

Honda Foundation Report No. 193
Commemorative Lecture at the 46th Honda Prize
Award Ceremony on November 17, 2025

Vertical-Cavity Surface-Emitting Laser (VCSEL): Born Small and Grown Big - From Smartphones to huge Data Centers -

Dr. Kenichi Iga

- Professor Emeritus, Tokyo University of Science
- 18th President of the former Tokyo Institute of Technology

HONDA FOUNDATION

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Honorary Professor, Institute of Science Tokyo
18th President of former Tokyo Institute of Technology



■ Date of Birth

June 15, 1940, Hiroshima, Japan

■ Education

1963 B. Eng., Tokyo Institute of Technology
1968 Dr. Eng., Tokyo Institute of Technology

■ Research and Professional Experiences

1968 - 1973 Assistant Professor, Tokyo Institute of Technology
1973 - 1984 Associate Professor, Tokyo Institute of Technology
1979 - 1980 Guest Researcher, Bell Laboratories
1984 - 2001 Professor, Tokyo Institute of Technology
1995 - 1999 Director, Precision and Intelligence Laboratory, Tokyo Institute of Technology
2000 - 2001 Director, Library of Tokyo Institute of Technology
2001 - present Professor Emeritus, Tokyo Institute of Technology
2001 - 2007 Executive Director, Japan Society for the Promotion of Science
2003 - present Chair, Microoptics Group, Japan Society of Applied Physics
2003 - 2004 President, Institute of Electronics, Information and Communication Engineers
2007 - 2012 President, Tokyo Institute of Technology
2022 - present Honorary Professor, Tokyo Institute of Technology (Currently 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 The Order of the Sacred Treasure, Gold and Silver Star
2021 Machida City Honorary Citizen
2022 Person of Cultural Merit (MEXT)

■ Prizes

1990 Ichimura Foundation for New Technology, Ichimura Prize for Science and Technology, Outstanding 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 The 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, The Bower Award and Prize for Achievement in Science
2021 IEEE, Edison Medal
2024 OPTICA, Frederic Ives Medal/Jarus Quinn Prize
2024 Okawa Prize

■ Introduction

Vertical-Cavity Surface-Emitting Laser (VCSEL)



Introduction by:

- Kenichi Iga
- Institute of Science Tokyo



(Formerly Tokyo Institute of Technology)

Thank you very much for the introduction and it is a great honor to be here today. Having been awarded the Honda Prize for my research on Vertical-Cavity Surface-Emitting Lasers (VCSEL), I would like to share the history of this work with you from now on.

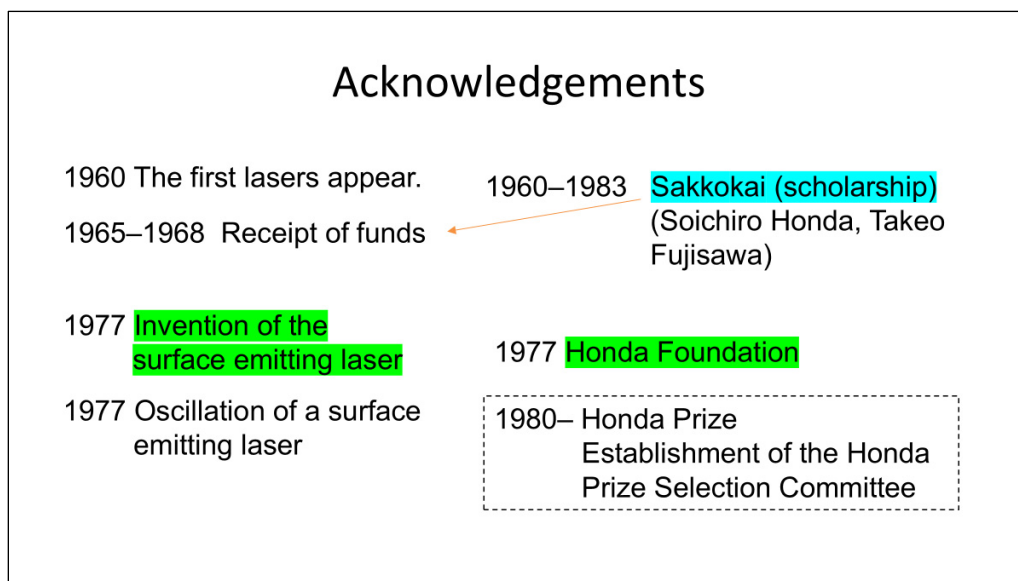


Fig. 1

〈Fig. 1〉 I would like to talk briefly about Sakkokai, as mentioned by Mr. Seiji Kuraishi. I received the Sakkokai scholarship during my doctoral studies. The foundation provided a monthly stipend comparable to the starting salary of a university graduate. This support allowed me to focus on my research and collect essential texts. I was able to spend my doctoral years in such a fruitful research environment thanks entirely to the Sakkokai Scholarship. I would like to take this opportunity to express my heartfelt gratitude to its founders, Mr. Soichiro Honda and Mr. Takeo Fujisawa.

