

Development of Diode Lasers for Pumping High Power Ultrashort Pulse Lasers

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Ultrashort pulse lasers have found increased applications in material processing with particular emphasis on laser-based micromachining applications, biomedical areas such as hard tissues ablating, and military fields. A new era of ultrashort pulse lasers was started when diode laser pumping gradually became more and more feasible, especially after the “high-power diode lasers” became available. In recent years, more and more wavelengths were covered by high-power diode lasers so that a large variety of solid-state laser and fiber laser materials could be diode-pumped or became good candidates for direct diode pumping. Diode lasers are playing a key role in the technology advancement and wide spread application of high power ultrashort pulse lasers. On the other hand, high power ultrashort pulse solid state lasers and fiber lasers demand higher performance and more reliable diode lasers to be developed. To achieve high pumping efficiency and reduce the thermal load of a high power ultrashort pulse laser, the spectrum of the pumping diode laser should be narrow enough to be mostly within the absorption region of the gain medium and more importantly the wavelength of should be kept near the absorption peak of the gain medium over the operation temperature and condition. Also the beam uniformity and brightness of the pumping source significantly affects the beam quality of a high power ultrashort pulse laser. Furthermore, for different applications, the requirements of the pumping diode lasers are different. In this paper, the development of diode lasers for pumping high power ultrashort pulse solid state lasers and fiber lasers is reviewed and discussed. We review the technology development trend of high power semiconductor lasers, including single emitters, bars, horizontal bar arrays and vertical bar stacks. We will discuss the strategies and approaches to achieve high output power, high brightness, narrow spectrum, low “smile” and long lifetime. Different diodes pumped ultrashort lasers and amplifiers are demonstrated to illustrate the effect of the pumping diode lasers. For example, the shortest pulse with 150fs are generated in Yb fiber laser with ring cavity and intracavity dispersion control using the single mode(SM) diodes with stable narrow linewidth by fiber grating. After two-stage dispersion compensation, the clean shortest pulses less than 30fs are generated. In high average power fiber amplifier, the largest pulse energy of 150uJ are generated at 30kHz with pulse width of 525fs after bulk grating compressor using high power multimode diodes by large size pigtailed fiber.