Photoluminescence at up to 2.2 μm wavelengths from InGaAsBi/AlInAs quantum well

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III-V semiconducting alloys containing dilute amounts of bismuth have attracted increasing interest due to the large band gap reduction after the introduction of a relatively small content of Bi. It makes bismides promising materials for optoelectronic applications in the near and mid-infrared (MIR) spectral range [1-3]. It is known that the band gap of $GaAs_{1-x}Bi_x$ with x<0.05 reduces as fast as ~88 meV/%Bi [4]. Moreover, as the Bi-incorporation affects mainly the valence band, the spin-orbit splitting $\Delta\varepsilon_{SO}$ increases and for x>0.1 becomes larger than the energy band gap ε_g suppressing Auger recombination losses as well improving performance characteristics of light emitting bismide-based devices. Photoluminescence (PL) at wavelength of 1.5 μm from $GaAs_{1-x}Bi_x$ layer was already observed [4]. Even longer PL wavelengths (up to 6 μm) can be achieved in lattice-matched with InP substrate quarternary GaInAsBi alloy layers.

In this communication, the first results on GaInAsBi quantum wells will be presented. 5 nm, 10 nm and 20 nm thick $Ga_{0.53}In_{0.47}As_{1-x}Bi_x$ quantum wells were grown on (100) oriented InP:Fe substrates in a SVT-Associates MBE reactor at a temperature of about 240^{o}C. The top and bottom barriers of quantum structures were 50 nm and 100 nm-thick AlInAs lattice-matched with InP. The bismuth content in the wells was nominally 3.7%. Transmission electron microscopy images revealed sharp interfaces between the well and barrier layers and their rather good homogeneity. PL signals with a wavelengths reaching 2.2 μm were observed over the whole temperature range from 4 K to 300K. PL was stronger in thin wells, where relaxation and clustering effects were avoided. For the 5 nm and 10nm thick wells the PL peak energy dependences on the temperature were well described by the Varshni equation with fitting parameters significantly smaller than in other III-V semiconductors. For 20 nm thick well such dependence was "S-shaped" indicating the effects of carrier localization. These results show that bismuth containing compounds could be prospective materials for MIR light sources without antimony.

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