Photo-generated carriers in InAs slab at THz frequencies induced by a continuous wave low irradiance

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E. Alvear-Cabezón[1,2]*, R. Smaali[1], S. Blin[2], P. Nouvel[2], F. Gonzalez-Posada[2], T. Taliercio[2] and E. Centeno[1].

[1] *Univ. Clermont Auvergne, CNRS, Institute Pascal, F-63000 Clermont-Ferrand, France*
[2] *IES, Univ. Montpellier, UMR CNRS 5214, Montpellier, France*
*Correspondence e-mail: Eduardo_Antonio.Alvear_Cabezon@etu.uca.fr

***Abstract*: We theoretically and experimentally study the THz electromagnetic properties of photo-generated carriers in an undoped-InAs slab. We use an optical pump to modify the permittivity. These modifications are calculated by solving the ambipolar rate equation for the photo-carriers. Experiments demonstrate that InAs is a promising semiconductor that can be used to manufacture fast and efficient on-chip THz components. We show a high modulation of the THz transmission up to 100% from 0.75 to 1 THz at very low pump fluence in the continuous wave regime.**

INTRODUCTION

Terahertz electromagnetic waves with frequencies lying from 0.3 to 10 THz attract much interest owing to their potential applications in several domains ranging from medicine, telecommunication or security. Recent developments of bright terahertz (THz) sources and efficient detectors accelerate the progress of non-destructive THz systems. However, the demand for versatile THz components able to address a wide range of frequencies is high. Among the envisaged approaches, artificial structures named metasurfaces based on subwavelength electromagnetic resonators were used to control THz waves [1]. A real-time and dynamical control has in particular been demonstrated with photo-generated metasurfaces [2,3]. Here, the metasurfaces are optically printed into a semiconductor layer. However, several issues must be bypassed in terms of modulation rate or pump power before this approach might be implemented in the application domain.

DESCRIPTION OF THE STUDY

In this work, we theoretically study the THz electromagnetic properties of photo-generated carriers in an undoped-InAs slab as presented in Fig. 1. The modifications of the permittivity induced by an optical pump are calculated by solving the ambipolar rate equation for the photo-carriers. The photo-carrier diffusion plays a crucial role in the search of optimal geometry [4]. To understand the nature of the phenomenon and to reveal the real impact of the carrier diffusion in the InAs material, we have created a multiphysics code to calculate the electromagnetic properties of the InAs slab illuminated by a THz plane wave. We have analyzed the electromagnetic properties of the InAs slab as a function of the thickness "*h*", the pump fluence and the polarization (TE and TM) of the THz wave and demonstrated a high modulation of the THz radiations.

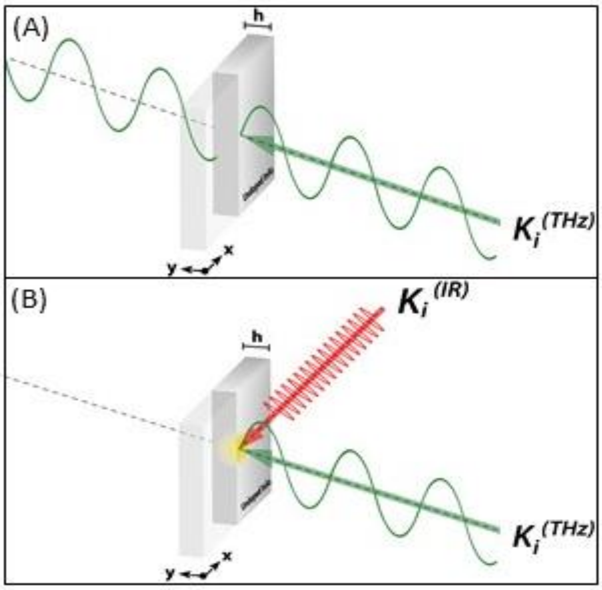

Fig. 1. (A) Schematic of the Undoped-InAs slab of thickness "*h*" radiated by a THz plane wave from 0.75 to 1 THz. (B) The radiated InAs material is pumped by an IR plane wave which allows to obtain a modulation in transmission of the THz radiation.

We have performed the experiments described in Fig. 1 using a continuous-wave (CW) laser with an irradiance of only tens of W/cm^2. This is enough to modulate the transmission of the THz waves up to 100% at frequency ranging from 0.75 THz to 1 THz. The THz beam can be modulated at a frequency of at least few tens of kHz.

CONCLUSION

We have demonstrated that InAs is a promising semiconductor for the development of on-chip fast and efficient THz components. Using CW laser at an irradiance of only tens of W/cm^2 is sufficient to modulate the transmission of the THz waves up to 100% on a broad frequency range from 0.75 THz to 1 THz.

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