Q 66: Poster – Quantum Technologies III

Color Centers and Ion Traps

Time: Thursday 17:00–19:00 Location: Philo 2. OG

Q 66.1 Thu 17:00 Philo 2. OG

SLE-structuring and surface polishing for the fabrication of multi-segmented ion traps — •Jan Christoph Müller[1], Can Leichtweiss[1], Alexander Müller[2], Björn Lekitsch[1,2], and Ferdinand Schmidt-Kaler[1,2] — [1]QUANTUM,Institut für Physik, 55128 Mainz, Germany — [2]neQxt GmbH

The up-scaling of trapped ion quantum computers relies on the segmentation and miniaturization of the traditional macroscopic ion traps to enable the storage of multiple sub clusters of the ions that serve as qubits [1]. We want to achieve this while maintaining favorable qualities like a deep trapping potential and low heating rates at room temperature, both associated with 3D Paul traps. We established a special purpose clean room where we can fabricate trap chips with versatile 3D-geometries in fused silica using Selective Laser-induced Etching (SLE), followed by surface polishing using a scanning CO_2-Laser [2] and metallic sputter deposition. We report on different fabricated trap designs and on tests with $^{40}Ca^+$ ions.

[1] V. Kaushal et al., AVS Quantum Sci.; 2 (1):014101.
[2] C. Weingarten et al., J. Laser Appl.; 29 (1):011702.

Q 66.2 Thu 17:00 Philo 2. OG

Progress on Our Next-Generation Quantum Computing Setup — •James Rumbold[1], Helin Özel[1], Julian Wiener[1], John Wolff[1], Felix Stopp[1,2], Jonas Vogel[1,2], Björn Lekitsch[1,2], and Ferdinand Schmidt-Kaler[1,2] — [1]QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]NeQxt GmbH

To further enhance the capabilities of trapped-ion quantum computing systems, hundreds of qubits with higher operational fidelities are required. In our next-generation quantum computer we plan to increase our qubit count up to 100 by implementing two independent computational zones, with each holding ten ions and enacting gates simultaneously. Our ion trap features 40 DC segments that can hold additional ion chains and perform transport operations, facilitating all-to-all connectivity. To improve the computational fidelities the setup will feature three layers of mu-metal shielding, no magnetic parts surrounding the vacuum chamber, and a redesigned addressing system for reduced crosstalk. The poster will present the current progress of the experimental system, including optical and electronical qubit control, as well as some preliminary characterisation results of the new components.

Q 66.3 Thu 17:00 Philo 2. OG

Setup of a Confocal Fluorescence Microscope for the Detection and Characterization of Single NV Centers in Diamond — •Manuel Riedmann, Lucas Kirchbach, and Andreas Stute — Technische Hochschule Nürnberg

Single nitrogen vacancy (NV) centers in diamond serve as a photonic platform for quantum sensing and computing applications. They can be created deterministically using femtosecond laser pulses. Such writing process requires high-resolution fluorescence detection with a high signal-to-noise ratio, which is accomplished by setting up a homebuilt confocal fluorescence microscope. The microscope shall monitor the fluorescence of newly formed NV centers during the writing process. In addition, it will be used to characterize the NV centers' spin coherence times, orientation in the diamond lattice and single-emitter characteristics via the intensity correlation function $g^{(2)}(\tau)$. In the future, this setup is also planned to be employed for STED-microscopy of twin NV centers.

Q 66.4 Thu 17:00 Philo 2. OG

Diamond Thin Film Creation for Color Centers — •Nick Brinkmann[1,2], Caius Niemann[1], Donika Imeri[1,2], Leonie Eggers[1,2], Sunil Mahato[1,2], Lasse Irrgang[1], Konstantin Beck[1], Rikhav Shah[1], and Ralf Riedinger[1,2] — [1]Universität Hamburg, Institut für Quantenphysik, Hamburg, Deutschland — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany

Diamond nanophotonic structures hold immense potential for breakthroughs in quantum information technologies and are a leading platform for developing quantum memory chips. One challenge in the development of nanophotonic structures lies in the reliable transfer and bonding of single-crystal diamond thin films onto suitable substrates. Here, we present an innovative and scalable process, which holds promise for efficiently and securely managing the transfer of these diamond thin films. This method can advance the fabrication of nanophotonic structures on diamond, which can serve as interfaces between the spins of color centers, such as SiV, and photons. Thus, it opens up new possibilities for integrating such structures into photonic networks, promising significant advances in quantum optics and communication.

Q 66.5 Thu 17:00 Philo 2. OG

Quantum photonics using color centers in a diamond membrane coupled to a photonic structure — •Surena FATEMI[1,2], Jan Fait[1], Roy Konnoth Ancel[2], Christophe Couteau[2], and Christoph Becher[1] — [1]Fachrichtung Physik, Universität des Saarlandes, Saarbrücken, Germany — [2]Université de Technologie de Troyes, Troyes, France

In recent years, color centers in wide band-gap materials have attracted significant attention due to their exceptional potential in quantum technologies. Among these, group-IV color centers in diamond stand out for their long spin coherence times and superior optical properties, including narrow emission lines, high spectral stability, and bright single-photon emission. A key challenge in developing quantum devices based on color centers is the inefficient photon out-coupling from diamond, resulting in low extraction rates. To address this limitation, we investigate group-IV color centers in diamond membranes integrated with TiO2-based photonic waveguides. Leveraging Finite Element Method simulations and Monte Carlo optimization, we refine membrane geometry, coupling interfaces, and waveguide design to enhance photon out-coupling and achieve high photon extraction rates, paving the way for practical, efficient quantum devices. We also present the fabrication process and initial investigations of these optimized structures.

