A 1.37 THz Waveguide-based 2 X 2 Beam Divider Fabricated by Two Microfabrication Technologies

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To improve the mapping speed, multi-pixel radio astronomy receivers are favored [1]. Observation speed will be increased by a factor of the pixel number of the receiver. Therefore, high science throughput can be produced.

Currently, there are only few heterodyne array receivers at THz. One of the challenges is the distribution of the local oscillator (LO) beam to all pixels. Often phase gratings are used to split a single LO beam into multiple beams. Here we propose a waveguide-based beam divider. In order to evaluate the performance of waveguide splitters, we use a single LO generated by a VDI Amplifier / Multiplier Chain. The LO beam is captured by a horn, transferred to waveguide and T-junctions split the signal first in two signals and then in four signals. These signals exit through circular horns into free space and are then overlayed onto the astronomical signal using a beam splitter [2]. The two signals are subsequently focused by lenses onto HEB mixers. We designed a waveguide splitter for 1.37 THz. The cross-sectional size of the WR0.65 waveguide is only 164 μm X 82 μm and is challenging to fabricate.

The beam divider contains two parts: feeding network and circular horn array [2]. The feeding network consists of one E-plane junction and two H-plane junctions. The feeding network has been fabricated using two technologies: a new technology, named Femtosecond laser assisted wet etching or 3D-laser microfabrication technology [3], and silicon etching using an inductively coupled plasma-deep reactive ion etching (ICP-DRIE) [4]. The 3D-laser microfabrication can fabricate highly accurate 3D -geometries based on fused silica by direct f-s laser writing and wet etching. The SEM pictures of the fabricated feeding networks by the two technologies are shown in Fig. 1. The total thickness of the feeding network is 400 μm, and the designed waveguide channel depth is 82 μm. A comparison of both 3D-laser and ICP-DRIE microfabrication is summarized in Table I. The feeding network fabricated by 3D-laser was plated with a 1.9-μm thick gold layer. The 3D-laser is easier to fabricate, but the bottom layer is rougher. On the other hand, the side wall of the feeding network manufactured by the ICP-DRIE is rougher. The estimated simulated waveguide insertion losses of the two types waveguide are 0.35 dB/mm and 0.31 dB/mm, as shown in the Table I. The length and the inner aperture diameter of the circular horn is 5 mm and 1.7 mm, respectively. The circular horn array is the only part fabricated by conventional mechanical machining. The 14.36-mm length waveguide in the feeding network contributes an additional insertion loss of 4.5-5 dB for each LO beam, according to the simulation. The first beam divider for demonstration has been assembled and will be characterized soon.

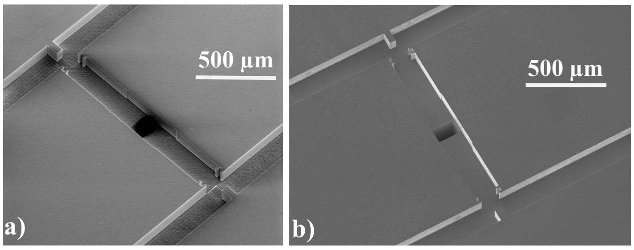

Fig. 1 SEM pictures of the T-junction details, (a) 3D-laser (b) ICP-DRIE

Table I. Comparison of the two manufacturing technologies investigated.

Technology	3D-laser	ICP-DRIE
Material	Fused silica	Silicon
Side angle	90°	~89°
Number of mask	Not needed	2
Mask misalignment	The issue does not exist	<2 μm
Bottom surface roughness	Rq ~367 nm*	Rq ~28 nm
Channel depth	84~88 μm	82~83 μm
Estimated waveguide insertion loss	0.35 dB/mm	0.31 dB/mm

*The value is measured after gold deposition.

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