Development of superconducting magnetic heat switches for an Ideal Integrating Bolometer

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We are working to develop an Ideal Integrating Bolometer (IIB), a novel detector for far infrared applications [1]. An IIB consists of a dissipationless temperature sensor, such as a magnetic penetration thermometer (MPT), weakly coupled to a thermal bath through a heat switch. If the thermal conductance of the heat switch in the "off" state is much smaller than the conductance of the switch in the "on" state, then the temperature of the thermometer will depend linearly on integrated incident power, until the bolometer temperature is reset by changing the conductance to the "on" state. While in the "off" state, the thermal fluctuation noise across the bolometer conductance is much less than for a bolometer with constant conductance. We have fabricated prototype IIB devices designed to test a superconducting magnetic heat switch on both solid substrates and membranes. The solid substrate devices, which consist of an aluminum film surrounded by a thin film niobium field coil, are designed to measure the critical current of the aluminum as a function of applied magnetic field. The membrane devices consist of a Johnson noise thermometer and a heater on a central membrane that is supported by four suspended silicon nitride legs. One of the legs serves as the heat switch, featuring an aluminum film that is surrounded by a niobium field coil. The "off" state occurs when the aluminum film is superconducting, and the "on" state when the aluminum is driven normal by applying a current through the niobium. Eventually the Johnson noise thermometer will be replaced by an MPT, and the heater by an infrared absorber, but the prototype membrane devices allow us to measure the thermal conductance of the heat switch as a function of applied magnetic field. In this work, we will present details on the design, fabrication, and experimental performance of our prototype IIB devices.

[1] A. Kogut et al., "Ideal Integrating Bolometer," Proc. Far-IR, Sub-mm & mm Detector Technology Workshop, Monterey, CA 2002.