SPECTRAL SENSITIVITY AND TEMPORAL RESOLUTION OF NbN SUPERCONDUCTING SINGLE-PHOTON DETECTORS

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Future radioastronomy missions will require detectors that simultaneously provide the ultimate, background limited, sensitivity and the fast response in the submillimeter wavelength range. Single-photon detectors are the most promising devices, providing that they can achieve large enough quantum efficiencies (QE) for counting far-infrared photons. Very recently we have demonstrated an optical, superconducting single-photon detector (SSPD) consisting of a 10-nm-thick, 0.2-μm-wide, and approximately 1-μm-long NbN stripe[1], kept at temperature well below the material's superconducting transition T_c, and current-biased just below the stripe's critical current. The detection mechanism of the device was based on photon-induced, supercurrent-assisted formation of a resistive, hotspot barrier across the superconducting stripe.

The aim of this report is to present the performance of 4x4 μm^2 and 10x10 μm^2 active-area, meander-type NbN SSPD's, excited by photons within the 0.4-μm to 3.0-μm-wavelength range, coming from both pulsed and CW optical sources. We observed that the SSPD spectral sensitivity followed activation-type dependence. The exponential character of the QE dependence on both the photon wavelength and the current bias was qualitatively explained in terms of superconducting fluctuations in our ultrathin, submicron-width NbN stripes. The device temporal resolution in the single-photon counting mode was found to be below 150 ps, directly limited by the phonon escape time for our 10-nm-thick NbN film deposited on the sapphire substrate.

Since the QE drops with the increase of the wavelength, there is a cutoff wavelength for our SSPD, and for above discussed detectors, it occurs at approximately 2.5-μm wavelength. However, in general, the ability of the SSPD to register a single photon is the trade-off between the material parameters, operating temperature, and the detector geometry. The use of a superconductor with the low value of the energy gap will shift the cutoff towards far-infrared wavelengths. Provided a sufficiently high optical coupling, such a low-T_c quantum detector should successfully compete with traditional background-limited thermal detectors in the submillimeter wavelength range.

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