Heat Capacity and Thermal Conductance Measurements of a Superconducting/Normal Mixed State by Detection of Single 3 eV Photons in a Magnetic Penetration Thermometer

T.R. Stevenson\textsuperscript{1}, M.A. Balvin\textsuperscript{2}, S.R. Bandler\textsuperscript{2}, K.L. Denis\textsuperscript{3}, S.-J. Lee\textsuperscript{2}, P.C. Nagler\textsuperscript{1,}\textsuperscript{1}, S.J. Smith\textsuperscript{4,}\textsuperscript{2}

\textsuperscript{1} Detector Systems Branch, NASA Goddard Space Flight Center, Greenbelt, MD, USA
\textsuperscript{2} X-ray Astrophysics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA
\textsuperscript{3} Department of Physics, Brown University, Providence, RI, USA
\textsuperscript{4} University of Maryland Baltimore County, Baltimore, MD, USA

\section*{MPT operation}

- A persistent current is trapped in the bias circuit above the $T_c$ of aluminum wirebonds that each sensor in its associated SQUID.
- As we cool or warm through the MoAu sensor’s superconducting transition, the inductance of the meander changes as the MoAu film expels or allows entry of flux, and we measure a current proportional to the sensor’s magnetic response.
- MPTs give us a unique avenue to probe superconducting effects in MoAu films.

\section*{C and G Measurements}

1. Using 3-eV photons from a Blu-ray diode

- An example data set at 1001 uA and 100 mK (photon number resolved)
- 405 nm (3.0 eV) photons from a Blu-ray diode outside the crystal
- Photon pulse width: 0.7 us, repetition rate: 70 Hz
- 10,000 triggered records at each $T$

\section*{Theory}

1. Free-energy difference between superconducting and normal states of MPT

- $f = \text{fraction of meander length for which MoAu enters a partly-normal intermediate state}$
- $g = \text{fractional width of normal strips in intermediate state region}$
- $C^\text{M} = \text{superconducting energy gap reduction in Ginzburg-Landau equation}$

$$dC/dT = \frac{C}{\Delta T}$$

2. Heat capacity from second derivative of free energy

- In superconducting regions, recombination of quasiparticles into Cooper pairs should be dominant cooling mechanism.
- In normal regions, quasiparticles cool by only phonon emission.
- We estimated Kaplan’s $\tau_3$ and Wellstood’s $\tau_2$ from the electronic and mechanical parameters for Mo and Au. A priori values fit all data within one order of magnitude.
- Fit results: $\tau_3 = 56 \mu s$, $2 = 1.1 \times 10^{10} W/(K m^2)$.

3. Thermal conductance: quasiparticle recombination & electron-phonon cooling

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\section*{Conclusions}

- We measured the variation in heat capacity and thermal conductance of a molybdenum-gold Magnetic Penetration Thermometer (MPT) near its field dependent Meissner transition temperature.
- We did this by two methods: detection of pulses in response to absorption of one or more 3 eV photons, and equilibrium noise measurements.
- Observed C & G show peaks in approximate agreement with a Ginzburg-Landau model of the superconducting intermediate state of an MPT.

\section*{References}