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Toward THz Single Photon Detection with a Superconducting Nanobolometer

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Abstract—**Testing a single-photon-sensitive THz detector poses significant technical challenges, especially for a bolometric detector. The challenge is the very low background required over a frequency range dc to several THz. In addition, the thermal conductance due to *photons* must be made less than that due to phonons. To enable device optimization prior to developing a full THz test system, we propose an alternative testing technique that is much easier to implement. A short microwave pulse with a total energy equal to a single THz photon is coupled to the detector. The microwave coupling can be precisely calibrated, and the detector can be well isolated from background IR photons. We call this microwave test pulse a faux photon, or *fauxton*. We use a 20 GHz source with a pulse width of 200 ns. The pulse width is much shorter than the thermal time constant of the detector (~5 μs). The energy of the fauxton can be changed simply by adjusting the amplitude of the microwave source, equivalent to adjusting the THz single-photon frequency. The detector response is determined from the change in the power reflection coefficient measured with a 1.3 GHz CW probe. This readout technique is well suited to frequency-domain multiplexing of a multi-pixel detector array.**

The detector consists of a superconducting Ti nanobridge 4 μm long, 0.4 μm wide, and 70 nm thick with a critical temperature (T_c) of 300 mK. The nanobridge spans thick Nb contacts, which have a higher T_c and hence create Andreev barriers that block the outdiffusion of hot electrons from the nanobridge. The resulting bolometer is phonon-cooled, with a thermal conductance proportional to T^3 at low temperature. Minimizing both the thermal conductance and the operating temperature is essential for achieving high sensitivity. Current micron-size Ti bolometer devices can clearly resolve mid-IR fauxtons with a device-limited sensitivity. Sufficient sensitivity to detect single THz photons can be achieved by scaling down the active device volume or by reducing T_c.