Q 66.6 Thu 17:00 Philo 2. OG

Adhesion Tests for Multi-Layer Surface-Electrode Ion Traps in Cryogenic Ultra-High Vacuum — •Nica Schiffelholz[1], Jacob Stupp[1], Nora D. Stahr[1], Masum M. Billah[1], Marlon Kuhn[1], Christine Marachoris[1], Friederike Giebel[2], Eike Iseke[1,2], Nila Krishnakumar[1,2], Konstantin Thronberens[2], and Christian Ospelkaus[1,2] — [1]Institute for Quantum Optics, Leibniz University Hannover, Welfengarten 1, Hannover, 30167, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, Braunschweig, 38116, Germany

Quantum computers are expected to solve certain computational problems significantly faster than classical computers. Trapped-ion based approaches offer the advantage of scalability and low error rates. Trapping ions in surface-electrode ion traps offers improved optical access, while multi-layered designs allow more complex signal routing in multifunctional trap designs. In our design, subsequent gold layers are microfabricated with a dieletric polyimide film between each level. Here we investigate the adhesive behavior between the polyimide layer and the subsequent layers for use in cryogenic ultra-high vacuum under varying manufacturing parameters. Titanium and chromium are tested as adhesive layers, and their effect on the gold layer is studied.

Q 66.7 Thu 17:00 Philo 2. OG

Characterization of shallow, low temperature annealed tin-vacancy centers in diamond — •Gabrielle A. Hunter-Smith, Jan Fait, Kilian Mark, Surena Fatemi, and Christoph Becher — Universität des Saarlandes, Fachrichtung Physik, Campus E2 6, 66123 Saarbrücken

Group-IV color centers in diamond are well known for their suitability as nodes within quantum networks due to their excellent spin and optical coherence. In particular the negatively charged tin-vacancy center (SnV-) has proved promising, with previous work showing that after high pressure, high temperature (HPHT) annealing, the spread of spectral peaks may be significantly reduced [1].

However, HPHT annealing is both a costly and restrictive procedure, as well as being potentially destructive to delicate surface structures, e.g. nano-photonic elements.

We here present initial investigations on shallow SnV- centers generated by focused ion beam implantation and annealing under vacuum at 1200°C. In particular, we consider the effects of surface terminations and etched microstructures on the surface of thin diamond samples through monitoring the emission spectra, saturation curves, and background fluorescence levels.

[1] Görlitz, J. et al, 2020 New J. Phys. **22** 013048

Q 66.8 Thu 17:00 Philo 2. OG

Adaption and Evaluation of Custom Microwave Antennas for NV Center Coherence Measurements — •Yannick Resch, Anish Thomas, Stefan Johansson, Dennis Lönard, Alena Erlenbach, Jonas Gutsche, and Artur Widera — Department of Physics and State Research Center OPTIMAS, RPTU University Kaiserslautern-Landau, 67663 Kaiserslautern, Germany

Due to their biocompatibility, nitrogen-vacancy (NV) centers in diamonds can be implanted into cells and algae to investigate magnetic-field signals and temperatures inside these biological samples. The sensitivity of the magnetic field and temperature sensing with NV centers is, however, often limited by the inhomogeneity of the microwave field used to drive the NV centers' spin states.

In this work, we report on the adaptation and evaluation of different designs of microwave patch antennas tailored for integration into an existing setup for probing biological samples. We investigate a double split-ring resonator and a planar ring design for their ability to generate homogeneous microwave fields and their efficiency in exciting the spin-resonance transitions of NV centers.

To achieve suitable impedance characteristics and field distribution, we used high-frequency simulations and characterized the resulting prototypes by experimental S-parameter analysis as well as magnitude and homogeneity of the microwave field, which was determined by measuring Rabi oscillations in several NV-diamond specimens.

Q 66.9 Thu 17:00 Philo 2. OG

Exploring Nickel Vacancies for Improved Colour Centres — •Florian Rickert, Nick Brinkmann, Caius Niemann, and Ralf Riedinger — Institute for Quantum Physics, Hamburg, Germany

As quantum computers advance, the need for quantum networks becomes more apparent. In order to realize a quantum internet, we need to connect processors over long distances. With quantum cryptography, security levels in communication could then be raised to unprecedented levels.

Due to the exponential loss of photons in fibers over long distances, an optical quantum network relies on quantum repeaters that allow for qubit storage with sufficiently long coherence times. A thoroughly investigated platform for such repeaters is the silicon-vacancy (SiV-) color center in diamond. At temperatures below 100 millikelvin, this defect exhibits spin memory long enough to enable entanglement over a distance of 500 kilometers. The major drawback of this platform, despite its impressive performance, is the extremely low temperature requirement which demands expensive dilution refrigeration.

A promising candidate to overcome this limitation is the NiV color center in diamond. Due to stronger spin-orbit coupling, the ground state splitting of Nickel is larger, making the spin qubit stable at temperatures up to about 2K. These temperatures are reached with a much more affordable and transportable setup.

