Carrier dynamics in high quality GaSbBi/GaSb quantum wells emitting between 1.9 and 2.5 μm.

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GaSb quantum wells (QWs) with a small amount of Bi have attracted considerable attention driven by their interesting electronic properties suited for long-wavelength optoelectronics, solar cells, and spintronic devices. Incorporation of Bi reduces the bandgap of the host material and increases the spin-orbit interaction essential for, e.g. the control of a spin state. However, the Bi atom has a large size and therefore is hardly incorporated into the III-V compounds tending to segregation, forming Bi droplets, and defects. Consequently, electronic processes including carrier dynamics and general optical response of typical dilute bismides like GaAsBi/GaAs QWs were mostly defect-related. In this work, we show that alloying of GaSb and Bi lead to high crystal quality GaSbBi/GaSb QWs opening the rout to study carrier dynamics in dilute bismides without strong defect-related phenomena.

Here we studied low-temperature carrier dynamics and general optical properties of high-quality, molecular beam epitaxy grown GaSbBi/GaSb QWs with nearly 10% of Bi content and varied in the QW width from 7 nm to 15 nm. Carrier dynamics is studied by the non-degenerate pump-probe transient reflectivity (TR) technique and time-resolved photoluminescence (TRPL). The particular phase change of the TR amplitude across the pump pulse photon energy allowed to establish the fundamental absorption edge of each QW. Lack of strong energy difference between the absorption edge and the position of PL emission suggests that the PL is mostly determined by the density of states (DOS) in the nearest vicinity of the QW band edge and not the defect-related DOS. This conclusion is additionally supported by the lack of strong spectral dispersion of the obtained decay times. The decay times are short and much below nanosecond values[2] typical for dilute bismides, antimonides or nitrides. The average decay time for a 7 nm-wide GaSbBi/GaSb QW is ~260 ps, whereas for 11 nm, and 15 nm QW it is ~210 ps, and ~150 ps, respectively. Similar values are obtained for TR and TRPL experiments. Note, while the TR experiment can probe separate electron and hole dynamics, the TRPL fundamentally probes the joined e-h (exciton) dynamics. It suggests that observed decay time parameters are solely related to exciton dynamics and are weakly dependent on the electron or hole relaxation among defect-related DOS. Comparison of the obtained exciton lifetime (τ_X) to theoretically predicted values for QWs (free exciton lifetime of 10-50 ps for GaAs/AlGaAs QWs) further suggest the existence of a weak exciton localisation on the fluctuations of the QW potential rather than on defects. The fluctuations can be generated by the variation in the well width, chemical content, and strain. A theoretically expected trend also supports the scenario with weakly localised excitons in QWs where the τ_X decreases with the well width.

These experimental findings prove high quality of investigated GaSbBi/GaSb QWs. It allows tracking dynamics of weakly localised excitons in such QWs that is not hindered by the previously reported defect-related dynamics in dilute bismides.

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