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F Bavedila, Etienne Okada, Jean-Francois Lampin, Guillaume Ducournau, Emilien Peytavit. LT-GaAs-based photomixers with >2 mW peak output power up to 320 GHz. 2019 44th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), Sep 2019, Paris, France. 10.1109/IRMMW-THz.2019.8874037 . hal-02323311

HAL Id: hal-02323311
https://hal.science/hal-02323311

Submitted on 21 Oct 2019

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LT-GaAs-based photomixers with >2 mW peak output power up to 320 GHz

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***Abstract*— It is shown in this communication that a LT-GaAs photomixer based on an optically resonant cavity is able to generate peak output powers above 2 mW up to 320 GHz when it is driven by optical pulses of 5 ns width at a repetition rate of 10 MHz.**

The generation of microwaves by optical heterodyne of coherent sources on a photodetector, also called photomixing, has been proposed and demonstrated in the 1950s by A. Forrester et al. through the generation of 10 GHz-frequency microwaves thanks to the beating on a photocathode of Zeeman lines of a Hg202 source [1]. After the few attempts made in the 1960s following the invention of the laser [2], the interest for this photonics-based CW source has been revived in the late 1990s when Brown et al. demonstrated the generation of electromagnetic waves from 0.1 THz up to 3.8 THz [3], using an ultrafast photoconductor coupled to a wideband antenna and pumped by two 0.8 µm-wavelength lasers. Its frequency tunability is indeed limited only by the properties of the photomixer, and not by the optical sources. This is because a negligible relative variation in the frequency of the infrared lasers is translated in a great relative variation in the microwave or terahertz frequency range. From a practical point of view, it allows, unlike electronic sources such as frequency multipliers, to generate waves continuously from dc to a few terahertz with the same optical sources mixed in only one wide band or several narrow band photomixers. Some years ago, we have demonstrated by means of on-wafer measurements that up to 1.8 mW around 250 GHz could be generated by a LT-GaAs vertical resonant photoconductor (see Fig.1), thanks to a metallic mirror-based Fabry-Pérot cavity (FP) and to a deep submicron electrode spacing resulting in high carrier and current densities[4]. Since this demonstration, a number of other teams have proposed photomixers with mW level peak output powers in the THz frequency range thanks to the modulation of the pump optical power[5]. Here we show that the resonant cavity photoconductor is able to generate peak power between 2 and 5 mW in the 220-325 GHz band when it is pumped by a modulated optical power at a frequency of 10 MHz and a duty cycle of 5%.

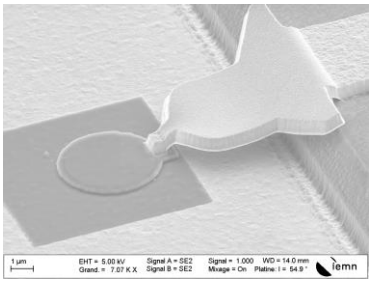


Fig. 1: SEM picture of a Fabry-Pérot cavity photoconductor couple to a thin film microstrip line

The optical beatnote is generated by spatially overlapping the emission of two 780-nm-fiber-coupled DFB laser diodes, by means of a 50:50 polarization maintaining fiber coupler and used to seed a fiber-coupled Lithium Niobate Mach-Zehnder intensity modulator driven by 4-V amplitude 10-MHz-frequency pulses with time duration between 5 ns and 20 ns. The modulated optical intensity is then amplified by a tapered semiconductor optical amplifier. The optical wave is finally focused on the device by a lensed fiber providing a gaussian beam spot of minimum width around 4 µm. The RF power generated in the photoconductor at the beating frequency is collected by a 220-325 GHz waveguide coplanar probe (CascadeMicrotech i325) and coupled to a powermeter (Erickson PM4). The measured power levels are corrected for losses induced by the waveguide coplanar probe, the waveguide taper needed for J-Band power measurements and the powermeter internal losses. Measurements performed by the manufacturers show that the total losses reach 4 dB around 220 GHz and 5 dB at 300 GHz.

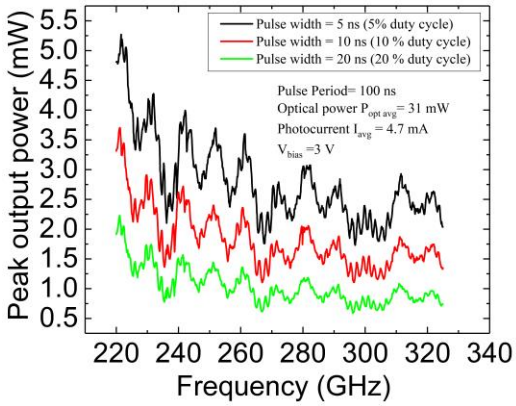


Fig. 2: Peak Output power as a function of frequency

The peak output power (P_{peak}) as a function of the beatnote frequency generated by is shown in Fig. 2. It has been deduced from the average output power measured by the powermeter (P_{avg}) and from the duty cycle (d_{cycle}) of the electrical pulses driving the modulator: $P_{peak} = P_{avg}/d_{cycle}$. The temporal shape of the THz pulses has been also measured by means of a 220-325 zero-bias Schottky diode allowing us for using this relation between the average power and the peak power. It is worth to notice, that the oscillations in the power spectrum come mainly from the standing waves created by the reflections inside the coplanar probes. It can be seen that peak powers reaching 5 mW at 220 GHz and around 3 mW at 315 GHz has been obtained with only 31 mW of average optical power which is, to the best of our knowledge, the highest power ever reported for a single photomixer in the 220-325GHz Band.

REFERENCES

[1] A. T. Forrester, R. A. Gudmundsen, and P. O. Johnson, "Photoelectric Mixing of Incoherent Light," *Phys. Rev.*, vol. 99, no. 6, pp. 1691–1700, 1955.

[2] O. Svelto, P. D. Coleman, M. DiDomenico, and R. H. Pantell, "Photoconductive Mixing in CdSe Single Crystals," *J. Appl. Phys.*, vol. 34, no. 11, p. 3182, 1963.

[3] E. Brown and K. McIntosh, "Photomixing up to 3.8 THz in low-temperature-grown GaAs," *Appl. Phys. Lett.*, vol. 66, no. 3, pp. 285–287, 1995.

[4] E. Peytavit, P. Latzel, F. Pavanello, G. Ducournau, and J.-F. Lampin, "CW Source Based on Photomixing With Output Power Reaching 1.8 mW at 250 GHz," *IEEE Electron Device Lett.*, vol. 34, no. 10, pp. 1277–1279, Oct. 2013.

[5] C. W. Berry, M. R. Hashemi, S. Preu, H. Lu, A. C. Gossard, and M. Jarrahi, "Plasmonics enhanced photomixing for generating quasi-continuous-wave frequency-tunable terahertz radiation," *Opt. Lett.*, vol. 39, no. 15, p. 4522, Aug. 2014.