

Epitaxial Nitride Josephson Junctions

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Principal Investigator(s): Valla Fatemi

User(s): Benjamin Byrd, Kushagra Aggarwal

Affiliation(s): School of Applied and Engineering Physics, Cornell University

Primary Source of Research Funding: AFOSR

Contact: vf82@cornell.edu, ka543@cornell.edu

Website: <https://fatemilab.aep.cornell.edu>

Primary CNF Tools Used: Heidelberg MLA 150 Maskless Aligner, PT 770, ICP Etcher, JEOL-9500FS E-beam

Lithography System, Zeiss Ultra SEM, SC4500 Even-hour Evaporator, AJA Sputter 1.

Abstract:

Superconducting quantum technologies have traditionally relied on aluminum-based devices because of the ease of fabrication and the self-limiting growth of aluminum oxide. However, aluminum has a relatively low critical temperature (1.2K) requiring helium-3 refrigeration, and it suffers from surface oxides and dielectric loss. In this work, we focus on fabricating Josephson junctions from nitride-based materials grown by molecular beam epitaxy (MBE). These crystalline materials are more resistant to surface oxidation and have the potential to reduce material-related losses in superconducting qubits, thereby enabling significantly improved coherence times.

Summary of Research:

A trilayer stack comprising NbN (7 nm) – AlGaN (3 nm) – NbN (7 nm) is grown using MBE. The Josephson junction is fabricated using a bottom-up approach, as shown in Figure 1. In a first step, the stack is etched to define the bottom layer. Then, a central region is defined as the junction and the top two layers are etched everywhere else, defining the bottom electrode. The top electrode is connected using an Nb wiring layer. Since there is a possibility of the top wiring layer getting connected to the bottom NbN, a spacer layer made of SiO₂ acts as an electrical isolation between the top Nb and bottom NbN.

Conclusions and Future Steps:

In this work, we have completed the lithography steps of the junction with proper alignment and isolation achieved between the layers. In the next steps, we will work on removing the SiO₂ to eliminate any source of dielectric losses and improving the quality of the MBE grown films.

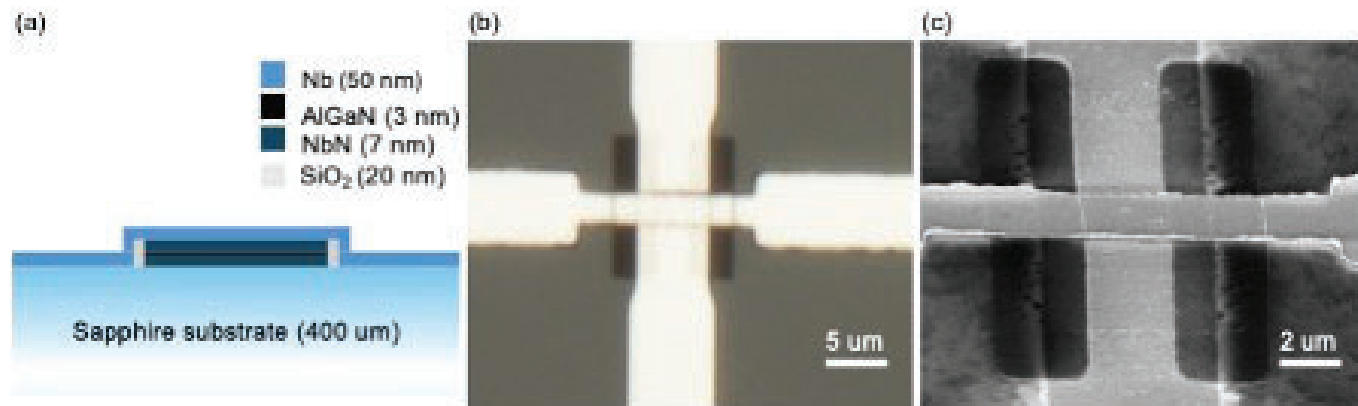


Fig. 1: Epitaxial nitride Josephson junction: (a) NbN (7 nm) – AlGaN (3 nm) – NbN (7 nm) stack grown using MBE on a sapphire substrate. (b) An optical image of the patterned junction. (c) A scanning electron microscope image showing the junction, where a top Nb wiring layer is connected and SiO₂ isolates the Nb wiring layer from the bottom.