Here we present recent efforts for chip integration of NiV color centers.

Q 66.10 Thu 17:00 Philo 2. OG

Time-resolved coherent optical spectroscopy on an ensemble of tin-vacancy color centers in diamond — •Fabian Voltz, Anna Fuchs, and Christoph Becher — Universität des Saarlandes, Saarbrücken 66123, Germany

Single negatively charged group IV-vacancy (G4V) color centers in diamond are among the leading candidates for qubit systems in quantum communication due to their long spin coherence times and stable optical emission lines. While most studies focus on single centers, dense ensembles of G4V centers offer enhanced light-matter coupling, as shown for ensembles of silicon-vacancy (SiV^-) centers [1], enabling applications such as Raman-based quantum memories or quantum sensing.

Among the G4V centers, single tin-vacancy (SnV^-) centers stand out with long spin coherence times at elevated temperatures (~ 2 K) [2,3]. However the spin dynamics of ensembles of SnV^- centers remain largely unexplored, despite the potential benefits of higher signal levels.

In this work, we investigate the spin coherence time of a dense SnV^- ensemble by combining coherent optical spectroscopy with time-resolved measurements. We will present our recent results on SnV^- ensembles and discuss the implications of these findings for ensemble-based quantum technologies that aim to combine strong light-matter interaction with long spin coherence.

[1] Weinzetl et al., Phys. Rev. Lett. 122, 063601 (2019)
[2] Karapatzakis et al., Phys. Rev. X 14, 031036 (2024)
[3] Görlitz et al., npj Quantum Inf 8, 45 (2022)

Q 66.11 Thu 17:00 Philo 2. OG

Scalable formation of tin-vacancy centers in diamond for quantum technology applications. — •Aikaterini Tzanetou[1], Felix Hoffmann[1], Ella Schneider[2], Gianfranco Aresta[3], Mukesh Triparthi[4], Julian Rickert[4], and Daniel Hähnel[1] — [1]Fraunhofer Institute for applied Solid State Research IAF, Freiburg, 79108, Germany — [2]Surrey Ion Beam Centre, University of Surrey, Guildford GU2 7XH, UK — [3]Ionoptika Ltd.B6 Millbrook Close, Chandler's Ford, Hampshire SO53 4BZ, UK — [4]XeedQ GmbH, Augustusplatz 1-4, 04109 Leipzig, Germany

The tin-vacancy (Sn-V) center in diamond has emerged as a promising emitter for the realization of quantum information processing protocols. We here report on a process flow that targets the precise, reproducible and localized formation of tin-vacancy centers in diamond intended for use in quantum technology applications. On this basis, tin ions (117-Sn2+) are implanted on high-purity diamond substrates by means of focused-ion-beam single-ion implantation. The implantation pattern consists of 100-spot arrays each formed by discrete number of ions per spot. Thermal annealing in vacuum is applied for the color center generation and consequently the defects are studied with optical characterization tools. Localization at the nanoscale with spot sizes below 90 nm is reported from stimulated emission depletion (STED) microscopy measurements. Spectral analysis and photoluminescence intensity measurements provide insights on Sn-V formation as a function of ion fluence. The process flow is evaluated in a statistical framework with a focus on scalability and process yield.

Q 66.12 Thu 17:00 Philo 2. OG

A Modular Multi-Card AWG Platform for High-Fidelity Control of Segmented Ion Traps — •Maximilian Orth[1,2], Björn Lekitsch[1,2], and Ferdinand Schmidt-Kaler[1,2] — [1]QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]neQxt GmbH

We present a new modular AWG platform for segmented ion traps, implemented as a multi-card system within a single chassis. DC-AWG, RF-AWG and main-controller cards are interconnected via a shared backplane, forming a freely scalable control architecture. The fully linear output behaviour allows for compensation and accurate modelling of the output distortion behind the trap*s filter network.

The DC-AWG cards provide 32 channels per module and a +-40V output. The main-controller card supplies deterministic digital I/O and system-wide timing with an update rate of 20ns, while the RF-AWG card generates the frequency-agile signals required for AOM/AOD-based laser-driven qubit gate operations. We also implement branching and looping, conditioned on counter input signals as required e.g. for quantum error correction. The DC AWG low noise floor enable accurate qubit register reconfiguration operations in complex shuttle-based trapped ion quantum processor architectures. This includes the transport, splitting/merging with multi-ion crystals.

Q 66.13 Thu 17:00 Philo 2. OG

High Frequency Ion-Photon Interfaces for Distributed Quantum Computing — •Lasse Jens Irrgang, Luca Graf, Cathérine Matthies, Hannah Koeth, Tuncay Ulaş, Rikahv Shah, and Ralf Riedinger — Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany

Decades of excessive research have proven the key towards a quantum advantage of quantum computing compared to classical computers is the scalability of the quantum processor. In analogy to classical super computing clusters we propose a network of small interconnected trapped-ion-based quantum processors to achieve flexibly scalable quantum computing.

In detail, a fibre-based Fabry-Pérot cavity integrated in an ion-trap provides an efficient ion-photon interface. This enables entanglement of ion-qubits in spatially separated traps at a high frequency, and therefore distributed computing in a network of ion-based quantum processors.

