Resonant cavity enhancement of light emission of InGaAs/GaAs LED

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In conventional LEDs it is difficult to achieve high quantum efficiencies. High difference between the refractive index of GaAs and the air results in low critical angle and extraction efficiency of the order of 2% for isotropic light source. On the other hand if the light source is placed in side a microcavity the emitted light is coupled to the cavity modes and if the proper design is applied it can be completely extracted [1]. In recent years due to development of the nano-scale semiconductors technologies a number of optoelectronic devices employing microcavity structures were proposed. The most notable examples of such devices are Resonant Cavity Light Emitting Diodes (RC LED) realized in the early nineties [2]. The main advantages of resonant cavity LEDs over conventional devices are higher emission intensities, higher spectral purity and more directional emission patterns. In RC LED the record external quantum efficiencies in excess of 20% have been reported [1]. All above mentioned features make RC LEDs attractive alternative for lasers in many applications.

In this paper we report on the InGaAs/GaAs RC LEDs. The devices were fabricated from the Molecular Beam Epitaxy (MBE) grown heterostructures. The cavity was constructed normal to the substrate plane by stacking the multilayer films including the active region, spacer and two dielectric mirrors. Such a structure forms a one-dimensional Fabry – Perot cavity resonator. A dielectric mirror was formed with a periodic stack of quarter wavelength thick layers of alternating (GaAs) high and (AlAs) low refractive index material. It is referred to as a distributed Bragg reflector (DBR). The active region consists of a GaAs spacer layer of the thickness equal to integer multiple of the half wavelength and of one or several $In_{0.2}Ga_{0.8}As$ quantum wells (QWs). The quantum wells were situated at the antinodes of the standing wave pattern. The optimization of the microcavity requires proper tuning of the wavelength of radiation emitted from the active region, the peak reflectivity of the DBRs, and the cavity resonance. This requires the extremely high precision of the thickness control. The thicknesses of the layers constituting the DBR have to be controlled within the single monolayers.

Here, we report on the successful MBE growth of the heterostructures and the fabrication of the resonant cavity enhance device. The microcavity impact on the emission properties of the devices is discussed along with the electrical consideration.

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