Type II InSb quantum dots in narrow-gap InAs(Sb,P) matrix: structural, electrical and luminescent properties

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We report on study of structural, transport and optical properties of narrow-gap type II heterostructures with InSb quantum dots (QDs) inserted into the InAs-based matrix. The samples with InSb QDs were grown on the (100)-orientated surface by both liquid phase epitaxy and metal-organic vapour phase epitaxy. The self-assembled InSb QDs were obtained under Stranski-Krastanow growth mode. The high density ($2*10^{10}$ cm^{-2}) uniform QDs with dimensions of 3 nm in height and 14 nm in diameter were found to be dislocation-free without any extended defects. Structural parameters of the InSb QDs such as size, shape and internal strain will be demonstrated and discussed. Technological conditions, where transition between two mechanisms of QDs formation (Volmer-Weber and Stranski-Krastanow) can be realised, will be considered.

Use of the multicomponent In-As-Sb-P solid solutions lattice-matched with InAs substrate as matrix layers leads to a considerable change of the surface chemistry of a matrix material and allows controlling size distribution and sheet density of the InSb QDs deposed. High-resolution TEM cross-section images of the free-standing InSb QDs and ones buried into the InAs(Sb,P) matrix were obtained for the first time.

Local I-V characteristics of the single InSb QD situated on the InAs-rich surface were studied by scanning probe microscopy at room temperature to investigate tunnelling carrier transport through the confined states. Intense positive and negative electroluminescence (EL) for the mesa-diode heterostructures with the InSb QDs was found in the spectral range 3-4 μm at temperatures 77-300 K. Evolution of the EL spectra in dependence on applied external bias was observed. The energy band diagram of the InSb/InAs(Sb,P) heterostructure with a type II quantum dot at the heterointerface will be proposed.

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