Quantum Science and Technology Mini-Symposium
Room 208 W - Session QS1-TuA

Interdisciplinary Quantum Applications

Moderators: Yi-Ting Lee, University of Illinois at Urbana Champaign, **Kasra Sardashti**, University of Maryland College Park

2:15pm **QS1-TuA-1 A Study of Superconducting Behavior in Ruthenium Thin Films***, **Bernardo Langa Jr.,*** University of Maryland*; Brooke Henry,* Clemson University*; Ivan Lainez,* University of Maryland*; Richard Haight,* IBM*; Kasra Sardashti,* University of Maryland

Ruthenium (Ru) is a promising candidate for next-generation electronic interconnects due to its low resistivity, small mean free path, and superior electromigration reliability at nanometer scales. In addition, Ru exhibits resistance to oxidation, low diffusivity, and most importantly, superconductivity below 1 K. These qualities make Ru an attractive material for superconducting qubits where its stability may help mitigate two-level system defects. Here, we investigate the superconducting behavior of Ru thin films (11.9–108.5 nm thick), observing transition temperatures from 657.9 mK to 557 mK. A weak thickness dependence appears in the thinnest films, followed by a conventional inverse thickness dependence in thicker films. Magnetotransport studies reveal type-II superconductivity in the dirty limit ($\xi >> l$), with coherence lengths ranging from 13.5 nm to 27 nm. Finally, oxidation resistance studies confirm minimal RuOx growth after seven weeks of air exposure. Our findings provide key insights for integrating Ru into superconducting electronic devices and explore its potential in advancing scalable, high-coherence quantum devices.

2:30pm **QS1-TuA-2 Exploration and Synthesis of Uranium and Uranium Ditelluride Thin Films***, **Colin Myers,** Deepak Kumar,* University of Maryland, College Park*; Kasra Sardashti,* Laboratory for Physical Sciences*; Johnpierre Paglione,* University of Maryland, College Park

Uranium Ditelluride (UTe2) has recently emerged as one of the most interesting superconducting materials to date. Possessing a superconducting transition temperature Tc ≈ 1.8 K, this heavy fermion exhibits unconventional spin-triplet superconductivity, suggested to be caused by spin fluctuations. With highly anisotropic critical fields up to 35 T and evidence of topological superconductivity, UTe2 garners significant interest as a candidate not only to study exotic superconductivity but also for integration into superconducting devices and quantum computation. The majority of research on UTe2 has been done on bulk crystals with shockingly little in the way of thin film studies. This is in part due to the challenging nature of incorporating tellurium, a low-vapor-pressure material, with heavy uranium atoms on a heated substrate. Epitaxial growth of UTe2 films becomes increasingly difficult when trying to fine-tune substrate temperature, lattice mismatch, and annealing times. Here, we present an approach to UTe2 film growth via pulsed laser deposition with consideration of epitaxial uranium and an overview of progress on UTe2 thin film growth.

2:45pm **QS1-TuA-3 Enabling Quantum Information Science with DNA-Templated Quantum Materials***, Xin Luo, Jeffrey Gorman, **Mark Bathe,*** Massachusetts Institute of Technology

Quantum information science is limited by the lack of materials that enable precise, rational control over quantum photonic, excitonic, and spin states and other properties of the quantum materials. While DNA nanotechnology offers in principle such control via spatial templating of chromophores, quantum dots, and molecular spin centers with nanometer-scale precision, this capability requires interfacing with silicon-based 2D devices to enable quantum information science with translational impact on devices. Toward this end, we previously demonstrated that programmable DNA templates can position quantum materials such as colloidal quantum dots and rods with nanometer-scale precision for integration with photonic devices through top-down electron beam lithography [1]. Here, we apply this approach to fabricate photonic cavities to control single-photon emissive properties and photonic waveguides for photonic quantum circuits. We additionally demonstrate pathways towards controlling molecular spins and excitons with DNA templates for quantum information science and technology. This scalable approach to templating quantum materials opens new applications to quantum sensing, networking, and simulation, with potential impact on secure communications, medical diagnostics, computing, and beyond.

[1] Luo, X. *et al.* DNA origami directed nanometer-scale integration of colloidal quantum emitters with silicon photonics. *bioRxiv*, doi: 10.1101/2025.01.23.634416 (2025).

