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An array scalable zero-bias far-IR detector with noise thermometry readout

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We report on a new development effort to achieve an array of ultra-sensitive (NEP < 1E-20 W/sqrt(Hz)) far-IR detectors for applications in spectrometers on Origins Space Telescope (OST) or similar low-background platforms. The detector uses a submicron-size hot-electron bolometer (HEB) sensor made from normal metal (non-superconducting Ti) coupled to a planar microantenna. The detector does not require any bias (dc or rf). The Johnson Noise Thermometry using a quantum noise limited microwave amplifier (LNA) allows for the direct read of an increase of the electron temperate caused by the absorbed far-IR radiation. At 50 mK, the NEP is less than 1E-20 W/sqrt(Hz) is expected whereas the dynamic range is 60-100 dB. Multiplexing of a 1000-pixel array is feasible using a single LNA with a bank of narrowband bandpass filters for channel multiplexing.

In this paper, we will present an initial experimental study of the electrical NEP in a 1μm × 1μm detector. A set of superconducting narrow band-pass (Q = 100-1000) and low-pass filters defines the readout bandwidth around the center frequency of 1.5 GHz. A commercial HEMT LNA with the noise temperature T_A ≈ 1 K largely determines the system sensitivity (NEP ≈ 1E-19 W/sqrt(Hz) @ 50 mK). Electrical NEP is measured by sending a dc current through the device and measuring a change of the output noise power caused by the heating. Switching to a quantum noise limited parametric kinetic inductance amplifier will allows us to reach an NEP close to 1E-20 W/sqrt(Hz). The next phase of this work will be using much smaller HEB devices (e.g., 0.5μm × 0.25μm) where NEP = 3E-21 W/sqrt(Hz) is predicted. Because of the very high dynamic range and optical saturating power, various additional higher background or/and higher operating temperature applications of such a sensor are envisioned.

Less than 5 years of experience since completion of Ph.D

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Student (Ph.D., M.Sc. or B.Sc.)

N

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