

LETTERS

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150-W, 808-nm quasi-cw diode arrays based on AlGaAs/GaAs heterostructures with improved thermal characteristics

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Abstract. **Laser diode arrays emitting at 808 nm with extremely high output parameters are manufactured. The 150-W output power of diode arrays at a pumping current of 146 A and a pulse duration of 0.2 ms is limited by the power supply current. The external differential quantum efficiency measured from the output mirror was 80 %, and the maximum total efficiency was 51 %.**

Keywords: *high-power diode array, quantum differential efficiency.*

1. Introduction

Laser diode arrays are among the main components of the pumping systems of solid-state lasers. The complexity of designing and production of diode arrays is associated with the fact that these are integral monolithic devices containing 50 – 100 single- or multistripe laser structures having a total width of 10 mm. Laser arrays of power 100 W or more can be manufactured only by providing a high uniformity of the output parameters of all stripe lasers. Otherwise, because of the local nonuniformities of the heterostructure parameters, resonator mirror defects or the assembly defects at pumping currents, as a rule, up to 100 A, one or more stripe lasers become inoperative, which leads to a degradation of the parameters of the entire array. From the point of view of practical applications, the diode arrays are subjected to stringent requirements, the most important among them being a high output power, a small variation in the radiation wavelength near the absorption band of the solid crystal being excited, a high total efficiency, a high reliability, and a long service life.

2. Construction of diode arrays

Laser heterostructures used for fabricating diode arrays were grown by MOCVD hydride epitaxy and contained AlGaAs/GaAs double heterostructures with separate carrier confinement and a single quantum well of width 10 nm. The planar array structure contains 50 stripe lasers with an active stripe width of 170 μm, separated by deep grooves with active layer etching to the *n* emitter to suppress the amplified spontaneous emission in a direction perpendicular to the direction of the resonator axis. Thus, the radiative aperture of the array comprises 85 % of the total width 10 mm. The diode arrays were assembled on Cu – W thermocompensators for matching the thermal expansion coefficients of the heat sink and the semiconductor crystal using an Sn-based 'hard solder'.

3. Experimental results

Laser diode arrays were pumped with an SDL-928 power supply. The output power and the energy per pulse were measured with a calibrated integrating sphere and an Ophir Nova power meter with a PE-25 pyroelectric head. During measurements, the temperature of the array case was maintained at 20 °C with the help of a thermoelectric cooler.

Typical threshold currents for the arrays were in the range 20 – 23 A (Fig. 1), while the average slope of the watt-ampere characteristics from the output mirror side was about 1.2 W A^{-1} for a pulse duration of 0.2 ms and a pulse repetition rate up to 100 Hz. The maximum power was 150 W for a pumping current 146 A and pulse duration 0.2 ms, which amounts to an average pulse power of 3 W from each of the 50 stripe lasers. The deviation of the watt-ampere characteristic from linearity for a maximum current 146 A and pulse duration 0.2 ms did not exceed 1.5 %. For a pulse duration of 1 ms, the maximum power was 140 W, and a significant deviation of the watt–ampere characteristics from linearity was observed for powers exceeding 120 W.

Fig. 2 shows the dependence of the total efficiency of the diode array on the pumping current. The maximum efficiency was found to be 51.5 % for a pumping current 100 A and pulse duration 0.2 ms.

The energy of the diode array per pulse was measured for a pump pulse duration in the range 0.2 – 1 ms with a step of 0.2 ms. The dependence of the pulse energy on the pumping current for various pulse durations is shown in Fig. 3. A noticeable deviation of these dependences from linearity was observed for pulse durations of 0.8 ms and more, which indicates to a high quality of assembly and a high uniformity of the parameters of the initial epitaxial heterostructure and of the fabricated active element of the laser diode array.

