

Study of Vortex Dynamics in Josephson Junction Arrays

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Principal Investigator(s): Katja Nowack

User(s): Cequn Li

Affiliation(s): Laboratory of Atomic and Solid State Physics, Cornell University

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Contact: kcn34@cornell.edu, cl2775@cornell.edu

Research Group Website: <https://nowack.lassp.cornell.edu/>

Primary CNF Tools Used: JEOL JBX-6300FS, Heidelberg MLA 150 Maskless Aligner, Angstrom E-Beam Evaporator, AJA sputter, Zeiss Ultra SEM, Zeiss Supra SEM, Glen 1000 Resist Strip

Abstract:

An array of Josephson junctions provides a tunable platform for studying competing vortex states and the quantum phase transitions [1-4]. Here, we fabricate Nb-Au Josephson junction arrays and study vortex dynamics by combining electrical transport measurements and scanning superconducting quantum interference device (SQUID) microscopy. Our preliminary data shows the presence of periodic vortex lattice formed in the square and hexagonal arrays. Experiments on the vortex dynamics driven by an external current will be studied.

Summary of Research:

We fabricated Nb-Au Josephson junction arrays (JJA) and studied the formation of commensurate vortex patterns using transport measurements and scanning superconducting quantum interference device (SQUID) microscopy at low temperatures. Figure 1 illustrates the process to fabricate Nb-Au JJAs. First, we patterned Au/Ti (40/5 nm) films on Si substrates using optical lithography and electron-beam evaporations. Then we performed electron-beam lithography and sputtered Nb/Ti (70/2 nm) on the pre-patterned Au/Ti. Figure 2 shows an SEM image of an exemplary Nb-Au square JJA device. The Nb islands are only connected by the underneath Au films, forming superconductor-normal metal-superconductor networks.

The JJAs were characterized by low-temperature transport measurements. We confirmed the JJAs are superconducting with the critical temperatures ranging between 5 K and 7 K. Furthermore, we observed maxima in the critical currents as a function of the external magnetic fields, indicating the formation of periodic vortex lattices [2]. We also performed scanning SQUID measurements to visualize the vortex lattices at

different magnetic fields.

Conclusions and Future Steps:

We successfully fabricated Nb-Au JJAs with the critical temperatures ranging between 5 K and 7 K. Through electrical transport measurements and scanning SQUID microscopy, we detected the presence of vortex lattice in the JJAs, leading to enhancements of the critical currents at specific magnetic fields. We will visualize the motion of vortices driven by an external current for the understanding of the vortex dynamics [3, 4].

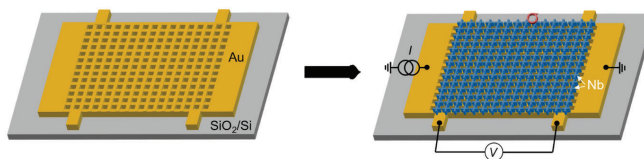


Figure 1: Schematics of fabrication process of Nb-Au Josephson junction arrays.

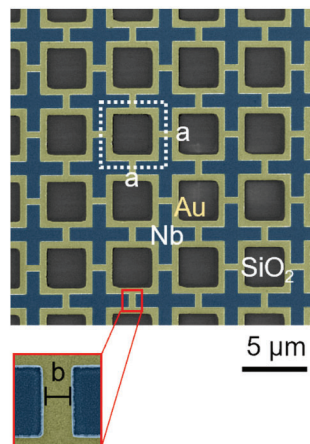


Figure 2: An SEM image of an exemplary Nb-Au JJA device.

References:

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