

## Northwestern Quantum Week Opening Science Workshop: Superconducting Qubits for Quantum Computing

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**Akshay Murthy** is an associate scientist and group leader at Fermilab. As part of the Superconducting Quantum Materials and Systems (SQMS) center, he serves as the deputy center director and the materials science lead. At Fermilab, his research group focuses on applying a variety of materials characterization techniques such as electron microscopy, x-ray photoelectron spectroscopy, and time-of-flight secondary ion mass spectrometry, to improve the quality and performance of superconducting qubits and resonators as well as spin qubits. Akshay received his Ph.D. in Materials Science and Engineering from Northwestern University in 2020 and his B.S. in Materials Science and Engineering in 2015 from the University of Illinois at Urbana-Champaign. He was originally hired as a postdoctoral research associate at Fermilab in 2021.

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### Identifying Decoherence Mechanisms in Superconducting Qubits through Advanced Materials Characterization

**Abstract:** Although superconducting qubits have emerged as a leading technology platform for quantum computing through large improvements in device coherence times and gate fidelity in recent years, the presence of defects and impurities at the interfaces and surfaces in the constituent materials continue to limit performance and serve as a critical barrier in achieving scalable quantum systems. Understanding and eliminating these sources of quantum decoherence in superconducting qubit devices requires dedicated studies aimed at establishing robust structure-property relationships that will enable researchers to target and eliminate defects strategically. As part of the Superconducting Quantum Materials and Systems (SQMS) center, we have extensively employed state-of-the-art materials characterization techniques, including scanning/transmission electron microscopy, secondary ion mass spectrometry, atom probe tomography, x-ray diffraction, and x-ray photoelectron spectroscopy in conjunction with device measurements to elucidate such relationships. In this talk, I will discuss some of our recent findings, including linking atomic defects to microwave loss in surface oxides, linking impurities in the Josephson Junction to qubit parameters, and linking low temperature precipitates to device performance. By applying these insights, we have been able to strategically develop and implement mitigation strategies for reliable fabrication of high coherence superconducting qubits.