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Intensity-dependent photoconductivity spectroscopy of InGaAs/GaAs dot-chain structures

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Optical properties of multi-layer InGaAs/GaAs dot-chain heterostructures are studied at room temperature by means of lateral photoconductivity (PC), absorption and deep level TSC spectroscopy. The focus is on the nonlinearity of PC with intensity at the excitation within the main structure components. The structure is found to be photosensitive in the wide range of quantum energies since 0.6 eV. The quantum dots (QDs), structure defects, wetting layer and GaAs, strongly interacting, are involved to formation of the PC spectrum. Participation of deep levels being, in particular, electron traps in PC mechanism is clarified. The PC dependences on intensity at different energies of excitation quanta are explained by the presented theory involving generation and recombination of the free charge carriers in QDs, GaAs barrier layers and energy states embedded to GaAs bandgap and exchange processes between these objects. It is shown that QDs are the effective centers of generation of free charge carriers at excitations above 1 eV, as the probability of the carrier escape to GaAs environment is much higher than that of reverse process and recombination. The studied structure demonstrates sensitivity up to 10 A/W at low excitation intensities. For higher excitation powers the sensitivity decreases being intensity-dependent in different way for all the range of quantum energies. Since the excitation occurs predominantly within QDs, high photosensitivity at low excitation intensities is observed. The sensitivity for higher intensities is lower because recombination of free charge carriers in both the QDs and GaAs environment is mainly direct, which implies sublinear dependence of carrier number on excitation. This study is promising for application in high-sensitive lateral QD infrared photodetectors operating at near-room temperature with wide dynamic range allowing low-light detection.