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Improving Heterointerface Abruptness of InGaAs/InP Superlattice by Optimizing a Purging Period of Group-V Gas

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An abruptness of InGaAs/InP heterointerfaces in the superlattice (SL) structure grown by metal-organic vapor-phase epitaxy has been improved by optimizing a gas-purging period of tertiary-butyl phosphine (TBP) onto the InGaAs terminated surface, and tertiary-butyl arsenide (TBA) onto the InP terminated surface. The non-abrupt heterointerface is a result of intermixing layer formation caused by two main effects: (1) carry-over and (2) diffusion of group-V atoms. The sample composes of 20 periods of InGaAs (2 nm)/InP (10 nm) epitaxially grown on the InP substrate in [001] direction. The In composition in InGaAs was adjusted to be 53% which is a lattice match to InP. The layer structure was characterized by high-resolution X-ray diffraction. Crystal quality and relaxation were analyzed from the reciprocal space mapping result recorded around diffraction from the InP (-2-24) asymmetric plane. Lattice mismatch and layer thickness were examined by the 2θ-ω results around the InP (004) symmetric plane. In this work, we proposed a model in order to estimate the thickness of intermixing layers by using the Fourier transform of a periodic trapezoid-shape scattering function to fit an intensity of high-order satellite diffraction peaks. Since InGaAs has a lower energy gap than InP, the InGaAs layer could be considered as a quantum well (QW) inserted between the InP barriers. Hence, we also analyzed the QW shape of SL structures via the ground-state transition energy characterized by room-temperature photoluminescence. Our results show that purging the InGaAs terminated surface with TBP for 2-4 s could effectively remove residual As atoms and reduce As carry-over into the next-grown InP. By purging the InP terminated surface with TBA, even though an effect of P carry-over is reduced, the structure becomes more suffered from diffusion of As atoms into the beneath InP layer.

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