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Time-multiplexing generates a diode laser beam with high beam quality

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Abstract

The beams of four pulsed high-power laser diodes are time-multiplexed resulting in a laser beam of high quality. A combination of polarization switches and filters forming a digital time-multiplexer is utilized to guide laser pulses produced by the individual laser diodes onto a common optical path. A resulting beam with an optical power of 10 W and a beam quality comparable with that of a single laser diode at a wavelength of 960 nm is obtained.

Keywords: Time-multiplexing; Diode laser; Beam quality

1. Introduction

Due to their compactness and high efficiency diode lasers play an increasingly important role in modern industrial manufacturing. Soldering, brazing, welding of plastics, hardening, cladding and heat conduction welding are their main applications.

Unfortunately the poor beam quality of diode lasers limits or prevents their use in applications like cutting of metals, marking or drilling.

The performance of a laser depends not only on its optical power but also on focusability, which can be characterized by the so called beam parameter product (BPP). It is defined as the product of the beam-radius in the beam waist w_0 and the far-field divergence angle Θ_0 (half width at $1/e^2$) [1], $\mathrm{BPP} = w_0 \Theta_0$. A small BPP corresponds to high beam quality and focusability. For the astigmatic diode laser beam an average BPP $\langle \mathrm{BPP} \rangle$ can be defined as the geometric mean of the values for the slow and the fast axis.

The main reason for the poor beam quality of diode lasers is the incoherent combination of light emitted by many beam sources [1]. One way to improve beam quality is coherent coupling of laser diodes, which had limited success up to now [1]. We suggest time-multiplexing, so far only proposed for solid state lasers [2] and CO_2-lasers [3], as a new method to combine individual laser diode beams. In the described setup laser diodes are emitting laser pulses with high peak power, operated such that one diode after another emits a pulse. The pulses are directed onto a common optical path by means of a fast scanner. The resulting pulse train has the same beam quality as a laser beam produced by only one laser diode but an average beam power comparable to the high peak power of the laser diodes.

2. Scheme of time-multiplexing

For an effective use of time-multiplexing a very fast scanner is needed, so we use an inverse digital scanner based on electro-optics [4]. A schematic diagram of our experimental setup for multiplexing of four laser diodes is depicted in Fig. 1.

The multiplexer consists of a combination of two half-wave-plates, three polarization filters and two polarization switches (Pockel's-cells) made of $LiNbO_3$-crystals. The polarization of linearly polarized light passing the crystal can be turned by 90° by applying the half-wave-voltage to the electrodes of the switch. Fig. 2 shows the switching sequence: The voltage across the switches is turned on and off with constant frequency and equal on- and off-times. During a period without applied voltage the laser diodes 1 and 3 emit a pulse. The light from laser diode 1 is

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