Photoconductive switches for high resolution and polarized resolved THz spectroscopy

K. Maussang[1], J. Palomo[2], J.-M. Manceau[3], R. Colombelli[3], I. Sagnes[3], L. H. Li[4], E. H. Linfield[4], A. G. Davies[4], J. Mangeney[2], J. Tignon[2] and S. S. Dhillon[2]

[1]*Institut d'Electronique et des systèmes, Université de Montpellier, 860 rue de Saint-Priest, 34 095 Montpellier Cedex 5, CNRS, Montpellier, France*

[2]*Laboratoire Pierre Aigrain, Ecole Normale Supérieure-PSL Research University, CNRS, Université Pierre et Marie Curie-Sorbonne Universités, Université Denis Diderot-Sorbonne Paris Cité, 24 rue Lhomond, 75231 Paris Cedex 05, France*

[3]*Centre de Nanosciences et de Nanotechnologies, CNRS, Univ. Paris-Sud, Université Paris-Saclay, C2N – Orsay, 91 405 Orsay cedex, France*

[4]*School of Electronic and Electrical Engineering, University of Leeds, Leeds, LS9 2JT, United-Kingdom*

Corresponding author: kenneth.maussang@umontpellier.fr

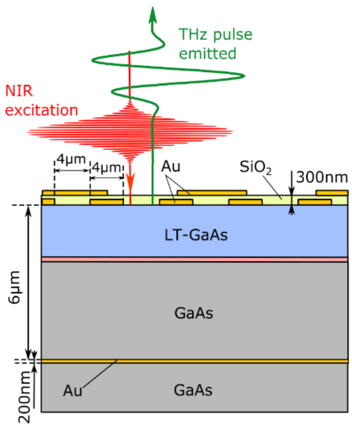

Fig. 1: Buried metal geometry for echo-less detection with LT-GaAs active layer.

Interdigitated photoconductive (iPC) switches are powerful and convenient devices for time-resolved spectroscopy, with the ability to operate both as sources and detectors of terahertz (THz) frequency pulses. However, reflection of the emitted or detected radiation within the device substrate itself can lead to echoes that inherently limits the spectroscopic resolution achievable from their use in time-domain spectroscopy (TDS) systems. For example, with a photoconductive switch made from a 500 µm thick GaAs wafer, the first THz echo arises after only 12 ps, limiting the resolution to ~ 90 GHz (3 cm^{-1}). This can restrict applications such as high resolution THz spectroscopy of many polar molecules, where pure rotational spectra typically have linewidths ranging from 0.1 cm^{-1} to 10 cm^{-1}. A novel iPC switch that suppresses unwanted echoes from the substrate, without power losses, is proposed and demonstrated in emission [1] and in detection [2]. It provides a monolithic "on-chip" solution without any mechanical positioning of external elements post processing. For emitter, this is realized through a buried metal geometry where a metal plane is placed at a subwavelength thickness below the surface switch structure and semi-insulating GaAs active layer. For detector, this is realized through a buried multilayer low-temperature-grown GaAs (LT-GaAs) structure that retains its ultrafast properties, which after wafer bonding to a metal-coated host substrate, results in an iPC switch with a metal plane buried at a subwavelength depth below the LT-GaAs surface (see Fig.1). Using these devices as emitter and detector together enables echo-free THz-TDS and high-resolution spectroscopy, with a resolution limited only by the temporal length of the measurement governed by the mechanical delay line used. Rotational lines of water have been resolved as a proof-of-principle. Additionally, iPC switches emit linearly polarized THz radiation. Most of polarization measurements in THz range are performed by the use of mechanically controlled elements, which limits inherently the swiftness and the precision of the measurement. Here, we propose an innovative concept of a THz pulse emitter with a fully electrically-controlled polarization based on a scalable and large-area design. These two improved iPC switches permit high resolution measurements both in frequency and in polarization, and are compatible together for monolithic "on-chip" solution with no external mechanical part for high performances THz spectroscopy and polarimetry.

<u>*References:*</u>

[1] K. Maussang *et al.*, IEEE Trans. Terahertz Sci. Technol. **6**, 20 (2016)

[2] K. Maussang *et al.*, Appl. Phys. Lett. **110**, 141102 (2017)