An original aspect of this scholarship was that the names of the benefactors were not disclosed to us until the program ended in 1983. This spirit later evolved into the Y-E-S Program. Many engineers who completed their doctoral programs during that same period remain profoundly grateful for this support even today. I believe it was an incredibly significant program that ultimately nurtured more than 1,000 engineers who went on to lead the academia and industry.

In 1977, the same year the Honda Foundation was established, I conceived the basic concept for the surface-emitting laser. The Honda Prize was later established in 1980, as our first surface-emitting lasers were emerging. I feel a deep connection between my work and the Honda Foundation. I would like to thank Mr. Hiroto Ishida, President of the Honda Foundation, Prof. Hirohisa Uchida, Chairperson of the Honda Prize Selection Committee, and the committee members.

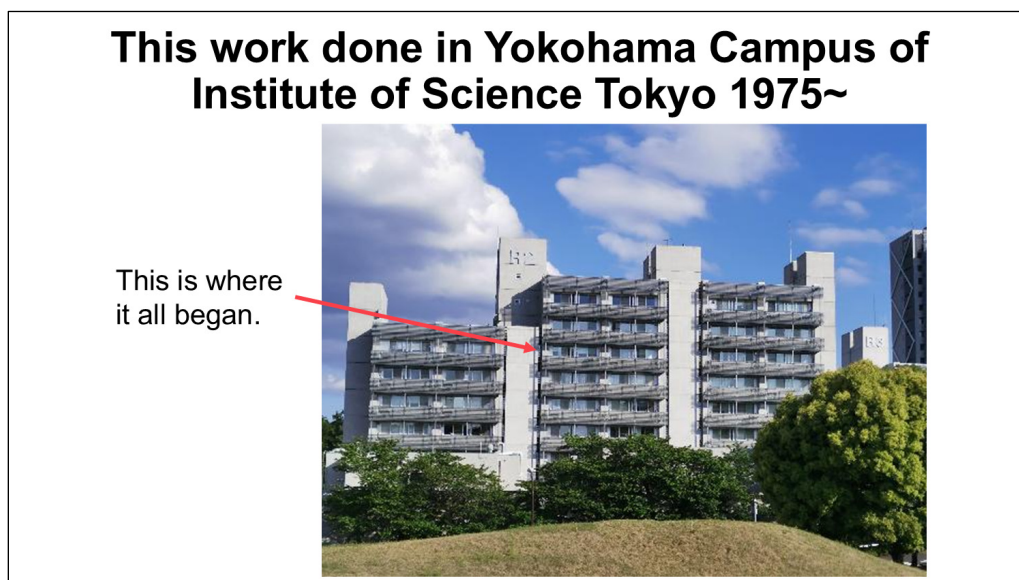


Fig. 2

〈Fig. 2〉 As Prof. Naoto Ohtake, President and CEO of Institute of Science Tokyo mentioned, our Suzukakedai Campus opened in 1975. It is located in the north of Yokohama city, so I refer to it as the Yokohama Campus. Shortly after I became an associate professor, the Research Laboratory to which I belonged was transferred to this campus from the Ookayama Main Campus.

My office was located where the red arrow indicates. Since then, I have conducted my research on surface-emitting lasers at this location.

■ Background to semiconductor lasers

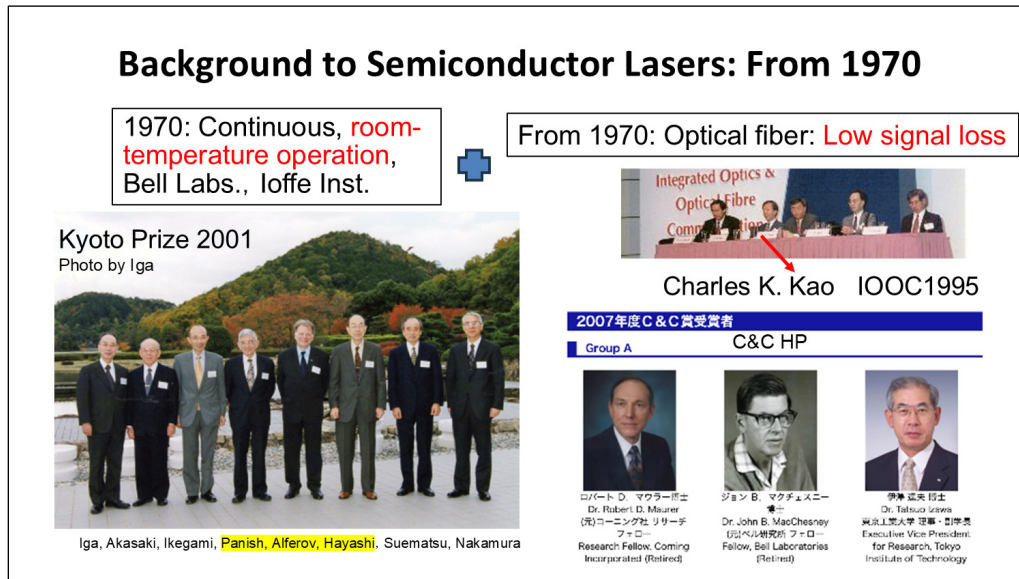


Fig. 3

〈Fig. 3〉 Semiconductor lasers are extremely small light sources, and I would like to briefly look back at their history. The first demonstration of a semiconductor laser was in 1962, but at that time, operation was limited to pulsed mode. It was around 1970 that continuous-wave (CW) operation at room temperature became possible.

