Kelvin. We developed some techniques to perform a linear and a nonlinear characterisation of titanium in-diffused lithium niobate waveguides inside a closed cycle cryostat. These techniques allow us to characterise the waveguide losses and the second harmonic generation at cryogenic temperatures. The examined samples show that losses and nonlinear phasematching bandwidths are not strongly affected in this temperature range. Moreover, these characterisation techniques allow to investigate the pyroelectric properties of lithium niobate.

FM 84.12 Thu 16:30 Tents

Design and impelementation of a segmented ion trap with an integrated fiber cavity — •Omar Elshehy, Stephan Kucera, and Jürgen Eschner — Universität des Saarlandes, Experimentalphysik, Campus E2.6, 66123 Saarbrücken

Efficient atom-photon interfaces are a basic requirement for any quantum network [1,2]. The efficiency of such interfaces has been shown to increase significantly by the use of cavities [3]. We present a segmented ion trap design for $^{40}Ca^+$ ions with an integrated fiber cavity. The fiber cavity is incorporated into the center electrodes of the trap, which protects the ion from charge accumulation on the fiber mirrors and shields the fibers from lasers. A simulation of the trapping potential shows its tunability for micro-motion compensation and ion-shuttling operations. Moreover, preliminary characterization measurements of coupling efficiency and finesse of the fiber cavity are presented.

[1] C. Kurz et al., Nat. Commun. **5**, 5527 (2014)
[2] M. Bock et al., Nat. Commun. **9**, 1998 (2018)
[3] T. G. Ballance et al., Phys. Rev. A **95**, 033812 (2017)

FM 84.13 Thu 16:30 Tents

Time-multiplexed photonic quantum walks with 4D coins — •Lennart Lorz[1], Evan Meyer-Scott[1], Thomas Nitsche[1], Václav Potocek[2], Aurél Gábris[2], Sonja Barkhofen[1], Igor Jex[2], and Christine Silberhorn[1] — [1]Integrated Quantum Optics, Universität Paderborn, Warburger Straße 100, 33098 Paderborn, Germany — [2]Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Brehová 7, 115 19, Praha 1, Czech Republic

Discrete time quantum walks, realized in time-multiplexed architectures, are an essential tool to experimentally study quantum transport phenomena. We have implemented the well-established time-multiplexing scheme in a Michelson interferometer loop, in contrast to the standard Mach-Zehnder setup. By exploiting the two different traveling directions in the loop in addition to the two possible polarizations of the walker, we devise a four dimensional coin space for a one dimensional quantum walk. Making use of the extra degrees of freedom, we are able to generate quantum walks on loop structures of various sizes and topologies, with mixing and non-mixing coins and different input positions and polarizations. By capitalizing on the full dimensionality of the coin, we demonstrate walk evolutions on so-called figure of eight graphs consisting of two loops connected by a central vertex of rank four.

FM 84.14 Thu 16:30 Tents

Efficient single-photon collection for long-distance entanglement of atoms — •Robert Garthoff[1], Tim van Leent[1], Kai Redeker[1], Matthias Seubert[1], Wei Zhang[1], Wenjamin Rosenfeld[1,2], and Harald Weinfurter[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [2]Planck- Institut für Quantenoptik, Garching, Germany

Photon mediated entanglement between distributed quantum systems forms the basis of future quantum networks and thus will be essential for secure quantum communication and distributed quantum computing. Currently, efficient collection of photons from the quantum memory limits the generation of remote entanglement in entanglement swapping based schemes.

Here we present the details and experimental results of a new setup with optimized photon collection efficiency from a single Rb-87 atom. Using a custom designed high-NA microscope objectives, corrected for our specific experimental geometry, we observe an increase of the collection efficiency by a factor of 2.5. This now enables an improved rate to achieve remote entanglement by a factor of 6, which in turn forms the crucial ingredient to apply frequency conversion to telecom wavelengths in order to efficiently obtain entanglement between quantum memories on a suburban scale.

[1] W. Rosenfeld, Phys. Rev. Lett. **119**, 010402 (2017).

FM 84.15 Thu 16:30 Tents

Multi-photon Entanglement via Quantum Interference Buffering — Evan Meyer-Scott[1], •Nidhin Prasannan[1], Ish Dhand[2], Christof Eigner[1], Viktor Quiring[1], Sonja Barkhofen[1], Benjamin Brecht[1], Martin B Plenio[2], and Christine Silberhorn[1] — [1]University of Paderborn, 33098 Paderborn, Germany — [2]Institüt für Theoretische Physik and Center for Integrated Quantum Science and Technology(IQST), University of Ulm, 89069 Ulm, Germany

We present an experimental method to generate multi-photon entangled state which utilises quantum buffering and temporal source multiplexing. Our all optical polarization insensitive buffer memory is able to store photonic qubits with good efficiency and state fidelity. Quantum state tomography reveals photonic qubit state fidelity of 99% for 200ns and above 88% for $1\mu s$ storage time. A Sagnac based polarization entangled source is pumped by a femtosecond laser to fire Bell pairs with high entanglement visibility. Combining temporal source multiplexing and memory loop we apply a quantum interference buffering technique to entangle subsequent Bell pairs towards a four photon GHZ state. We achieve a state fidelity above 80% for the GHZ state. Temporal multiplexing of 20 sources shows nine fold increase in four photon generation rates.

