Modeling of a CW Nd:YVO₄ laser longitudinally pumped by high power VCSEL modules at 808 nm

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Recent progress in high power vertical-cavity surface-emitting lasers (VCSEL) and their unique features make them a good alternative to edge emitting laser diodes for longitudinal pumping of solid-state laser gain media. In comparison with edge emitting laser diodes, VCSELs have low threshold current, wavelength stability with temperature variation, low fabrication cost and circular beam shape. Stability of wavelength with temperature variation results in a simplified cooling system of laser pumps as well as increased laser reliability when operating at high temperatures.

On the other hand, among the variety of Nd-ion based gain media, crystals of Nd:YVO₄ have relatively high absorption cross section and narrow absorption line width at 808 nm. Therefore, narrow emission bandwidth and wavelength stability of VCSELs against changes in temperature make them an attractive optical pump source for longitudinal excitation of Nd:YVO₄ lasers at 808 nm.

In our numerical model, commercially available 6W and 15W VCSEL modules were studied as the pump sources for a CW Nd:YVO₄ laser. To the best of our knowledge, this is the first time that VCSELs were considered and analysed for longitudinal pumping of a CW laser. For each case the optimum output couplers were determined. Next, the calculations of slope efficiency, maximum output power and optical-to-optical efficiency were carried out. For example, for a 6W VCSEL, the maximum output power reached 2.5W with a slope efficiency of 48% using a 10 % output coupler. In this case the optical-to-optical efficiency was found to be 42%. For a 15W VCSEL, using a similar output coupler, the maximum output power of 6W was reached with a slope efficiency of 47% and optical-to-optical efficiency of 40%. Our results indicate that VCSELs can serve as efficient pump sources of the CW Nd:YVO₄ lasers. A comparison with pumping of a Nd:YAG crystal will be also presented.