Optical characterization of high sensitivity TES detectors designed for the SPICA/SAFARI 30-60 μm channel

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Abstract**—High sensitivity TES detectors have been selected as the baseline detector technology for the SAFARI instrument on the SPICA telescope. SAFARI is an imaging Fourier transform spectrometer operating over the wavelength range from 34 – 205 μm (1.5-10 THz). The SAFARI detectors are divided into 3 focal plane units, each covering an octave in wavelength: 34-60, 60-110 and 110-205 μm. The low background environment places a requirement on the sensitivity or noise equivalent power (NEP) of the detectors to be NEP=2-3 × 10^{-19} W/√Hz. In this paper, we describe the characterization of high-sensitivity TES detectors designed for operation in the short wavelength band of SAFARI from 34-60 μm (5-10 THz). Each detector consists of a TiAu TES thermometer and an optical absorber fabricated from a thin Tantalum (Ta) film deposited on a thermally isolating silicon nitride (SiN) structure. The TES thermometers have transition temperatures of approximately 100 mK and the thermal conductance, G, varies from G = 0.2-2 pW/K for different thermal isolation geometries. We measure the NEP for several devices as a function of frequency from the measured noise spectral density and electrical responsivity and routinely obtain values for the NEP=4-6 × 10^{-19} W/√Hz with time constants of < 1 ms. With these devices, we measure the absorbed optical power and corresponding photon noise from a blackbody source as a function of source temperature through a set of two high pass and two low pass filters defining a pass-band from 5-10 THz. The radiation from the blackbody source is coupled to an integrating cavity containing the TES and absorber using an electroformed conical horn. We find that these detectors have good optical performance and the dependence of absorbed power on blackbody temperature agrees with the values calculated from the combination of the blackbody emission spectrum and the measured filter transmission. The measured photon noise allows a confirmation of the calibration of the measured NEP from the electrical responsivity, a direct measurement of the optical response time of the detector and confirms that the mean energy of the absorbed photons is 5.6 THz.**