High-Efficiency Photon-Number-Resolving TiAu Transition-Edge Sensors: A Multi-Facility Performance Comparison

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Single-photon detectors with photon-number-resolving (PNR) capability are essential building blocks for quantum computing, secure communications, and advanced characterization of non-classical light sources. Among existing technologies, transition-edge sensors (TESs) [1] represent the gold standard due to their near-unity efficiency and intrinsic ability to resolve the number of incident photons with high energy resolution.

In this work, we present the cross-facility characterization of a high-performance TES based on a TiAu thin film, optimized for telecom wavelengths (1550 nm) [2]. The device, developed at AIST and characterized within the framework of the European SEQUME project [3], features an integrated fiber-coupling structure designed to minimize optical losses [4]. To validate its performance for demanding quantum applications, an extensive measurement campaign was conducted across three different world-leading laboratories.

The results of this comparison highlight the exceptional capabilities of the TiAu TES platform. The experimental data consistently show a system detection efficiency around 94.5%, placing this device among the highest-performing fiber-coupled detectors reported to date. Beyond high efficiency, the sensor demonstrates fast recovery times (below 200 ns), enabling megahertz-range counting rates, and an energy resolution capable of clearly discriminating states with up to 10 photons.

The successful comparison between different experimental setups confirms the robustness of the technology and its readiness for large-scale quantum optical experiments. These features make the TiAu TES an ideal candidate for quantum optics protocols that require full-state information extraction, surpassing the limitations of conventional "click/no-click" detectors and providing a scalable path for future quantum networking.

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