Characterization of a High Precision TES Light Detector for Neutrinoless Double Beta Decay Search

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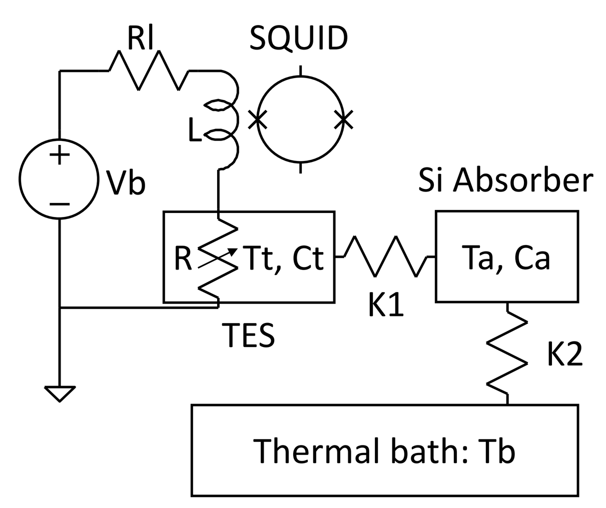
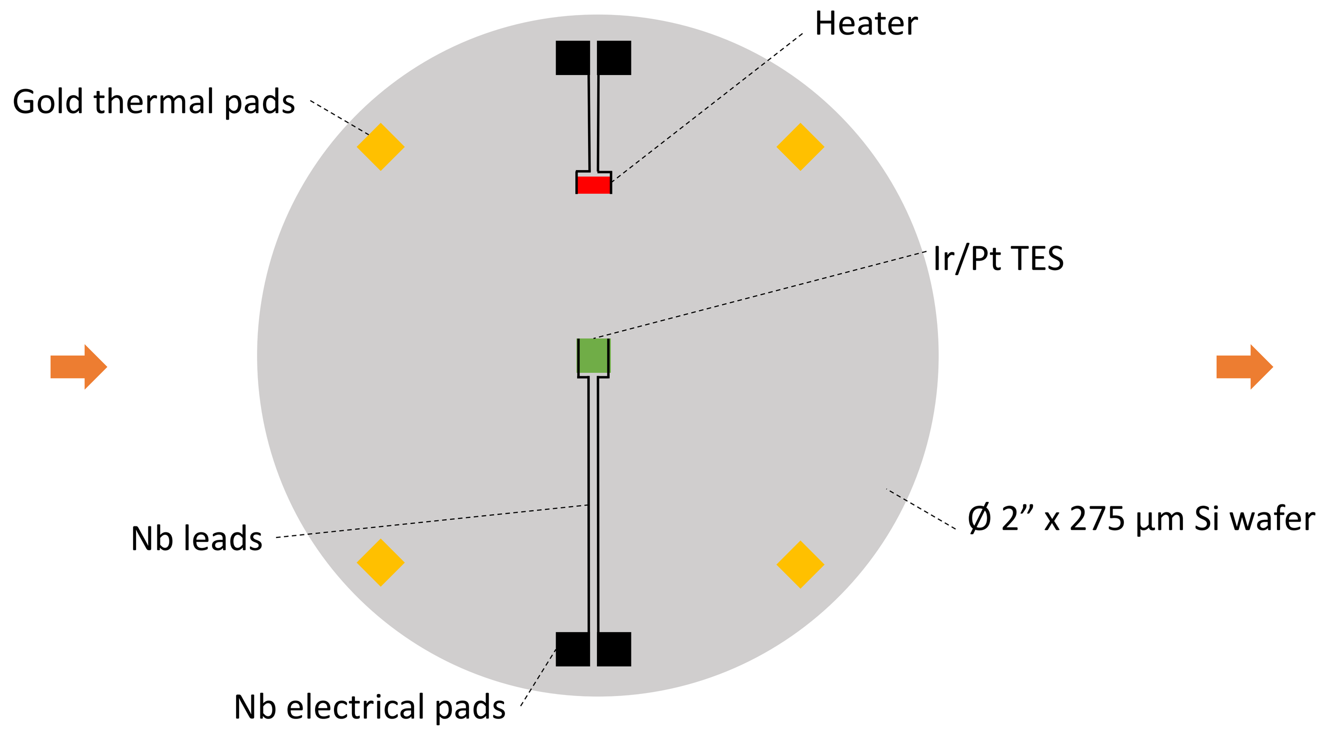
Motivation: A *Fast*, *High Energy Resolution,* and *Thermal* TES Light Detector