In the photograph, from the third person from the right, are Dr. Izuo Hayashi, Dr. Zhores Alferov, and Dr. Morton Panish. They are the researchers who first achieved room-temperature CW operation and received the Kyoto Prize in 2001. Alongside the Kyoto Prize laureates shown on the left, these are the individuals who pioneered the field of semiconductor lasers, and they are truly the foundational figures of this technology.

Around the same period, research into optical fibers also made significant progress. Optical fibers are glass strands thinner than a human hair through which light travels. Previously, losses due to scattering and absorption were high, but the prospect of long-distance transmission with low loss was becoming clear. Dr. Charles K. Kao, shown in the figure, theoretically and experimentally demonstrated this possibility and was later awarded the Nobel Prize.

The group photograph at the top right was taken during an international conference called IOOC. I am the second person from the right. Regarding the practical application of optical fibers, there were major contributions from Corning, Bell Laboratories, and Dr. Tatsuo Izawa of NTT. Their achievements have been recognized with the C&C Prize.

■ Prof. Yasuharu Suematsu Proposed the Necessity of a Single-mode Laser.

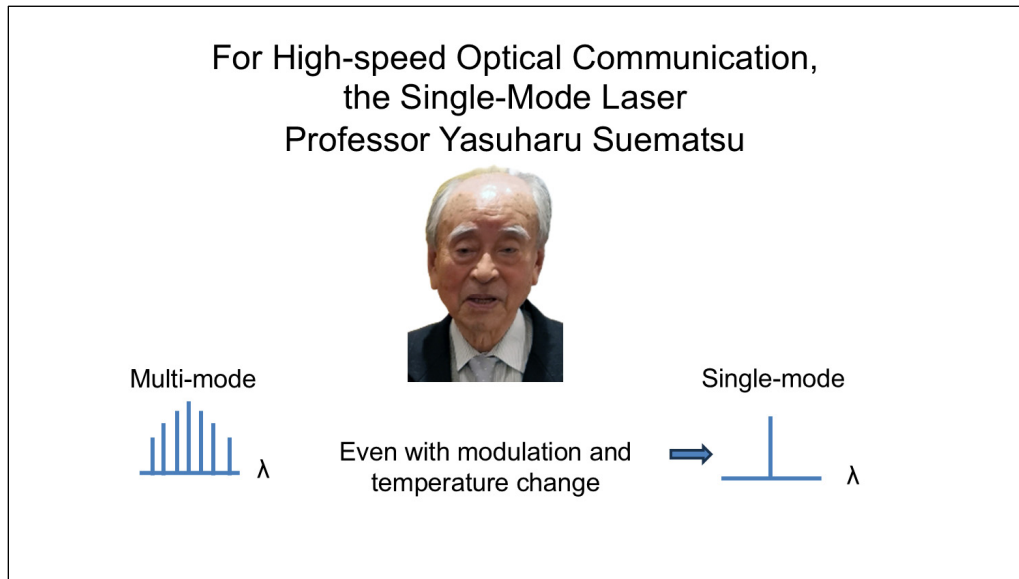


Fig. 4

〈Fig. 4〉 At that time, achieving continuous-wave operation of semiconductor lasers at room temperature was a significant step forward, but challenges remained. As shown in the spectrum on the left side of the figure, the laser did not oscillate at a single wavelength; instead, multiple wavelengths oscillated simultaneously. When used for optical communications, this causes the signal to spread because different wavelengths travel at different group velocities through the optical fiber. This phenomenon is called "dispersion," and it represents a major obstacle to communication quality.

Therefore, for communication purposes, it is essential to have a single oscillation wavelength—that is, "single-mode" operation—as shown on the right. It was my mentor, Professor Yasuharu Suematsu, who pointed this out early on and proposed the importance of single-mode lasers. Professor Suematsu did not stop at proposing the idea; he also demonstrated it through research in his own laboratory.

As President Ohtake mentioned earlier regarding the IEEE Milestones, Professor Suematsu's work on edge-emitting lasers (horizontal lasers) has been recognized with this honor. It is a great pleasure for me that two independent achievements—the surface-emitting laser and the edge-emitting laser—have both been recognized as IEEE Milestones. At the beginning of my career as a researcher, it was a natural progression for Professor Suematsu's philosophy on the importance of single-mode lasers to become the starting point for my own research.