Being per se platform-independent, the concept is firstly demonstrated connecting a room-temperature blade trap and a cryogenic blade trap. A novel blade-integrated design of the fibre-cavity ensures plenty of free-space access for cooling and operation lasers. To cope with accumulating charges in the dielectric glass-fibres, disturbing the trapping field, an in-house designed conductive coating applied to the fibres circumvents these effects.

Q 66.14 Thu 17:00 Philo 2. OG

Addressed Raman Gates in a Shuttling-based Architecture — •Daniel Wessel[1,2], Robin Strohmaier[1], Tabea Stroinski[1], Janis Wagner[1], Ulrich Poschinger[1,2], and Ferdinand Schmidt-Kaler[1,2] — [1]QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz — [2]neQxt GmbH

High-fidelity, individually addressed quantum gates are a central requirement for scalable trapped-ion quantum information processing. In this poster, I present the implementation of addressed Raman gates on $^{40}Ca^+$ ions confined in a 3D segmented Paul trap, enabled by UV Raman beams and fast beam steering using acousto-optic deflectors (AODs). The 3D trap architecture provides enhanced optical access and precise control of ion positioning, while the segmentation allows for flexible ion shuttling and reconfiguration of computational zones [1]. We demonstrate site-selective Raman interactions using tightly focused UV beams at 395 nm, achieving high spatial discrimination between ions and minimizing crosstalk through optimized beam geometry and AOD-driven dynamic addressing. Our results show that AOD-based UV addressing is a powerful and scalable approach for parallel gate operations in advanced ion-trap architectures, and we outline pathways for extending this technique to larger arrays and modular quantum computing platforms.

[1] Kaushal, et al. *AVS Quantum Sci. 2*, 014101 (2020)

Q 66.15 Thu 17:00 Philo 2. OG

Manufacturing of Highly Integrated Ions Traps for Quantum Computing — •Marlon Kuhn[1], Jacob Stupp[1], Nora D. Stahr[1], Masum Billah[1], Nica Schiffelholz[1], Christine Marachoris[1], Friederike Giebel[1,2], Eike Iseke[1,2], Nila Krishnakumar[1,2], Konstantin Thronberens[2], and Christian Ospelkaus[1,2] — [1]Institute for Quantum Optics, Leibniz University Hannover, Welfengarten 1, Hannover, 30167, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundasallee 100, Braunschweig, 38116, Germany

Trapped ions are one of the most promising platforms for the implementation of quantum computing and quantum simulations. For demanding computation, a scalable device, capable of trapping, manipulating, moving and cooling trapped ions is needed. Microfabricated surface electrode traps (Paul traps) are ideally suited for these applications. We present an overview on our manufacturing methods and how to overcome upcoming problems that come with scaling these devices to higher densities to accommodate more ions. We also present strategies for integration of further functionalities like permanent magnets, microwave electrodes or integrated photonics, to enhance the scalability of trapped ion systems.

Q 66.16 Thu 17:00 Philo 2. OG

Design and implementation of a multi-segment Paul trap — •Franz Krieger[1], Lara Becker[1], Stephan Kucera[1,2], Jan C. Müller[3], and Jürgen Eschner[1] — [1]Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken, Germany — [2]Luxembourg Institute of Science and Technology, 4362 Belvaux, Luxembourg — [3]Johannes Gutenberg Universität Mainz, 55122 Mainz, Germany

Single trapped ions as quantum memories and single photons as quantum information carriers are promising building blocks for quantum networks, enabling high-fidelity entanglement through controlled single-photon absorption and emission [1]. Ion-photon interfaces are thus well-suited for quantum repeaters [2] and linking quantum processors into quantum computing networks. We are developing a multi-segment linear Paul trap for $^{40}Ca^+$ ions, fabricated from glass with a segmented metal-coated electrode structure. This design addresses pitfalls encountered in the previous segmented ferrule trap [3], offering improved mechanical stability, and more flexible fabrication. The new setup also allows integration of a fiber cavity for efficient photon collection and generation. In the first prototype, the trap is implemented without the cavity. The compact design enables the entire system, including the vacuum chamber, control electronics, and ablation and photo-ionization lasers, to fit within a single transportable rack.

[1] E. Arenskötter et al., npj Quantum Inf. 9, 34 (2023).
[2] M. Bergerhoff et al., Phys. Rev. A 110, 032603 (2024).
[3] L. Becker et al., poster Q 62.9, DPG Spring Meeting, Bonn (2025).

Q 66.17 Thu 17:00 Philo 2. OG

Rack-mounted ion trap with integrated fiber cavity — •Lara Becker[1], Jolan Costard[1], Stephan Kucera[1,2], and Jürgen Eschner[1] — [1]Universität des Saarlandes, Experimentalphysik, 66123 Saarbrücken, Germany — [2]Luxembourg Institute of Science and Technology, 4362 Belvaux, Luxembourg

Single trapped ions as quantum memories and single photons as quantum information carriers are promising building blocks of quantum networks [1], providing high-fidelity entanglement in controlled single-photon absorption and emission [2]. Ion-photon interfaces are thus a promising platform for implementing a quantum repeater and for connecting quantum processors into a quantum computing network.

