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A millijoule-level q-switched Nd:YLF laser pumped by high-power LEDs

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A Nd:YLF laser pumped by high-power LEDs

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Right now, high-intensity and high-energy laser systems are pumped by flash lamps or laser diodes. The flash lamps have a very large emission bandwidth (>2000 nm), which makes them inefficient and limits the repetition rate of the laser, while the narrow-bandwidth laser diodes (2-6 nm) remain very expensive (30-50$/W). These characteristics are problematic for the application for laser-driven fusion, because a commercially-functioning power plant would require high repetition rates, high efficiency and low costs. In this contribution, we focus on the question if LEDs can serve as a good compromise between flash lamps and laser diodes.
In the past years, LEDs have developed tremendously as well as in cost as in performance. For example, the price for light (per kilolumen) dropped by a factor of 15 over the course of the last decade, driven by the lighting industry. In addition, the performance/efficiency increased over time. They have an acceptable bandwidth (20-60 nm), so there is significantly less unnecessary energy deposited in the amplifier material compared to flash lamps. In comparison to the laser diodes, they are a lot cheaper (20-40 ct/W). However, LEDs still exhibit low emission power densities, which has been regarded as a challenge for laser applications. A work around is the possibility to overdrive LEDs in pulsed operation mode, which has received little attention so far.
In this contribution, we report, to the best of our knowledge, on the first millijoule level Nd:YLF laser directly pumped by high-power LEDs. The laser works in cavity dumped q-switch mode. It exhibits near diffraction limited operation (Mx=1.08 and My=1.15) with a maximum pulse energy of 3.6 mJ (maximum small signal gain of 1.223). The pulse fluctuations are 2.3 % (standard deviation over mean) at a repetition rate of 0.5 Hz.
In addition, we developed a first generation of pulsed LEDs together with OSRAM, which were tailored for our application. The new LEDs have an emission wavelength centered around 800 nm and they exhibit a significantly increase in power density, reaching up to 120 W/cm2 in a 600 ms pulse. This should improve the laser performance dramatically. In total, we have three different LEDs with 3 different wavelengths to match absorption peaks of the gain medium.
Future plans include to implement the new asm-OSRAM LEDs to enhance the overall performance of the laser. It is also planned to change the design to enable cooling to enhance the repetition rate. It is also desirable to implement index matching to couple the LED light better into the gain medium. We also want to use the setup to pump Nd:Glass, to show that the method of direct pumping is now feasible for Nd:Glass.

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