Development of a Terahertz HEB Mixer-Amplifier with SiGe HBTs

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Abstract— **We report on the development of a terahertz hot electron bolometer (HEB) mixer-amplifier module with an intermediate frequency (IF) band from 0.5-5 GHz.**

I. Introduction

We are developing highly-sensitive heterodyne receivers for frequencies above 1 THz. In terms of noise performance and radio frequency (RF) bandwidth, an HEB mixer is the most promising device at present. On the other hand, as is well known, it would be difficult to achieve wider intermediate frequency (IF) compared with SIS mixers, because the roll-off frequency of IF is limited by relaxation time τ. Therefore, in general, HEB receivers choose low IF below 5 GHz. In order to ensure wider IF bandwidth, IF signal from lower frequency has to be amplified in low noise. In the current standard receiver, components limiting the IF bandwidth are a low-noise amplifier and an isolator. Especially, the isolator imposes a limitation of the IF bandwidth within not more than an octave, e.g. 1-2 GHz.

This time we developed a module which directly combines an HEB mixer and an amplifier (Fig. 1). For the amplifier, we adopted SiGe Heterojunction Bipolar Transistors (HBTs) that has low-noise characteristic from nearly DC to several GHz. We tested several kinds of commercially-available HBTs by measuring DC properties at 15 K. We found that HBTs provided by Infineon Technologies Inc. had the highest current gain and we chose these transistors for our mixer-amplifier module. The amplifier was based on the transistor and incorporates a bias-T to supply DC bias current to the HEB mixer. Measured at an ambient temperature of 4 K, the amplifier has a noise temperature below 10 K up to 4 GHz and a gain of more than 22 dB up to 10 GHz.

Using the module, the receiver performance was evaluated at local oscillator (LO) frequency of 900 GHz. The mixer block was designed based on the ALMA Band-10 one incorporating a diagonal horn for LO injection and a 13-dB LO coupler [1]. The HEB chip was fabricated in a clean room at the University of Tokyo [2]. The amplifier is connected to the IF port of the HEB chip by a 50-Ohm transmission line with the length of 10 mm. Two SiGe amplifiers having 20-dB gain up to 8 GHz were used for the room temperature IF chain. The heterodyne measurement result showed receiver noise temperature of 2000-3500 K from IF 0.5 to 5 GHz (Fig. 2). Optimization of the circuit between HEB chip and the amplifier are expected to improve the IF performance.

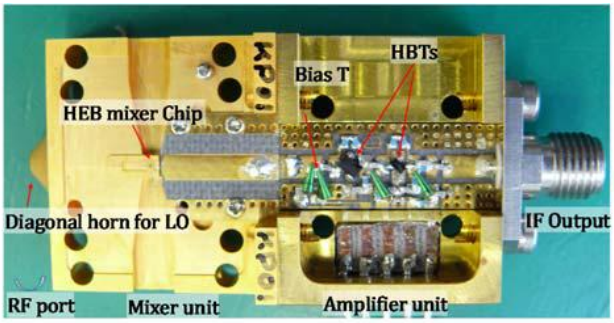

Fig.1 Photograph of an HEB mixer-amplifier module

Acknowledgment

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References

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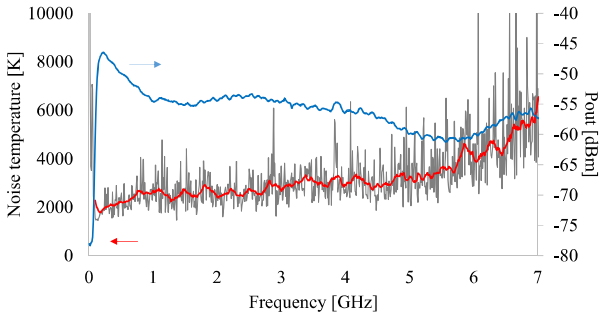

Fig.2 Measurement result of noise temperature as a function of IF. Blue, grey and red lines indicate output power for the hot load at room temperature, noise temperature based on raw data and averaged over 200 MHz, respectively.