Quantum Science and Technology Mini-Symposium
Room Ballroom BC - Session QS-ThP

Quantum Science and Technology Mini-Symposium Poster Session

QS-ThP-1 Frugal Quantum Magnetometry for Education*, John Muth, Jonathan Rabe,* North Carolina State University

The use of color centers for magnetometry is well established, with the nitrogen-vacancy (NV) center in diamond being the most prominent example. Recently, there has been growing interest in using silicon carbide as a more cost-effective alternative material. However, for educational purposes, the cost of associated optics and electronics can present a significant barrier with many approaches costing in excess of $10,000.

This poster presents the design of a printed circuit board using off-the-shelf electrical components, integrated with an adjustable 3D-printed optical mount. The entire system can be built for under $500 (excluding the cost of the diamond). The stand-alone device is compact and portable, and can be connected to a laptop for data acquisition and analysis.

Collected data demonstrate that the system achieves sensitivity in the low microtesla range and that hyperfine splitting can be observed. It can be used to generate color maps that visualize Zeeman splitting and to investigate how the orientation of NV centers affects the fitting of the zero-field splitting. As an alternative to optically detected magnetic resonance (ODMR) in diamond, the use of spin-dependent recombination to enable an all-electrical quantum magnetometer based on silicon carbide will also be briefly discussed.

QS-ThP-4 Telecom Quantum Photonics Enabled by Erbium-Doped SiC Nanostructures: A Scalable Nanofabrication and Materials Science Engineering Approach*, Alexander Kaloyeros*[1]*, Spyros Galis,* University at Albany-SUNY

The development of scalable photonic technologies relies on integrating compact, on-chip nanoscale devices into quantum photonic integrated circuits (qPICs). Key components of these systems, such as quantum LEDs (qLEDs) that are based on engineered point-defect nanoscale emitters, require material platforms that support operation at elevated temperatures, enable electrical addressability, and are compatible with high-yield, large-scale fabrication. Additionally, operation in the highly desirable telecom C-band (~1540 nm) is critical for low-loss optical communication. However, despite significant progress, none of the current material systems has been able to meet all these requirements within this important set of constraints. Current technologies are limited by non-ideal emission wavelengths, low-yield fabrication of emitters (e.g., randomness in spatial placement, orientation, and emission frequency), and the need for cryogenic temperatures.Collectively, these challenges pose major barriers to scalable integration. We present a nanofabrication- and materials-engineering-driven strategy to create a material platform that resolves these key challenges. Notably, this platform enables coherent optical control at 77 K, including the ability to resolve Rabi oscillations from a single Er^{3+} emitter, which emit in the telecom C-band (~1534 nm), and narrow optical linewidth of ~90 MHz. The approach is based on the fabrication of arrays of Er^{3+}-doped silicon carbide (SiC) hollow nanopillars (HNPs) and nanowires (NWs) using a scalable, CMOS-compatible process. A key breakthrough is the precise spatial positioning of Er^{3+} ions with sub-5 nm accuracy. This is achieved through a novel strategy in which placement is governed not by lithographic patterning but by the critical dimension of the nanostructures, defined by our highly controlled conformal SiC deposition. This addresses one of the primary limitations of current single-photon emitter platforms: the randomness in emitter location, orientation, and spectral properties that impedes large-scale integration. The fabrication of these foundational structures and their properties will be presented in the context of advancing quantum photonic integrated devices. Furthermore, we demonstrate the ability to control both the density and spatial distribution of Er ions, enabling the isolation of single and few Er^{3+} ions at temperatures ≥77 K—capabilities not previously achievable in bulk systems. Together with polarization control and compatibility with optical cavity integration, these results highlight the potential of this platform for scalable, high-performance quantum photonic technologies.