The CUORE Upgrade with Particle ID (CUPID) project, successor of the Cryogenic Underground Observatory for Rare Events (CUORE) experiment, is investigating the possibility of utilizing ^{100}Mo-enriched Li_2MoO_4 bolometers to search for the 0νββ decay. Accidental pileups of the 2νββ events could be a main source of background because of the relatively short half-life of the 2νββ transition for ^{100}Mo ($T_{1/2} = 6.9 \times 10^{18}$ y). Rejection of this background will require light detectors with 10-100 μs time resolution, which requires short rise times and excellent signal-to-noise ratio.

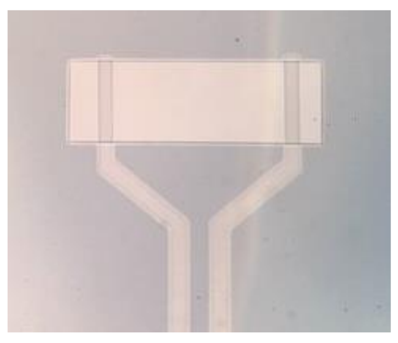
Detector Design, Fabrication, and Test



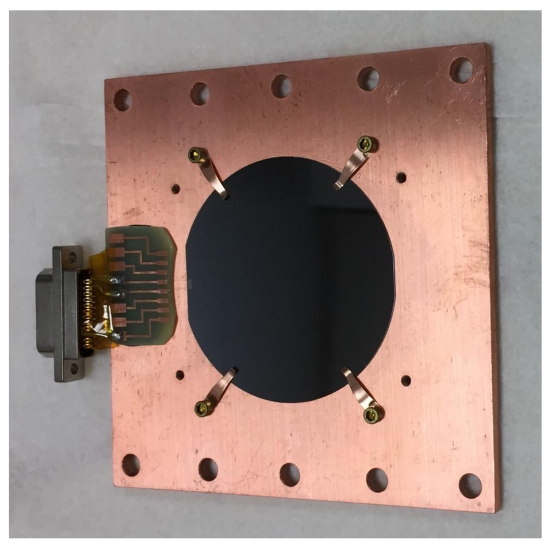
A. Electrical-thermal model of the light detector



