

Performance of an HEB Direct Detector Utilizing a Microwave Reflection Readout Scheme

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Abstract— We report the results of our study on the performance of a hot electron bolometric (HEB) direct detector, operated by a microwave pump. The HEB devices used in this work were made from NbN thin film deposited on high resistivity silicon with an in-situ fabrication process.

The experimental setup employed is similar to the one described in [1]. The detector chips were glued to a silicon lens clamped to a copper holder mounted on the cold plate of a liquid helium cryostat. Thermal link between the lens and the holder was maintained by a thin indium shim. The HEBs were operated at a bath temperature of about 4.4 K. Conventional phonon pump, commonly realized by raising the bath temperature of the detector, was substituted by a microwave one. In this case, a CW microwave signal is injected to the device through a directional coupler connected directly to the detector holder. The power incident on the HEB device was typically 1-2 μ W, and the pump frequency was in the range of 0.5-1.5 GHz. The signal sources were 2 black bodies held at temperatures of 295 K and 77 K. A chopper wheel placed in front of the cryostat window switched the input to the detector between the 2 sources. A modulation frequency of several kilohertz was chosen in order to reduce the effects of the HEB's flicker noise. A cold mesh filter was used to define the input bandwidth of the detector. The reflected microwave signal from the HEB device was fed into a low noise amplifier, the output of which is connected to a room temperature Schottky microwave power detector. This Schottky detector, in conjunction with a lock-in amplifier, demodulated the input signal modulation from the copper wheel. As the input load was switched, the impedance of the HEB device at the microwave pump frequency also changed in response to the incident signal power variation. Therefore the reflected microwave power follows the incident signal modulation. The derived responsivity from this detection system nicely correlates with the HEB impedance.

In order to provide a quantitative description of the impedance variation of the HEB device and the impact of a microwave pump, we have numerically solved the heat balance equations written for the NbN bridge and its surrounding thermal heat sink [2]. Our model also accounts for the impact of the operating frequency of the detector because of non-uniform absorption of low-frequency photons across the NbN bridge [3]. In our measurements we varied the signal source

wavelength from 2 mm down to near infrared range, and hence we indirectly performed the impedance measurements at frequencies below, around and far beyond the superconducting gap. Preliminary results show good agreement between the experiment and theoretical prediction. Further measurements are still in progress.

REFERENCES

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