Our experimental setup is a multi-segment Paul trap for $^{40}Ca^+$ ions with an integrated fiber cavity to increase the photon collection and generation efficiency of the interface. The trap consists of two laser-machined and metal-coated ceramic ferrules, into which the fiber cavity with sub-mm spacing is integrated. In a first prototype we integrated a cavity with $220\,\mu$m length and 8000 finesse with a trap of $190\,\mu$m electrode separation. The trap, together with a laser-beam distribution system, detection optics and control electronics, is mounted in a 19-inch rack. Its future implementation will enable quantum repeater protocols [3] over the Saarbrücken fiber link [4].

[1] M. Bock et al., Nat. Commun. 9, 1998 (2018)
[2] E. Arenskötter, et al., npj Quantum Inf. 9, 34 (2023)
[3] M. Bergerhoff, et al., Phys. Rev. A 110, 032603 (2024)
[4] S. Kucera, et al., npj Quantum Inf. 10, 88 (2024)

Q 66.18 Thu 17:00 Philo 2. OG

Advanced fabrication and characterization of solid immersion lenses in diamond and silicon carbide — •Alexander Spyrantis[1,2], Anna Mogilatenko[1], Kilian Unterguggenberger[2], Stefan Facsko[3], Bailiang Li[4], Gerhard Hobler[4], Tommaso Pregnolato[1,2], Tim Schröder[1,2], and Katja Höflich[1,2] — [1]Ferdinand-Braun-Institut (FBH), 12489 Berlin, Germany — [2]Humboldt-Universität zu Berlin, Institut für Physik, 12489 Berlin, Germany — [3]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [4]Technische Universität Wien, 1040 Wien, Austria

Solid immersion lenses (SILs) are hemispherical microstructures that increase the light collection efficiency of defect-based quantum emitters in high refractive index materials like diamond and silicon carbide. They can be created by focused ion beam (FIB) milling in a mask-less approach.

Previous attempts required post-processing and lacked reproducibility due to beam damage and redeposited material at the side walls. Using a continuous spiral pattern, we resolved those issues and achieved SILs with optimal curvature, yielding a 8.5-fold improvement in the light collection efficiency for NV centers in diamond.

Depending on the ion beam energy, step edges of different sizes form at the side walls of the lens. This is studied using continuum and binary collision modeling. In line with the predictions from modeling, microstructural characterization shows only a thin amorphization layer on the intact crystalline material due to the suppressed redeposition.

Q 66.19 Thu 17:00 Philo 2. OG

Surface-Electrode Ion Trap Design with Chip-Integrated Microwave Conductors for Near-Field Microwave Quantum Control — •Janina Bätge[1], Florian Ungerechts[1], Rodrigo Munoz[1], Masum Billah[1], Phil Nuschke[1], Axel Hoffmann[2], Giorgio Zarantonello[3], and Christian Ospelkaus[1,4] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Germany — [2]Institut für Hochfrequenztechnik und Funksysteme, Leibniz Uiversität Hannover — [3]Qudora Technologies GmbH, Braunschweig, Germany — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Surface-electrode ion traps are a promising platform for scalable quantum computers. In the Quantum CCD architecture, transport of ions between registers allows to limit the number of ions that has to be kept in a single potential well at any given time and to implement specialized registers for storage, cooling, detection and gate operations. Here we present the design of a demonstrator chip based on an X junction and quantum gate operations with chip-integrated microwave conductors. This design has been developed with the goal of increasing the storage capacity, optimizing laser access and improving gate operations.

Q 66.20 Thu 17:00 Philo 2. OG

Towards notch-filtered adiabatic rapid passage non-resonant coherent excitation scheme in vacancy centres in diamond — •Leon Reichgardt[1], Cem Güney Torun[1], and Tim Schröder[1,2] — [1]Department of Physics, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, 12489 Berlin, Germany

Group-IV color centers in diamond have emerged in the past decade as a hardware so- lution for quantum repeaters to transmit quantum information over long distances. One of the key required ingredients is the generation of on-demand indistinguishable single photons. When using optical resonant excitation, one of the challenges faced is that the photons used for excitation cannot be distinguished from the photons emitted by the color center. We report on the experimental implementation of the off-resonant excitation scheme, notch-filtered adiabatic rapid passage (NARP), in the SnV center. The scheme is based on an up-chirped pulse with a notch-filtered spectral component overlapping with the targeted resonance frequency. For the collection of the single photons, the scattered excitation pulse is suppressed using a bandpass filter. This excitation scheme is suitable for emitters in a cavity with a large Purcell factor and short lifetimes due to the broadband nature of the laser pulse. Applying NARP to SnV centers introduces a novel excitation technique from the ex- tended toolbox of quantum optics to diamond color centers..

Q 66.21 Thu 17:00 Philo 2. OG

An Interface Concept for Ion Quantum Computers: Fiber-Based Cavities for Enhanced Optical Connection — •Luca Graf, Lasse Irrgang, Catherine Matthies, Hannah Koeth, Tuncay Ulas, and Ralf Riedinger — Zentrum für optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany

The development of quantum computers promises to solve computational complex problems in the future that cannot be solved with classical computers. Just as in conventional computing clusters, quantum computers must also be networked in a scalable way. We present an innovative concept for an interface that has been specially developed for ion quantum computers. This approach uses special coated fiber-based cavities to establish an efficient optical connection between ion traps. Furthermore, this approach can be used to couple optical qubits, such as entangled photons, with ions in the trap. For our experiments, we will utilize barium ions as qubits and ytterbium ions as sympathetically cooled reference ions.

