VCSEL Review 2
Principle, Device Physics, and Merits for Applications

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*) **The New Name of Tokyo Institute of Technology after merging with Tokyo Medical and Dental University**

Abstract

In this review talk, we will trace the development of the vertical-cavity surface-emitting laser (VCSEs) from its conception by the author in 1977 to their significant role in today's social life. We will begin with explaining the basic concept of the VCSEL, followed by a discussion on its principle. We learn principal device physics, including resonant cavities, active regions, highly reflective distributed Bragg reflectors (DBRs) and high-contrast grating (HCG) reflectors, threshold conditions, power output, direct modulation, noise, and arrays. From a device perspective, we will explore the technologies of current and optical confinement. We will then introduce the advantages and characteristics of VCSELs for various applications. Finally, we will highlight the key features of these applications and how their underlying principles are utilized in communication and sensing technologies. If time permits, we will also discuss on micro-cavities and photon behavior connecting to quantum technology.

Kenichi Iga received his Bachelor of Engineering (B.E.) degree in 1963, his Master of Engineering (M.E.) degree in 1965, and his Doctor of Engineering (Dr. Eng.) degree in 1968, all from the Tokyo Institute of Technology. He joined the P&I (Presently FIRST) Laboratory at the Tokyo Institute of Technology in 1968, became an Associate Professor in 1973, and was promoted to Professor in 1984. After a distinguished career, he retired in March 2001 and was honored with the title of Professor Emeritus. Dr. Iga served as Executive Director of the Japan Society for the Promotion of Science (JSPS) from April 2001 to September 2007. He then served as President of the Tokyo Institute of Technology from October 2007 until September 2012. Additionally, he spent time at Bell Laboratories as a Visiting Technical Staff Member from 1979 to 1980.

Professor Iga is renowned for his pioneering research on vertical-cavity surface-emitting lasers (VCSELs) and microoptics. His contributions to the field have been recognized with numerous prestigious awards, including the Ichimura Award in 1990, the IEEE/LEOS William Streifer Award in 1992, the IEEE/OSA John Tyndall Award in 1998, and the IEEE Daniel E. Noble Award in 2003. He received the Medal with Purple Ribbon in 2001, the Rank Prize in 2002, the Fujiwara Award in 2003, the C&C Prize in 2007, and the NHK Broadcast Cultural Award in 2009. In 2013, he was awarded the Franklin Medal with the Bower Award and Prize in Science. He also received the Order of the Sacred Treasure, Gold and Silver Star in 2018, the IEEE Edison Medal in 2021, and was honored as a Person of Cultural Merits by the Japanese Government in 2022. Most recently, in 2024, he received the Frederic Ives Medal /Jarus Quinn Prize from OPTICA.

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Books

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