Superconducting transition edge sensor (TES) single photon detectors have demonstrated high quantum efficiency and photon number resolving capability. Furthermore, Ti-based TES is very fast (response time of ~100 ns) thanks to the high critical temperature of ~400 mK.

We have developed Ti-based TES, and studied its electrical and optical performance. Here, we present the improvement of detection efficiency of Ti-based TES embedded in an optical cavity.

### Optical cavity

- Optical cavity composed of anti-reflection coating (AR) and dielectric mirror (DM);
- AR and DM consist of 16 and 4 layers of SiO₂ and Ta₂O₅, respectively;
- Thickness for DM is fixed to 0.25 μm far from TES;
- Thickness for AR optimized with Macleod software;
- Absorptance increased by a factor of 2 by adding AR.

### Fiber alignment

- Fiber ~20 μm far from TES;
- Light spot from the fiber is Gaussian distribution;
  \[ I(x, y) = \frac{2}{\pi \sigma_0^2} \exp \left( -\frac{4(x^2 + y^2)}{\sigma_0^2} \right) \]
- TES active area overlaps the light spot;
  \[ \eta_{\text{calc}} = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} I(x, y) \, dx \, dy \]
- Calculated coupling efficiency is over 90%.

### Thermal conductance

- I-V measured with SQUID readout;
- Data points chosen at a resistance of 0.7 Ω;
- G from I-V at different Tₐₐ₇.

| Tc (K) | n | G (pW/K) | ΔVₚₑₑₑₚ|m | τₑₑₑₑ (μs) |
|-------|---|----------|-----------|----------|
| Before AR coating | 0.323 | 3.7 | 314 | 0.53 | 1.7 |
| After AR coating | 0.258 | 4 | 64 | 0.35 | 5.9 |

### Detection efficiency

- Pulse response measured with a 1550 nm laser source;
- Output signal recorded by a digital oscilloscope;
- τₑₑₑₑ = 1.7 μs before AR coating, increased to 5.9 μs after AR coating;
- Detection efficiency is 40%, increased by a factor of 2.

### Pulse response

\[ V(t) = V_0 \exp \left( \frac{t - t_0}{\tau_0} \right) - \exp \left( \frac{t - t_0}{\tau_1} \right) \]