Q 66.22 Thu 17:00 Philo 2. OG

Highly Indistinguishable Single Photons from Tin-Vacancy Centers in Diamond — •Dennis Herrmann[1], Robert Morsch[1], Detlef Rogalla[2], Matthew Markham[3], and Christoph Becher[1] — [1]Fachrichtung 7.2, Universität des Saarlandes, Campus E2.6, 66123 Saarbrücken, Germany — [2]RUBION, Ruhr-Universität Bochum, Universitätsstraße 150, D-44801, Bochum, Germany — [3]Element Six Global Innovation Centre, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire, OX11 0QR, UK

The tin-vacancy (SnV) center in diamond has emerged as a powerful platform for photonic quantum technologies offering bright and spectrally stable single-photon emission together with optically addressable spin states that reach coherence times of up to 10 ms under dynamical decoupling. By combining a cross-polarization excitation scheme with polarisation-based laser suppression exceeding seven orders of magnitude and driving the emitter with coherent 180 ps optical pulses, we demonstrate two-photon quantum interference of consecutively emitted, highly indistinguishable single photons on the C-transition. Under these conditions, we obtain raw Hong-Ou-Mandel visibility values above 95 % at photon generation rates up to 3000 Hz, together with raw single-photon purities below 0.02. These results represent a key advancement towards a functional spin-photon interface - an essential component for quantum repeaters, large-scale quantum networks, and photonic cluster-state generation.

Q 66.23 Thu 17:00 Philo 2. OG

Quantification of Spectral Diffusion Rate for Tin-Vacancy Quantum Emitters in Low-Temperature Annealed Diamond — •Linus Ehre, Dennis Herrmann, and Christoph Becher — Fachrichtung Physik, Universität des Saarlandes, Campus E2.6, D-66123, Germany

The Tin-Vacancy color center (SnV) in diamond is a promising candidate as a solid-state quantum network node, emitting highly indistinguishable lifetime-limited photons.
While the SnV's inversion symmetry in an ideal diamond lattice prevents first-order Stark shifts, a high defect-density causes distortions of this ideal structure. Consequently, the SnV becomes more susceptible to spectral diffusion (SD) in fluctuating charge environments, broadening the optical transition. High-pressure high-temperature (HPHT) annealing at $T = 2100\,^\circ C$ minimizes this effect, but causes damage by graphitizing the surface. In contrast, annealing at lower temperatures (LT), i.e. $T = 1200\,^\circ C$ for up to 80 hours is a more accessible method and mostly leaves the diamond surface intact. However, this LT-treatment appears to be less effective in suppressing spectral diffusion, due to remaining symmetry distortions and charge traps.
In this work, we present a method to determine the SD rate for single SnV centers in an LT-annealed diamond sample. Variation of experimental conditions allows for a comparison to HPHT-treated diamonds and thus an evaluation of possible tradeoffs. Our results offer key insights into the LT-treated SnV's suitability as a stable high-quality photon source for future quantum network applications.

Q 66.24 Thu 17:00 Philo 2. OG

Towards sympathetically cooled qubits in a 30-qubit X-junction chip — •Kevin Rempel[1], Vanessa Wienzek[1], Markus Duwe[1,2], Sascha Agne[2], Celeste Torkzaban[1], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Featuring high fidelities, long coherence times and all-to-all interconnectivity of qubits, surface-electrode ion traps represent a promising physical platform for realizing a universal quantum processor for quantum computing and simulation. In our experiment, we encode qubits using a hyperfine transition in $^{9}\mathrm{Be}^{+}$ ions that is magnetic-field insensitive to first order. The internal and motional states are manipulated by trap-integrated microwave conductors.
We will upgrade our experiment with a cryogenic X-junction-style trap chip which will allow us to handle up to 30 qubits. It includes independent storage, detection and gate zones. To improve gate fidelities and extend the number of gates we can run before directly re-cooling the qubits, we are preparing to use $^{40}\mathrm{Ca}^{+}$ ions to sympathetically cool our $^{9}\mathrm{Be}^{+}$ qubits by coupling specific motional modes of the ion crystal. This can be achieved by resonantly tuning the third-order Coulomb interaction or by applying oscillating electric potential modulations to the existing confining trap potential. We will report on our simulation results and the necessary hardware modifications.

Q 66.25 Thu 17:00 Philo 2. OG

Hybrid platform for cavity enhanced SnV centres for quantum applications — •Victoria Voinkova[1], Georgii Grechko[1], Jonathan Ensslin[1], Roman Kolesov[1], Vadim Vorobyev[1], and Jörg Wrachtrup[1,2] — [1]3. Physics Institute, University of Stuttgart, Germany — [2]Max Plank Institute of Solid State Research, Stuttgart, Germany

The tin-vacancy colour centre in diamond (SnV) has emerged as a highly promising constituent for next-generation quantum networks owing to its outstanding optical and spin characteristics. High rates of coherent emission are pivotal for obtaining big cyclicity and realising the effective communication protocols. Coupling emitters to the resonance structures is a compelling mechanism for light-matter interaction enhancement, efficiency of which is proven by numerous recent research, illustrated with (but not limited to) nanobeam and 2D photonic crystal cavities, open microcavities and ring resonators. However, maturing of this technology is hindered by fabrication methods, scalability and robustness of which is still being a challenging topic. Here we propose the scalable method of fabrication of the diamond photonic devices, scalability of which stems from the hybrid integration with electrooptically tunable platform of Thin Film Lithium Niobate. The proposed method combines the *SnV - friendly* manufacturing flow, wide variety of tuning options and perspectives for further photonic device interconnection on one chip. This would be an important step towards creating diamond colour centre based quantum network infrastructure.

