ANALYSIS OF LASER-STRUCTURE ANISOTROPIC SEMICONDUCTORS
BY THE BLOCH-FUNCTION METHOD

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The method of Bloch functions is used to obtain the radiation makeup of a semiconductor laser structure consisting of periodically alternating waveguide and antiguide regions, and the differential gains for the different modes are determined. Pumping of antiguide regions with different structure parameters makes it possible to obtain the maximum gains of a Bloch mode made up of "outflowing" waveguide modes at the center of the Brillouin lobe. The directivity pattern contains in this case sideband satellites in addition to the central lobe. When the structure is optimized, the intensity of the central lobe amounts to 70% of the total emission intensity.

1. INTRODUCTION

Much attention is being paid of late the problem of increasing the power of single-mode emission from semiconductor lasers (see, e.g., [1]). For all their attractive properties such as efficiency, operating speed, ease of tuning, compactness, service life, and others, it is difficult to monitor the mode composition of the emission of such lasers when the pump levels are high and the active medium volumes are large (and certainly multimode). The point is that in semiconductors there can easily develop above threshold a tremendous gain that contributes to the development of parasitic generation, especially if the desired mode does not consume the pump energy sufficiently uniformly over the volume (i.e., a spatial inhomegeneity factor comes into play). As to structures known to be single-mode, their volume is as a rule small and the single-mode power is limited by optical-endurance and heat-transfer factors (even though specifically, i.e., with respect to single-mode power from a unit volume of the active medium, semiconductor lasers are by far superior to other lasers).

The basic way of solving this problem is apparently to build up a large laser working volume by adding single-mode volumes in which the lasing is mutually synchronized. Such structures include phased multielement (multistripe) lasers. Experience with such structures shows that they are frequently subject to the onset of not too beneficial coupled modes. To quench the undesirable modes, the corresponding medium must have definite properties that can be analyzed within the framework of the Kronig–Penney problem, if the active medium has periodic properties in a direction transverse to the cavity axis. Thus, the task is to construct a semiconducting medium with a specified optical anisotropy that contributes to formation of modes having a desirable configuration, and to create for such modes the greatest advantages with respect to effective gain (i.e., to contribute to mode selectivity of the medium itself).

The most widely used method of describing collective modes of multilobe structures is the method of coupled modes [2, 3]. It should be noted that in this method the collective modes ("supermodes") are made up of coupled modes from individual waveguides. In this case one must exclude from consideration "outflowing" modes of individual waveguides. The method of Bloch functions can be used to analyze the supermodes (Bloch modes) made up either of coupled modes of waveguides or of outflowing modes. It will be shown below that such modes have a number of interesting properties and in some cases the maximum gain is obtained from phased Bloch modes that ensure a single-lobe structure in the far lobe of the emission. The present paper is devoted to an analysis of periodic laser structures by the Bloch-function method.

In Sec. 2 we describe the mathematical model and obtain the basic relations. In Sec. 3 are given the calculation results and their discussion.

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Fig. 1. Profile of dielectric-constant array.

Fig. 2. Dispersion of the real part of the propagation constant $\beta'(q)$ for array parameters: $\epsilon_0' = 12.25$, $\Delta \epsilon' = 0.2$, $l_1 = l_2 = 3 \mu m$. 