Side-band-separating heterodyne mixer for band 9 of ALMA.

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Abstract— **In this paper we will present the realization of a side-band-separating (2SB) heterodyne mixer for the frequency range from 602 to 720 GHz. This frequency range corresponds to band 9 band of ALMA. The mixer, in brief, consists of a quadrature hybrid, two LO injectors, two SIS junctions, and three dumping loads. All the parts were modeled and optimized prior construction. The fabricated SSB mixer exploits waveguide technology and has been constructed in the split-block technique. We used state-of-the-art CNC micromachining which permitted to obtain details as small as $\sim$ 70 μm with tolerances of $\sim$ 2 μm. Finally, we will present the performance of the SIS junctions that will be used in the 2SB mixer.**

I. Introduction

Of the receiver bands that are currently being constructed for the Atacama Large Millimeter Array (ALMA), only band 9, operating at the highest frequencies (602-720 GHz) uses double side-band mixers. Despite of the well known advantages of a side-band-separating (2SB) mixer, it has not been implemented in band 9 as the involved dimensions are prohibitory small. However, the current state-of-the-art micromachinning technology has proved that the complicated structures necessary for this development are attainable [1], [2]. We have already reported a complete design of a 2SB mixer for band 9 together with a full simulation of the RF components [1]. The purpose of this article is to present the physical realization of such mixer including the corresponding IF circuit. We also present the testing results of the SIS junctions that will be used in the mixer. The results show a good homogeneity which are desirable for a good performance of the complete mixer.

II. 2SB mixer block

Recently, we proposed a design for the 2SB mixer for ALMA band 9 which is reproduced in Fig. 1a.[1] The idea behind the design is to have a compact unit which will contain all the main components: defluxing magnets, DC biasing board, and the IF circuit filtering. The realization of such block is presented in Fig. 1b. It was obtained via state-of-the-art CNC micromachining. In Fig 2 we show a detailed view of the core of the mixer consisting of a quadrature hybrid, two LO injectors, two SIS junctions, and three dumping loads. The quality of the finishing is excellent and meets the required tolerances.[2]

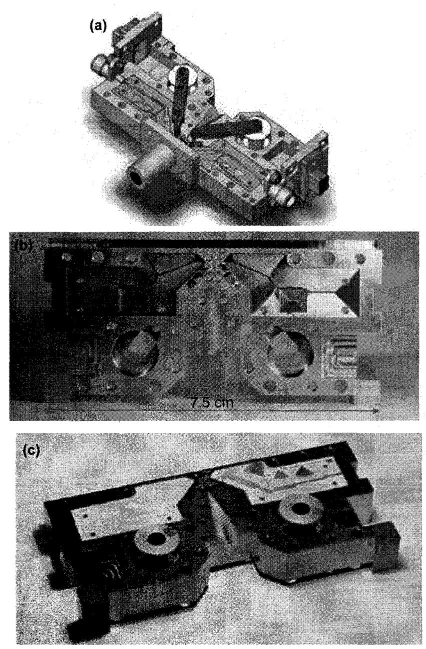

Fig. 1. (a) Proposed design of a 2SB mixer for ALMA band 9. (b) Micromachinning realization of the mixer. (c) Mixer with the IF circuit board and magnets.

III. IF circuit

For the 4 to 8 GHz IF circuit we have opted for the use of parallel coupled suspended microstrip lines. This is a compact unit containing the IF match, DC-break, bias tee, and EMI filter. The advantage of such planar structure has already been demonstrated and selected to be used in various astronomical instruments (see, for example, Ref. [3]). The already mounted circuit can be seen in Fig. 1. It has to be noted that, for this

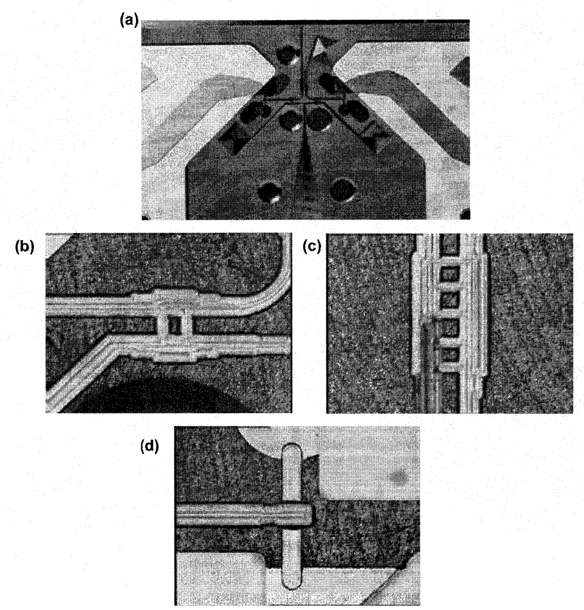

Fig. 2. (a) Detailed view of the RF components of the mixer. (b) LO injector. (c) RF quadrature hybrid. (d) Room for the mixers.