Q 66.26 Thu 17:00 Philo 2. OG

Creation of Group IV color centers — •Kathrin Schwer[1], Selene Sachero[1], Emilio Corte[2], Elena Nieto Hernandez[2], Jens Fuhrmann[1], Sviatoslav Ditalia Tchernij[2], Fedor Jelezko[1], and Alexander Kubanek[1] — [1]Ulm University, Ulm, Germany — [2]Turin University, Turin, Germany

Efficient coupling between quantum emitters and optical cavities is essential for scalable quantum photonic technologies. Group IV vacancy centers in diamond have emerged as promising candidates due to their spectral stability, high Debye-Waller factor and large orbital splitting in groundstates. Reduction of the diamond host size to the nanoscale enables new opportunities in terms of integration and scalability. However, creating optically coherent quantum emitters in nanodiamonds remains a major challenge. Here, we present the fabrication ofGroup IV color centers by means of ion implantation and describe the optical properties of the created color centers. We achieve high-purity singlephoton emission via resonant excitation and strong coherent drive. The obtained results demonstrate the potential of Group IV centers in nanodiamonds as a coherent single-photon source for quantum networks.

Q 66.27 Thu 17:00 Philo 2. OG

Recent results and ongoing developments in microwave-driven trapped-ion quantum computing experiments — •Erik Dunkel[1], Najwa Al-Zaki[1], Tobias Pootz[1], David Stuhrmann[1], Radhika Goyal[1], Sascha Agne[2], Celeste Torkzaban[1], and Christian Ospelkaus[1,2] — [1]Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Trapped ions are a highly promising platform for both quantum computing and quantum simulation. We utilize surface-electrode ion traps with integrated microwave conductors to trap ions and drive qubit rotations and entangling gates by manipulating the internal and motional states of the ions.

Our qubit transitions for $^{9}Be^{+}$ and $^{43}Ca^{+}$ feature first-order magnetic field insensitive hyperfine transitions. We will share results of the simultaneous trapping of different ion species in our cryogenic apparatuses, which is an essential step towards implementing sympathetic cooling. In addition, we will discuss the steps made towards implementing a junction-style trap chip, so that we can transport ions between storage, quantum logic and detection zones, along with our plan for testing and characterizing a waveguide chip in a second apparatus.

Q 66.28 Thu 17:00 Philo 2. OG

Toward a Scalable NV-Based Quantum Processor: Fiber Interconnects in Diamond Photonics — •Leon Büttner, Lara Ruppert, Christian Giese, Rebekka Eberle, and Daniel Hähnel — Fraunhofer Institute for Applied Solid State Physics, Freiburg im Breisgau, Germany

Heterogeneously integrated NV centers in photonic structures hold great promise for scalable, fiber-connected quantum information processing. We pursue a diamond-based photonic platform that combines efficient spin control, stable NV emission, and robust optical outcoupling to enable a modular, fiber-connected quantum processor. We explore strategies for vertical optical outcoupling in small-footprint NV-containing diamonds to achieve efficient, localized readout of NV centers. Together with microwave structures, this yields a modular device addressing the photonic and electronic challenges of an NV device. Fiber integration obviates the free-space optical path, creating a robust platform for quantum information processing. Future work could target heterogeneously integrating fiber-to-chip coupling, including lithographically defined spin-control structures, to drive toward a scalable NV-based quantum processor.

Q 66.29 Thu 17:00 Philo 2. OG

Femtosecond-Laser Written Waveguides and Surface Structures for High-Efficiency NV-Center Fluorescence Collection in Diamond — Andreas Giese[1], Lucas Kirchbach[1], Andreas Stute[1], Stefan Nolte[2], and •Bernd Braun[1] — [1]Technische Hochschule Nürnberg, Nuremberg, Germany — [2]Friedrich-Schiller-Universität Jena, Jena, Germany

Nitrogen-vacancy (NV) centers in diamond are a promising platform for applications in optical quantum technologies such as quantum sensing and quantum computing. In addition to the precise and deterministic fabrication of NV centers in diamond using direct laser writing, efficient fluorescence collection is of crucial importance.

We investigate strategies for the enhancement of photon extraction from NV-centers in diamond. Directly laser written waveguides inside the diamond crystal enable efficient coupling and potential fiber-based detection for integrated photonic architectures. Numerical simulations support the experiments and are used for the optimization of the volume modifications. Further approaches for increasing the collected fluorescence are based on laser structuring of the diamond surface, for example through the fabrication of microlenses to enhance the extraction of emitted photons. These methods provide pathways toward highly efficient, scalable collection schemes for diamond-based quantum photonic devices.

