A 100 GHz BAND PLANAR TYPE SIS MIXER

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ABSTRACT

A planar type SIS (Superconductor-Insulator-Superconductor) mixer at 100 GHz band has been developed. From the viewpoint of both mechanical stability and reproductivity, a planar type mixer has advantages compared with waveguide type mixers. Experimental results show a minimum receiver noise temperature of 90 K (DSB) in the 100 GHz band.

INTRODUCTION

In recent years, the spectroscopy of the atmosphere from satellites in millimeter-wave and sub-millimeter-wave bands has been proposed. In the system for this spectroscopy, ultra low noise characteristics are required for the receiver. In order to obtain low noise characteristics, HEMT amplifiers are usually used up to 100 GHz, and SIS mixers are usually used above 100 GHz. Several SIS mixers were developed [1]-[4], and most of them were of waveguide type. For waveguide SIS mixer, great efforts are also required to sustain against mechanical and thermal shocks to achieve space qualifications. This paper describes a planar type SIS mixer consisting of microwave integrated circuit elements. This mixer has advantages compared with waveguide type mixers as follows: (1) mechanical stability, (2) manufacturing precision, and (3) reproductivity. Experimental results of the fabricated SIS mixer at 100 GHz are presented.

2. CIRCUITS CONFIGURATION AND FABRICATION

Fig.1 and Fig.2 show the block diagram and the configuration of the mixer, respectively. RF and LO signals are supplied to the mixer through the space in order to isolate heat conduction from the outer circuits. These two signals are received by separate horn antennas, and then supplied to the mixer chip through waveguide-microstrip transitions individually. In order to supply DC bias to the SIS junction, a bias tee is connected to the IF output port of the mixer. The mixer chip consists of a 100 μ m thick sapphire substrate (R-cuts), and the metal of both strip and ground conductors is Nb. The other chips consist of alumina substrates, and the metal is Au. Both chips are fixed on Cu-W carrier plates. The mixer is mounted on a 4K stage, and an IF amplifier connected to the IF output port of the mixer is cooled down at 12K.

Fig.3 shows the configuration of the mixer chip. The chip size is 2 mm x 3 mm. This chip contains (1) a directional coupler which combines RF and LO signals, (2) matching circuits [5], (3) 8 SIS (Nb/Al-AlOx/Nb) junctions with normal resistance of 100 ohm, and (4) a band rejection filter (BRF) which rejects the RF and LO signals, and transmits the IF signal. The size of the unit

SIS junction is 1.5 μm x 1.5 μm. Fig.4 shows SEM photograph of the SIS junctions.

3. EXPERIMENTAL RESULTS

Fig.5 shows the unpumped and LO pumped I-V characteristics of the 8 SIS junctions . At the potential of the 2nd and 3rd photon assisted steps, hysteresis caused by negative resistance is observed.

The total receiver noise temperature is determined by Y-factor method using hot (295 K) and cold (77 K) load. The reference plane for these measurements is the input of the horn antenna. Fig.6 shows the measured receiver noise temperature in DSB. Bias voltage is fixed at the potential of the 2nd photon assisted step. LO frequency is 100 GHz. Minimum noise temperature of 90 K is obtained at 6.3 GHz IF frequency.

4. CONCLUSION

A planar type SIS mixer at 100 GHz band has been developed. The mixer has advantages compared with waveguide type mixers. Experimental results show the minimum receiver noise temperature of 90 K (DSB) at 100 GHz band. By combining two mixers of this type, single-side-band SIS mixer will be obtained in the near feature.

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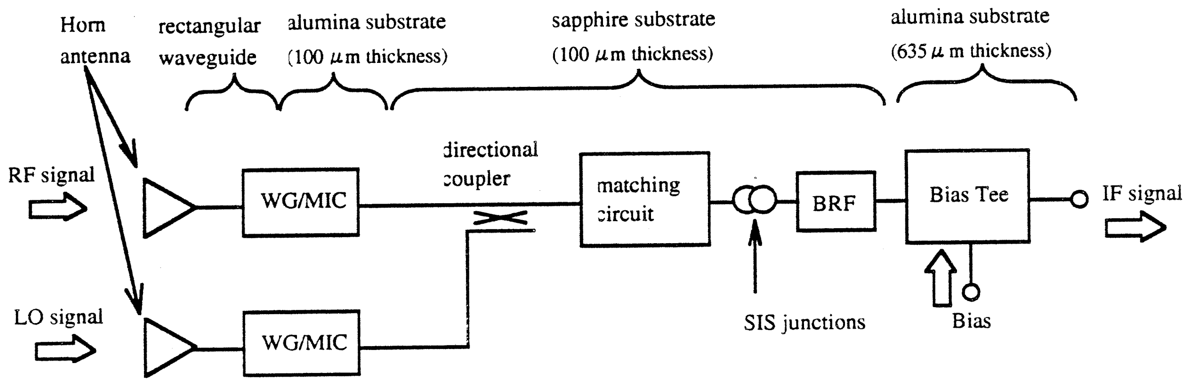

