

# Preface

Vertical-cavity surface-emitting lasers (VCSELs) are firmly established in the laser diode market for about 15 years meanwhile. It took about 17 years before these devices were commercialized. Multimode fiber optical networks with data rates in the 1 Gbit/s range were the initial market. In 2004, VCSELs were first incorporated in optical computer mice. Today, these two application areas approximately equally share a production volume of almost 100 million units per year. In future, high volumes can be expected also, e.g., for diverse sensing and illumination purposes, the latter using high-power laser arrays.

Enormous progress in VCSEL performance has been witnessed over the last ten years. In particular, digital data rates of 10 Gbit/s are now routinely achieved, and 25 Gbit/s is the next step to be taken very soon. As for the first commercial devices, emission wavelengths of 850 nm are still dominating both for optical datacom and optical mice. However, also 1.3 and 1.55  $\mu\text{m}$  wavelength VCSELs for telecommunications have reached a high level of maturity. On the long-wavelength side, electrically pumped devices are available up to about 2.4  $\mu\text{m}$ . For short wavelengths, a major breakthrough was achieved in the year 2008 with the first continuous-wave room-temperature operation of a GaN-based VCSEL at about 414 nm wavelength. A pulse-mode electrically driven VCSEL with green emission at 503 nm was demonstrated in the year 2011. Large-area two-dimensional arrays are now exceeding previous expectations with conversion efficiencies of about 50% and continuous-wave output powers of some hundred watts for wavelengths of approximately 800 to 1100 nm.

This book covers basic VCSEL concepts as well as the state of the art in modelling, performance, and application areas of VCSELs. Single-mode emission, polarization dynamics and control, high-speed operation, high-power generation, high-contrast grating devices, blue, red, and long-wavelength spectral regimes, wavelength tuning, fiber-optic transceiver, video link and parallel optical link technologies, as well as optical mouse sensors and laser printing are described in some detail by distinguished experts in the respective fields. The text is not only suited for scientists and engineers who develop and apply VCSELs, but also for

graduate students who strive to deepen their knowledge about most modern semiconductor laser diodes.

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