Q 66.30 Thu 17:00 Philo 2. OG

Nuclear-nuclear Bell-state preparation of ^{13}C nuclear spins coupled to a negatively charged silicon vacancy (SiV^{-}) center. — •David Opferkuch[1,2], Marco Klotz[1], Andreas Tangemann[1], and Alexander Kubanek[1,2] — [1]Institute for Quantum Optics, Ulm University, Albert-Einstein-Allee 11, 89081 Ulm, Germany — [2]Center for Integrated Quantum Science and Technology (IQST), Ulm University, Albert-Einstein-Allee 11, Ulm 89081, Germany

Due to presumed high scalability, spin qubits in solid state hosts are promising candidates for the realization of quantum networks. As such, negatively charged silicon-based vacancy centers (SiV^{-}) in nanodiamonds (ND) combine the good spin properties of diamond as a host with the good optical properties of group-IV defects.
We are using highly strained SiV^{-} in ND, which demonstrate orbital ground state splittings exceeding 1THz. Thus, phonon induced dephasing of the spin qubit is mitigated at liquid Helium temperatures. We have demonstrated coherent control of up to three ^{13}C nuclear spins coupling to a single SiV^{-}. Here we present nuclear-nuclear spin entangling in the three qubit register. A Bell-state between two nuclear spins is created using a 2π-gate. We thus demonstrate reliable nuclear-nuclear spin entanglement for use in a three-qubit quantum memory architecture.

[1] M. Klotz et al., https://arxiv.org/pdf/2508.05255, (2025)
[2] M. Klotz et al., npj Quantum Inf. 11, 91 (2025)

Q 66.31 Thu 17:00 Philo 2. OG

Investigation of the Dynamic 14N Nuclear Spin Polarization at Different Magnetic Field Strengths and Angles in Nitrogen-Vacancy Ensemble in Diamond — •Glen Neiteler[1], Jonas Homrighausen[1], Dennis Stiegekötter[2], Ludwig Horsthemke[2], Peter Glösekötter[2], and Markus Gregor[1] — [1]Department of Engineering Physics, FH Münster University of Applied Sciences, Stegerwaldstr. 39, 48565 Steinfurt, Germany — [2]Department of Electrical Engineering and Computer Science, FH Münster University of Applied Sciences, Stegerwaldstr. 39, 48565 Steinfurt, Germany

The spin-states of the nitrogen-vacancy (NV) centers in diamond can be studied and manipulated at room temperature and optically read out, making them uniquely suitable for low-cost quantum education kits, like a 3D-printed modular setup for quantum sensing or for coherent control experiments. As a first step toward developing a new educational kit for controlling the electron-nuclear spin interaction, we aim to demonstrate the 14N nuclear spin polarization in NV ensemble in diamond. Thus, we experimentally investigate dynamic 14N nuclear spin polarization at small magnetic field angles and angles larger than 2 °, which have not yet been reported in literature, for various magnetic field strengths from 0-60 mT, covering the region of excited-state level anticrossing. This study helps us to identify a compromise between sufficient 14N nuclear spin polarization, magnetic field strength and magnetic field orientation for development our new educational kit.

Q 66.32 Thu 17:00 Philo 2. OG

A Quantum Frequency Conversion Interface for Silicon Vacancy based Quantum Networks — •Konstantin Beck[1], Donika Imeri[1,2], Leonie Eggers[1,2], Lasse Irrgang[1], Nick Brinkmann[1,2], Sunil Mahato[1,2], Rikhav Shah[1], Roman Schnabel[1,2], and Ralf Riedinger[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany

Silicon vacancy (SiV) centers in diamond have shown great potential for applications in quantum sensing and quantum communication, due to their optically addressable spin transitions and stability against noise. At temperatures below 300 mK, the SiV has a long-lived spin degree of freedom that enables its use as a quantum network node.

We propose a high bandwidth quantum frequency conversion (QFC) interface for SiV centers in diamond, aimed at enabling their integration into fiber based quantum networks. The concept relies on a one*step conversion process in a compact, doubly resonant cavity, enabling efficient translation of SiV emission into the telecom E*band while preserving quantum coherence. This architecture outlines a pathway toward scalable, SiV based quantum networks and photonic cluster states.

Q 66.33 Thu 17:00 Philo 2. OG

Optical and spin properties of highly strained silicon vacancy centers in diamond host — •Michael Gstaltmeyr[1], Florian Feuchtmayr[1], Robert Berghaus[1], Selene Sachero[1], Gregor Bayer[1], Julia Heupel[2], Tobias Herzig[3], Jan Meijer[3], Cyril Popov[2], and Alexander Kubanek[1] — [1]Institut für Quantenoptik Universitat Ulm — [2]Institute of Nanostructure Technologies and Analytics, Center for Interdisciplinary Nanostructure Science and Technology, University of Kassel — [3]Division of Applied Quantum Systems, Felix Bloch Institute for Solid State Physics, University Leipzig

Spin qubits in solid-state hosts are, due to their promise of scalability, candidates for the realization of quantum networks. The good spin properties of diamond paired with the optical properties of group-IV defects make them of special interest. Using highly strained silicon-vacancy centers effectively decouples the defect spin from the diamond lattice, mitigating disturbing spin dephasing at liquid-helium temperatures. To make use of this type of emitter, the optical and spin properties have to be well understood. This work presents how to create strain up to 500 GHz by bonding a diamond membrane to a DBR mirror and simulates the resulting changes in optical and coherence properties.