Low noise, wide band MgB_2 hot electron bolometer mixer at 5.3 THz and 20 K

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***Abstract*—We present a low noise and wide band superconducting MgB2 hot electron bolometer (HEB) mixer characterized at 5.3 THz and 20 K, where a DSB receiver noise temperature of 2920 K is obtained and an IF bandwidth is 9.5 GHz. The frequency of 5.3 THz represents the highest frequency, where an MgB2 HEB mixer has ever been characterized at so far, providing an insight to their applicability for probing important higher frequency molecular/atomic emission lines. The operating temperature of 20 K enables an HEB mixer to operate in compact, low power consumption coolers, which can significantly reduce the cost and complexity of any relevant instruments specially in the case of space, where tight supply conditions and limitations apply.**

***Keywords*— MgB2, HEB mixer, 20 K cooler**

I. Introduction

Superconducting HEB mixers have been the most applicable heterodyne detectors for frequencies above 1 THz. Thanks to their superior sensitivity they have been used for very high spectral resolution spectroscopy in different THz observatories, including space born. Great sensitivities are acquired based on the optimal properties of the employed superconducting material i.e. NbN, although it by nature can only provide a limited intermediate frequency (IF) bandwidth (~3.5 GHz) and requires an operating temperature around 4 K, which are both influential parameters to determination of the instrument science targets, the complexity, and the cost etc. Therefore, any considerable improvement of these two figures of merit requires the change of the superconducting material.

MgB_2 has been under study [1-3] as a suitable candidate mainly for enhancing the IF bandwidth of HEBs significantly to above 13 GHz, which is a good compromise for their reduced sensitivity comparing to NbN HEBs. However, so far no published results of their performance above 2 THz can be found in literature although some data exist in other labs, such as Chalmers University and NASA JPL . Here we report the first experimental study of an MgB_2 HEB mixer [4] at 5.3 THz, when it is operated at 20 K as a projected temperature for compact space born cryo coolers.

II. Measurement Setup and Results

We focus on an HEB with dimensions of 285 x 850 nm^2 and a T_c of 38.4 K, fabricated at TU Delft. It is based on a 7 nm thick MgB_2 film on SiC substrate, developed at Chalmers University. An elliptical silicon lens was used to focus the radiation to a spiral antenna coupled HEB, which was mounted on a mixer block with an integrated heater and temperature sensor. An FIR gas laser was used to provide a 5.25 THz local oscillator. The intermediate coupling optics were set up in vacuum to minimize THz absorption in air.

A DSB receiver noise temperature (T_{rec}^{DSB}) of 3960 K was measured at 20 K operating temperature, which could be reduced to 2920 K with an optimally coated silicon lens and a thinner beam splitter. This value is about 2.5 times T_{rec}^{DSB} of a NbN HEB operated at 4 K in our lab. Fig. 1 shows a relatively weak increase of noise by 12 % when temperature rises from 6.5 to 20 K.

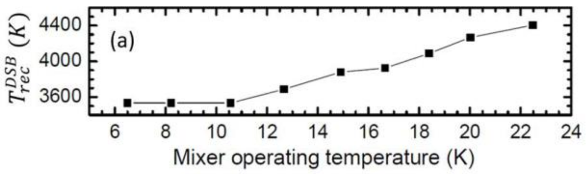

Fig. 1. Receiver noise temperature versus operating temperature

An IF bandwidth of 9.5 GHz was measured at 20 K, which is around 3 times wider than what NbN HEBs normally provide.

We also observed an interesting change in the current voltage (IV) curves of this device when it was pumped at 1.6 and 5.3 THz, which can be attributed to the existence of two superconducting gaps uniquely in MgB_2.

References

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