B. Cartoon of the light detector layout. Heaters and gold thermal pads can be optionally added



C. Micrograph of the Ir/Pt TES element

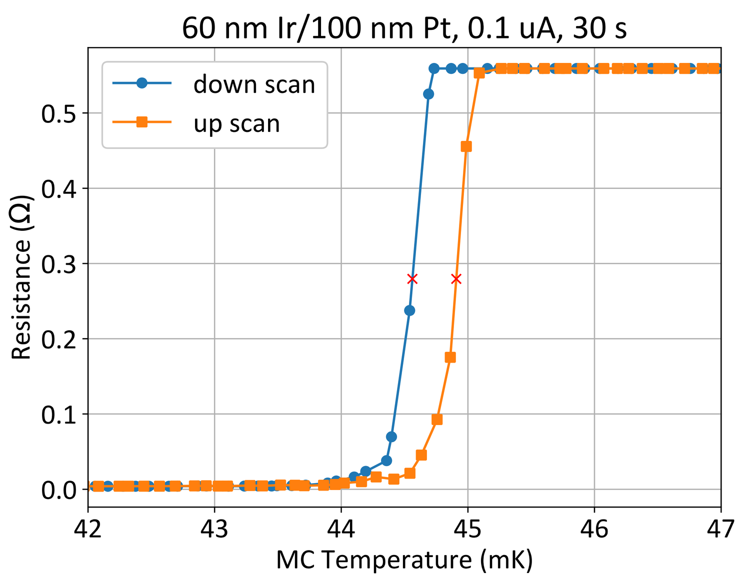


D. Light detector mounted on detector holder

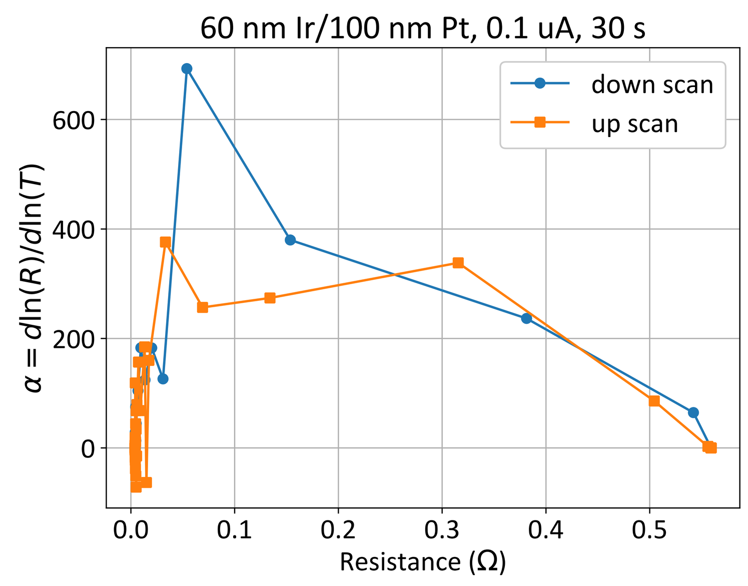
The entire detector assembly is tested in a Bluefors LD400 dilution refrigerator with STAR Cryoelectronics pcSQUID readouts. Multiple versions of the light detector and holder have been created during the detector development iterations.