■ March 22, 1977: An Inspiration for a New Laser Concept

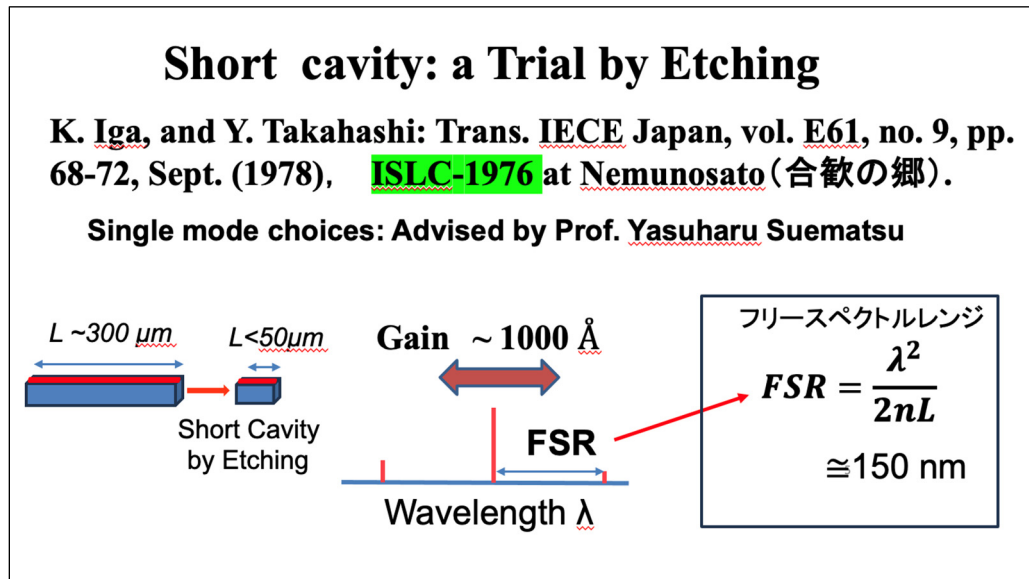


Fig. 5

〈Fig. 5〉 This diagram is somewhat technical, but it illustrates the discussion on whether the laser cavity could be made shorter. In the edge-emitting lasers (horizontal lasers) commonly used at the time, the cavity length was approximately 300 micrometers. I began with theoretical calculations to see if single-mode operation could be achieved by reducing this length to 50 micrometers or less.

In a resonator where light bounces back and forth between two mirrors, if the cavity length is significantly longer than the wavelength, many modes-similar to "overtones" in a musical instrument-appear simultaneously. To avoid this, one simply needs to shorten the cavity. The logic itself is very straightforward.

However, in the case of edge-emitting lasers, there was a technical challenge: the mirrors were formed by cleaving the crystal. This made it extremely difficult to produce an exceptionally short cavity. Therefore, I had begun to make the cavity short by chemical etching.

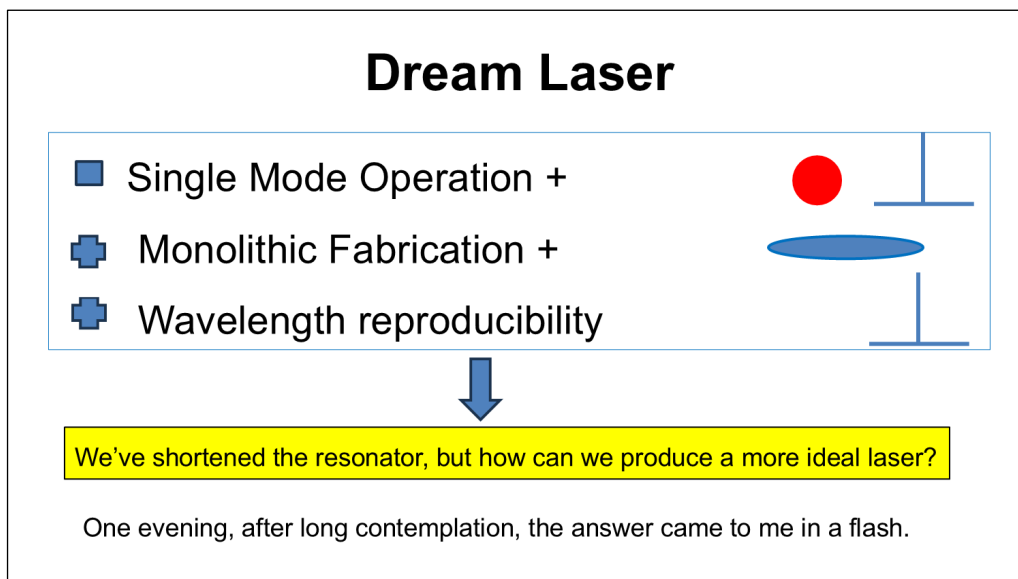


Fig. 6

〈Fig. 6〉 To address these challenges, I identified three essential conditions. First, the laser must operate at a single wavelength. Second, it should allow for monolithic fabrication—meaning it can be manufactured collectively on a wafer, much like LSIs. Third, it must have wavelength reproducibility. Before becoming an associate professor, I spent six years for the research on frequency standards, where I learned firsthand the vital importance of reproducibility. I believed that lasers should meet the same standard.

