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Evaluation of a commercially available high efficiency photomixer

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Abstract

Application of photomixer technologies to radio astronomy has been developed under the collaboration between NAOJ and NTT Laboratories[1-7]. We have evaluated high efficiency photomixers for W-band (75 - 110 GHz) and D-band (110-170GHz) using UTC-PD[8] photodiodes developed by NTT Photonics Laboratories and fabricated by NTT Electronics Co. (NEL)[9-10]. Responsivity of the photodiode is approximately 0.4 A/W. The photomixer output power is measured for photocurrents ranging from 1mA to 10mA. The output power with an optical input power of 0.7mW (0.28mA photocurrent) is estimated to be 1μW. This result indicates that the photomixers meet the requirement for the ALMA photonic reference system without using the optical amplifier at each antenna. We also measured output powers for 75GHz – 350GHz and noise performances for 130GHz – 165GHz.

2. Output power from photomixers

The UTC-PD is placed in a standard butterfly case with RF matching circuit, RF signal line, and substrate. An optical fiber module with focusing lens is welded to the case. Figure 1 shows a picture of the photomixer.

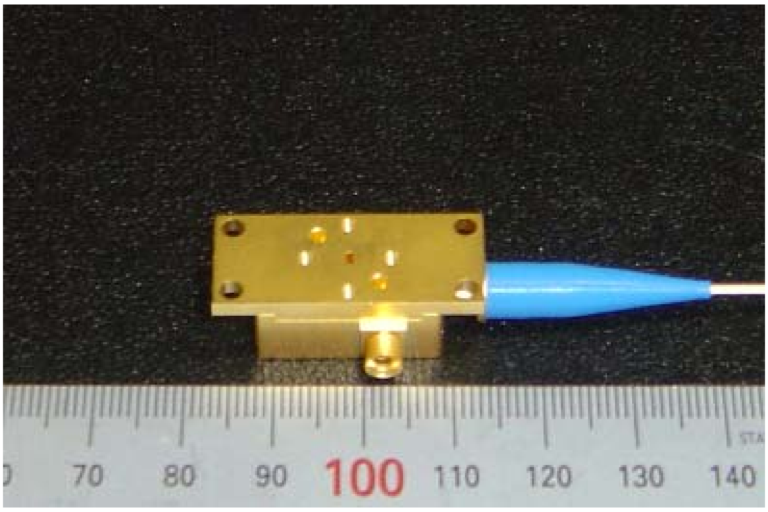

Fig. 1 A picture of the photomixer (Dimensions : 30 (L) x12.7(W) x10(H) mm).

The UTC-PD is driven by the heterodyne beat note of the combined output of two distributed feed-back laser-diodes whose emission wavelengths are around 1.55 □m and the output power is 20 mW. Optical input power of the photomixer is about 15 mW at the photomixer's fiber connector. The laser line width is a few 100 kHz at free running. A responsivity of the photodiode is approximately 0.4 A/W. A relation of photocurrent and output power is shown in Fig. 2. The output power is also measured by using power meter (PM2: Erickson Inst.). The dashed lines show extrapolated output power of the W and D band photomixers. The output power with an optical input power of 0.7mW (0.28mA photocurrent) is estimated to be 1μW. This result indicates that the photomixers meet the requirement for the ALMA photonic reference system[11] without using the optical amplifier at each antenna.

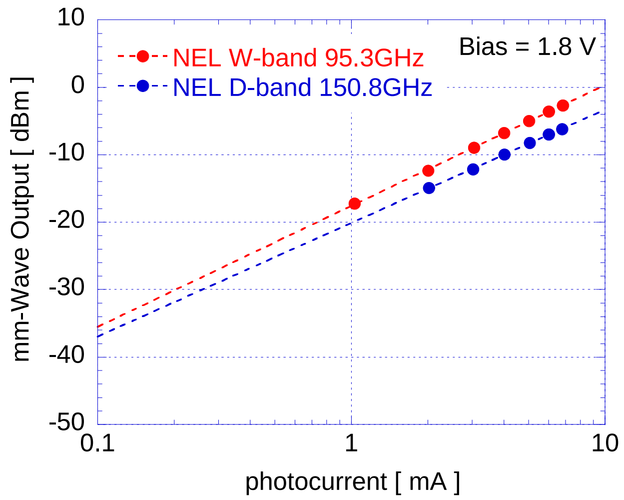

Fig. 2 A relation of photocurrent and photomixer output power.

