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Bismide technology for temperature independent IR range semiconductor laser diodes

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In recent years, promising results have been achieved in the development of GaAsBi quantum structure growth technology for optoelectronic systems, especially for lasers. Electrically pumped laser diode containing by molecular beam epitaxy (MBE) grown multiple quantum well (QW) structure of GaAsBi with 6% 4Bi in active area and operating at room temperature, was demonstrated by Butkutė et al. in 2014 [1]. Adding even a small amount of Bi to AIII - BV semiconductor lattice, such as GaAs, reduces Auger recombination in the IR wavelength range [2]. In addition, E_g has been shown to have weak temperature dependency in bismide compounds.

In this work, GaAsBi QW structures were grown using the MBE method on semiconducting GaAs (100) substrates. First, the MBE growth conditions of GaAsBi QW with AlGaAs barriers were optimized by varying the flux ratio As_2 / Ga in the range of 1 - 1.1. Low temperature growth (425 C) was used to introduce Bi to GaAs lattice and prevent surface segregation. The optical measurements showed that the intensity of the photoluminescence (PL) gradually decreases with increase of Bi concentration. PL temperature dependent measurements demonstrated the weak energy peak shift over the whole temperature range of 3 to 300 K (Fig. 1).

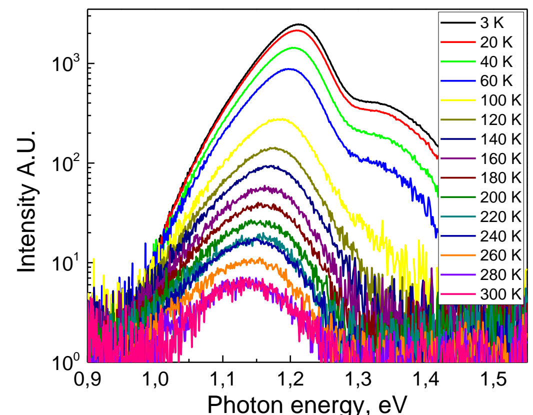

Fig. 1 Photoluminesce vs temperature dependence of GaAsBi quantum well based diode structure.

Finally, laser diode structures were grown under optimal growing conditions onto n-GaAs (100) substrate. The n-type and p-type AlGaAs waveguide layers were 1.5 μm thick and doped up to 1×10^{18} cm^{-3} by silicon and beryllium, respectively. GaAsBi / AlGaAs laser diode geometry was formed using UV photolithography. The diodes were characterized by current-voltage (I-V) and current-power (I-P) dependencies. Laser diodes with active GaAsBi / AlGaAs region showed electroluminescence at 1.09 μm.

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