A Phonon-Cooled Nb Direct Detector for SubMM Imaging and Spectroscopy

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We present the data on fabrication and test of an antenna-coupled Nb hot-electron direct detector. The detector device is a 1 μm × 1μm × 12 nm Nb bridge with the critical temperature ~ 6K and the normal resistance of 25 Ohm. The device contacts are made from a thick (~ 150 nm) Nb film with the critical temperature ~ 8.5 K. The larger energy gap in the contacts helps to confine the electron energy within the small device volume due to the Andreev reflection. The device is fabricated on a Si substrate together with the planar spiral antenna covering the 150 GHz-2 THz range. A hybridized elliptical Si lens is used for narrowing the antenna main lobe.

The detector sensitivity (NEP) and the time constant are determined by the electron-phonon interaction in the thin Nb film. The time constant is ~0.4 ns and does not depend on the device size. The estimated NEP due to the phonon noise is ≈ 1.5×10^{-14} W/Hz$^{1/2}$. This figure can be made by a factor of 5 smaller for a submicron size device.

The detector spectral response has been measured in the 250-990 GHz range using a set of backward-wave oscillators and was found to be essentially flat. The current work focuses on the integration of the detector with a sensitive broadband amplifier and a cold submm bandpass filter for optical NEP tests and applications in laboratory spectroscopy.

Although, neither the time constant, nor the NEP sets the record by itself, the combination of the parameters is quite unique and very desirable for a number of applications in laboratory and space spectroscopy as well as in security imaging applications.

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