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To cite this version:

Julien Guise, Stéphane Blin, Hajasoa Ratovo, Laurent Cerutti, Monique Thual, et al.. Waveguide-Integrated optically-tuned THz modulator. French-German TeraHertz Conference, May 2022, La gande Motte, France. hal-04283152

HAL Id: hal-04283152
https://hal.umontpellier.fr/hal-04283152

Submitted on 13 Nov 2023

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Waveguide-Integrated optically-tuned THz modulator

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In order to fill the gap of THz modulators, previous works have shown the possibility to optically modulate a THz beam passing through an InAs slab [1]. Indeed, by using an optical pump one can generate many free carriers in the semiconductor by absorption process. The presence of these carriers allows to reach a quasi-metallic effect of the slab in the desired THz range. We can then modulate the transmission of the THz wave passing through the modulator by switching it between an optically "unpumped state" (dielectric that transmits the THz wave) and an "optically pumped" state (metal that reflects the THz wave).

In continuation of this work, we seek to integrate this modulator inside a standard WR1.0 waveguide. A 1550-nm optical excitation was chosen to take advantage of on-shelve fibre-optics components and home-made integrated micro-lensed fibres [2]. Additionally, since the density of photogenerated carriers is proportional to optical density, integration allows to decrease the required optical power for modulation.

To reduce insertion losses, it is necessary to use a sub-wavelength thickness of InAs (about few µm). However, to ensure a sufficient mechanical strength of the slab, we proposed an epitaxial structure of InAs on a GaAs substrate (transparent for THz) in a longitudinally-resonant Fabry-Perot configuration to improve transmission at resonance. COMSOL simulations of different configurations and preliminary experimental results will be discussed in terms of insertion loss and modulation depth, as shown in Fig. 1 for a given configuration.

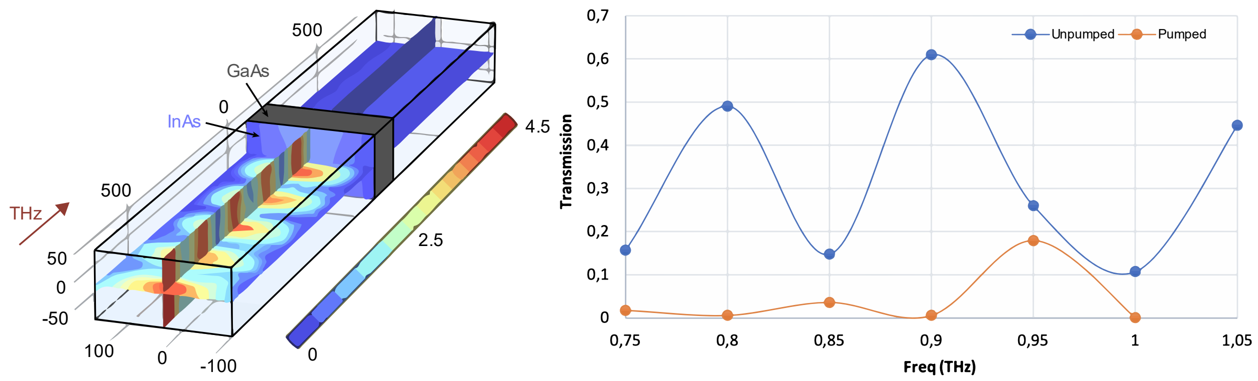

Figure 1. Comsol simulation of the WR1.0-integrated InAs (1 µm) / GaAs (370 µm) structure. (Left) Normalized Electric Field propagation. (Right) Transmission spectrum (1/370).

References:

[1] E. Alvear et al, "Epsilon near-zero all-optical terahertz modulator", Appl. Phys. Lett. 117, 111101 (2020)

[2] M. Thual et al, "Contribution to research on Micro-Lensed Fibers for Modes Coupling", Fiber and Integrated Optics 27(6), (2008)

Acknowledgment:

Partial funding by the French "Investment for the Future" program (EquipEx EXTRA ANR-11-EQPX-0016)