A Microwave Pumped HEB Direct Detector Using a Homodyne Readout Scheme

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We report the results of our study on the noise performance of a fast THz detector based on the repurpose of hot electron bolometer mixer (HEB). Instead of operating with an elevated bath temperature, microwave power is injected into the HEB device, which enhances the sensitivity of the detector and at the same time provide a mechanism for reading out impedance changes of the device induced by the modulated incident THz radiation [1]. We have demonstrated an improvement of the detector's optical noise equivalent power (NEP). Furthermore, by introducing a homodyne readout scheme based on a room temperature microwave mixer, the dynamic range of the detector is increased.

The HEB devices used in this work were made of 4 nm thick NbN film. The detector chips were installed into a waveguide mixer block fitted with a corrugated horn, mounted on the cold plate of a liquid helium cryostat. The HEBs were operated at a bath temperature of 4.2 K. The signal beam was terminated on black bodies at ambient and liquid

nitrogen temperatures. A chopper wheel placed in front of the cryostat window operating at a frequency of 1.48 kHz modulated the input load temperature of the detector. A cold mesh filter, centered at 830 GHz, was used to define the input signal power bandwidth. Microwave was injected through a broadband directional coupler inside the cryostat. Our experiments were mostly conducted at a pump frequency of 1.5 GHz. The reflected microwave power from the HEB device was fed into a cryogenic low noise amplifier (LNA). The output of the LNA was connected to the RF input port of a room temperature microwave mixer, which beat the reflected signal from the HEB using a copy of the original 1.5 GHz injection signal in a homodyne demodulation scheme. The amplitude of the detected power was measured by a lock-in amplifier, which was synchronized to the chopper frequency.

Preliminary results yield an optical NEP of ~1 pW/ $Hz^{1/2}$ which corresponds to an improvement of a factor of 3 compared to [1], driven mainly by a lowering of the system noise floor. The dynamic range was also increased by similar amount.

References

1. A. Shurakov et al. "A Microwave Pumped Hot Electron Bolometric Direct Detector," submitted on Oct 18, 2013 to *Appl. Phys. Let.*