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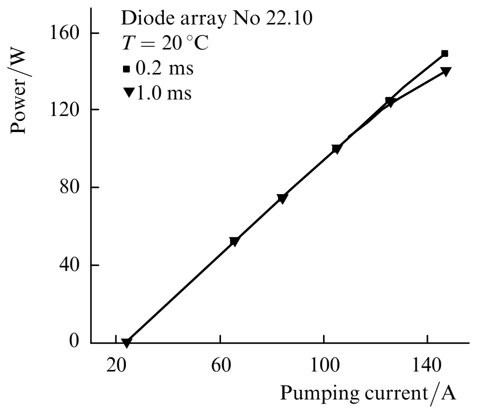

Figure 1. Watt–ampere characteristics of a laser diode array for a pumping pulse duration of 0.2 and 1 ms and a pulse repetition rate of 20 Hz.

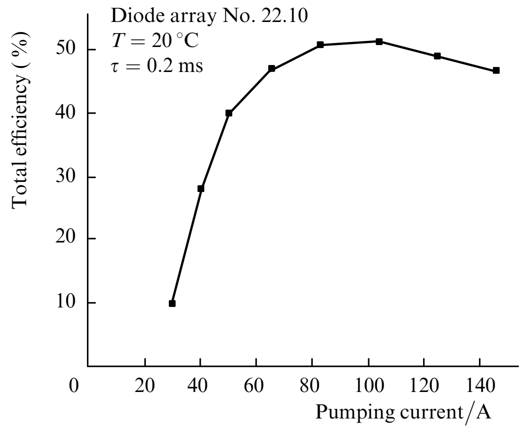

Figure 2. Dependence of the total efficiency of a laser diode array on the pumping current for a pump pulse duration of 0.2 ms.

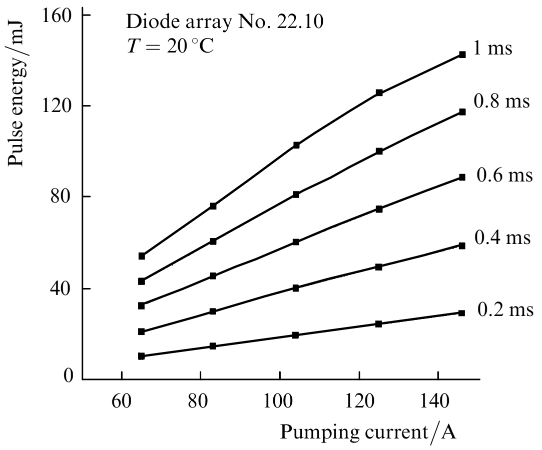

Figure 3. Dependence of the radiation pulse energy of a diode array on the pumping current for a pulse duration of 0.2 – 1 ms.

4. Discussion of results

The output parameters of laser diode arrays, such as the maximum output power, the external differential quantum efficiency, and the total efficiency, obtained by us have record values. These parameters are in principle superior to those presented in Ref. [1] and are better than the parameters of the arrays manufactured by leading companies [3] (a maximum power of 120 W was attained for a pulse duration of 0.2 ms).

Training of the diode arrays during 10^6 pulses produced no changes in the output parameters. In our opinion, this was achieved due to a series of measures. First of all, considerable efforts were made to optimise the process of MOCVD hydride epitaxial growth, which resulted in a more than 50 % total efficiency of the structures [2]. The planar processes of fabricating the active element and the technique of producing cavity mirrors were refined and developed. Finally, the process of assembly of diode arrays was improved, primarily owing to the use of Cu – W thermocompensators and 'hard solders', which improve the thermal contact of the crystal with the heat sink in the absence of mechanical stresses in the laser crystal. An important role was played by the improvement of metrological equipment for testing the output parameters of the diode arrays. The high output power obtained in the 808-nm diode arrays for large pump pulse durations raises hopes of attaining similar radiative parameters in diode arrays operating in other spectral ranges intended for pumping crystals with the fluorescence lifetime up to 1 ms.

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