Sub-mm Wave Schottky Mixer Pumped with 170µW Optically Generated Local Oscillator Power

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***Abstract*—This paper presents a sub harmonic mixer at 270-320GHz, utilizing Low Barrier Schottky Diodes (LBSD). The novelty of this work is the use of a local oscillator (LO) power signal generated by an optical heterodyning system to pump the low barrier high-performance mixer. The Low Barrier Schottky Diodes (LBSD) used in this design can be pumped with a 170 µW LO signal over the band 135-160GHz.**

Keywords*— *Sub-Harmonic Mixer, Low Barrier Schottky Diodes, UTC-PD.

I. Introduction

The demand in commercial application such radar, communication, spectroscopy, and imaging of a high-power, compact and low power consumption THz devices is increasing day after day. The lack of available commercial power amplifiers in THz range makes necessary to implement a solution to lower down the high radio frequency (RF) signal to be easily amplified and handled. Mixers are a crucial component for such a purpose, being their main role to convert the high frequency received RF signal to an intermediate frequency (IF) signal. The amplitude of the IF signal is linearly related to the RF signal while featuring a much lower frequency. Due to the development of this technology, the frequency and bandwidth of many applications is increasing, leading to the research of a high-performance broadband mixers [1]. In this paper, the design, simulation, and characterization of a low barrier and high-performance Schottky Diode Mixer is presented, performing the measurements with an optical setup.

The state-of-the-art Sub Harmonic Mixers (SHMs) at 300GHz can achieve Conversion Loss between 6.5 and 10 dB using 2-4 mW of LO power featuring LO bandwidths between 20-60GHz [2-4].

The novelty of this research is the use of optical lasers and Uni-Traveling Carrie Photo Diode (UTC-PDs) optoelectronic device to create both the LO and RF signals used for the LBSD mixer. The aim of using optical pumping is the relative low phase noise they introduce and the simplification of the LO source. Usually, the electrically generated LO is up-converted, i.e., the phase noise is increased by 20*log(N) dBc/Hz, being N the multiplication factor [5]. The optically generated LO is down-converted, i.e., the phase noise does not increase, thus, the total noise of the system decreases considerably.

The results of joining the electrical mixer with an optical RF and LO signals will be explained and shown in the next sections.

II. 270-320 GHz Low Barrier Mixer

The low barrier high-performance mixer presented in this paper has been fully designed and fabricated in ACST GmbH. Figure 1 shows the mechanical block of the Mixer and the anti-parallel diodes used on it; the mixer architecture is like the one shown in [4].

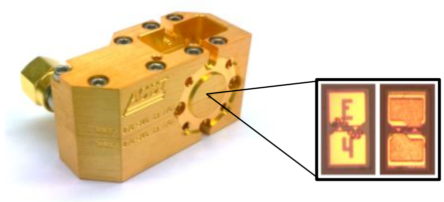

Fig. 1. 270-320 GHz Sub-Harmonic Low Barrier Mixer

The Mixer's features are described in Table 1:

TABLE I. Main Features of the 270-320 GHz SHM

	Min.	*Typ.*	*Max.*
LO Frequency (GHz)	135		160
LO Power (dBm)	-8	-7.5	-3
RF Frequency (GHz)	270		320
Input RF Power (dBm)			-17
IF Frequency (GHz)	0		18
DSB Conv. Loss (dB)	15	16	18

As Table 1 describes, the typical LO power requirement for the presented mixer is -7.5 dBm, which in comparison with the state-of-the-art achieved with GaAs SBDs it needs 10 dB less LO power. The typical DSB Conversion Loss in this LBSD is expected to be higher than in GaAs based Schottky mixers. The diode manufacture for the presented

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mixer wasn't as precise enough and the electrical properties were deviated from the expected values. The improvement in the diode properties fabrication can improve this mixer Conversion Loss (CL) in 4-5 dB. However, the performance of the presented mixer is still good enough for a wide range of applications. Although the Conversion Loss is higher, the optical pumping reduces the phase noise of the system, compensating those extra losses induced by the LBSD.

III. Measurement Setup

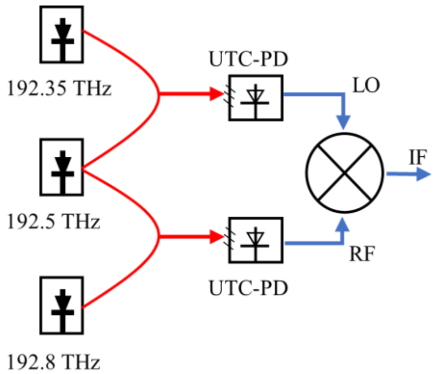

Fig. 2. Schematic of the measurement setup

The setup consists in three lasers, two are used as optical signal sources and the third one as a tuneable source. A commercial UTC-PD is used as RF source and a PD designed and fabricated in University Duisburg Essen (UDE) is used as LO source to pump the mixer. The optical signals generated by the lasers are coupled in pairs into 2 single optic fibers and amplified by 2 different Erbium-Doped Fiber Amplifiers (EDFAs).

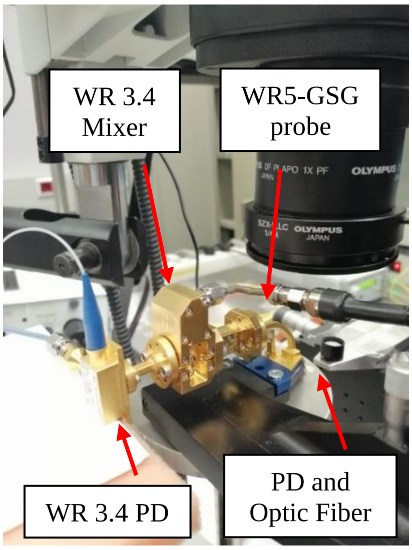

Fig. 3. Mixer connected to the commercial WR3.4 UTC-PD. Also connected to the PD through a WR5 probe and WR5-to-WR6 transition.

After that, the RF and LO signals are coupled-out from the UTC-PD output and the PD to the WR3.4-mixer by means of WR3.4-flange and G-S-G WR5-probe and WR5-to-WR6 adapter, respectively. The IF output of the mixer is then connected to an Electrical Spectrum Analyzer to show the IF power.

IV. Results

Experimental results of the DSB Conversion Loss at room temperature are shown in Fig. 4. The measured values are from 18.2-25dB averaging 21dB.

Expected CL are 16dB, these dB difference could mainly be due to the lack of power delivered by the UTC-PDs. The graph below doesn't show any ripples or drops, illustrating the flat behaviour of the mixer. No mismatches are induced by the PDs.

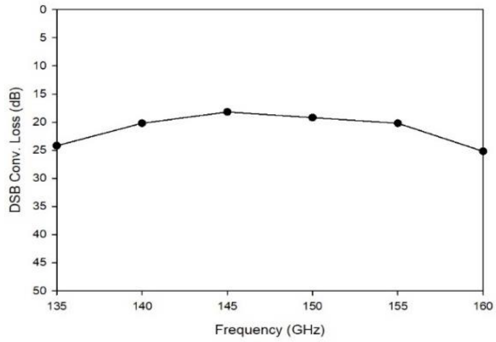

Fig. 4. DSB Conversion Loss using optical pumping

V. Conclusions and Future work

A Low Barrier SHM has been demonstrated with only 170 µW LO power requirements and up to 16 dB DSB Conversion Loss using UTC-PD optical pumping. Improved manufacture LBSD are planned to improve the Mixer CL in 4-5 dB.

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