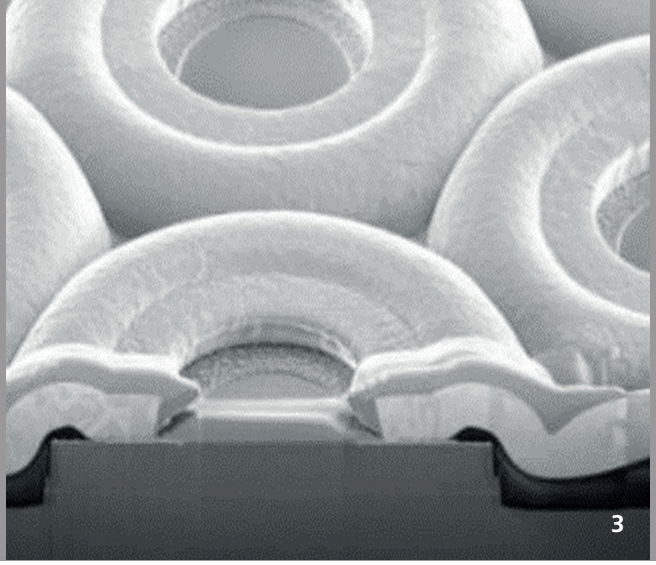
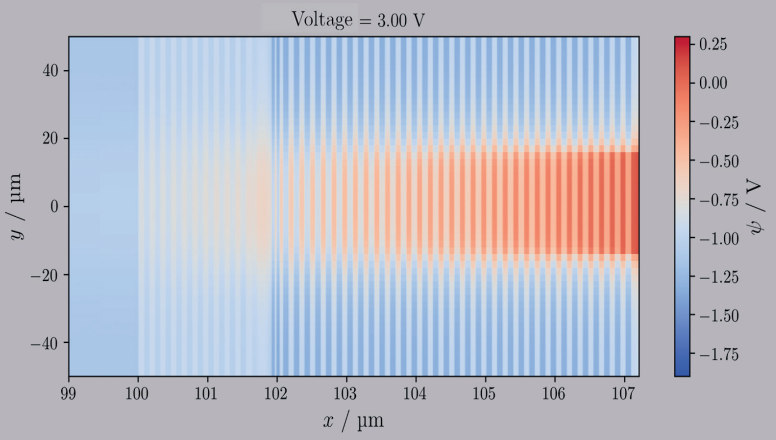


3




4

# MODELING AND SIMULATION OF VERTICAL-CAVITY SURFACE-EMITTING LASERS

## Task

Vertical-cavity surface-emitting lasers (VCSELs) constitute an increasingly important alternative to edge-emitting laser diodes. Despite their low manufacturing costs, diffraction-limited, narrow-band emission and excellent modulation capability, VCSELs were only used for optical data transmission and sensor technology for a long time since the good beam quality could only be generated at single mW per individual emitter. For several years now, Fraunhofer ILT has been working in close collaboration with TRUMPF Photonic Components GmbH to improve VCSEL for high-power applications. In addition to increasing the brightness of high-power VCSEL by means of external resonators, Fraunhofer ILT's activities are currently focusing on developing chip designs for selectively addressable VCSEL arrays of high pulse energy for use in driver assistance LIDAR systems.

## Method

Fraunhofer ILT is developing the SEMSIS software to simulate, either isolated or coupled, various physical phenomena relevant to semiconductor lasers. These include electrical as well as heat transport and light propagation in semiconductor nanostructures or the optical properties of light-amplifying quantum well structures. In close connection with experimental work, Fraunhofer ILT is using computer simulations to investigate real or potential semiconductor laser structures in terms of the achievable laser parameters.

## Results

The software enables users to develop a fundamental understanding of the specific laser parameters and their limiting effects as well as the design of novel semiconductor structures, all of which are optimized with respect to beam quality, output power or pulse parameters. Thus, they can significantly reduce cost- and time-consuming parameter studies on real manufactured semiconductor lasers.

## Applications

In addition to the classic fields of application – optical data transmission and sensor technology – these vertical cavity emitters are increasingly being used in high-power applications, e.g. in the heat treatment of materials. Since selectively addressable VCSEL arrays can be used to dynamically generate flexible intensity profiles, they have become interesting beam sources for digital production in addition to their use in the driver assistance LIDAR systems investigated here.

Parts of the work presented in this report were carried out on behalf of the Federal Ministry of Education and Research under the grant number 13N14895.

## Contact

Dipl.-Phys. Thomas Schwarz
Telephone +49 241 8906-565
thomas.schwarz@ilt.fraunhofer.de

Dipl.-Ing. Dipl.-Wirt.Ing. Martin Traub
Telephone +49 241 8906-342
martin.traub@ilt.fraunhofer.de

*3 SEM image of a VCSEL array.*

*4 Simulation of the spatial distribution of the electrostatic potential in a VCSEL semiconductor heterostructure.*