Towards High-Efficiency Optical-TES Arrays for Quantum Applications

F. Malnati[1,2], M. Malerba[1], E. Monticone[1] and M. Rajteri[1]

[1]*Istituto Nazionale di Ricerca Metrologica (INRiM), 10135, Turin, Italy*

[2]*Politecnico di Torino – Department of Applied Science and Technology, 10129, Turin, Italy*

Transition-Edge Sensors (TESs) have emerged as one of the most promising technologies for photon-number-resolving detection in quantum optics, offering near-unity detection efficiency, extremely low dark count rates, and excellent energy resolution.
At INRiM, we have already demonstrated competitive performance in several TES figures of merit, including a dark count rate (DCR) of ~10^{-4} Hz [1], a resolving power of ~4 [2] (Fig. 1 Left), detection efficiency exceeding 80% for Au/Ti TES devices with an anti-reflection coating (ARC) [3], and count rates above 1 MHz in Ti/Au TES with Au banks [2] (Fig.1 Right) coupled to a single-mode optical fiber.

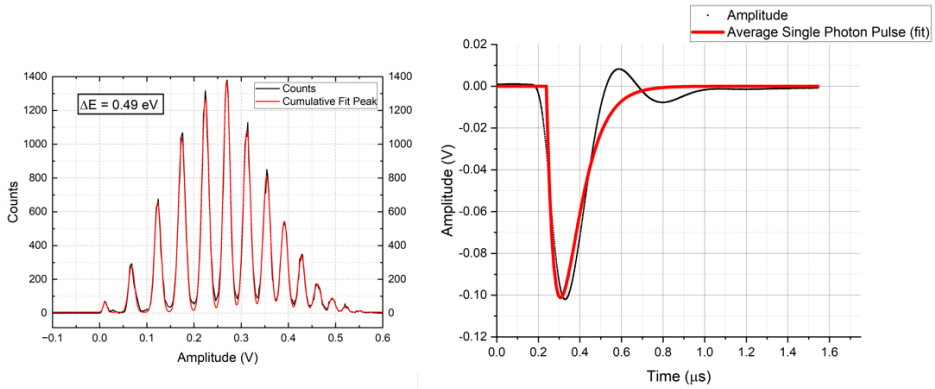

Fig. 1. Left: *Amplitude histogram from 50k waveform acquisitions with a 690 nm pulsed laser, showing an energy resolution of 0.49 eV for an Au/Ti TES with anti-reflection coating (ARC).*
Right*: Average single-photon pulse for a Ti/Au TES with Au banks. The response time was evaluated to be 68 ns from the fit.*

However, many emerging quantum protocols require the simultaneous detection of photons across multiple spatial or temporal modes, motivating the development of scalable detector architectures. Moving from single detectors to arrays of optical TES devices represents a key step toward enabling high-rate, multi-channel quantum measurements while preserving the exceptional performance of individual sensors.
In this work, we present recent progress toward the development of high-efficiency optical TES arrays tailored for quantum applications. In particular, we discuss improvements in the experimental setup for multi-detector systems, including the use of electron-beam lithography (EBL) for the fabrication of small TES devices, the design and implementation of our Precise Optical Line-up And Reference Imaging System (POLARIS), a hexapod-based system for precise fiber alignment to detector arrays, and the first characterization of the uniformity of detector performance across the array. Preliminary results demonstrate promising energy resolution and stability, highlighting the potential of TES arrays as a scalable platform for next-generation quantum photonic experiments.

References

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