RT, IV, Time Constants, and Complex Impedance Measurements

Resistance vs Temperature

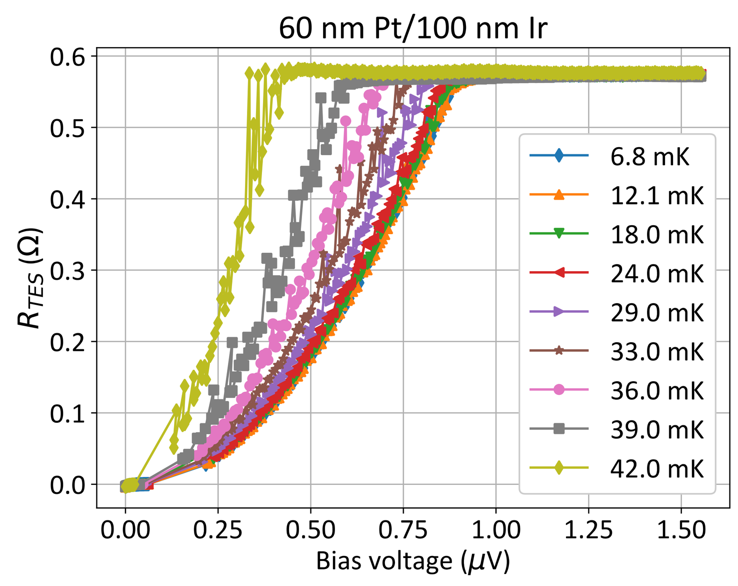


E. Up and down temperature scans of the TES resistance. Hysteresis is due to thermal relaxation of holder

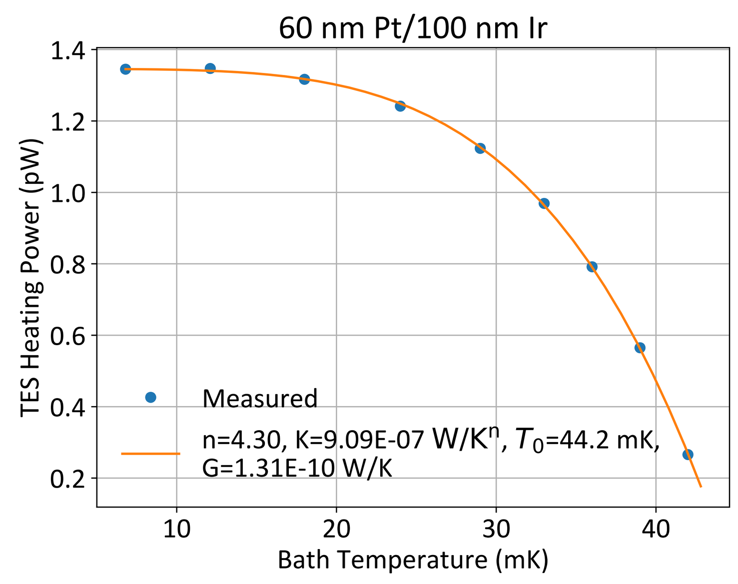


F. $\alpha = d\ln(R)/d\ln(T)$ vs TES resistance

IV Curves

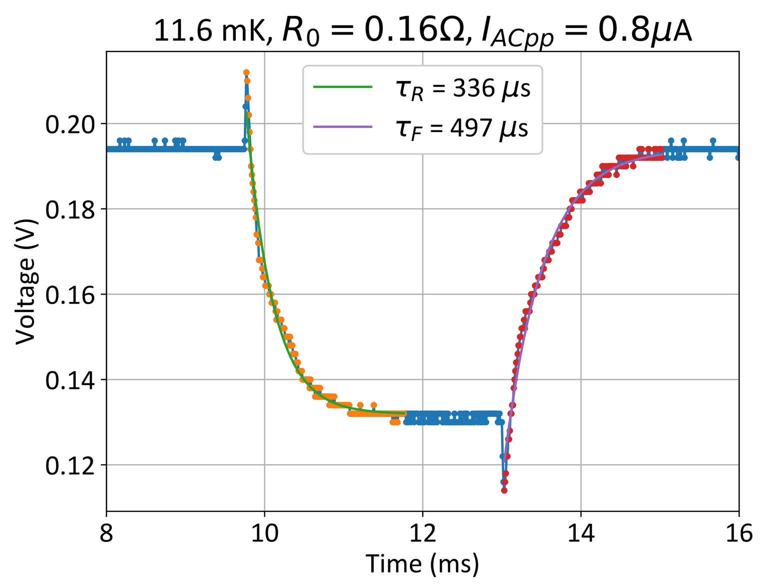


G. Temperature dependence of TES resistance vs bias voltage from IV measurements. Resistance jumps are largely due to cosmic ray pulses



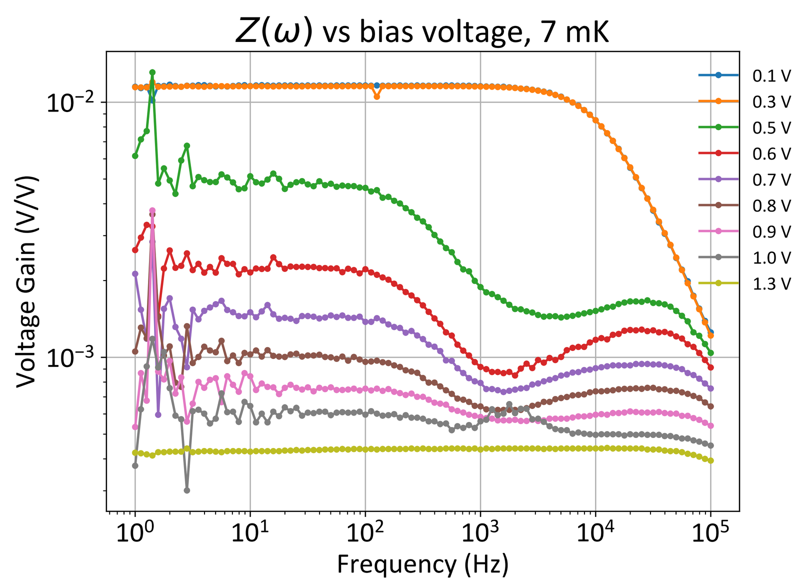
H. TES Joule heating power vs bath temperature and the fit to a power law

Time Constants



I. TES time constants measured with a small amplitude square pulse excitation

Complex Impedance



J. Voltage gain vs frequency at different TES DC biases. $Z(\omega)$ data identifies the thermal poles easily

Figures E to J all are data collected with a 500 μm × 500 μm, 60 nm Ir/100 nm Pt bilayer TES with $T_c = 44.5$ mK and $R_n = 0.56\ \Omega$.

Conclusions: A fast (O(100) μs fall time and much faster rise time) and high energy resolution (O(1-10) eV σ_{E_0}) thermal TES light detector design can be realized through parameter optimization. We have obtained preliminary positive results with the prototype detectors and further improvements are underway.

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