FM 84.16 Thu 16:30 Tents

Quantum repeater protocols assisted by single- and two-qubit memory — •Martin Steinel, Matthias Kreis, Jan Arenskötter, Stephan Kucera, and Jürgen Eschner — Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken

The generation of entanglement over long distance is a fundamental ingredient in quantum networks that may be employed for quantum key distribution or distributed quantum computing. Because of fiber loss, the transmission efficiency decreases exponentially with distance. To counteract this, quantum repeaters [1] are required. The Lütkenhaus protocol [2] promises to achieve higher entanglement rates by combining quantum repeater methods with quantum memories (QM) in the middle of the link. Focusing on an implementation based on trapped ions as quantum memories [3-5] and an SPDC source of entangled photon pairs [6], we compare protocols for a quantum repeater link using two QMs with protocols using a single QM. We consider efficiency, scalability, and rates in a case study for our existing setup.

[1] H.-J. Briegel et al., Phys. Rev. Lett. **81**, 5932 (1998) [2] D. Luong et al., Appl. Phys. B **122**, 96 (2016) [3] C. Kurz et al., Nat. Commun. **5**, 5527 (2014) [4] C. Kurz et al., Phys. Rev. A **93**, 062348 (2016) [5] M. Bock et al., Nat. Commun. **9**, 1998 (2018) [6] S. Kucera et al., in preparation

FM 84.17 Thu 16:30 Tents

Towards long-time entanglement between a single optically trapped atom and a single photon — •Wei Zhang[1], Tim van Leent[1], Robert Garthoff[1], Kai Redeker[1], Matthias Seubert[1], Wenjamin Rosenfeld[1,2], and Harald Weinfurter[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [2]Planck- Institut für Quantenoptik, Garching, Germany

The most fundamental task for a quantum network is to generate atom-photon entanglement with long coherence time.

At present, for atom-photon states of a single optically trapped Rb-87 atom and its emitted photons, there are two decoherence mechanisms. One is motional decoherence in the dipole trap and the other is magnetic decoherence caused by the fluctuation of external magnetic fields. The proposed method is to use a standing-wave dipole trap to confine the atom in space thus reducing motional decoherence. At the same time, this optics can be used to apply stimulated Raman adiabatic passage to coherently transfer the entangled atomic state to the new atomic states which is 500 hundred times less-sensitive to magnetic-field fluctuations.

The coherence time for an atom-photon entangled state is expected to be increased by 2 orders of magnitude, from the (current) 100 microseconds to 10 milliseconds, which would be sufficient for communications over more than 100 km.

FM 84.18 Thu 16:30 Tents

Single-photon source design for quantum telecommunication networks — •Nico Sieber[1,2], Matthias Bayerbach[1,2], and Stefanie Barz[1,2] — [1]Center for Integrated Quantum Science and Technology — [2]Institute for Functional Matter and Quantum Technologies

Photonic devices are key to a large range of quantum technologies, for example quantum communication and wider quantum networks. When transmitting quantum information over long distances, minimizing losses is crucial to any quantum protocols. Thus, the favourable wavelength is in the telecom regime (1550nm). Many quantum protocols thus rely on pure and indistinguishable photons at this wavelength. Here, we demonstrate the generation of single photons at telecom wavelength using type II spontaneous parametric down-conversion (SPDC) in periodically-poled potassium titanyl phosphate (ppKTP) crystals. When being used in quantum network tasks, the probabilistic nature of SPDC fosters the occurrence of multi-photon pair generation leading to reduced fidelities of the tasks to be implemented. Following that, we perform a simulation of this effect on a variety of quantum network tasks.

FM 84.19 Thu 16:30 Tents

Hybrid Devices of Spin-photon Interfaces for Singlet-triplet Quantum Dots — •Zheng Zeng[1], David Fricker[1], Arne Ludwig[2], Marcel Schmidt[2], Chao Zhao[1], Hendrik Bluhm[3], and Beata Kardynał[1] — [1]Peter Grünberg Institute 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr- Universität Bochum, 44780 Bochum, Germany — [3]JARA-Institute for Quantum Information, RWTH Aachen University, 52074 Aachen, Germany

Connecting quantum processors over long distances using photon qubits would enable more complex quantum computing architectures and quantum networks. Recently a protocol to transfer a quantum state from a photonic qubit to a singlet-triplet spin qubit in GaAs/AlGaAs heterostructure has been theoretically demonstrated. In practice, the coherent transfer is facilitated by a hybrid device where a GaAs/AlGaAs gate-defined double quantum dot (GDQD) is tunnel coupled to a self-assemble quantum dot (SAQD), in which a conversion between a photon state and a spin state takes place. In this contribution we discuss fabrication techniques to achieve the precise alignment of both types of QDs both in energy as well as in space, which is essential for the device operation. We fabricate front- and back-gates to enable tuning the energy levels of the quantum dots. We discuss the method to align the gates of the GDQD to a SAQD. Further we explore methods of QDs growth to minimize the impact on the GDQDs. In particular we compare the performance of strain-free droplet QDs with high quality Stransky-Krastanov QDs in the hybrid devices.