Citation

Surface-Emitting Laser (VCSEL): Its invention and leading research that led to the creation of new photonics field, particularly in high-speed interconnects and sensing

Dr. Kenichi Iga

Positions and Organizations :
Honorary Professor, Institute of Science Tokyo
18th President of Formerly Tokyo Institute of Technology

Date of Birth : June 15, 1940

Degree : Dr. Eng. (1968, Tokyo Institute of Technology)

Brief Biography :
1963 Faculty of Science and Engineering, Tokyo Institute of Technology
1968 Doctoral course at the Graduate School of Tokyo Institute of Technology (Doctor of Engineering)
1968 Assistant Professor, Tokyo Institute of Technology
1974 Associate Professor, Tokyo Institute of Technology
1979 Guest Researcher, Bell Laboratories (~1980)
1984 Professor, Tokyo Institute of Technology
1995 Director, Precision and Intelligence Laboratory, Tokyo Institute of Technology
2000 Director, Library of Tokyo Institute of Technology
2001 Professor Emeritus, Tokyo Institute of Technology
2001 Executive Director, Japan Society for the Promotion of Science
2003 Representative, Microoptics Group, Japan Society of Applied Physics
2003 President, Institute of Electronics, Information and Communication Engineers
2007 President, Tokyo Institute of Technology (~2012)
2022 Honorary Professor, Tokyo Institute of Technology
2024 Honorary Professor, Institute of Science Tokyo

Member of Academic Societies :
IEICE Honorary member Fellow
JSAP Distinguished member Fellow
Laser Society of Japan Fellow
IEEE Life Fellow/ OPTICA Life Fellow/NAE Foreign Member

Honors :
2000 Tokyo Metropolitan Government Merit Award (Technology Promotion Merit)
2001 Purple Ribbon Medal
2007 Machida City Merit Award (Culture and Arts Merit)
2013 Machida City Citizen Honor Award
2018 Grand Cordon of the Order of the Sacred Treasure
2021 Machida City Honorary Citizen
2022 Person of Cultural Merit (MEXT)

Prizes :
1990 Ichimura Foundation for New Technology, Ichimura Prize for Science and Technology (Lifetime Achievement Award)
1993 IEEE/LEOS, William Streifer Award
1995 Toray Science Foundation, Science and Technology Prize
1998 IEEE/LEOS+OSA, John Tyndall Award
1998 Asahi Foundation, The Asahi Prize
2002 Th Rank Foundation (UK), The Rank Prize
2003 Institute of Electronics, Information and Communication Engineers, Lifetime Achievement Award
2003 Fujiwara Science Foundation, The Fujiwara Prize
2003 IEEE, Daniel E. Noble Award
2006 Japan Society of Applied Physics, Achievement Award
2007 NEC C&C Foundation, The C&C Prize
2009 NHK Foundation, NHK Broadcast Cultural Award
2013 Franklin Institute, Franklin Medal/Bower Award for Science
2021 IEEE, Edison Medal
2024 OPTICA, Frederic Ives Medal/Jarus Quinn Prize

Main Achievements :

Dr. Kenichi Iga is the inventor of the "surface-emitting laser," which has a new structure that emits light perpendicular to the semiconductor substrate. In 1976, he felt the need for a semiconductor laser that satisfied three characteristics: 1) oscillates at a single wavelength, 2) can be manufactured monolithically like Si-LSI, and 3) has reproducible wavelength. These were difficult problems that no one had anticipated at the time. After careful consideration, he invented it in 1977. He named it "surface-emitting laser" with the advice from Prof. Yasuharu Suematsu and it is now called VCSEL (Vertical Cavity Surface Emitting Laser).
Dr. Iga and his team continued their challenge for realization and in 1979 they achieved the world's first laser oscillation by current injection. In 1982, they fabricated a surface-emitting laser with a cavity length of 10 microns and confirmed single-wavelength operation. Furthermore, in 1988, together with Dr. Fumio Koyama (this award recipient), they achieved continuous operation at room temperature, and at the same time created a 5x5 two-dimensional array surface-emitting laser, demonstrating the possibility of monolithic manufacturing. In 1992, they created a surface-emitting laser with a mechanically variable wavelength, which is essential for achieving the intended wavelength reproducibility. These research results satisfied the three requirements. Theoretical considerations were also carried out in parallel with the experiments.
Dr. Iga also worked to popularize surface-emitting lasers by giving lectures at universities and research institutes around the world, which sparked the creation of a new industrial field. Perhaps due to this influence, the number of researchers and institutions involved in surface-emitting lasers increased dramatically worldwide from 1990 onwards. The golden age of device research continued over 2000. During this time, Dr. Iga's research team worked to develop technologies that were predicted to be essential for surface-emitting lasers in the future. These technologies included the application of metalorganic chemical vapor deposition to surface-emitting lasers, automatic formation of dielectric multilayer reflectors, the introduction of quantum wells and the invention of quantum multi-barriers, the study of continuous wavelength sweeping methods, coherent arrays using Talbot resonators, optical confinement by tunnel junction breakdown, tandem active layers using tunnel junctions, spontaneous emission control, the creation of an AlAs steam oxidation control device and laser aperture control by *in situ* observation, and verification of the suitability of semiconductor materials for surface-emitting lasers (GaInAsP/InP, GaAlAs/GaAs, GaInAsN/GaAs, InGaN/GaN, II-VI compounds, etc.).
At the same time, cooperation research between industry and academia was promoted, and a surface-emitting laser array was developed for high-definition laser printers, leading to the practical application of a 4800 DPI high-speed digital color printer in 2001. Dr. Connie Chang-Hasnain (award recipient) took over the mechanical wavelength sweeping method using MEMS, and through joint research with companies, it has become a practical device. This has brought about technological innovation in optical coherence tomography (OCT) of the eyeball and teeth.
In the field of optical communications, surface-emitting lasers have been adopted for Internet LANs since around 2000 and have been standardized for short distances. In optical wiring, more than 90% of optical connections in data centers are made up of surface-emitting laser transceivers. Furthermore, with the use of array and multiplexing (PAM4, etc.) technologies, the realization of transceivers that do not require DSP and can connect at speeds of 1.6 TB/s using optical cables for optical wiring is now in sight through the research of successors. In addition, the use of surface-emitting lasers in in-vehicle networks has been standardized.
In the field of optical sensing, a surface-emitting laser mouse that operates using a single wavelength was created, and by around 2011, approximately 1.1 billion units had been produced. Then, in 2017, Apple announced a 3D face recognition system for the iPhone X that used a surface-emitting laser array. Research into LiDAR is also progressing.
As a Japanese innovation, the surface-emitting laser has become a fundamental device that has led to the creation of a wide range of fields, including optical communications and optical sensing. The achievements of Dr. Iga, who has led the way from the beginning, are world-renowned and truly worthy of the Okawa Prize.