Experimental Study of a Monolithic Planar-integrated Dual Polarization Balanced SIS Mixer

Wenlei Shan[1], Shohei Ezaki[1], Akihira Miyachi[1], Takafumi Kojima[1], and Yoshinori Uzawa[1]

Coherent radio astronomical observation delivers precise chemical and kinematic information of celestial objects, which incoherent observation does not convey. However, the complexity of coherent receiver frontends imposes a limit to the number of pixels arrayed in the focal plane of a radio telescope and results in a narrow field of view, which is usually much less than the available field of view constrained by the radio telescope optics.

We have been developing compact focal plane heterodyne detector arrays with SIS mixers for wide field-of-view astronomical observation. Then central idea to achieve improved compactness is the integration of multiple pixels in a monolithic silicon chip. We have constructed the conceptual technical solution to implement this idea in our previous works and carried out proof-of-concept study to proof the feasibility with a prototype receiver [1-3]. Although important experimental evidences were obtained, which strongly support the feasibility of the concept, a complete experimental investigation had not been available.

The prototype single-pixel SIS mixer chip has most of the key features of the concept. The mixer is designed to operate at ALMA Band 4 frequencies. The mixer chips are fabricated from silicon-on-insulator (SOI) wafers, which are locally thinned to 6 μm thick membranes on which probes lie to couple the LO and the signal from the waveguides (see the insets in Fig. 1). An orthogonally placed polarization-sensitive probe is adopted for signal coupling with polarization separation. For each polarization a balanced mixing configuration is adopted, which is a representative of various complex circuitries that can be potentially integrated.

In this presentation we will report a complete experimental study of the prototype receiver in the full frequency band. According to the measurement results, the cross-polarization is lower than -20 dB for any frequency in the band. The major reason for the cross talk between the two polarizations will be discussed. The noise rejection ratio is better than 15 dB as shown in Fig. 1. This relatively high noise rejection ratio is believed to be an advantage of good balance of the circuit achieved by photolithography technique. With the balanced mixer we measured the LO noise, which is difficult to be measured with other means. The receiver noise is found to be lower than 40 K in the frequency band and does not noticeably depend on the frequency.

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

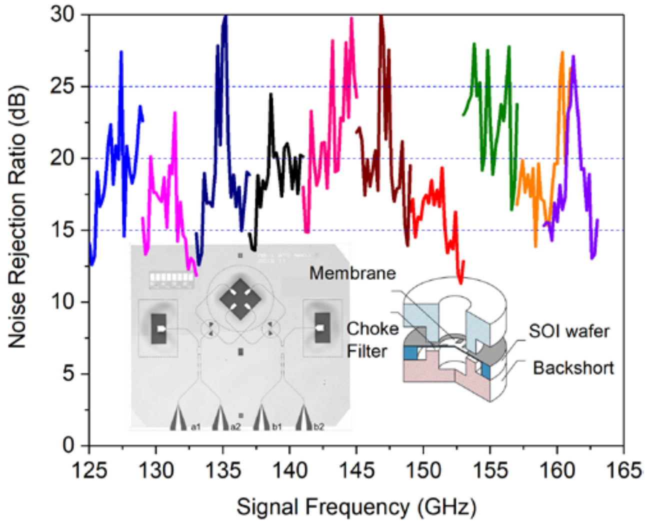

Fig. 1. The noise rejection ratio of the balanced SIS mixer as a function of the signal frequency. The insets show the image of the front side of the mixer chip and a schematic drawing of the membrane waveguide probe as well as the mounting method.

References

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