SINGLE-MODE GENERATION IN INJECTION LASERS

P.G. Eliseev and V.P. Strakhov
P.N. Lebedev Physics Institute, USSR Academy of Sciences
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Injection lasers based on GaAs offer many advantages over other types of lasers, especially when it comes to efficiency [1, 2]. Attempts were made recently [3, 4] to improve the spectral composition of the radiation, to permit the use of these lasers in spectroscopy and holography. Usually when the generation threshold is exceeded by 10 - 20% and more, several of longitudinal modes, occupying a band 5 - 10 Å, are observed in the spectrum. An analysis shows that the emission band of a GaAs laser should behave like a homogeneously broadened one [5]. Nonetheless, the ease with which multimode generation is excited indicates a deviation from homogeneity. A noticeable increase of the spontaneous emission intensity is also observed once the threshold is reached. For example, in [6] we obtained an increase of 60% on the short-wave line wing at a two-fold excess above threshold (approximate diode area 10^{-4} cm^2). A similar result was reported recently in [7].

We have proposed [6] that these deviations are connected with spatial inhomogeneities in the active region, one manifestation of which are the known generation "channels." To verify this, we investigated the influence of the resonator dimensions on the laser spectrum we used (cw lasers of the epitaxial type [2] at 77°, with thresholds 0.8 - 10 mA). The resonator was produced by cleavage on four sides. The diode cross section was close to quadratic. As seen from Fig. 1 with decreasing resonator dimensions it is possible to increase the relative threshold of multimode generation (i.e., the ratio of the threshold for the appearance of two or more modes to the threshold of the first mode) to 8 - 10 at an area smaller than 10^{-5} cm^2. The next observation shows that this effect is due not so much to the selectivity of the resonator as to the improvement of the conditions for uniformly filling the resonator. Figure 2 shows how effectively the growth of the intensity of the spontaneous emission is suppressed after the threshold is reached (2 mA) in a laser of small area; this growth does not exceed 5% and 25% for two-fold and five-fold excess above

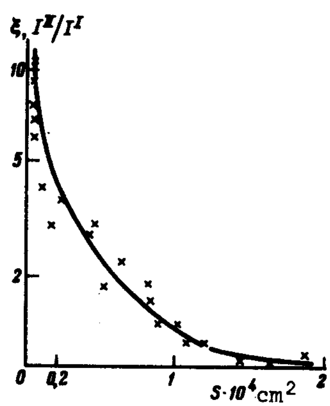

Fig.1

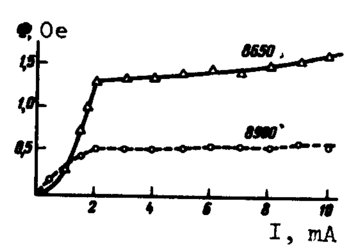

Fig.2

Fig. 1. Influence of diode area S on the relative threshold ξ of multimode generation in quadrilateral (square) resonators (the best results are given for each value of the area). 77°K, cw operation.

Fig. 2. Intensity φ in the wings of the emission band vs. the current I below and above the generation threshold (2 mA). Generation wavelength approximately 8700 Å, the wavelength in Å is indicated in the figure. 77°K, cw operation.

threshold, respectively. It follows therefore that inhomogeneities with a characteristic dimension close to 10^{-5} cm^2 make an appreciable contribution to the x excitation of the multimode generation (not only by contributing to independent channels, but also by stopping stationary generation by internal Q-switching, mode competition, etc.).

While a small-size laser cannot increase appreciably the power of single-mode generation, it does improve the ratio of the coherent-to-incoherent radiation intensity and can serve as a generator that drives a power amplifier. A similar behavior was observed in diodes of large resonator length but of width not larger than 20 μ. In this case about 100 mW of practically single-frequency cw emission was obtained at a threefold excess above threshold.

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