ISBN: 978-3-95450-184-7 doi:10.18429/JACoW-IPAC2018-WEPML067

SECOND SOUND QUENCH DETECTION ON SUPERCONDUCTING CAVITIES*

Zhenchao Liu†, Sha Bai, Jie Gao, Feisi He, Haiying Lin, Pei Zhang, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China

Abstract

Second sound is an effective way to detect the quench position on superconducting cavity. A second sound quench site detection system is under developing for the PAPS. High gradient is very important for super conducting cavity, however it may be limited by quench on the cavity high field region. Quench can be caused by various reasons. To locate the position is the key to reveal the mysteries of quench. Now we are developing the quench position detection system by RTD sensors such as Cernox and OST sensors.

INTRODUCTION

Second sound is an effective way to detect the quench position on superconducting cavity. It was first used to detect the quench position on the SC split-ring resonators at ANL by a germanium resistor sensor [1]. Oscillating Superleak Transducers (OST) were used to locate the quench site of the 1.3 GHz 9-cell cavity at Cornell University [2]. Later after that second sound quench site detection of SC cavity by OST was widely used on the world. Second sound detection was also used in standard dressed TESLA-Shape SRF cavity at DESY [3]. Other types of sensor were also developed to detect second sound. For example, transition edge sensors was used in second sound test [4, 5].

A second sound quench site detection system is under developing for the PAPS. We chose the highly sensitive thermometers such as germanium bare chip resistor or Cernox bare chip resistor and OST as the second sound detection sensors. Tests with SC cavity and heater in liquid helium at 2K were taken.

PRINCIPLE

The time duration between the RF quench time and the first second sound rise times the speed of second sound is the distance between quench point and detector. The quench position can be calculated by three detectors with known positions. Figure 1 shows the second sound signal transporting from the quench point to the detectors. Figure 2 shows the speed of the second sound [6].

EXPERIMENTS

There are several types of detectors can be used to detect the second sound signal. OST is a sensitive detector designed for second sound with a bias voltage. It was developed for second sound detecting. Thermometer sensors can also be used to detect second sound signal such as Cernox bare chip sensors or germanium bare chip sensors. Transition edge sensors can also be used for such detections. We have tested the Cernox bare chip sensors and germanium bare chip sensors. We are also developing the OST sensor.

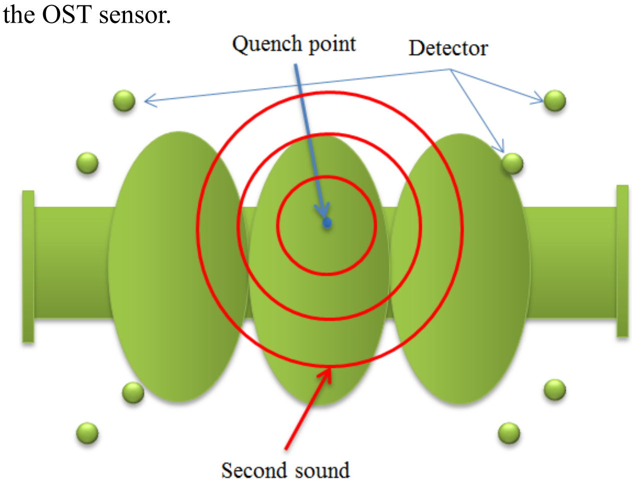

Figure 1: Principle of quench site detection by second sound.

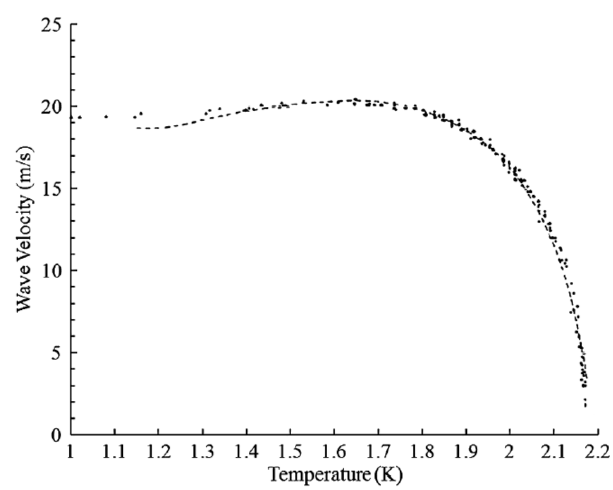

Figure 2: Velocity of second sound propagating in liquid helium.

