TUPPO032

Argonne NATIONAL LABORATORY

ANL Physics Division

A Simple Second Sound Detection Technique for SRF Cavities

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Historical Context

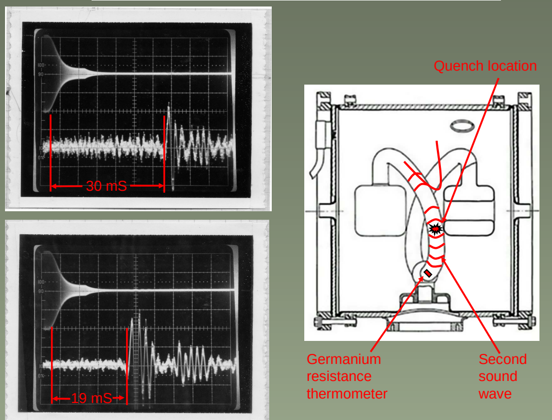

Figure 1. (Left panels) A pair of second sound measurements performed by Shepard et al. in 1977 by inserting a germanium resistance thermometer inside the helium filled loading arm of an ATLAS split-ring SC cavity (right panel) . The technique was used to locate defects leading to quench along the arm and used to assist in performing targeted repairs on the rf surface. Positional accuracy in this quasi one-dimensional system was 1-2 cm.

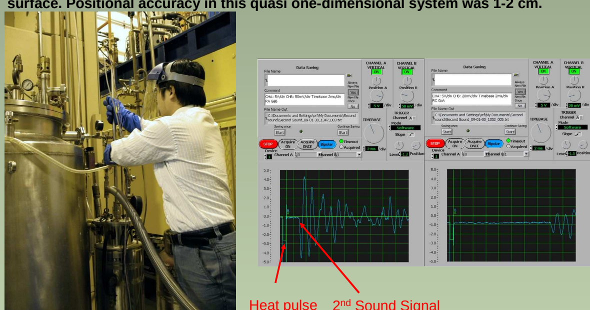

Figure 2. Test setup using 6” helium dewar and a commercial germanium resistance thermometer mounted on a moveable insert. A pair of film resistors also mounted to the insert are used to generate a simulated cavity breakdown by generating a fast heat pulse into 1.9 Kelvin liquid helium. The first heater is mounted 1.5 cm from the germanium thermometer (scope trace-left) and a second heater is mounted 8 cm from the thermometer (scope trace-right). The measured response time of the thermometer system is better than 0.5 mS, corresponding spatial resolution is 1 cm or better.

Second sound parameters	
Ge RTD resistance 300 K (LakeShore)	1.3 – 2.0 Ω
Ge RTD resistance 300 K (ANL)	18 – 54 Ω
Ge RTD resistance 4 K (LakeShore)	469 – 701 Ω
Ge RTD resistance 4 K (ANL)	6 – 28 kΩ
R_1	0 – 5 MΩ
R_2	18 kΩ
Film Resistor Model	TA205PA10R0JE
Film resistance @ 2 K	13 Ω
Cell Voltage	8 V
Pulse width	0.5 – 1 mS
Pulse height	12 - 70 V

Table 1. Primary parameters for the germanium resistance thermometers and film resistors used to perform the measurements shown in Figure 2.

ABSTRACT

A simple technique based on an in-situ moveable germanium resistance thermometer is used to measure the quench location in a superconducting (SC) cavity in superfluid liquid helium. SRF cavities are very often limited in operating field level by thermal instability manifesting as a transient "quench" of the electromagnetic field. The field energy is transferred into the superfluid helium bath as a heat pulse and may be detected as a wave of phonons at a thermometer. The germanium thermometer technique was developed at Argonne three decades ago and used to measure time-of-flight of the second-sound to locate defects in split-ring resonators for the ATLAS SC linac at Argonne. The present goal is to extend and adapt the second-sound diagnostic technique in a simple, easy-to-use and cost effective way for use with cavities under development today. These include for example, the 9-cell, 1.3 GHz SC cavities, as well as, reduced beta superconducting cavities such as half-wave and quarter-wave structures cavities. Example applications planned for the near future are discussed here.