From 1976 into 1977, I continued to contemplate a "dream laser" that would satisfy all three of these ambitious conditions. Perhaps because I had been thinking about it for so long, the inspiration suddenly came to me one night.

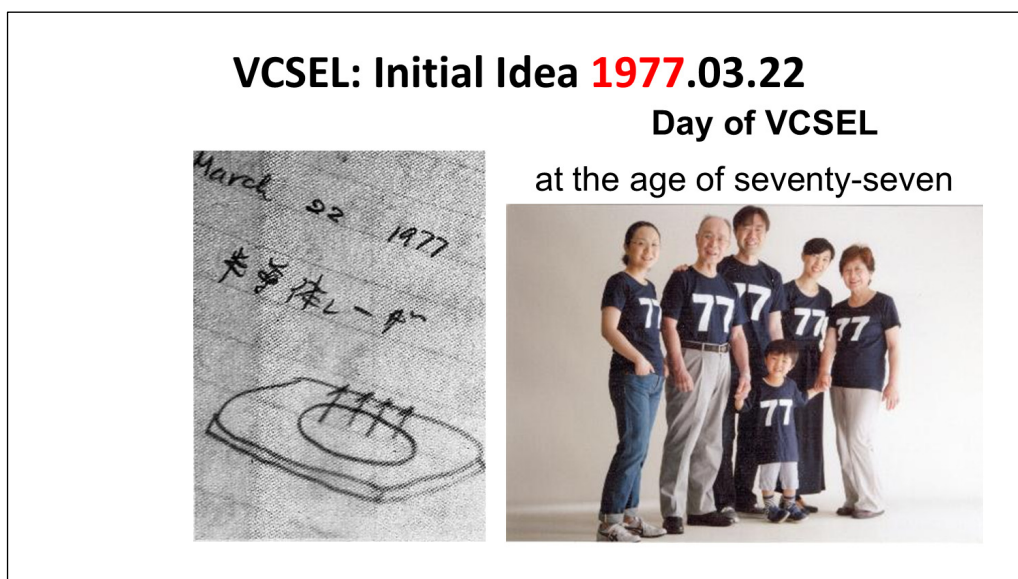


Fig. 7

〈Fig. 7〉 The image on the left is the sketch I drew at that moment. I realized that if

the horizontal structure had its limits, I should orient the laser vertically and make it thin. As soon as the idea came to me, I sketched it in my notebook. The date was March 22, 1977.

By the way, when I turned 77—a milestone age in Japan known as *kiju* (喜寿) —I personally designed a T-shirt to commemorate reaching that age. I gave these shirts to my family, colleagues at academic societies, and my friends in the orchestra. As you can see, the number ‘77’ holds a very special meaning for me.

Furthermore, March 22 has been officially registered with the Japan Anniversary Association as "VCSEL Day." It also happens to be the same day as "Broadcast Day" in Japan.

■ The Laser is Like a Tiny Hamburger.

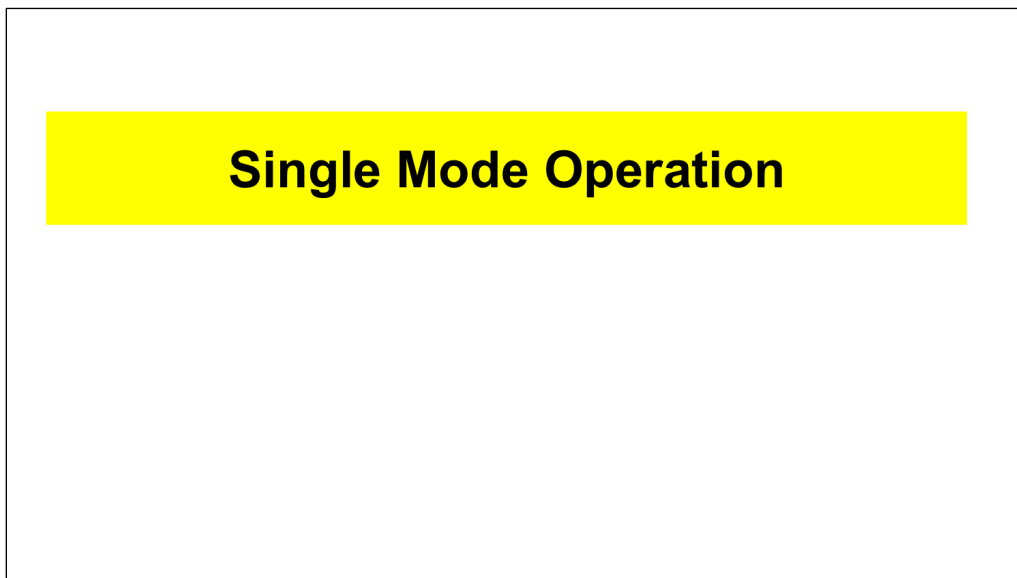


Fig. 8

〈Fig. 8〉 From this point, I would like to discuss the first of the three conditions: how we generate high-quality single-mode light and the ways in which it can be utilized.