The circuits for the RTD sensors and OST sensor is similar for testing. Figure 3 shows the circuits of the second sound detection by the RTD sensors such as Cernox and germanium resistors. Figure 4 shows the circuits of the second sound detection by the OST sensors. Both the pickup signal and second sound signal are shown on the oscilloscope. The RTD sensors connected with a DC

* Work supported by PAPS
† zcliu@ihep.ac.cn

ISBN: 978-3-95450-184-7 doi:10.18429/JACoW-IPAC2018-WEPML067

current which have a range of 10μA to 5mA. A DC voltage power source from 0 to 100V is used for the OST. We have also developed a rectangular pulse source for the film resistor which can make second sound signal. It can provide 15-50V pulse with a frequency of 0.9-31Hz and pulse length of 0.3ms-18.2ms. Figure 5 shows the rectangular pulse source.

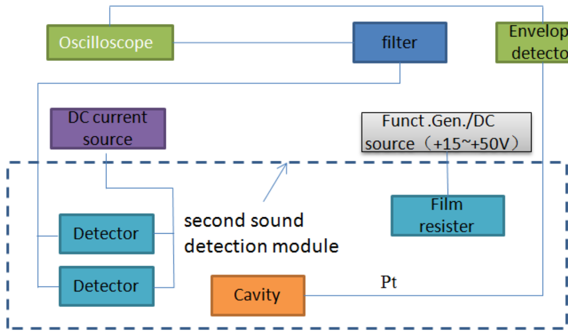

Figure 3: Circuits of second sound detection experiments in liquid helium for RTD sensors.

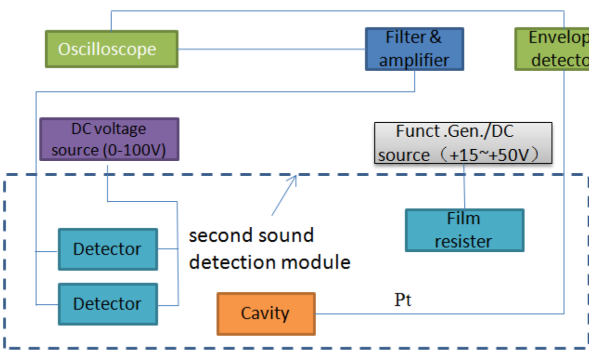

Figure 4: Circuits of second sound detection experiments in liquid helium for OST sensors.

Figure 5: The rectangular pulse voltage source for the film resistor.

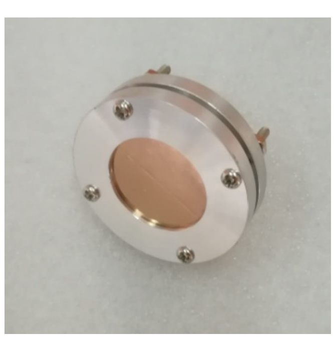

Figure 6: The OST sensor made at IHEP.

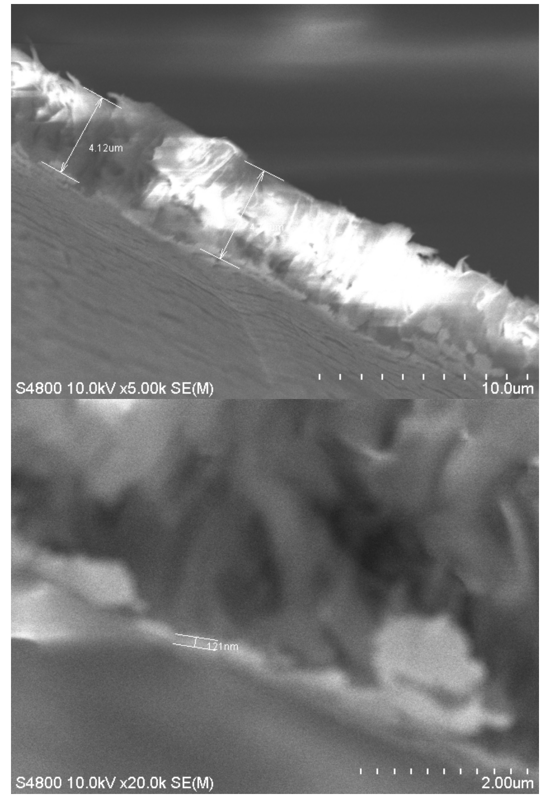

Figure 7. SEM measurements on the thin gold film on the membrane. Up: membrane is 4.12μm. Down: gold film is below 121nm.

We have fabricated an OST sensor in the lab factory (Fig. 6). The thin film sputtered with gold was checked by SEM. The membrane is 4.12μm sputtered with a less than 121nm gold film. Figure 7 shows the SEM results of the membrane.

To produce second sound signal without a superconducting (SC) cavity, a thin film heater was used as second sound source. A SC cavity was put in liquid helium dewar for quench site location. The detecting thermal resistors were connected with a current source and oscilloscope by four leads method. Signals from the resistor were displayed on the oscilloscope. There are noises from the coupler tuner motor and the RF source. Such signals are filtered by 2 KHz low pass filter and 50Hz notch filter.

Figure 8 shows the position of the second sound detector with the QWR cavity. The detector is a Cernox bare chip RTD (CX-1050-SD). It was placed close to the high magnetic field area of the QWR where quench may happen. A heating resistor was put close to the detector to produce second sound signal. In the vertical test of the QWR cavity, we have investigated the second sound signal from the QWR cavity. However, there is 50Hz electric noise with the second sound signal. In the later test, 50Hz notch filter is added and the noise is suppressed. Figure 9 shows the position of the OST sensor with the HWR cavity.

ISBN: 978-3-95450-184-7 doi:10.18429/JACoW-IPAC2018-WEPML067

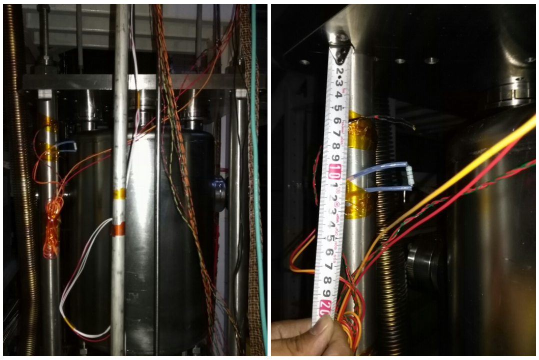

Figure 8: Position of second sound detector with QWR cavity.

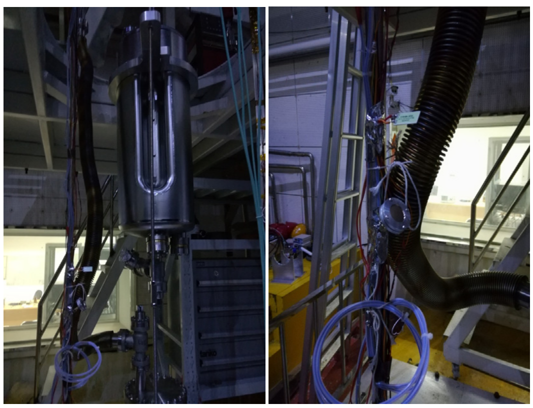

Figure 9: Position of second sound detector with HWR cavity.

We have investigated the second sound signal from a film resistor by a germanium resistor sensor (Fig. 10). Here we use a DC source for the film resistor to produce second sound signal. The DC source convert the 50Hz 220V electric to ±5V and ±12V DC source. Therefore the second sound signal has a frequency of 100Hz.

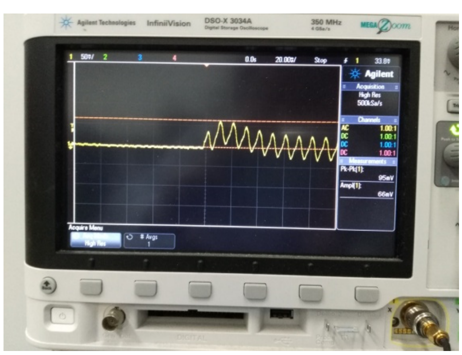

Figure 10: Second sound signal detected by germanium resistor from the film resistor.

Figure 11 shows the circuits of the second sound detection system of PAPS. There are three testing dewars for cavity vertical test and each has a second sound detection module. Each module has eight sensors placed around the SC cavity. The second sound signals from each dewar are filtered and acquired by Labview with data acquisition card. The cavity quench signal (pickup signal of the cavity, P_t) is also stored in the Labview system and has synchronous time with the second sound signal from the detectors. There is one oscilloscope connected to the detector for display.

DETECTION SYSTEM

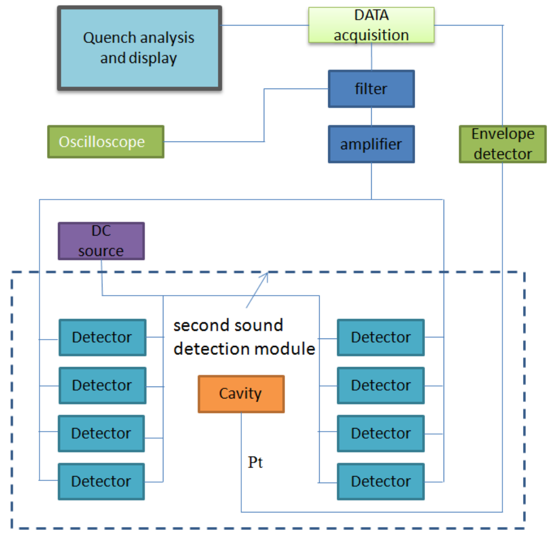

Figure 11: Circuits of second sound detection system of PAPS.

An analyzing code will be developed to calculate the quench site on the cavity. It will be used to analyze the data saved by Labview system and give the 3D coordinate of the quench point on the SC cavity.

CONCLUSION

Second sound quench site location system is an economic high efficiency quench detection method for massive SC cavity inspection. We have tested two types of RTD sensors for the second sound detection and fabricated one OST sensor. A second sound detection system and analysis code will be built for the PAPS.

REFERENCES

[1] K.W. Shepard *et al.*, "Split Ring Resonator for the Argonne Superconducting Heavy Ion Booster," IEEE Trans. Nuc. Sci., NS-24, Pg. 1147 June 1977.

[2] Z.A. Conway *et al.*, "Oscillating Superleak Transducers for Quench Detection in Superconducting ILC Cavities Cooled with He-II," LINAC 2008, Victoria, British Columbia, Canada, September 2008, THP036.

[3] Y. Tamashevich, E. Elsen and A. Navitski, "Second Sound Quench Detection of Dressed TESLA-Shape SRF Cavities," in Proceedings of SRF2015, Whistler, BC, Canada, TUPB079.

[4] H. Furci, *et al.*, "Recent developments in thermal mapping for SRF," CERN SRF Workshop, December 2016.

[5] A. Lunt, *et al.*, "Towards robust design of thin film transition edge sensors for use in the next-generation superconducting radio frequency cavities," Materials and Design 122 (2017) 403–404.

[6] J. R. Pellam, Phys. Rev. 75, 1183 (1949).