Power scaling of high power lasersystems

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1 Summary

The increasing consciousness on the ongoing climate change is pushing the demand for more efficient, energy saving, and CO_2 emission cutting technologies. Photonics is known to be one of the key technologies that can help not only to make whole productive sector cleaner and more efficient, but also to enable its entry into the circular economy. In particular, the high power laser technology has the potential to revolutionize, among the others, the materials processing and the entire manufacturing industry. However, in doing so, an increasing request for a combination of higher efficiency, beam quality, and brightness will have to be satisfied.

In this monograph several techniques and approaches to scale up the output power of laser systems are analyzed.

In more detail, in Ch. 1 the coherent multiplexing approach is numerically analyzed exploiting a new "ad hoc" introduced wave optic framework.

In Ch. 2, the spectral multiplexing approach is discussed. This represents an alternative, less complicated, thus less expensive, multiplexing technique, suitable for applications in which the spectral purity of the beam is not crucial. Spectral multiplexing is particularly interesting for the power scaling of high-power laser modules made by the combination of a number of single chips in a common package – the so-called "multiemitters". In this chapter, first, the spectral multiplexing is theoretically evaluated through a stochastic model. Then, using the developed framework, the design and experimental characterization of a family of multiemitters is reported.

Since the spectral multiplexing requires starting from beams with a narrow and stable spectrum, which is not the case of high-power semiconductor laser chips, prior to its use it has been necessary to investigate the spectral stabilization of laser diodes with external cavities. This is discussed in Ch. 4, where, to the extend of the author's knowledge, a novel spectral stabilization approach, based on the use of fiber Bragg gratings manufactured by direct point-by-point inscription through femtosecond laser pulse in highly multimode optical fiber, is experimentally presented for the first time.

Finally, Ch. 5 presents the conclusions and provides an outlook on future perspectives of the activities carried out during the three year work.