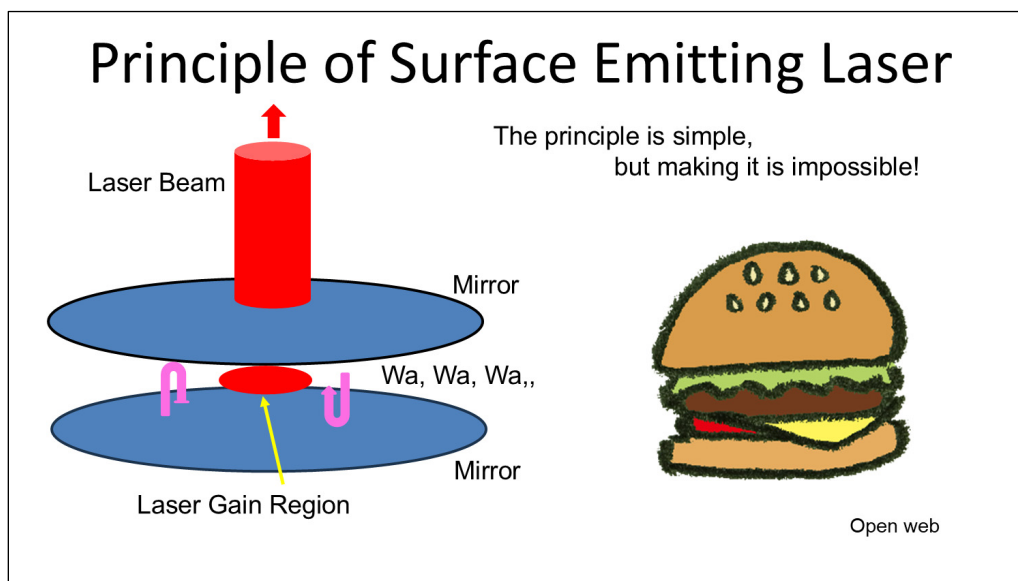


Fig. 9

〈Fig. 9〉 The principle of the surface-emitting laser is not inherently difficult to understand. As shown in the red plate-like section on the left of the figure, there is a region that emits and amplifies light; this is called the "active layer." Today, quantum well structures are used for this purpose, but the basic role remains the same. Reflective mirrors are placed above and below this layer, allowing light to bounce back and forth and create resonance.

When explaining this to junior or senior high school students, I often say that a surface-emitting laser is like a hamburger, as shown in the figure on the right. There are "ingredients" in the middle, and the "buns" on the top and bottom are the reflective mirrors. In terms of size, it is a very tiny hamburger, measuring approximately 10 micrometers.

To use an acoustic analogy, it is like a variety of sounds resonating until one specific tone remains dominant. Light behaves similarly; when certain conditions are met, a specific wavelength becomes intensified. This phenomenon is called "oscillation."

Explaining oscillation can be a bit complex. The light inside increases and decreases until it reaches a state of equilibrium, resulting in "coherent" light, where the phases are perfectly synchronized to a resonant frequency cavity. Electrical oscillators operate on essentially the same principle.

Unfortunately, the term "oscillation" is rarely used in newspapers or magazines. It is often replaced by other terms, perhaps because it is difficult to explain intuitively that it requires two simultaneous elements: an amplifying part and a resonant part. A familiar example is the high-pitched "shriek" that occurs when a microphone is brought too close to a speaker; that, too, is a type of oscillation. The same process occurs with light.

