

# Energy-efficient Surface Emitting Lasers, the Next Huge Photonics Market after LEDS

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**Abstract**— VCSEs are spanning today wavelength ranges from UV to IR. Quantum jumps in materials growth and processing technologies are the enablers. For each wavelength window there exist specific applications, like material ablation cutting, drilling for UV lasers. The largest growth rates are reported for near IR-lasers based on the GaAs and InP-material systems. In addition the GaSb-material system is emerging.

Sensor arrays based on VCSEs are omnipresent in mobile phones and are conquering the automotive market, inside and outside cars, e.g., LIDAR. Since 2018 novel consumer applications like Netflix, Block Chain, 5G and 6G . . . and most recently AI not known at 10 years ago have led to a huge increase of internet traffic of 60%/year. This increased use of the internet is increasing its electrical power consumption due to increased data traffic mostly inside data centers. The energy consumption of new data centers has crossed the 500 MW level, equivalent to the power produced by one block of a standard nuclear power plant. This unsaturated increase of energy consumption to an extent not further tolerable enforces development of novel **green** device technologies, in particular for GaAs-and InP-based devices. Some recent brake-throughs on energy-efficient device designs based on these material systems are reported here [1–5]. Our new designs are expected to allow for the first time more energy efficient dense wavelength multiplexing across distances of several hundred m to 1 km in data centers.

Dieter Bimberg received the Ph.D. magna cum laude from Goethe University, Frankfurt, Germany. He held for 7 years a Principal Scientist position at the Max Planck-Institute for Solid State Research, Grenoble, France. After serving as a Professor of Electrical Engineering, Technical University of Aachen, Germany, he assumed the Chair of Applied Solid-State Physics at Technical University of Berlin. He is the Founding Director of its Center of NanoPhotonics. He was holding guest professorships at the Technion, Haifa, U.C. Santa Barbara, CA, USA, and at Hewlett-Packard in Palo Alto, CA. He was Distinguished Adjunct Professor at KAU, Jeddah 2012–2018. In 2018 he was appointed



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He is a member of the German Academy of Sciences Leopoldina, the EU Academy of Sciences, a Foreign Member of the Russian Academy of Sciences, the US Academies of Engineering and of Inventors, Fellow of the Chinese Optical Society, a Life Fellow of the American Physical Society and the Institute of Electrical and Electronics Engineers, IEEE, a Fellow of the Chinese Optical Society, Vice-President of the International Artificial Intelligence Association and a honorary member of the Ioffe Institute of the RAS. He is recipient of many important international awards, like the UNESCO Nanoscience Award, the Max-Born Award and Medal of IoP and DPG, the Heinrich-Welker-Award, the Nick Holonyak Jr. Award, the Oyo Buturi and MOC Awards of the Japanese Society of Applied Physics, the Jun-Ichi Nishizawa Medal and Award of IEEE, the Stern-Gerlach Award of DPG (the highest German physics award), to mention a few. He received honorary doctorates of the University of Lancaster, UK, and the St. Petersburg Alferov University of the Russian Academy of Sciences.

He has authored more than 1600 papers, 71 patents and patent applications, and six books. The number of times his research works has been cited exceeds 69,000 and his Hirsch factor is 115 (@ Google Scholar). His research interests include physics and technology of nanostructures, nanostructure based photonic and electronic devices, and energy efficient data communication.

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