QS-ThP-5 Accurate Atomic Correlation and Total Energies for Correlation Consistent Effective Core Potentials (ccECP) for Transition Metals*, Aqsa Shaikh,* North Carolina State University, India

In this work we utilize the correlation consistent effective core potentials (ccECPs) and present highly accurate correlation and total energy calculations for a selected set of transition metals and other heavy elements. We calculated the total energies using a variety of sophisticated correlated methods including configuration interaction (CI), coupled-cluster (CC) to multiple excitations and also with stochastic sampling approaches such as Quantum Monte Carlo (QMC). Calculations were performed with basis sets up to cc-pV5Z to limit discrepancies and then extrapolated to estimate the complete basis set limit. Kinetic energies were similarly assessed through CI to various excitation levels. We also present diffusion Monte Carlo (DMC) energies, providing insight into fixed-node/phase biases in single-reference trial wave functions. These results establish reliable benchmarks for ccECP performance across a broad spectrum of electronic structure methods, ensuring their utility in future high-accuracy calculations in correlated deterministic and stochastic frameworks.

QS-ThP-6 Optimization of DC Magnetron Sputtering Process for Coherent Nb-based Superconducting Quantum Electronics*, Kiana Reed,* *Joseph Falvo, Marcelo Velasco-Forest, Ivan Lainez, Kasra Sardashti,* Laboratory for Physical Sciences

Niobium (Nb) is a widely used superconducting material in thin-film form for quantum and superconducting electronic applications. In this work, we develop a robust Nb sputtering process optimized for evaluating candidate substrates for superconducting qubits. Thin Nb films were deposited on Si (001) substrates using direct current (DC) magnetron sputtering under varying powers and deposition times. Initial process optimization was guided by DC transport measurements, including critical temperature, critical field, and residual resistance ratio. Promising recipes were further assessed by fabricating Nb/Si coplanar waveguide resonators and measuring their internal quality factors at microwave frequencies. To mitigate dielectric losses at the metal–substrate interface, we implemented surface cleaning methods such as ex-situ HF etching (solution and vapor) and in-situ argon ion milling. Film morphology and interface quality were characterized using atomic force microscopy and scanning electron microscopy. Building on the optimized deposition parameters, we outline a pathway for screening alternative qubit-compatible substrates, including sapphire and silicon carbide.

QS-ThP-7 Tunable Superconducting Properties in Mesoscopic SNS Island Arrays*, Shiva Dahal,* Winston-Salem State University*; Bernadeta Srijanto,* Oak Ridge National Laboratory*; Kasra Sardashti,* University of Maryland College Park*; John Yi,* Winston-Salem State University

Superconductor array islands offer a uniquely tunable platform for probing fundamental quantum phenomena and advancing next-generation technologies. By precisely controlling Josephson coupling, charging energy, and disorder, these mesoscopic superconductor–normal-metal–superconductor (SNS) arrays enable direct exploration of key quantum phase transitions, including the superconducting–insulating transition and Berezinskii–Kosterlitz–Thouless (BKT) physics. Using advanced lithographic techniques, we pattern superconducting (Nb or Al) islands on thin metal films (Pt, Fe, Co, Ni, and Au) to investigate how geometry, size, spacing, and arrangement affect superconducting, resistive, and magnetic properties, including the critical temperature. Variations in island spacing and film thickness, combined with the use of metals with distinct electronic characteristics, are designed to uncover new strategies for controlling superconductivity and engineering high-performance heterostructures. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) verify fabrication accuracy, surface morphology, and dimensional precision, with observed uniformity and sharp edge definition expected to minimize scattering centers and defects, thereby preserving coherence and enhancing proximity-induced superconductivity. Resistivity measurements will probe the proximity effect, while magnetic characterization under applied fields will reveal flux dynamics and vortex behavior. The use of different metal films with varying electronic and transport characteristics is expected to yield novel material innovations. Overall, this research seeks to develop new strategies for controlling superconductivity, providing valuable insights into the design and fabrication of high-temperature superconductors and quantum devices. By combining precision nanofabrication, systematic materials variation, and rigorous transport and magnetic characterization, this work bridges fundamental condensed-matter physics with practical quantum device engineering, driving both scientific discovery and technological innovation.