■ Validating the Principle: Taking the First Step

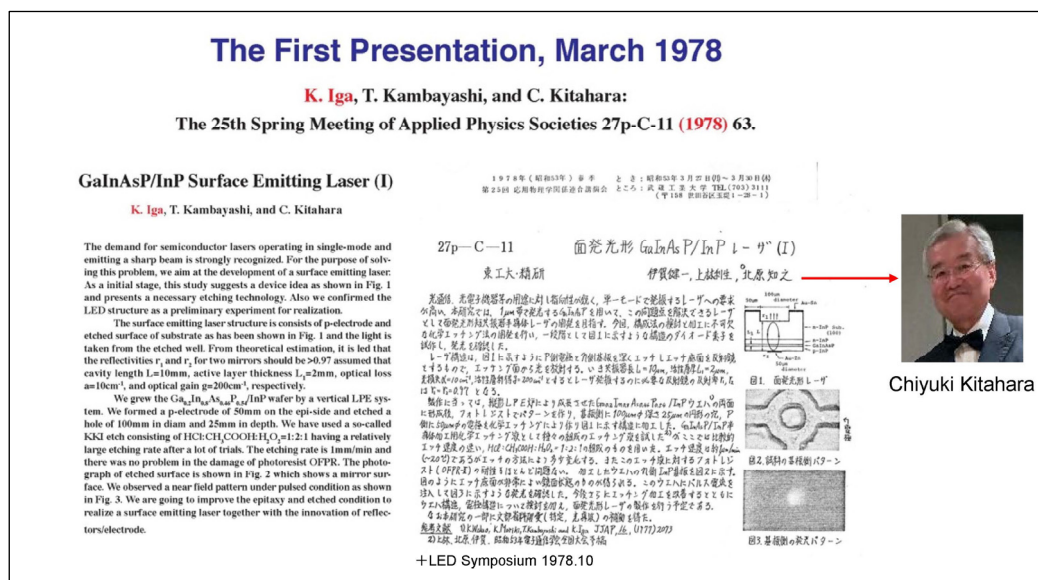


Fig. 10

〈Fig. 10〉 I conceived this idea in 1977, and the following year, in 1978, I presented it for the first time at a meeting of the Japan Society of Applied Physics. Although the details in this diagram may be too small to see clearly, it illustrates the basic principle and structure. This device was actually fabricated by Chiyuki Kitahara, who was an undergraduate student in my laboratory at the time.

For a researcher, presenting at academic societies is an essential part of the profession. To use a baseball analogy, it is like playing in an actual game on the field. This became the very first paper on the surface-emitting laser.

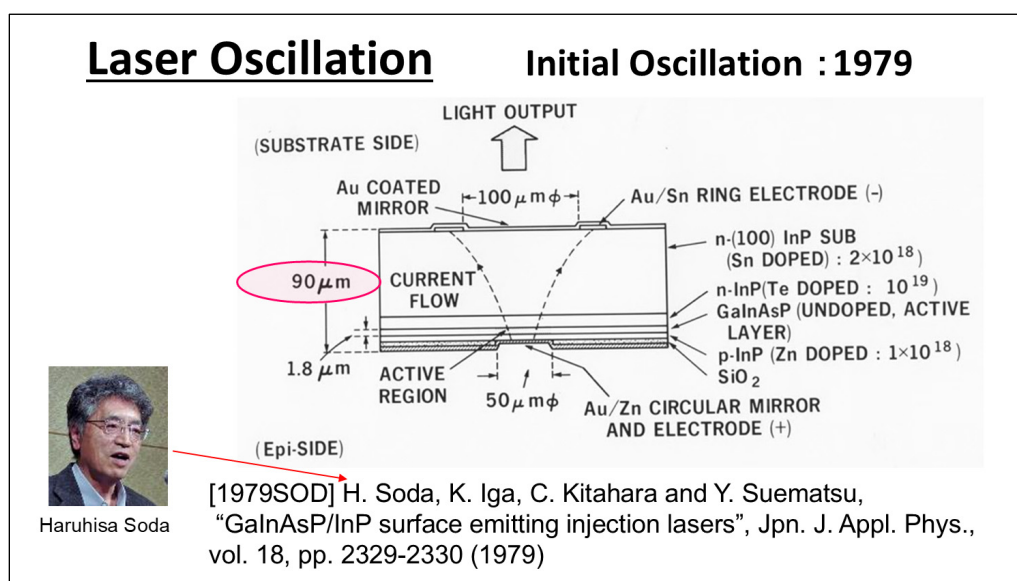


Fig. 11

⟨Fig. 11⟩ In 1979, the following year, we fabricated a surface-emitting laser using indium-

gallium-arsenic-phosphide (InGaAsP) crystals and confirmed its first oscillation. The structure consisted of an active layer at the center, with metal mirrors placed above and below it to allow for current injection. This device was developed by Haruhisa Soda, who was then a doctoral student in my laboratory.

The paper reporting this achievement was published in the Japanese Journal of Applied Physics (JJAP). It has since become one of the most frequently cited papers in the field of surface-emitting lasers. This work represents, so to speak, the starting point of our research.