3:00pm **QS1-TuA-4 Enhanced Readout Contrast of V2 Ensembles in 4H-SiC Through Resonant Optical Excitation***, **Infiter Tathfif,*** University of Maryland College Park*; Charity Burgess, Brenda VanMil,* Army Research Laboratory*; Samuel G. Carter,* Laboratory for Physical Sciences

Favorable optical and spin properties of the V2 silicon vacancy defect in 4H-SiC have made it a promising candidate for quantum technologies. For quantum sensing with defect spins, the contrast in optically-detected magnetic resonance (ODMR) is an important metric, which tends to be rather low (<1%) for V2 ensembles using off-resonant laser excitation. To improve contrast, we resonantly excite the V2 ensembles at low temperatures and compare our findings with off-resonant excitation. Our measurements show a ~90 times improvement for ODMR contrast over the off-resonant case for fairly low resonant excitation. We hypothesize that for a particular wavelength, the resonant laser excites a subset of defects within the ensemble and drives only one of the spin-selective optical transitions for each defect. This leads to a strong spin polarization, contributing to the high readout contrast. To test our hypothesis and further characterize the behavior, we examine the dependence of the contrast on the laser linewidth and the sample temperature. Modulating the resonant laser linewidth up to 1 GHz, corresponding to the splitting of the two optical transitions, results in the contrast decreasing by 50%. As the temperature is increased to 60 K, the contrast decreases and reaches the off-resonant value, presumably due to linewidth broadening. Although the PL signal is 50 times weaker than the off-resonant excitation due to the participation of the defect sub-ensemble, the sensing figure of merit (FoM) is 10 times higher, making the resonant approach still the best choice for sensing at low temperatures. Due to the high readout contrast and reduced laser power requirements, we plan to utilize this resonant technique for wide-field magnetic imaging of quantum materials and devices at low temperatures.

3:15pm **QS1-TuA-5 Quantum-Enhanced Communication Network Routing in Cyber-Physical Power Systems***, Shuyang Ma, **Yan Li,*** Penn State University

Communication networks in cyber-physical power systems play a vital role in ensuring reliable information exchange, enabling real-time monitoring, control, and coordination of distributed energy resources. However, ensuring real-time responsiveness while meeting strict Quality of Service (QoS) constraints, such as low latency and high reliability, introduces significant challenges. A central problem is the constrained shortest path (CSP), which seeks to minimize communication costs across the grid while adhering to a maximum delay threshold. This NP-hard problem becomes computationally infeasible for large-scale networks using conventional approaches. To tackle this, we propose a novel method that transforms the CSP problem into a Quadratic Unconstrained Binary Optimization (QUBO) model, subsequently mapped to an Ising Hamiltonian. This reformulation enables the use of the Quantum Approximate Optimization Algorithm (QAOA), a hybrid quantum-classical technique that exploits quantum parallelism to efficiently approximate optimal routing solutions. Our approach offers reduced computational complexity and improved scalability compared to traditional methods. Through numerical simulations, we demonstrate that this QAOA based strategy successfully identifies cost-effective paths that satisfy QoS requirements, underscoring its potential to revolutionize network optimization in power grids as quantum computing advances.

4:00pm **QS1-TuA-8 Strain-Engineered Tin-Vacancy Qubits in Diamond: In-situ Synchrotron based Structural and Optical Probes at operational Temperatures***, **Philip Ryan,*** Argonne National Laboratory, USA

Next-generation quantum technologies demand precise control over the structural and electronic environment of solid-state qubits. Group IV color centers in diamond, particularly tin-vacancy (SnV) defects, have emerged as promising spin-photon interfaces due to their high optical coherence and symmetry-protected electronic states. However, practical deployment of these qubits is limited by low-temperature operational requirements driven by phonon-mediated decoherence.

This presentation will highlight a new synchrotron-enabled experimental platform under development to directly correlate local atomic structure and strain-induced quantum optical response in SnV qubits in diamond. Using micron-resolved high-resolution X-ray diffraction and diffuse scattering at the Advanced Photon Source, combined with integrated cryogenic photoluminescence spectro-microscopy, we are enabling in-situ studies of qubit behavior under extreme uniaxial tensile strain below 2 Kelvin temperatures.

The platform is based on a Joule-Thomson driven cryostat engineered for sub-2K operation, with nanometer positional control and wide-angle X-ray access. Strain engineering leverages enhanced spin-orbit coupling to suppress decoherence pathways, with the ultimate aim of achieving coherent qubit operation at liquid nitrogen temperatures.

This capability will resolve how long-range strain fields, local defect environments, and lattice disorder influence spin coherence and phonon scattering—key mechanisms governing both quantum state lifetimes and optoelectronic coupling. Our approach represents a new paradigm in synchrotron-enabled quantum materials research and paves the way for scalable, strain-tunable quantum devices.

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