Japan Academy Prize

Realization, Performance Enhancement, and Applications of Vertical-Cavity Surface-Emitting Lasers (Joint Research)

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■ Citation

Lasers play an essential role in optical measurement and communications. Semiconductor lasers, in particular, combine high electrical-to-optical conversion efficiency with compact size and account for most lasers in practical use. Conventional semiconductor lasers consist of stacked semiconductor layers; light travels along the layers, is reflected back and forth between the two crystal facets about 300 micrometers apart, is amplified to oscillation, and is emitted from an edge. Early concepts and experiments for surface-emitting devices, in which light travels perpendicular to the layers and emerges from the surface, appeared in the 1960s but were largely set aside for more than a decade because practical realization was difficult. Kenichi Iga conceived a surface-emitting device with a cavity only a few micrometers long, named it the “surface-emitting laser,” and demonstrated laser operation at low temperature in 1979. He continued to improve the vertical optical cavity, and in 1988, together with Fumio Koyama, achieved continuous-wave operation at room temperature. This breakthrough accelerated the development of VCSELs, which are now widely used in internet LANs, high-speed datacenter communications, facial recognition, LiDAR, and many other applications.

■ Research Milestones

1977 Concept of the surface-emitting laser	**1979** First laser oscillation	**1982** Sub-10-μm short cavity demonstrated
1988 Room temperature CW operation	**1992** Continuous wavelength tuning	**Around 2000‑Present** Expansion into communications and sensing

■ What Is a Surface-Emitting Laser?

Conventional edge-emitting laser Light travels along the semiconductor layers and exits from an edge.	**Surface-emitting laser (VCSEL)** Light travels perpendicular to the layers and exits from the device surface.

■ Key Features and Societal Impact of VCSELs

Low power consumption	High-speed operation	Two-dimensional arrays	Mass producibility
Efficient light emission	Suitable for high-capacity links	Many devices arranged in a plane	Wafer-scale fabrication and testing
LANs and the Internet	**AI datacenters**	**Facial recognition and 3D sensing**	**Broad application development**

VCSELs have evolved from a laboratory achievement into a global platform for information communications and sensing.