Balistinių fotosrovių sukelta terahercinių impulsų emisija iš puslaidininkinių heterosandūrų

Terahertz Pulse Emission from Semiconductor Heterostructures Caused by Ballistic Photocurrents

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When photoexcited by femtosecond optical pulses, most materials emit ultrashort pulses of electromagnetic radiation containing frequencies at the terahertz (THz) frequency range. THz pulse emission has been observed from semiconductors, dielectric crystals, metals, and even from gases, and liquids. This universal effect became an effective and popular tool for a contact-less investigation of various materials. THz emission spectroscopy (TES) can determine important parameters of the material band structure – direct band gap and subisdiary conduction band valley position. Determination of subsidiary valley position was well studied for A3B5 semiconductors like InAs, GaAs and InSb [1].

During the first few hundreds of femtoseconds, when the dipole is developing, the photoexcited electrons in narrow-gap A3B5 semiconductors are moving ballistically [2] over the distances reaching several hundred nanometers. Hz emission due to ballistic photoexcited electron propagation has been exploited for the measurements of conduction band offsets in GaAsBi/GaAs heterojunction [3]. Where onset of THz generation shows energy when carriers can overcome the heterojunction barrier. This is achieved when the lower bandgap material is thin enough and emission is very low when carriers are confined in that layer.

In this work Terahertz radiation pulses emitted after exciting semiconductor heterostructures from the substrate side by femtosecond optical pulses were used to determine the electron energy band offsets between different constituent materials. It has been shown that when the photon energy is sufficient enough to excite electrons in the narrower bandgap layer with an energy greater than the conduction band offset, the terahertz pulse changes its polarity (fig. 1). Theoretical analysis performed both analytically and by numerical Monte Carlo simulation has shown that the polarity inversion is caused by the electrons that are excited in the narrow bandgap layer with energies sufficient to surmount the band offset with the wide bandgap substrate [4]. This effect is used to evaluate the energy band offsets in GaInAs/InP and GaInAsBi/InP heterostructures.

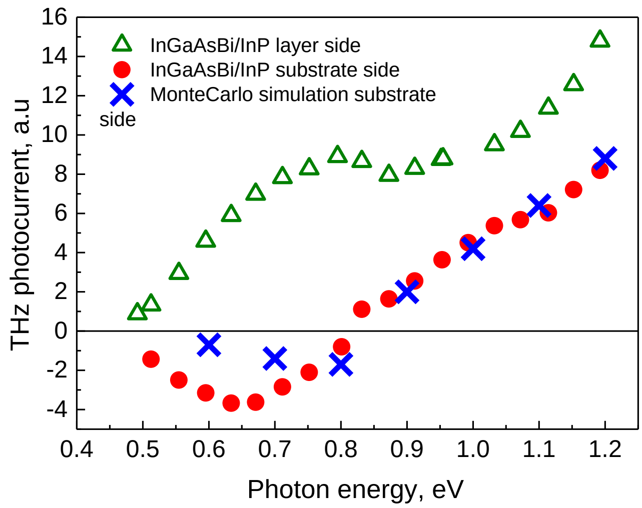

Fig. 1 THz excitation spectra of and GaInAsBi/InP heterostructure sample measured for cases of the layer-side photoexcitation (empty green triangles) and the substrate-side photoexcitation (full red circles). Blue crosses show the Monte Carlo simulation results.

Reikšminiai žodžiai: THz, THz emission spectroscopy, heterostructure, InGaAsBi/InP offset, Ballistic carrier excitation

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