Fig.1 Block diagram of the mixer.

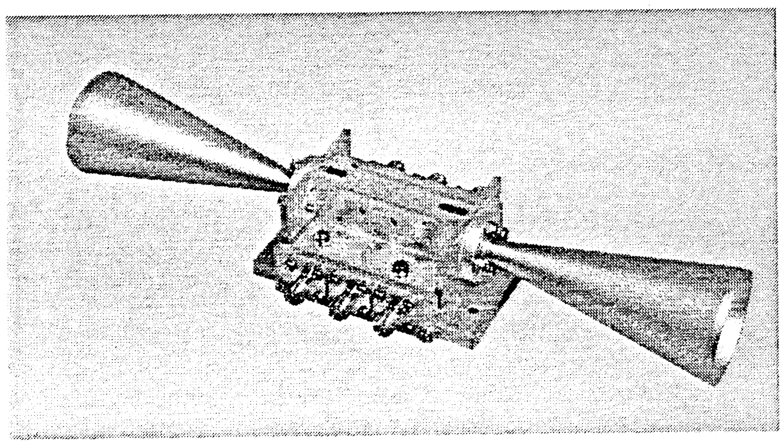

Fig.2 Configuration of the mixer.

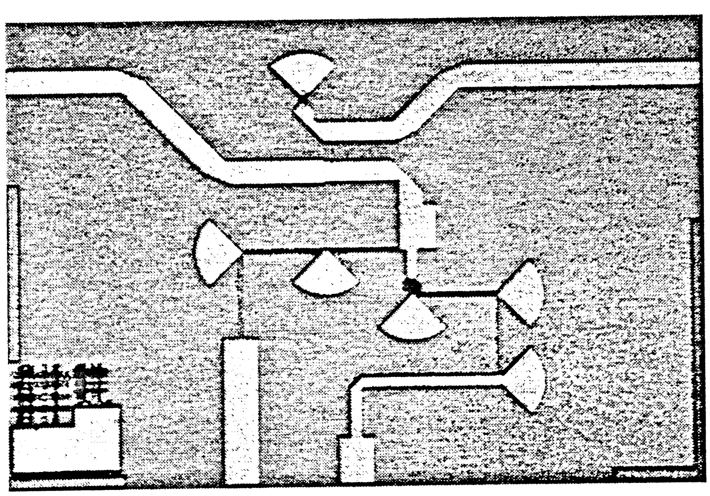

Fig.3 Configuration of the mixer chip.

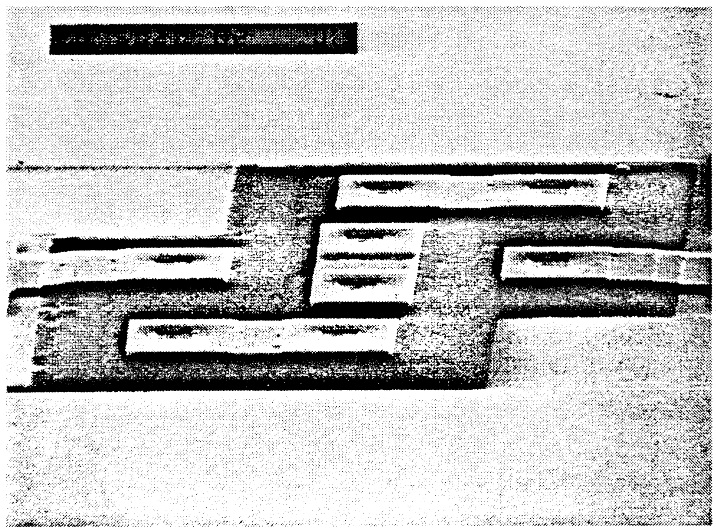

Fig.4 SEM photograph of the SIS junctions.

