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Complex impedance of optical transition-edge sensors with sub-microsecond response

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Optical transition edge sensor (TES) detectors which can resolve an energy of a single optical photon have proven desirable in quantum information and biological imaging. Optical TESs were designed to have a high detection efficiency at a specific wavelength and has achieved nearly 100 % at the wavelength. They have been proven to have the sensitivity at a wide bandwidth from near-infrared to visible regions. The energy resolution was typically 0.1 to 0.2 eV. Higher energy resolution is required for an application of the TESs in multicolor fluorescence microscopy. A question arising here is if we have reached the theoretical limit of the energy resolution. To calculate the limit, we need to measure parameters such as the temperature sensitivity α and the current sensitivity β, extracted from the complex impedance.
The optical TES is characterized by: (1) its small size (typically 5 to 10 μm) to be sensitive to the low-energy photons and (2) a fast response time (< 1 μs) determined by the heat capacity and weak thermal coupling between electrons and phonons in the detector. To extract β of a sub-microsecond TES, the complex impedances need to be measured at high frequencies (> 1 MHz), where the parasitic impedance in the circuit and reflections of electrical signals due to discontinuities in the characteristic impedance of the readout circuits become significant. To reduce the parasitic impedance and the discontinuities, we have replaced legacy twisted cables with coaxial ones and obtained cleaner transfer function of the readout. Figures show the complex impedance of a TES sensitive to MHz-electrical perturbations. We will discuss the theoretical limit of the energy resolution and a possible thermal model of the TES.

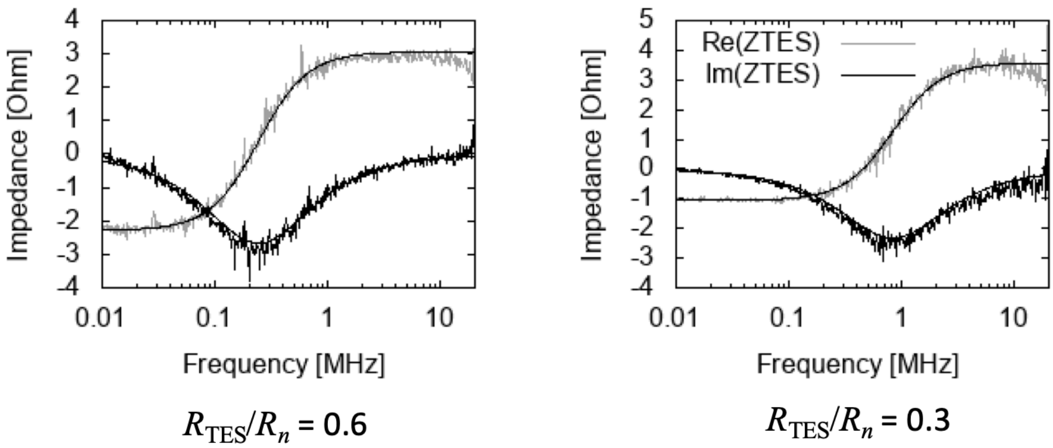

Figure 1: Complex impedance of an optical TES.

Less than 5 years of experience since completion of Ph.D

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Student (Ph.D., M.Sc. or B.Sc.)

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