WORKSHOP #15

Diagnosing Microscopic Sources of Qubit Decoherence by Multimodal Materials Analysis

Andi Barbour (NSLS-II), Robert Cava (Princeton), Nathalie de Leon (Princeton), Steven Hulbert (NSLS-II), Mingzhao Liu (CFN), Dario Stacchiola (CFN), and Andrew Walter (NSLS-II)

A quantum computer relies on superposition and entanglement in quantum two-level systems (qubits) to achieve information encoding capacity that is exponentially larger than classical bits, potentially enabling solutions to problems that are beyond the power of classical computing. The fragility of the qubit states, however, introduces errors and limits the scaling-up of quantum systems, which hinders the goal of achieving quantum advantage for computation and simulation. Most realizations of quantum hardware are in the solid state, e.g., superconducting qubits, color centers and quantum dots, and the solid state environment can host many sources of noises and dissipation. Specifically, surfaces and interfaces contain reconstructions and defects that contribute to electric and magnetic field noise. To date, a key challenge in quantum materials analysis is how to diagnose the dominant noise source from a large set of candidate defects in a material or in the combined materials and fabrication procedures that comprise a qubit device. The goal of this workshop is to bring together leading researchers from academia, industry and national laboratories, including DOE National QIS Research Centers, in a forum addressing how to bridge the seemingly wide gap between the fabrication/processing of materials and the evaluation of qubits. The discussion will be focused on the application of multimodal, high-throughput materials analysis for identifying proxies that reliably correlate with qubit performance and enables rapid feedback loops between materials fabrication and qubit characterization. Through a series of talks, we will demonstrate how a combination of state-of-the-art lab-based and synchrotron-based facilities/characterization techniques have been used to overcome the challenge. The workshop will also bring an opportunity to brainstorm new capabilities to look at the problem from previously inaccessible angles.

Start Time (ET)	Title	Speaker (Affiliation)
10:00am - 10:40 am	Real-time hamiltonian estimation techniques for probing noise spectrum in semiconductor quantum dot spin qubits	Dohun Kim Seoul National University
10:40am - 11:25 am	Measuring Ultra-long Spin Coherence	Steve Lyon Princeton
11:25 am - 11:30 am	VENDOR TALK	
11:30 am -12: 10 pm	Study of loss channels in Tantalum microwave superconducting devices	Aveek Dutta Princeton
12:10 pm - 1:00 pm	LUNCH BREAK	
1:00 pm -1:40 pm	Direct Detection of Surface Spins with Superconducting Qubits	David Rower MIT
1:40 pm -2:20 pm	Isolating single donors in ZnO using a plasma focus ion beam	Kai-Mei Fu University of Washington
2:20 pm - 3:00 pm	Millisecond coherence in a superconducting qubit: a case study	Vladimir Manucharyan University of Maryland

3:00 pm -3:05 pm	VENDOR TALK	
3:05 pm -3:45 pm	Probing microscopic origins of decoherence with nitrogen vacancy centers in diamond	Shimon Kolkowitz University of Wisconsin
3:45 pm - 4:25 pm	The Merged Element Transmon	John Mamin IBM
4:25 pm - 5:05 pm	Widefield magnetic, electric and strain imaging in diamond using layers of nitrogen-vacancy defects	Jean-Philippe Tetienne RMIT