Q 72: Quantum Technologies – Color Centers II

Time: Friday 11:00–12:45 Location: P 5

Q 72.1 Fri 11:00 P 5

Cavity-enhanced spectroscopy of the nitrogen-vacancy (NV^-) singlet transition and pump-laser-induced effects in NV-diamonds — •Tobias Probst[1], Florian Schall[1], Rüdiger Quay[1], Alexander M. Zaitsev[2], Takeshi Ohshima[3], Matthias Weidemüller[4], and Jan Jeske[1] — [1]Fraunhofer Institute for Applied Solid State Physics IAF, Freiburg, Germany — [2]College of Staten Island (CUNY), New York, USA — [3]National Institutes for Quantum Science and Technology (QST), Takasaki, Japan — [4]Universität Heidelberg, Heidelberg, Germany

Gaining a deeper understanding of the absorptive behavior of NV-diamonds in the near-infrared region is essential to optimize laser threshold magnetometry, as well as to improve enhanced sensing with long diamond light paths. With a tuneable Ti:Sa laser, the absorptive behavior of NV-diamonds was studied in a regime of 680-1060 nm, using a cavity to enhance the effects. The room temperature absorption of the microwave-sensitive NV^- singlet transition was separated from other absorbing effects. A distinctive phonon sideband was found to exist at room temperature, while the strongest change in the measurement signal occurred at the zero phonon line at 1042 nm. Several pump-laser-induced phenomena have been observed over various diamond samples and interpreted in a broad wavelength regime. They consist of an increased or decreased absorption of the Ti:Sa wavelength when pumping the NV-diamond with a green 532 nm pump laser. Possible explanations are proposed including the charge transfer between defects following ionization processes induced by the green pump laser.

Q 72.2 Fri 11:15 P 5

Electrical control for spin defects integrated in silicon carbide nanophotonic devices — •Adil Han Dogan[1], Timo Steidl[1], Pierre Kuna[1], Rainer Stöhr[1], Wolfang Knolle[2], Misagh Ghezellou[3], Jawad Ul-Hassan[3], Vadim Vorobyov[1], and Jörg Wrachtrup[1,4] — [1]3rd Institute of Physics, IQST, and Research Center SCoPE, University of Stuttgart, Stuttgart, Germany — [2]Department of Sensoric Surfaces and Functional Interfaces, Leibniz-Institute of Surface Engineering (IOM), Leipzig, Germany — [3]Department of Physics, Chemistry and Biology, Linköping University, Linköping, Sweden — [4]Max Planck Institute for Solid State Research, Stuttgart, Germany

Spin defects in silicon carbide are promising candidates for chip-scale quantum information processing. They combine atom-like optical transitions and long-lived electron and nuclear spin qubit clusters in a nanofabrication-friendly host material. Their integration in nanophotonic structures provides enhanced spin-photon interaction and increases photon collection efficiency. However, reproducible control knobs remain rare, and proximity to material interfaces in nanostructures impairs the emitter properties of the color centers. For this purpose, we develop electrical control of spin defects to mitigate near-surface spectral diffusion and offer tunability via Stark shift and Pockel's effect. Thus, we project a possible path towards on-chip quantum photonic information processing through key advances in nanofabrication and electrical control in silicon carbide.

Q 72.3 Fri 11:30 P 5

High-Q 1D photonic crystal cavities for V2 color centers in 4H-SiC — •Anantha Krishnan[1], Adil Han Dogan[1], Timo Steidl[1], Rainer Stöhr[1], Wolfgang Knolle[2], Misagh Ghezellou[2], Jawad Ul-Hassan[2], Vadim Vorobyov[1], and Jörg Wrachtrup[1,3] — [1]3rd Institute of Physics, University of Stuttgart — [2]Department of Physics, Chemistry and Biology, Linköping University — [3]Max Planck Institute for Solid State Research, Stuttgart, Germany

Scalable quantum networks rely on efficient spin photon interfaces. Existing platforms such as diamond or quantum dots offer high performance but often come with limitations in fabrication scalability or coherence properties. The V2 color center in 4H-SiC, emitting at 917 nm, combines long spin coherence with material and fabrication scalability, making it a compelling platform for integrated quantum nodes. In this work, we design high-Q 1D photonic crystal cavities to enhance the Zero-Phonon Line (ZPL) emission. Simulations of the optimized design predict a quality factor of $Q \approx 1.2 \times 10^5$ with a low mode volume, $V_{mode} \approx 1.3(\lambda/n)^3$. To realize this performance in a scalable photonic architecture, we fabricate the devices using advanced nanofabrication methods, followed by the integration of 45° undercut couplers, enabling efficient vertical excitation and collection. Transmission spectroscopy reveals narrow resonance peaks, validating the optical design. Combining high-Q engineering with efficient light coupling, this platform offers a scalable route for spin-photon interfaces in quantum networks.

