Improvement of light-current characteristic linearity in a quantum well laser with asymmetric barriers

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Abstract—The effect of asymmetric barriers on the light-current characteristic (LCC) of a quantum well laser was studied theoretically and experimentally. It is shown that the utilization of asymmetric barriers in a waveguide prevents the nonlinearity of LCC and, consequently, allows rising of the maximum output power.

Keywords—semiconductor lasers; quantum well; asymmetric barrier layers; light-current characteristic; parasitic recombination

The performance of semiconductor lasers suffers from the parasitic recombination in a laser waveguide. Particularly, the parasitic recombination leads to decay in internal differential quantum efficiency $\eta_{in}$ with increase in pumping current $I$, which in turn results in deviation from linearity of light-current characteristic (LCC) of the device (i.e. output power $P$ sublinearly grows and saturates with current) [1]. In this work we use a novel approach to suppress the parasitic recombination in the waveguide by means of asymmetric barrier layers (ABLs). Each ABL is located nearby the active region and blocks the transport of only one type of charge carriers (Fig. 1a). Previously [2] we have demonstrated the improvement of near-threshold laser performance with the use of ABLs. In this work we investigate the effect of ABLs on LCC of a quantum well laser at high currents well beyond the threshold where a considerable deviation from linearity usually occurs. 830 nm lasers were synthesized on GaAs substrate with GaInP and AlGaInAs layers acting as ABLs for different types of charge carriers. Lasers of various stripe width and resonator lengths were measured. We also studied the effect of temperature on LCCs. It is found that ABLs can significantly improve the linearity of LCC and therefore considerably increase the output optical power (Fig. 1c). The influence of ABLs was also studied theoretically. Analytical expressions were obtained for $\eta_{in}$ and $P$ as a function of $I$, which allowed establishing the impact of ABLs in case of complete suppression of undesirable transport (Fig. 1d and 1e).

Fig. 1. Schematic energy diagrams for LA B (a) and reference laser without ABLs (b); (c) – measured LCC in LAB and reference laser; calculated internal differential quantum efficiency (d) and optical power (e) in ideal LAB and reference laser vs. injection current. Presented dependencies are for lasers at room temperature with 100 $\mu$m ridge width and 2 mm cavity length.

REFERENCES

This work was supported by the Foundation for Development of the Center for Elaboration and Commercialization of New Technologies – Skolkovo Foundation.