[1] **JVST Highlighted Poster**

QS-ThP-8 Probing the Functional Efficacy of Tunable SSWM Microring Resonators as Couplers for Tri-State Entanglement in Photonic Quantum Processors*, **Arsh Jha,*** North Carolina Central University

Quantum photonic processors offer major advantages over classical computing through massive parallelism. Conventional two-photon couplers, however, are limited in scalability and flexibility. We present a photonic quantum circuit architecture using a Spontaneous Six-Wave Mixing (SSWM) microring resonator, adapted from classical photonics, as an active logic element generating triphoton entanglement. These three-photon interactions reduce coupler requirements and enable more qubits (greater integration density), hence allowing for greater computational power.

Decoupling allows qubits to temporarily store quantum information without unwanted interactions. Using MEEP simulations, the decoupled state was achieved by sweeping the ring index nring (semiconductor-compatible refractive index tuning) from 2.05 to 2.20 with the bus waveguide fixed at 2.05, until no light propagated into the ring. Coupling coefficients decreased from 0.1094 to 0.0200 (showing detuning) while the Q-factor remained stable (335.9 to 433.38), confirming robust functionality. Coupling spectra retained their shapes with only amplitude reductions, indicating unchanged behavior.

Photon state integrity was evaluated using a custom QuTiP-based photon–photon interaction model, with three modes of four photons each evolving under a Hamiltonian derived from the kappa interaction matrix. For both states, photon purity remained near 1, fidelity averaged 0.9 ± 0.1, and entropy stayed close to zero. Wigner function analysis showed minimal but consistent state differences, with their time-dependent rotation revealing precise windows for targeted control.

To measure circuit-level performance, a custom quantum photonic architecture was created: three data qubits underwent five different protocol classes i.e. teleportation, simple squeezing, etc. They operated under realistic noise channels with ancilla-assisted measurement. Kappa matrices (k) determined entanglement strengths and were swept over time from [0, kmax] to simulate detuning. This was compared to the control without kappa to determine if detuning affected circuit performance.

Metrics showed that the tunable SSWM microring resonator demonstrates strong potential in quantum photonic circuits with 4/5 protocols receiving better or consistent performance with (bi-state) detuning. Its protocol-dependent performance highlights opportunities for targeted applications, and future work will focus on simulation denoising and broader frequency sweeps to ensure robust, energy-efficient operation.

QS-ThP-9 Stability of Entanglement States in (A)Symmetric InAs/GaAs Double Quantum Dots*, **Patrick Flanigan,** Igor Filikhin, Branislav Vlahovic,* North Carolina Central University

Double quantum dots (DQDs) are systems where two quantum dots (QDs) are placed close enough together that a single electron will be coupled to both, potentially leading to delocalized states where its position expectation value is outside of the QDs themselves. The individual QDs can have different shapes, sizes, and material compositions, which in turn leads to differing energy level spectra. In a DQD system, the energy levels of a single electron will be a function of both. This makes the DQD a very promising tool for applications such as biochemical sensors and quantum computing. Of particular interest is the case where the QDs are nearly identical, but not exactly. In a real-world device, this kind of asymmetry is inevitable when considering the inherent limits of nano-scale fabrication technology. If DQD systems are to be employed as qubits or sensors, the role that this plays on their properties is critically important — this fabrication-induced surface coarseness can be the catalyst for turning a symmetric DQD into an asymmetric one, and thus will limit the DQD's usefulness in a working device. Here, we present results from 3D computational simulations of a DQD system that has been slightly shifted away from perfect symmetry to better understand the role that this effect plays on the electron's energy level spectrum, available eigenstates, and degree of localization. It was found that even minuscule deviations from total symmetry can cause an electron to transfer from a delocalized state to a localized one. The possibility of rectifying this effect through the use of an applied electric field was also considered.

Figure 1 shows that taking a symmetric pair and changing one of the semi-major axes by a tiny fraction (from 19 to 18.75 nm) causes strong localization. Figure 2 shows that applying an electric field will alter the probability (P) of finding the electron in the left/right QD's ground state in an asymmetric DQD system; however, a perfect 50-50 split is still not possible.

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