Nanocomposites and nanomaterials

EL2 deep levels in photoconductivity and absorption of In(Ga)As/GaAs nanoscale structures

S.L. Golovynskyi

Institute of Semiconductor Physics, NAS of Ukraine, pr. Nauki 45, 03028, Kyiv, Ukraine
E-mail: golovynskyi@gmail.com

Optical properties of EL2 defect centers in multilayer InGaAs/GaAs quantum dot (QD) structure grown by molecular beam epitaxy are studied. This is investigated using photocurrent spectroscopy at direct current which allows to detect the signal from deep levels, which commonly have a long-time kinetics, absorption and photoluminescent (PL) spectroscopy at 80 K and room temperature.

The investigated structure is found to be photosensitive in a comparatively wide spectral range. The threshold energies of photoconductivity (PC) spectra are 0.75 eV at room temperature and 0.24 eV at 80 K. The PL spectrum of QDs ground state at 80 K with band peaked at 1.23 eV (FWHM is about 60 meV) points out to the deep level nature of the PC signal underneath the PL band edge. The lateral PC spectrum measured using the Lock-In modulation technique at 80 K gives to make the similar findings. The signals with long-time kinetics, a time constant more than 0.1 s, are dramatically quenched with modulation frequency, so, the minimal energy of light resulting in a photocurrent measured at Lock-In technique is of 1.2 eV and there is no part of the spectrum caused by QD interface defect levels and defective GaAs. At higher photon energies the peculiarities on PC spectra can be ascribed to the wetting layer and GaAs.

Considering the deep level part of PC spectra, the room temperature low energy PC and absorption edge, 0.75 eV, definitely points out to EL2 levels. The value of threshold energy of 0.24 eV at 80 K is the energy of optical ionization of the most shallow photoactive defect level M2, $E_c - 0.22$ eV. Considering the data of energy spectrum of known defect levels in GaAs and at the InGaAs-GaAs interface other deep defect levels above the energy of M2 in the photocurrent spectrum have been identified as follows: M3 (0.35 eV), M4 (0.45 eV), EL3 (0.59 eV), EB4 (0.71 eV), EL2 family (0.75-0.85 eV), EB3 (0.9 eV) below the GaAs conduction band edge, E_c. Furthermore, in this study an optical quenching of the later PC of the QD sample exciting the EL2 deep levels by energy of 0.85 eV at room temperature is carried out. It is shown that EL2 centers, being the recombination centers with high density in the vicinity of interfaces, significantly influence on optical properties of GaAs based nanostructures.