Collimating laser diodes with hybrid optics

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Although conventional optics (refractive components) for laser diode collimation usually consist of several elements, their ability to correct wavefront aberrations (astigmatism, etc.) are limited. Diffractive elements in principle allow to generate any wavefront, but they show severe dispersion, diminishing the quality of a holographic Laserdiode collimator. An optical system with diffractive and refractive elements may combine the advantages of both concepts (arbitrary wavefront correction and low dispersion). Furthermore this concept helps to reduce the number of optical elements resulting in miniaturized optical systems.

The aim of our investigation is to transform the divergent laser beam emitted by a high power laser diode (HPLD: 250mW, 807nm) in order to increase the efficiency of a HPLD pumped solid state laser. In general it is difficult to correct and collimate the laser beam, because HPLDs show higher order modes depending on the injection current and the diode temperature. Each mode has its own characteristic wavefront.

Our experiments, however, show that for a fixed injection current and temperature the laser diode emits a wavefront belonging to one dominant transversal mode, which contains most of the energy (more than 70%). We identified the dominant mode as the 5th order Hermite Gaussian polynomial. Therefore the corresponding wavefront can be corrected by a three stripe binary phase plate (see Fig. 2). The phase plate concentrates the light energy on the optical axis. Thus the collimation optic consist of a gradient index (GRIN) lens (pitch length 0.23) with the phase plate on the front side of the GRIN lens. The collimating optic is placed 0.1mm in front of the laser diode with the phase plate designed to make a $-\pi$ phase shift where the phase of the propagating dominant mode is π (stripe width $11\mu m$, $11\mu m$ and $19\mu m$). We simulate the propagation of the wave with a Fourier transform to get the far field intensity distribution (Fig. 3, Fig. 4).

Experimentally the far field intensity distribution of the corrected and the uncorrected wave were verified and preliminary results are given in Fig. 5 and Fig. 6. They show that the beam energy of the corrected wave is collimated on the optical axis.

In future we intend to improve the laser diode collimation by a second diffractive element placed on the back side of the GRIN lens correcting remaining wavefront aberrations.

Fig. 1: Near field amplitude distribution
5th Hermite Gaussian polynom

Fig. 2: Near field phase distribution
5th Hermite Gaussian polynom

Fig. 3: Corrected far field intensity
distribution (simulation)

Fig. 4: Unco. rected far field intensity
distribution (simulation)

Fig. 5: Measured far field intensity
distribution with phase plate

Fig. 6: Measured far field intensity
distribution without phase plate