P26

Broadband Radiation Sensor Based on a Hot Carrier Ratchet Structure

Ihor Zharchenko[1,2], Oleksandr Masalskyi[1,2], Jonas Gradauskas[1,2], Steponas Ašmontas[1], Aldis Šilėnas[1], Aurimas Čerškus[1,2], Jonas Petrokas[1]

[1]*Laboratory of Electronic Processes, Center for Physical Sciences and Technology, Lithuania*
[2]*Vilnius Gediminas Technical University, Lithuania*
Email: oleksandr.masalskyi@ftmc.lt

Broadband radiation sensors are in high demand in optoelectronics, particularly in the infrared region, where conventional semiconductor detectors are limited by their bandgap and often require cryogenic cooling for effective operation. In this work, a GaAs/$Al_xGa_{1-x}As$ ratchet-based sensor operating on the hot carrier effect is presented, enabling detection from the visible to long-wavelength spectral range without cryogenic cooling or complex fabrication. The sensor is built on a periodic asymmetric potential of a MBE-grown GaAs/$Al_xGa_{1-x}As$ structure, with the AlAs mole fraction gradually changing from x = 0.3 to 0. In the dark, electrons are localized in potential wells (Fig. 1a). Under illumination, they become hot carriers and diffuse between neighboring wells (Fig. 1b). Their asymmetric relaxation and transport generate an electromotive force at the device terminals, producing a direct current in a closed circuit (Fig. 1c).

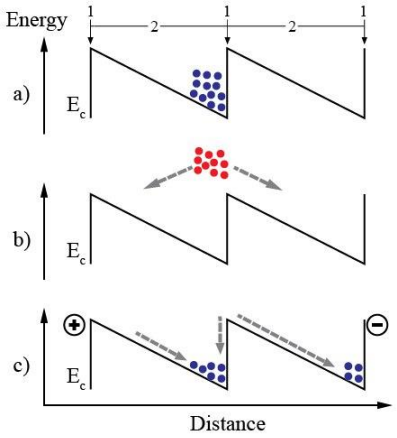

Fig. 1 Photovoltage formation across the sensor: (a) absence of irradiation; (b) heating of free electrons and their diffusion in both directions; (c) electron relaxation and redistribution between potential wells [1].

The sensor shows a linear photocurrent response under both inter- and intraband excitation in the studied intensity range. The photocurrent magnitude follows the strong spectral variation of the GaAs absorption coefficient. Temperature measurements show that at 0.532 μm the response is higher at room temperature due to stronger interband absorption and greater excess energy left for carrier heating, whereas at 1.064 μm the temperature influence is weak since the response is governed mainly by the free carrier absorption.

To conclude, the GaAs/$Al_xGa_{1-x}As$ ratchet-based sensor offers a promising approach for broadband radiation detection based on hot carrier effects. Its room-temperature operation and response to both high and low photon energy laser radiation make it a potential alternative to existing detectors requiring cryogenic cooling, particularly in the infrared region.

REFERENCES

[1] Gradauskas J., Ašmontas S., Sužiedėlis A., Masalskyi O., Zharchenko I. „Reketinis plataus spektro spinduliuotės jutiklis“ („Ratchet-based sensor of broad radiation spectrum“). Lietuvos Respublikos patentas Nr. LT 7030B (2023/02/17).