E-beam pumped resonant periodic gain GaInP/AlGaInP VCSEL

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Resonant periodic gain VCSEL with electron beam pumping is promising for laser cathode-ray tubes (LCRT) or as an efficient laser source for other display technologies [1]. The strong dependence of the laser characteristics on the period of the multi quantum well (MQW) structure and the parameters of the cavity may be a serious problem, resulting in poor uniformity of the laser power across the active element of the LCRT. This problem is the subject of our work.

17- and 25-period $Ga_{0.5}In_{0.5}P/(Al_{0.7}Ga_{0.3})_{0.5}In_{0.5}P$ quantum well structures were grown by MOVPE on GaAs substrates misoriented by 10^0 from (001) to (111)A. The period of 17- and 25 QW structure was intended to be equal to $3\lambda/2$ and λ respectively, where λ is the desired laser wavelength. On the top of each structure was a 4.5 μm thick AlGaInP passive layer. The GaAs substrate was removed by etching and each structure was fabricated into a microcavity with dielectric oxide mirrors. Lasing in the 619-644 nm spectral range with an output power up to 9 W was achieved under scanning electron beam longitudinal pumping at room temperature. The minimum threshold current density at an electron energy of 40 keV was 8 A/cm^2 which corresponds to a threshold density of nonequilibrium carriers per QW of about $3.5*10^{12}$ cm^{-2}.

Using the weak nonuniformity of the layer thickness across a structure, the influence of misalignment between material gain and MQW period on the threshold current, wavelength and output power of the laser were studied. Taking into account the temperature dependence of this misalignment, cathodoluminescence and laser characteristics were measured at different temperatures of the structure and laser active element from 77 K to 370 K. It is shown that a low threshold and high power lasing requires the position of the QWs to coincide with the antinodes of the cavity mode, at the maximum of the gain spectrum due to the QW ground state. To maintain a threshold within 10% of the minimum, the MQW period should be tuned within an accuracy of about 1% of the optimum value.

[1] V.I. Kozlovsky et al. Proc. of 12th Int. Symp. “Advanced Display Technologies: Basic Studies of Problems in Information Display (FLOWERS’2003), Korolev, Russia, August 25-28, 2003, pp.33-36.