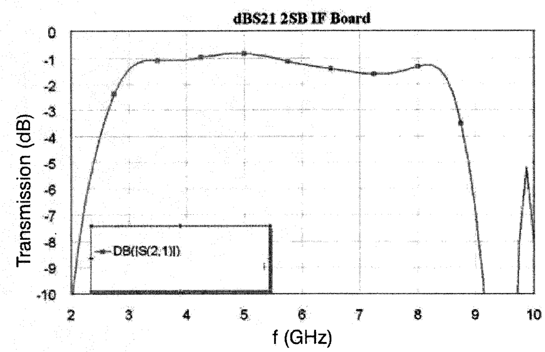

Fig. 3. Simulated transmission of the IF circuit.

filter to work, the ground plane directly underneath the filter has to be removed. Previous to fabrication, the dimensions were optimized for a good performance in the 4 to 8 GHz frequency range. As an example of this results, in Fig. 3, we show the transmission of this IF circuit.

IV. JUNCTIONS

For the SIS junctions we selected the design that contains both RF and IF matching. The exact layout is similar to the one presented by Risacher et al. [4] and is shown in Fig. 4. The chosen design was simulated [5] and its dimensions optimized for a maximum transmission and minimum reflection between ports 1 and 2 (see Fig. 4). We compared both a hammer type and a rectangular choke structure. The best reflection and transmission for both configurations are shown in Fig. 4. Given these results, a rectangular choke structure was fabricated.

The SIS devices were fabricated on a quartz substrate. First, a Nb monitor layer is deposited, after which an optically defined ground plane pattern of Nb/Al/AlOx/Nb is lifted off. Junctions are defined by e-beam lithography in a negative e-beam resist layer and etched out with a SF6/O2 reactive ion etch (RIE) using AlOx as a stopping layer. The junction resist pattern is subsequently used as a lift off mask for a dielectric layer of SiO2. A Nb/Au top layer is deposited and Au is etched with a wet etch in a KI/I2 solution using an optically defined mask. Finally, using an e-beam defined top wire mask pattern, the layer of Nb is etched with a SF6/O2 RIE, finishing the

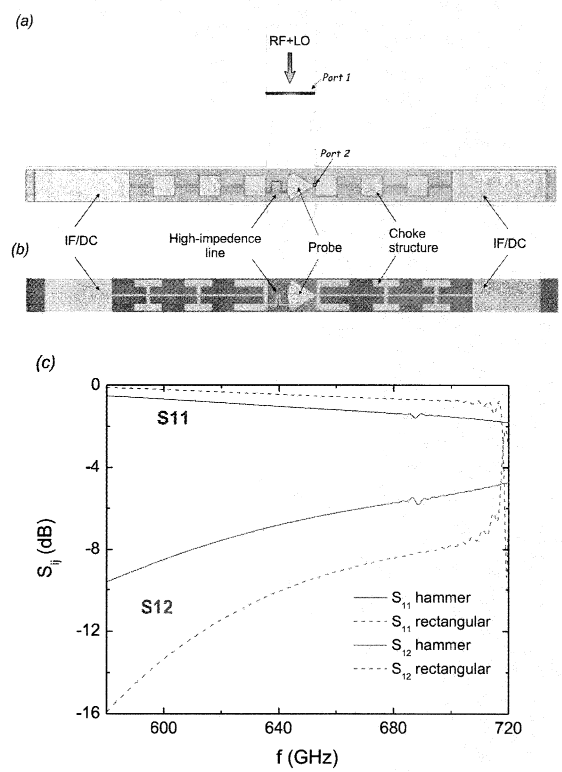

Fig. 4. *(a)* SIS design with a rectangular choke structure. The figure also shows the cavity were the junction will be placed. *(b)* SIS design with a hammer type choke. *(c)* Results of the simulations for the two types of choke structures.

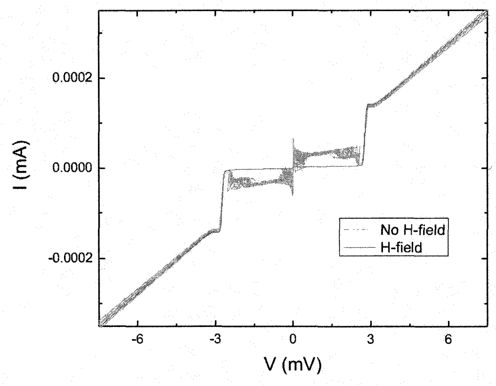

Fig. 5. IV curves of 12 different junctions intended to be used in the 2SB mixer. Notice the good repeatability necessary for a good performance of the mixer.

fabrication process. After dicing and polishing, we measured the resistance of the individual devices as indicated in Fig. 5. The results show that the chosen fabrication procedure results in a good reproducibility of the devices. This is a key element for the future performance of the mixer.

V. Conclusions

In this article we have presented the current status of the development of a side band separating mixer for ALMA band 9. Currently, all of the components have been simulated, fabricated and tested individually. The assembling is a going on task that will be completed in the next months.

Acknowledgement

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