Q 72.4 Fri 11:45 P 5

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.

Q 72.5 Fri 12:00 P 5

Creation and theoretical modelling of highly indistinguishable single photons from tin-vacancy centers in diamond — •Robert Morsch[1], Dennis Herrmann[1], Benjamin Kambs[1], Pierre-Olivier Colard[2], Matthew Markham[2], and Christoph Becher[1] — [1]Universität des Saarlandes, FR Physik, Campus E2.6, 66123 Saarbrücken — [2]Element Six Global Innovation Centre, Fermi Avenue, Harwell Oxford, Didcot, Oxfordshire, X11 0QR, UK

In quantum information processing (QIP), various schemes require long-lived stationary qubits that allow coherent state-control, optical readout and on-demand generation of single indistinguishable photons. The tin-vacancy center (SnV^-) in diamond is a promising solid-state candidate for these applications, combining an addressable, long-lived spin and bright, longterm-stable emission of single, transform-limited photons. However, achieving near-unity photon indistinguishability remains a significant challenge. In our work we investigate the indistinguishability of resonantly excited single SnV-photons. Employing a cascade of electro-optical modulators, we carve sub-nanosecond π-pulses with record-high extinction ratios from a resonant cw-laser. We efficiently suppress the residual laser in the detection path using a home-built cross-polarization setup and measure raw HOM-visibilities of $> 95\%$, being well on par with those of single emitters in leading solid-state platforms. Detailed theoretical modelling of our experiment confirms these values and reveals an even higher intrinsic degree of the photon indistinguishabily. Considering the SnV′s long-lived spin, these findings ultimately highlight the unique potential of our platform.

Q 72.6 Fri 12:15 P 5

Strained SiV color centers coupled to a fabry perot microcavity — •Florian Feuchtmayr[1], Michael Gstaltmayr[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

Group IV color centers in diamond, such as silicon vacancy (SiV), are promising for quantum optics because of their optical transitions, spin access, and good coherence properties. SiV centers typically require millikelvin temperatures, but increasing the ground state splitting improves coherence, allowing operation at higher temperatures. Here, we demonstrate the integration of a single-crystal diamond membrane into a high-finesse microcavity (F = 3000), achieving significant lifetime shortening with a Purcell factor of 2.2 in a liquid helium atmosphere. Absorption and strain spectroscopy confirm enhanced ground-state splitting, paving the way for a spin-photon interface.

Q 72.7 Fri 12:30 P 5

Raman signatures and spin relaxation mechanism of VB- in hBN quantum emitters — •Chanaprom Cholsuk[1], Viktor Ivády[2], Asli Çakan[1], Volker Deckert[3], Sujin Suwanna[4], and Tobias Vogl[1] — [1]Department of Computer Engineering, TUM School of Computation, Information and Technology, Technical University of Munich, 80333 Munich, Germany — [2]Department of Physics of Complex Systems, Eötvös Loránd University, Egyetem tér 1-3, H-1053 Budapest, Hungary — [3]Institute of Physical Chemistry, Friedrich-Schiller University, 07743 Jena, Germany — [4]Department of Physics, Mahidol University, Bangkok 10400, Thailand

Point defects in hexagonal boron nitride (hBN) are crucial for single-photon emission and can host controlled nuclear spins, making them applicable for quantum technologies. However, identifying the defects remains a challenge. Here, we propose Raman spectroscopy as a strategy for defect identification. Using density functional theory, we first benchmark the Raman signatures of the negatively-charged boron vacancy (VB-), and extend to 100 additional defects. We find that the local atomic environment is the primary determinant of the Raman lineshape, enabling discrimination among defects, as well as spin and charge states. Building on the VB- benchmark, we develop a low-temperature spin-dynamics model for T1 relaxation and demonstrate that the VB- forms a strongly coupled electron-nuclear spin core. Overall, our work establishes Raman spectroscopy as a route to defect identification, available at https://h-bn.info, and the model to capture spin interactions.