Figure 3. Germanium resistance thermometer from LakeShore model GR-200A-500 (left) and a thermometer fabricated in house at ANL from a bare single crystal of germanium. The germanium crystal for the purchased device has been exposed by carefully removing the cylindrical copper enclosure around the crystal as supplied by the manufacturer. The device on the left was fabricated at ANL starting with a bare germanium crystal and evaporating a thin gold film onto the ends of the crystal. Thick copper leads have been attached to the gold film by Indium soldering.

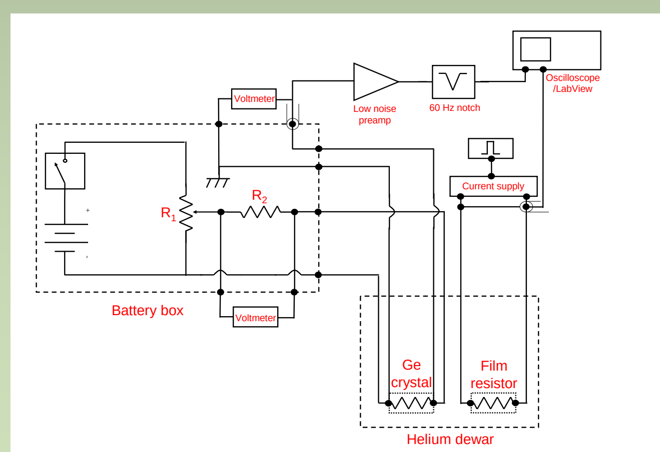

Figure 4. Basic circuit used for biasing and measuring second sound signals such as those shown in Figure 3. Also shown is the thin film resistor used to generate fast heat pulses into the 2 Kelvin helium dewar.

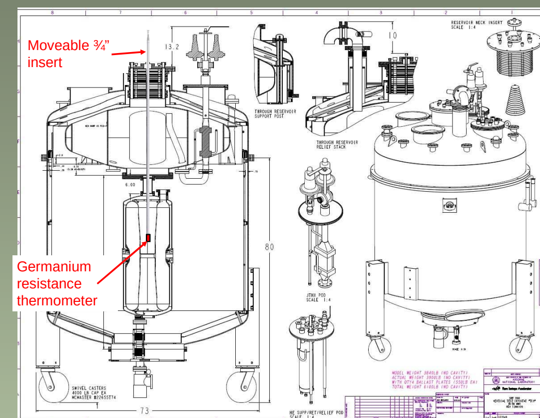

Figure 5. Halfwave cavity shown in the new ANL 2 Kelvin cavity test cryostat. Here a single Ge resistance thermometer has been attached to a long moveable insert into to liquid helium volume. Since the highest surface magnetic fields in this structure are located along the central loading element of the halfwave it is anticipated that the quench location in this cavity (presently at a field B_{peak}~80 mT) may be located using a single moveable thermometer.

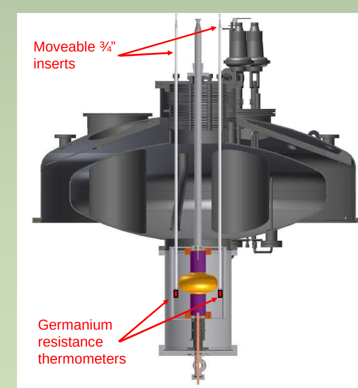

Figure 6. Single cell elliptical cavity in the 2 Kelvin test cryostat shown with multiple moveable germanium RTD's. A cavity and thermometry system in this configuration will be tested following the test described in Figure 6. above. Here, using only three RTD's, it should be possible to locate the quench location, typically somewhere along the circumference of the equator. The same system with essentially no modifications could be used to locate quench location in multi-cell elliptical cavities.