Heterodyne detection of sub-THz waves using LT-GaAs photoconductor controlled by a wavelength of 1550 nm

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The low-temperature-grown GaAs (LT-GaAs) is a suitable photoconductive material for THz optoelectronics devices because of its excellent electrical properties after post-growth annealing such as high dark resistivity, high free carrier mobility, and short free carriers lifetime (τ<1 ps) [1]. Recently, it has been shown that an efficient LT-GaAs photoconductor operating at λ= 1550 nm can be obtained by placing the LT-GaAs layer inside an optical resonant cavity [2]. We present here a photoconductor composed by a thin and small area LT-GaAs layer with a thickness t=450 nm and a diameter D=6 µm, placed between two gold mirrors/electrodes. The top face electrode is a nanostructured grating of gold with a sub-wavelength periodicity p=900 nm, an aperture a= 300 nm and a thickness h=300 nm. The device is shown in figure 1. RF waves at a frequency of f_{in}=67 GHz generated by a microwave synthesizer are send to the LT-GaAs photodetector through a first 50-Ω-microstrip line using a coplanar probe. At the same time the photoconductor is triggered by a 1550 nm optical pulse train produced by a mode-locked fs laser, giving rise to a conductivity comb with a teeth spacing equal to f_{rep}=1 GHz. At the photomixer output the beating of the RF wave with the comb teeth generates replicas spaced by f_{rep}. We are interested here in the base band replica which is below f_{rep}/2. This mixing signal is outcoupled by another coplanar probe through a second microstrip line and sent through a bias-T to a spectrum analyser. Figure 2 shows the detected signal power (P_s) for an input RF frequency at 67 GHz for different input power levels P_{in} and different optical powers P_{opt}. The conversion losses L=10×log (P_{in}/P_s) between the probes, are equal to 84 dB for P_{opt}=11.8 mW and 54 dB for P_{opt} =88.2 mW and are independent of the input power P_{in}. These results show the possibility to detect RF and THz waves by photoconductive sampling using LT-GaAs under 1550 nm illumination.

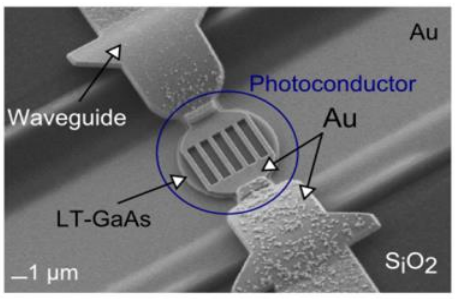

Fig.1. LT-GaAs photoconductor in resonant cavity linked to microstrip-lines

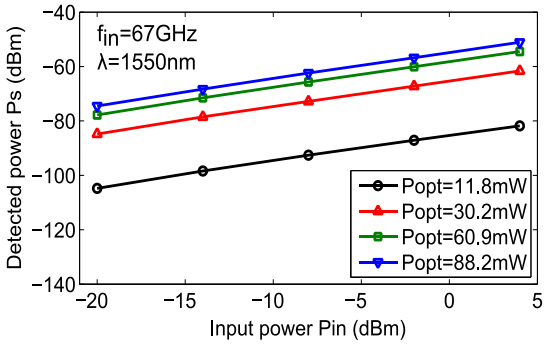

Fig.2. Detected power for an input signal at a frequency of 67 GHz for variable input power

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[1] E. S. Harmon, M. R. Melloch, J. M. Woodall, D. D. Nolte, N. Otsuka, and C. L. Chang, "Carrier lifetime versus anneal in low temperature growth GaAs," *Appl. Phys. Lett.*, vol. 63, no. 16, pp. 2248–2250, Oct. 1993.
[2] M. Billet, P. Latzel, F. Pavanello, G. Ducournau, J.-F. Lampin, and E. Peytavit, "Resonant cavities for efficient LT-GaAs photoconductors operating at λ = 1550 nm," *APL Photonics*, vol. 1, no. 7, p. 076102, Oct. 2016.