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Multiplexing of Hot-Electron Nanobolometers Using Microwave SQUIDs

B.S. Karasik *, P.K. Day, and J.H. Kawamura
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109
* Contact: boris.s.karasik@jpl.nasa.gov, phone +1-818-393-4438

***Abstract*—We will present the first data demonstrating multiplexed operation of the titanium (Ti) hot-electron nanobolometers at ~ 0.4 K. Nanobolometers are very promising for meeting the most demanding sensitivity requirements for THz spectroscopy in space [1]. At the same time, they have a short time constant (~ μs at 400 mK) that makes impossible application of time-domain or audio-frequency domain multiplexing schemes commonly use for leg-isolated (slow) superconducting bolometers.**

A novel solution pursued in this work is called MSQUID and uses dc SQUIDs coupled to X-band microresonators [2]. SQUIDs are very low-noise, low power dissipating superconducting devices commonly used for readout of superconducting bolometers. Their input bandwidth is limited by inductive coupling to the bolometer and does not exceed ~1 MHz that is suitable for one hot-electron detector pixel. At the same time, the SQUIDs themselves are very fast and can operate at many GHz. This gives a way to implement a multiplexed readout for nanobolometers by measuring a change of the Q-factor of an X-band coplanar waveguide (CPW) resonator coupled to the SQUID. The detected radiation causes a change of the current through the bolometer and through the input coil of the SQUID. This causes a change of the magnetic flux through the SQUID loop, which changes the SQUID impedance and introduces damping in a coupled resonator. Each SQUID in the array is coupled to its individual resonator. The unique resonator frequency (resonator length) provides microwave frequency encoding for each pixel. The number of channels (pixels) per one MSQUID depends on the Q-factor of the resonators and can be about several 100s. At the same time, all MSQUIDS require just 2 pairs of wires for biasing and flux modulation and two microwave cables for passing the probe signal through the resonators. The output of many (~100) MSQUIDs can be also multiplexed thus leading to a possibility to read a 10,000-pixel array using this approach. The type of the multiplexor was inspired by the Microwave Kinetic Inductance Detector (MKID) [3] and has the same advantages (large bandwidth, many pixels).

We are setting up a demo-array consisting of 4 hot-electron nanobolometers with the noise equivalent power NEP ~ 10^{-17} W/Hz$^{1/2}$ at 400 mK connected to a 4-element MSQUID chip. The entire system will operate in a He3 dewar with the optical access. We plan to demonstrate the complete recovery of the detector noise after demultiplexing and also the simultaneous detection of NIR single photons in all 4 channels. The latter is important since the nanobolometers are seen as potential THz calorimeters for on-chip FIR spectroscopy. The follow-up work will address larger scale fully integrated array of more sensitive nanobolometers hybridized with a matching MSQUID chip.

[1] J.Wei et al., *Nature Nanotechnology* 3, 496 (2008)
[2] I.Hahn et al., *J. Low Temp. Phys*. 151, 934 (2008)
[3] P.K.Day et al., *Nature* 425, 817 (2003)