Near infrared photon detectors using titanium-based superconducting transition-edge sensors

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Transition edge sensor (TES) detectors are showing great promise as single photon detectors in quantum information [1] and as fast bolometers in astronomical applications [2]. In the near infrared/optical range TESs offer good broadband quantum efficiency, high time resolution, and modest energy resolution. Therefore TESs provide the potential capabilities for the study of rapidly varying compact object systems. We are developing Ti-based TES as optical/near-infrared photon detectors [3].

The TES sensors are photolithographically patterned ~50 nm thick Ti films deposited on quartz substrate. These films exhibit a sharp superconducting to normal transition at about 400 mK. Niobium films are used as superconducting leads for the devices.

The sensors were mounted on the mixture stage of a Triton 400 dilution refrigerator. The sensor temperature is maintained within its superconducting to normal transition via the Joule heating produced by the voltage bias due to strong negative electrothermal feedback. A series array of dc SQUIDs, working as current-sensitive amplifiers readout the signal. The photons were introduced through a single-mode fiber with a 9 μm core and a 125 μm cladding. The fiber is aligned to the active area of the TES with the help of IR microscope to provide high coupling efficiency.

We have measured the current-voltage curves at different bath temperatures, based on which the calculated thermal conductance is ~300 pW/K for the 10μm×20μm TES (2C1) fabricated on a 1550 nm dielectric mirror. The effective time constant is about 20 μs. The input power is measured by a power meter and then attenuated by 42-45 dB. The absorbed power is the integral of the corresponding drop in current multiplied by the bias voltage. Thus system efficiency is the ratio of absorbed power to the input power. Fig. 1 shows the measured system efficiency as a function of their normalized resistance. The highest system efficiency is 33 % at 1550 nm, and drops down to 14 % as the resistance increases. In comparison, the TES devices (3B1 and 3C1) without dielectric mirror shows lower system efficiency, in good agreement with prediction.

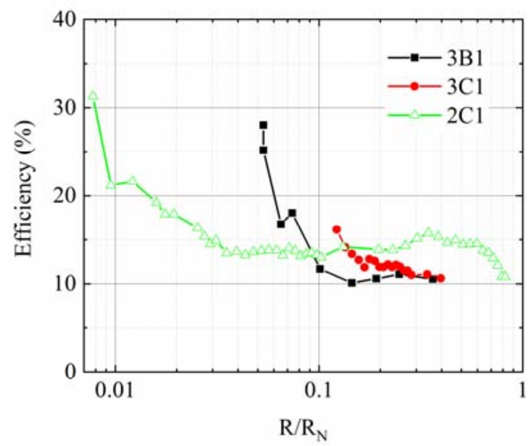

Fig. 1. Measured system efficiency of Ti-based TES detectors at 1550 nm.

In conclusion, we have designed and fabricated near infrared photon detectors using Ti-based superconducting transition edge sensor. The first generation devices have a system efficiency of ~30% and effective response time of 10 μs. The combination of system efficiency and high time resolution allows the construction of a wide-band high-speed spectrophotometers for a number of interesting applications, such as rapid time varying sources.

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