Superconducting Microwave Resonators for Probing Dissipation from Vortices

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Abstract:
We are fabricating superconducting microwave resonators for probing the response of vortices at high frequencies. Vortices are quantized bundles of magnetic flux that thread many different superconductors over a particular range of applied magnetic field. The vortex response depends on the interplay between the vortex viscosity and the pinning potential in the superconductor. Thus, these measurements are useful for probing fundamental physical properties of vortices. In addition, the presence of vortices in resonators can lead to a substantial increase in the loss. Therefore, this loss mechanism is an important consideration in the design of superconducting detectors and quantum coherent circuits.

Summary of Research:
Vortices in superconductors can respond quite differently in the microwave range compared to dc driving [1]. High-quality factor superconducting microwave resonators are useful tools for investigating this response and for exploring fundamental physical properties of vortices at microwave frequencies. Vortices trapped in superconducting traces can result in substantial reductions in the quality factor of such resonators. Thus, understanding this dissipation mechanism can be important in the design of superconducting systems that use microwave resonators, including sensitive photon detectors and quantum computing applications.

We are fabricating a system of superconducting, thin-film microwave resonators for studying the loss contributed by trapped flux over the frequency range from 2-11 GHz [2,3]. This design consists of a multiplexed set of quarter-wave, coplanar waveguide resonators with a wide range of lengths that are capacitively coupled to a common superconducting

Figure 1: Atomic force microscope (AFM) image showing portion of resonator, feedline and ground plane.
By cooling the resonators in different magnetic fields, we are able to probe the loss from vortices as a function of field at the resonance frequencies contained in our design.

We fabricate our resonators from aluminum films deposited onto sapphire wafers in our electron-beam evaporator at Syracuse University. We define the patterns on the Autostep and transfer them into the films with reactive ion etching. We measure these circuits in a 3He refrigerator in our lab at Syracuse University at a temperature of approximately 300 mK. In addition, we have measured similar resonators fabricated from superconducting rhenium films on sapphire substrates.

References:

