Measurement of Transmission Losses of Superconducting Coplanar Waveguide and Microstrip Lines with On-chip Resonators at 2 mm Wavelength

Wenlei Shan*[1], and Shohei Ezaki[1]

***Abstract*—Transmission losses of superconducting coplanar waveguide and microstrip lines are measured for the purpose of noise breakdown of MMIC SIS mixers operating at 2 mm wavelength. The measurement is done by measuring the resonance curves of on-chip resonators, with SIS junctions as direct detectors and planar OMT as power divider, which enables a calibration reference.**

Keywords—SIS mixer, superconducting transmission line, loss, MMIC

I. Introduction

We have been developing an innovative approach to enable compact focal plane heterodyne detector arrays with SIS mixers for wide field-of-view astronomical observation at mm and sub-mm wavelengths [1]-[3]. The new scheme is characterized by the adoption of superconducting monolithic microwave integrated circuits (MMICs), in which coplanar waveguide (CPW) and microstrip (MS) lines are adopted for guiding signals and LOs. The sensitivity of the SIS mixers is highly dependent on the transmission loss of these transmission lines, which remains not fully understood owing to the prohibitive difficulties in the measurement. We used a new method to measure the transmission loss by making use of our dual-polarization MMIC chips. In one of the polarization routes, half-wavelength resonators are coupled to the signal path, while the other polarization route is used as a calibration channel. By using a sweeping CW source and SIS junctions as direct detectors, the resonance curves of the resonators can be recorded. Finally, the transmission loss is retrieved from the Q-factor of these on-chip resonators. In this presentation, the results about this experiment will be presented.

II. Results

The intrinsic Q factors of CPW resonators and MS resonators were measured to be about 300 and 150 respectively at 4 K. According to these results, the transmission loss of superconducting thin film transmission lines, although not negligible, is not yet a limiting factor for the application of MMIC technology at mm wavelengths. In addition to our specific application, this measurement method can be applied to a wider range of applications for transmission loss investigation.

[1]National Astronomical Observatory of Japan, Tokyo, 181-8588, Japan

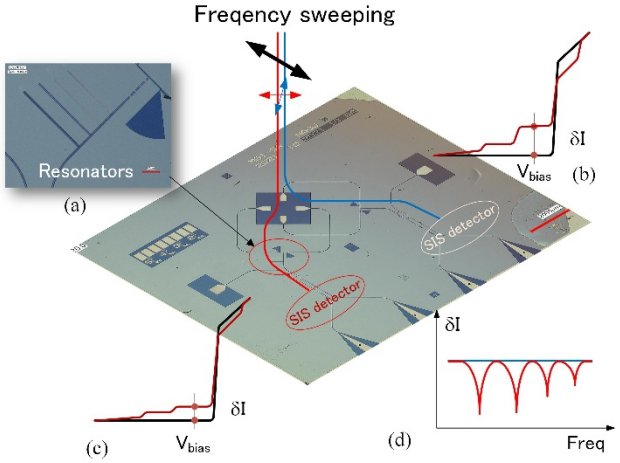

Fig. 1. The meaurement scheme. The central figure shows a dual polarization, balanced SIS MMIC mixer chip. The incident signal is polarized 45 degree with respect to the polarization directions of the planar OMT, so that each of the polarizatin channels received half of the incident power. In one of the two polarization channels, half-wavelength CPW and microstrip resonators are coupled to the signal path as shown in (a), while the other polarization channel is used as reference. The SIS junctions terminated in each polarization channel are used as direct detectors to measure the delivered signal by measuring the photon-asisted current δI as illustrated in (b) and (c). By sweeping the frequency of the signal source, which is composed of a signal generator followed by an amplifer and an x9 multiplexer, the resoance curves of the resonators can be measured after calibration for the freqeuncy dependence of the signal source by using the detection from the reference channel.

References

[1] Wenlei Shan, Shohei Ezaki, et al., "A Compact Superconducting Heterodyne Focal-Plane Array Implemented with HPI (Hybrid Planar Integration) Scheme," IEEE Transactions on Terahertz Science and Technology, vol. 10, no. 6, pp. 677-689, Nov. 2020.

[2] Wenlei Shan, Shohei Ezaki, et al., "Experimental Study of a Planar-Integrated Dual-Polarization Balanced SIS Mixer," IEEE Transactions on Terahertz Science and Technology, vol. 9, no. 6, pp. 549-556, Nov. 2019.

[3] Wenlei Shan, Shohei Ezaki, et al., "A New Concept for Quasi-Planar Integration of Superconductor-Insulator-Superconductor Array Receiver Front Ends," IEEE Trans. on Terahertz Sci. and Tech., vol. 8, no. 4, 472-474, Jul. 2018.

NOTES: