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Accession number:20114914584723

Title:Terahertz electromagnetic waves emitted from semiconductor investigated using terahertz time domain spectroscopy

Authors:Zhu, Yiming (1); Zhuang, Songlin (1)

Author affiliation:(1) Engineering Research Center of Optical Instrument and System, Shanghai Key Lab of Modern Optical System, University of Shanghai for Science and Technology, Shanghai 200093, China; (2) School of Microelectronics, Shanghai Jiao Tong University, Shanghai 200240, China

Corresponding author:Zhu, Y.(ymzhu@usst.edu.cn)

Source title:Chinese Optics Letters

Abbreviated source title:Chin. Opt. Lett.

Volume:9

Issue:11

Issue date:November 2011

Publication year:2011

Article number:110007

Language:English

ISSN:16717694

Document type:Journal article (JA)

Publisher:Science Press, 18,Shuangqing Street,Haidian, Beijing, 100085, China

Abstract:Ultrafast electromagnetic waves radiated from semiconductor material under high electric fields and photoexcited by femtosecond laser pulses have been recorded by using terahertz time domain spectroscopy (THz-TDS). The waveforms of these electromagnetic waves reflect the dynamics of the photoexcited carriers in the semiconductor material, thus, THz-TDS provides a unique opportunity to observe directly the temporal and spatial evolutions of non-equilibrium transport of carriers within sub-picosecond time scale. We report on the observed THz emission waveforms emitted from GaAs by using a novel technology, the time domain THz electro-optic (EO) sampling, which has a bipolar feature, i.e., an initial positive peak and a subsequent negative dip that arises from its velocity overshoot. The initial positive peak has been interpreted as electron acceleration in the bottom of Γ valley in GaAs, where electrons have a light effective mass. The subsequent negative dip has been attributed to intervalley transfer from Γ to X and L valleys. Furthermore, the power dissipation spectra of the bulk GaAs in THz range are also investigated by using the Fourier transformation of the time domain THz traces. From the power dissipation spectra, the cutoff frequency for negative power dissipation (i.e., gain) under step electric field in the bulk GaAs can also be obtained. The cutoff frequency for the gain gradually increases with increasing electric fields up to 50 kV/cm and achieves saturation at approximately 1 THz at 300 K. Furthermore, based on the temperature dependence of the cutoff frequency, we find that this cutoff frequency is governed by the energy relaxation process of electrons from L to Γ valley via successive optical phonon emission.

Number of references:26