Tunable speed single-photon THz nanobolometers

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***Abstract*— The superconducting hot-electron nanobolometer (nano-HEB) has been demonstrated to be the most sensitive detector of sub-mm/THz radiation with a recently achieved optical NEP = $3x10^{-19}$ W/Hz$^{1/2}$. Beside its impressive sensitivity in the power detection mode, additional improvements are expected in the photon counting mode. The latter will be possible for wavelengths less than 300 µm where the minimum detectable energy of a submicron-size bolometer becomes much smaller than the photon energy. With the proper thresholding, such a photon counter becomes nearly "noiseless" with the sensitivity limited by the photon statistics only. Given the very low rate of the background photons arriving on space spectrometers (e.g., SPICA/BLISS), photon counting operation is very attractive for achieving the NEP ~ 10^{-20} W/Hz$^{1/2}$ with the advantages of high dynamic range (40-60 dB) and higher operating temperature compared to micromachined TES.**

We have already achieved extremely small Ti nano-HEBs with the dimensions 0.3µm x 0.1µm x 20 nm, critical temperature ~ 300 mK, and large critical current. Currently, a single-photon detection experiment utilizing a 3-THz quantum cascade laser as a gated pulsed source is in progress. The nano-HEB devices can be used throughout the entire far-IR range (30-300 µm) where planar microantennas are available.

A novel element of our development effort is engineering of the photon-counter speed using a controllable cooling of electrons in a sensor via microwave photon emission. In its original version, the nano-HEB relies on the electron-phonon cooling process with the characteristic time ~ a few µs at 300 mK and a T^4 temperature dependence. Operating below 300 mK reduces the detector noise but also slows it down significantly. A small microwave circuit integrated with the sensor allows for emission of the 1D blackbody radiation of hot-electrons in the frequency range kT/h ~ GHz into a small heat-sunk resistor. The process bypasses the electron-phonon cooling and increases the count rate limit to ~ 2 Mcps independent of the temperature. Even a much higher speed (~ 10 Gcps) can be realized in such nanodevices when normal metal contacts are used to enhance the electron diffusion. The latter, however, requires new approaches for low-noise and broadband readout since SQUID amplifiers cannot be that fast.

Realization of a ~ 1000-pixel nano-HEB photon-counting array with an adequately fast microwave SQUID multiplexed readout is now quite feasible. Another area of interest for these devices may be in the single-photon THz interferometry.