Optical sensitivity measurements in nano-HEB detectors

B. S. Karasik[1*] and R. Cantor[2]
1 Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109*
2 STAR Cryoelectronics, Santa Fe, NM 84508
* Contact: boris.s.karasik@jpl.nasa.gov, phone +1 (818) 393-4438

***Abstract*—Recently, an interest to ultrasensitive submillimeter/FIR detectors has been driven due to the astrophysics community's and space agencies' plans to launch telescopes with cryogenically cooled primary mirrors where the thermal emission from the telescope would be largely eliminated. Several concepts of such telescopes (e.g., SAFIR, SPECS, CALISTO, FIRI, SPICA) have been proposed and studied. Moderate resolution spectroscopy would be the most demanding application requiring the detector noise equivalent power (NEP) to be less than 10^{-19} W/Hz$^{1/2}$ in the most of the submillimeter/FIR spectral range in order for the photon shot noise to dominate the detector noise. The SPICA mission led by the Japanese space agency is currently seen as the most feasible opportunity to realize such a sensitive astronomical platform. There are two instruments considered for far-IR spectroscopy on SPICA. ESA led SAFARI instrument would use a Fourier Transform Spectrometer in the 30-210 μm wavelength range. The detectors for SAFARI should have an NEP = 3×10^{-19} W/Hz$^{1/2}$. Another instrument (BLISS), which is under study in the US, is a grating spectrometer operating in the 35-433 μm range. The detector sensitivity goal here (NEP = 3×10^{-20} W/Hz$^{1/2}$) is non-precedent and requires an improvement of the state-of-the-art by 2-3 orders of magnitude.**

We have been addressing this sensitive detector needs via development of the superconducting hot-electron nanobolometer (nano-HEB). In this work for the first time, we have measured the optical NEP in twin-slot antenna coupled titanium (Ti) nano-HEBs. The bolometers were 2μm×1μm×20nm and 1μm×1μm×20nm transition-edge sensor (TES) devices with NbTiN contacts. The measurements were done at λ = 460 μm using a cryogenic black body radiation source delivering optical power from a fraction of a femtowatt to a few 100s of femtowatts. The detector readout was a dc SQUID with the noise ~ 2-3 pA/Hz$^{1/2}$. A record low NEP = 3×10^{-19} W/Hz$^{1/2}$ at 50 mK has been achieved. The optical efficiency of the tested detector was found to be ~50-70%. Along with the results we will discuss the details of the experimental method for determination of the ultralow calibration power and the NEP. The path for getting even lower NEP in the nano-HEB detectors will be discussed as well.