Optimizing of VCSEL photon lifetime for minimum energy consumption at varying bit rates

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The explosive growth of internet use leads to an explosion of the energy

consumption of data centers. Vertical cavity surface emitting lasers (VCSELs) are key enabling devices meeting the requirements of optical interconnects in such data centers up to a few hundred meters of single or multimode fiber due to their simplicity, low cost, and large data transmission rates. Achieving higher bit rates has been the stated goal of research and development during the last years.

The next challenge will be to focus on reducing the energy consumption of the lasers and drivers—a function of the bit rate. The energy cost of transmission at potentially the largest possible bit rates, use of predistortion or forward error correction needs to be compared with the energy cost of data transmission and device life time at lower bit rates. Finally, end of life considerations of the total cost of data centers will move the focus of operators of such centers.

Recently, Prof. Bimberg's group at Bimberg Chinese-German Center for Green Photonics Changchun at Institute of Optics, Fine Mechanics, and Physics, Chinese Academy of Sciences has developed VCSELs emitting at 850 nm, 880 nm, 910 nm, 940 nm, which were optimized to achieve 50+ Gb/s, enabling 200+ Gb/s data transmission across a multimode fiber. This was based on the PAM2-modulation scheme without any kind of predistortion leading to a spectral efficiency around 2 bit.

Furthermore, by optimization of the maximum bit rate of a system, the device lifetime, and the system's energy consumption, this group has demonstrated that 200 Gb/s transmission also can be achieved by using eight lasers with 25 Gb/s each. At 25 Gb/s EDR is even lower than 100 fJ/bit, presenting a 75% reduction as compared to the 50 Gb/s values. For the same BR of 200 Gb/s 50% energy reduction is achieved, although the number of devices has been doubled. In addition, the current density at operating conditions is reduced by 60% and risk of device failure is reduced.

Longer device lifetime together with the reduction total energy consumption by 50% will overcompensate the cost of doubling the number of devices. Lower power consumption leads to less heat, and temperature induced roll-over of the output power occurs at larger currents. Finally, less energy for cooling needs to be provided. Thus, the end of life cost is increased dramatically by choosing two lasers at a medium bit rate instead of one laser operating at maximum technically possible bit rate.

More information: Gunter Larisch et al, Optimization of VCSEL photon lifetime for minimum energy consumption at varying bit rates, *Optics Express* (2020). DOI: 10.1364/OE.391781

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