WORKSHOP # 1 – Tuesday, April 21, 2026

Probing Materials Challenges for Coherence and Scalability in Quantum Technologies

Organizers: Ekta Bhatia (NY Creates), Mingzhao Liu (CFN), Steven Hulbert (NSLS-II), Aswin Anbalagan (NSLS-II)

Quantum technologies are fundamentally limited by coherence and scalability, which are in turn constrained by nonidealities in materials properties, interfaces, and fabrication processes. Across quantum platforms, decoherence and device-to-device variability emerge from microscopic defects, surface chemistry, charge and spin noise, and other atomic-scale phenomena that remain incompletely understood. Superconducting quantum circuits and diamond-based quantum sensors provide complementary experimental platforms for probing these materials challenges.

In superconducting qubits and resonators, coherence and reproducibility are limited by materials-induced decoherence mechanisms, including defect-driven two-level-system (TLS) noise at surfaces and interfaces and non-equilibrium quasiparticles in the bulk. These sources of decoherence originate in the microstructure and surface chemistry of the superconducting films, their supporting dielectrics, and packaging materials, and are sensitive to fabrication processes. In diamond quantum sensors, closely related surface- and defect-mediated noise sources and paramagnetic noise similarly limit coherence and sensing performance. At the same time, these quantum sensors provide a controlled testbed for isolating and characterizing microscopic noise sources that are difficult to access directly in complex quantum circuits. Addressing these shared materials challenges requires tightly integrated efforts in materials synthesis, surface and interface engineering, advanced characterization, and predictive modeling.

This workshop will bring together the NSLS-II, CFN, and broader user communities to discuss materials problems central to the Co-design Center for Quantum Advantage (C2QA), with focus on superconducting qubit/circuit materials and diamond-based quantum sensors. The workshop will highlight how advanced x-ray spectroscopies, electron microscopy, scanning probes, nanoscale fabrication/analysis capabilities, and cryogenic characterization tools can be leveraged to identify microscopic sources of decoherence, establish structure-property-performance relationships, and guide materials and process optimization across quantum platforms. By directly connecting multimodal materials characterization with device-level performance metrics (e.g., qubit/resonator loss, noise spectroscopy, coherence times, and sensor sensitivity), the workshop aims to catalyze new collaborations and experimental approaches that accelerate progress toward coherent, scalable quantum hardware and quantum-limited sensing.

Start Time (ET)	Title	Speaker (Affiliation)
9:00	Opening Remarks	Chuck Black
9:15	Perfection meets thermodynamic entropy: What does it take to improve quantum performance of materials?	Tyrel McQueen
10:00	Millisecond lifetimes and coherence times in 2D transmon qubits	Faranak Bahrami
10:35	Break	
10:50	Towards scalable tantalum-on-silicon superconducting qubit devices	Valla Fatemi
11:25	Reconciling high kinetic inductance with low microwave loss in ternary TaCN superconductors	Davood Shahrjerdi
12:00 – 2:00 pm	*Lunch Break (travel to/from SUSC to Berkner Hall)*	
2:00	Opportunities and challenges in surface science for diamond quantum technologies	Alastair Stacey
2:35	Surface chemistry of bulk and nanoscale diamond with insights at the diamond-water interface	Abraham Wolcott
3:10	Break	
3:25	Broadband cryogenic transient dielectric spectroscopy: A new tool for Probing two-level-system defects	Mattias Fitzpatrick
4:00	Material characterization using infrared nanospectroscopy at the National Synchrotron Light Source II	Lukas Wehmeier
4:35	Panel	Ekta Bhatia Steven Hulbert
5:00	NSLS II/CFN Tours	Aswin Anbalagan Mingzhao Liu
6:00		Adjourn