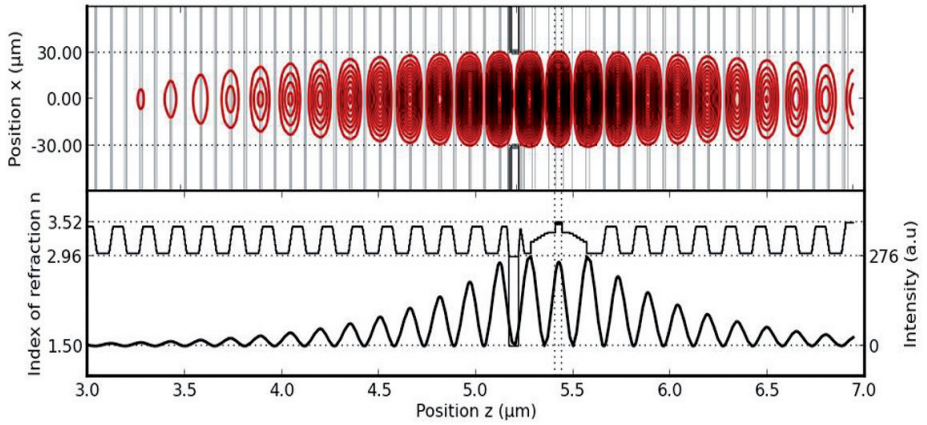

1

MODELLING AND SIMULATING SURFACE-EMITTING SEMICONDUCTOR LASERS

Task

Thanks to their advantages – lower manufacturing costs, modularity, symmetry of the beam profile and the simple implementation of arrays – surface-emitting semiconductor lasers with vertical resonators have been able to successfully compete against conventional edge-emitting models. Monolithic emitters (VCSEL) with output power of a few mW have long been used for optical data transfer and sensor technology. By means of arrays from high power emitters, output power in the range of several kW at low brightness can be reached. Emitters of high brightness and medium output power can be made when the semiconductor chip is combined with external resonator optics. To date, optically pumped single emitters (OPSL), with up to 100 W output power in the fundamental mode, could be demonstrated. Electrically pumped emitters with external resonators (VECSEL) represent a promising compromise between reducing the complexity of the beam source and its brightness. In the last three years, simulation software has been developed at Fraunhofer ILT for Philips Photonics to optimize resonator geometries and semiconductor layer structure of single mode VECSELs.

Method

To optimize the single mode VECSEL, simulation software was developed to predict the power and emission characteristics in dependence upon the operating parameters as well as upon the geometry parameters of the resonator and the composition of the semiconductor heterostructure. The model approach consists of solving microscopic equations to calculate the resonator eigenmodes, the band structure and gain spectrum of the active layers as well as the light-medium interaction. Electrical and thermal characteristics are taken into account through phenomenological laws, whose parameters are identified experimentally.

Result

In close cooperation with accompanying experimental work, the tendencies observed in the laboratory, or favorable resonator geometries in dependence upon the quality of the epitaxial material, could be understood. In addition, a central design criterion could be identified for dielectric layers for lateral current confinement (oxide aperture) with good optical properties in VECSELs. Subsequent to the cooperation, the output power of the single mode VECSELs from Philips Photonics could be increased by a factor of four.

Applications

Potential fields of application of VECSELs are pumping solid-state lasers, laser materials processing, printing and lettering technology as well as spectroscopy.

Contact

Dipl.-Phys. Thomas Schwarz
Telephone +49 241 8906-657
thomas.schwarz@ilt.fraunhofer.de

Dipl.-Ing. Hans-Dieter Hoffmann
Telephone +49 241 8906-206
hansdieter.hoffmann@ilt.fraunhofer.de

1 Numerically calculated fundamental mode of a VECSEL.