Photon-number resolution with Transition-Edge Sensors

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Abstract: Project STAR develops TiAu TES single-photon detectors with photon-number resolution, with the goal to achieve >90% detection efficiency and 1 μs response time. Results on TESs with gold banks and antireflection coatings are presented

Project STAR aims to develop an advanced array of single-photon detectors based on superconducting transition-edge sensors (TESs) with intrinsic energy and photon-number resolution. The primary objective is to integrate this cutting-edge detector array into the Spoke 6 photonic platform.

At INRiM, we are focused on prototyping a TES array with single-photon number resolution, high detection quantum efficiency (exceeding 90%), and rapid response times under 1 µs. To achieve these targets, the TESs are strategically designed with tunable transition temperatures, leveraging the proximity effect in a TiAu bilayer.

Reducing the detector's time constant is addressed by enhancing thermal conductance between the TES and the substrate [1]. Using gold banks on the TES edges, we fabricated a device with an active area of 60 μm × 60 μm and Tc= 123 mK, achieving photon discrimination up to 1.5 MHz [2], as shown in Fig. 1.

In parallel, we are developing an antireflection coating consisting of two layers (SiO_2 and TiO_2) applied to the TES surface. This structure has yielded a system detection efficiency of 85% at 690 nm. To further enhance efficiency, efforts are underway to implement an optical cavity beneath the TES to minimize transmission losses.

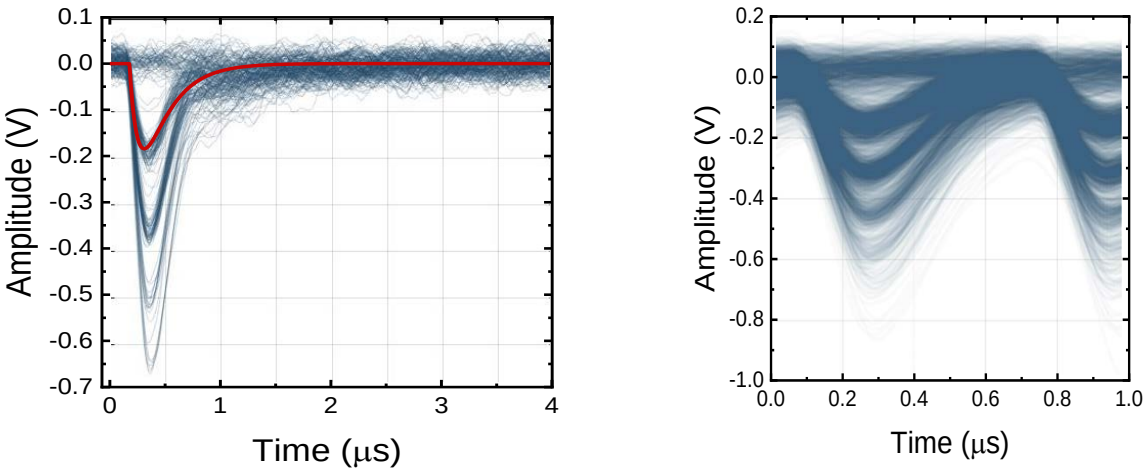

Fig. 1, Single photon detection with a TiAu TES with 60 µm x 60 µm active area, T_c=123 mK and increased thermal conductance with gold banks. (Left) Photon-number discrimination up to 4 photons at 405 nm. The red line is an exponential fit of 1 photon pulses. (right) Photon-number capability at a repetition rate of 1.5 MHz.

References

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