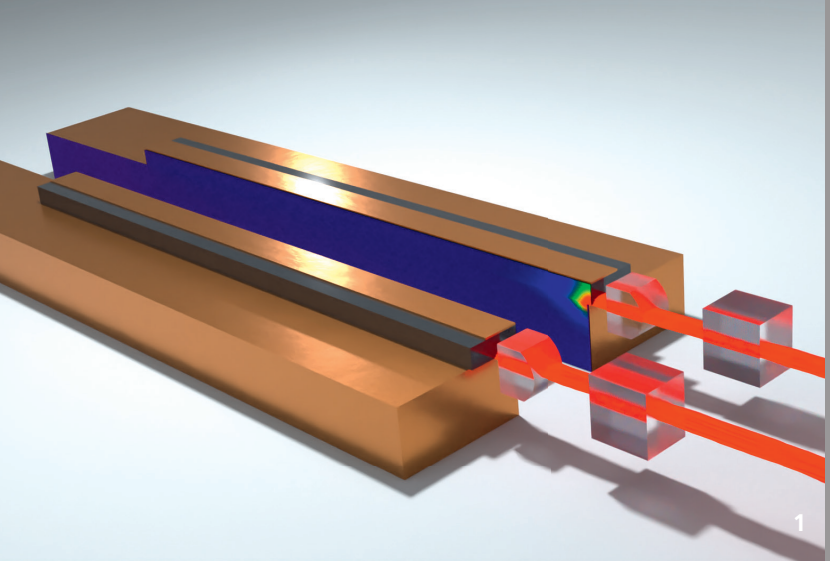

MODELING AND SIMULATION OF HIGH-POWER DIODE LASERS

Task

Diode lasers – either edge-emitting diode lasers (EEDL) or vertical-cavity surface-emitting diode lasers (VCSEL) – are the preferred laser beam source in a wide range of applications. At Fraunhofer ILT, computer simulations are used to optimize EEDLs and VCSELs with a focus on increasing output power and radiance. EEDLs are currently limited in their output power by the catastrophic optical damage (COD) threshold, while the limitations of VCSELs result from the smaller laser active volume and the reabsorption of laser radiation in the current-conducting, doped layers of the diode. Currently, Fraunhofer ILT is focusing its research on understanding the COD mechanism in EEDL as well as on increasing the light yield in VCSEL by stacking several active layers with so-called tunnel diodes.

Method

To analyze and optimize high-power diode lasers, Fraunhofer ILT is developing simulation software (SEMSIS) for the multiphysics simulation of EEDLs and VCSELs. Among other things, this software includes modules for simulating heat and electrical transport, for calculating the optical eigenmodes of the microcavities, and models for analyzing the properties of the light-amplifying quantum films. The institute is continuing to develop SEMSIS for our industrial partners.

1 Edge emitting laser diodes with external cavity (ECDL).

2 Structure of a VCSEL single emitter.

Furthermore, Fraunhofer ILT is combining it with commercial software tools for isolated or coupled simulation to identify improved heterostructure designs, contact geometries or external optical systems for partial feedback of the emitted radiation.

Results

Fraunhofer ILT has developed a more detailed understanding of the COD mechanism for free-running EEDLs as well as ECDLs (external-cavity diode laser), as compared to the state of the art. Furthermore it has identified improved designs for EEDLs with reduced slow axis beam divergence and radiance limiting factors of VCSEL single emitters with external resonators. Currently, it is helping develop a next-generation lidar system by running simulations on the electrical transport in VCSEL single emitters with tunnel diodes and on the thermomechanical properties of the VCSEL array with integrated silicon driver chip. In addition, it is designing the transmitter optics.

Applications

EEDLs with optical feedback are used as pump light sources for fiber and solid-state lasers, and VCSEL emitters are used in lidar sensors and direct material processing, among other applications.

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