The frequency dependence of the output power is shown in Fig. 3. The result shows that the D-band photomixers could be used as a direct photonic LO with 100μW output power up to 300GHz.

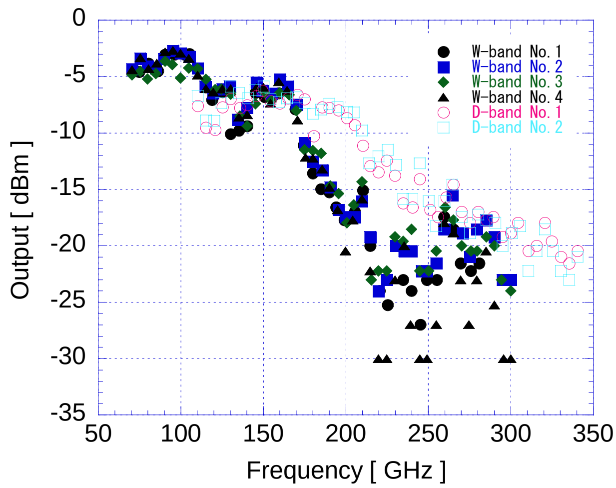

Fig. 3 Frequency characteristics of the photomixers. Measurements of output power are made over a wide frequency range from 75 to 350 GHz for a photo-current of 7mA at a bias point of -1.8 V.

3. Noise performance when the photomixer is used as a direct photonic LO

It was shown that Band-4 SIS mixers are able to be pumped by the output of the photomixers as local oscillator without any optical or RF amplifiers. To evaluate their amplitude noise, receiver noise temperature of an SIS mixer obtained in the case pumped by the photomixer as local oscillator source is compared to that pumped by a Gunn diode at the D band (Fig. 4). The IF frequency is 4 -8GHz and the output power is measured by a power meter. The maximum Y-factor, which is the difference of the IF output power between hot load (300 K) and cold load (77 K), is about 5 dB at the lowest temperature of the SIS mixer. Since it is difficult to find any clear difference between the two cases in the measurement accuracy at present, much more detailed and accurate measurement of the noise temperature is planned. Detail of a W-band photomixer characteristics are described in the reference [1-6].

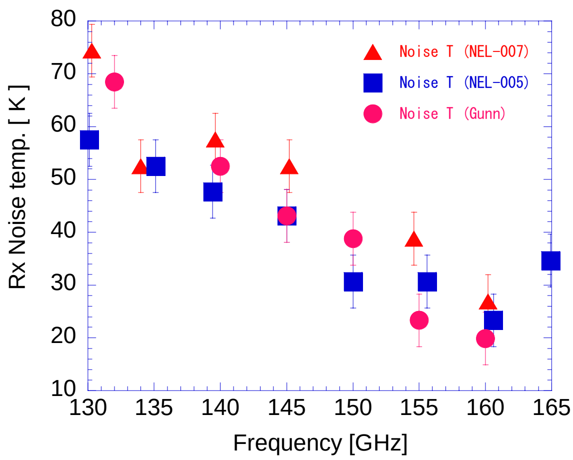

Fig. 4 Frequency dependence of SIS receiver noise obtained D-band photomixer (photocurrent = 5 mA , bias = -1.8V) and Gunn oscillator.

4. Summary

W-band and D-band photomixers are fabricated and demonstrated using the UTC-PD and are now commercially available from NEL. The typical output power is 0.5mW and 0.25 mW for W and D band photomixers at each band center. The photomixers can generate 1μW at 0.7mW optical power. This value meets requirement[11] for the ALMA photonic reference system without optical amplifier at each antenna. There is a concern of phase drift by an optical amplifier because it is inserted outside the round trip Line

Length Correction (LLC). Thus, a high efficiency photomixer is preferable for the photonic reference system.

Ito *et al.* tested the W-band photomixer for reliability under optical input stress (photocurrent = 10mA, photodiode bias = -2.0V) at room temperature during 8000 hours, but they could not observe any damage on the photomixer[12].

The photomixer and a Gunn oscillator have almost the same characteristics in heterodyne mixing using Band-4 SIS mixers with the noise temperature of 23 K.

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