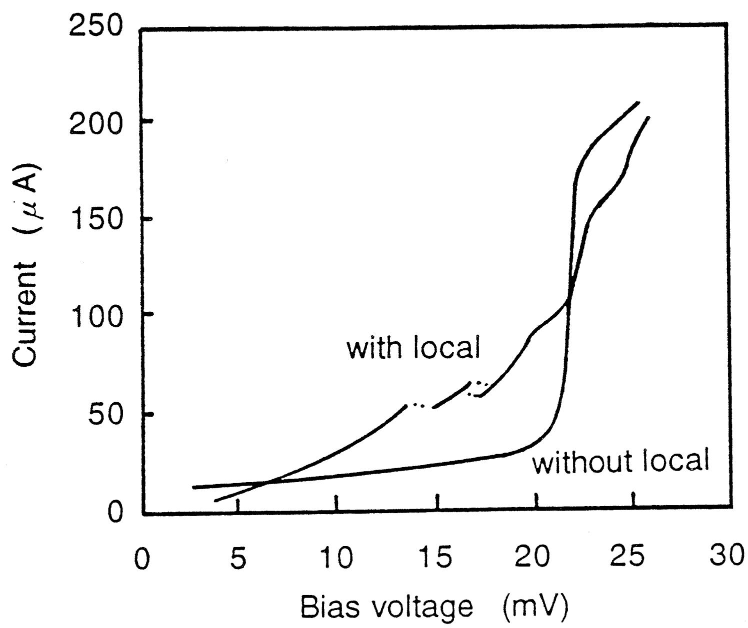

Fig.5 I-V characteristics of the 8 SIS junctions.

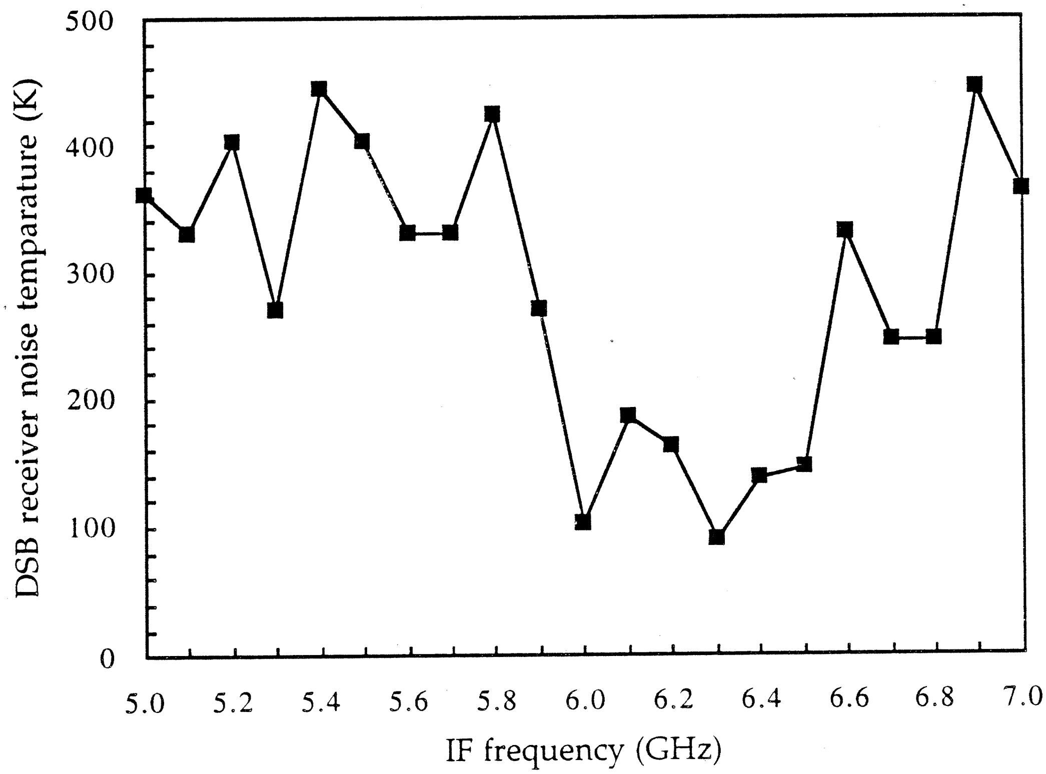

Fig.6 Noise performance of the receiver.