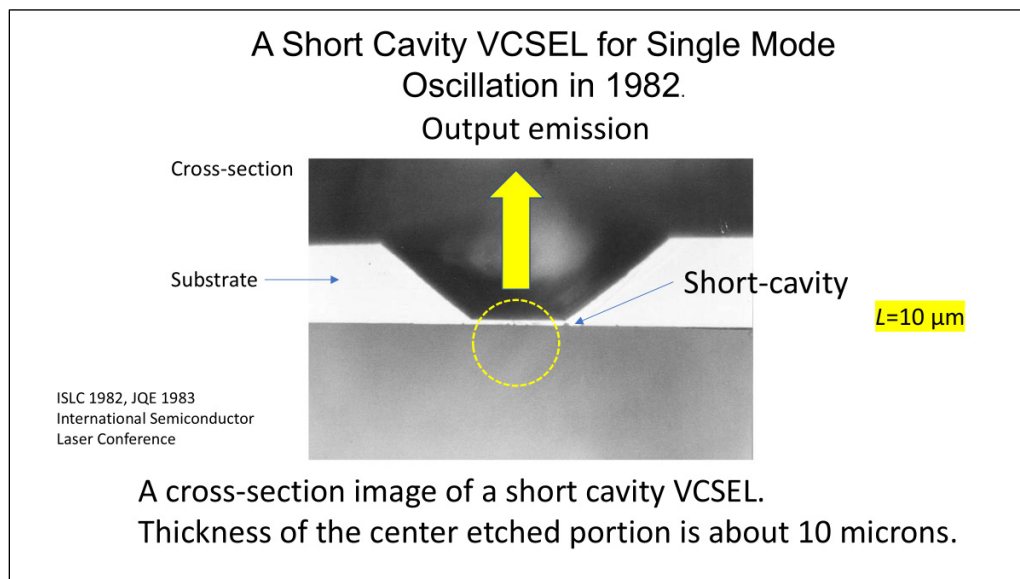


Fig. 12

〈Fig. 12〉 In our previous laser, the cavity thickness was 90 micrometers, which was still too thick for effective single-mode operation. Therefore, in 1982, we developed a structure where the substrate was removed, leaving only the essential active layer. This reduced the thickness to just 10 micrometers.

As a result, we obtained a clean single spectrum and a circular, sharp beam. I felt that at this moment, we had come significantly closer to the vision of the surface-emitting laser I had originally imagined.

However, at this stage, the device required cooling with liquid nitrogen and did not yet operate at room temperature. What we confirmed at this point was that the "principle was correct." From there, it became a matter of technical refinement.

In university research, the most important thing is to think of something new. However, being "new" is often a fine line from being merely "eccentric." At first, it is unclear whether an idea truly has merit. It is only by trying it out that we can determine if the principle is sound. I believe that crossing this line represents a significant hurdle in research.

■ Successful Room-Temperature Oscillation, First Experiments with Quantum Wells, and Toward Mass Production

Building a laser on a plate Monolithic Production

One thing has to be done first: Continuous oscillation at room temperature.
Mission impossible!

Room-temperature pulse oscillation
Kenichi Iga, Shin Ishikawa,
Shunsuke Ohkouchi, and Takayuki
Nishimura, "Room temperature
pulsed oscillation of GaAlAs/GaAs
surface emitting injection
laser," *IEEE J. Quantum Electron.*,
vol. QE-21, no. 6, pp. 663-668,
1985.



Susumu Kinoshita

Threshold: Pulse oscillation at 6 mA
Kenichi Iga, Susumu Kinoshita, and Fumio
Koyama, "Micro-cavity GaAlAs/GaAs surface
emitting laser with $I_{th} = 6\text{mA}$," *10th Int.
Semiconductor Laser Conf. (ISLC'86)*, paper
PD-4(post-deadline), Oct. 1986. 金沢

Fig. 13

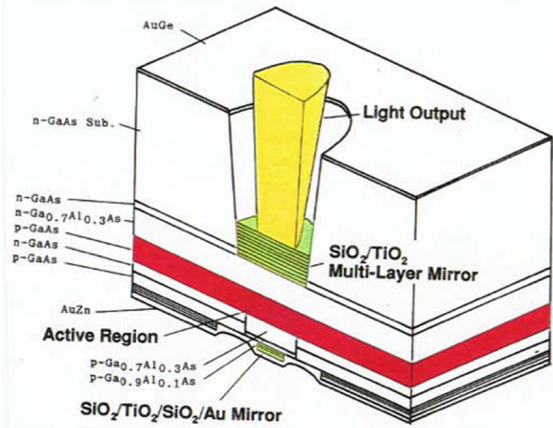
〈Fig. 13〉 Our next challenge was to determine whether the laser could oscillate as the temperature increased. Through repeated trial and error with my students, and following the publication of two significant papers, we achieved room-temperature oscillation in 1985, although it was in pulsed mode at that stage.

Room Temperature CW Operation 1988

Day by day, Step by step



F. Koyama and K. Iga



1988 Fumio Koyama

Fig. 14

〈Fig. 14〉 In 1988, various technical elements were integrated into an experiment led by Fumio Koyama, who was an assistant professor at the time (and later became a professor). One key element was the crystal growth system. We utilized a Metal-Organic Chemical Vapor Deposition (MOCVD) system, which had been completed within our laboratory, to grow crystals by spraying gas onto the substrate.

Another crucial development was the dielectric multi-layer reflector. This technology is similar to the coating used on eyeglasses, and it enabled us to fabricate high-quality mirrors. By bringing these technologies together, Koyama's experiment finally achieved the first continuous-wave (CW) operation at room temperature. I believe this success was the result of steady, day-to-day progress.

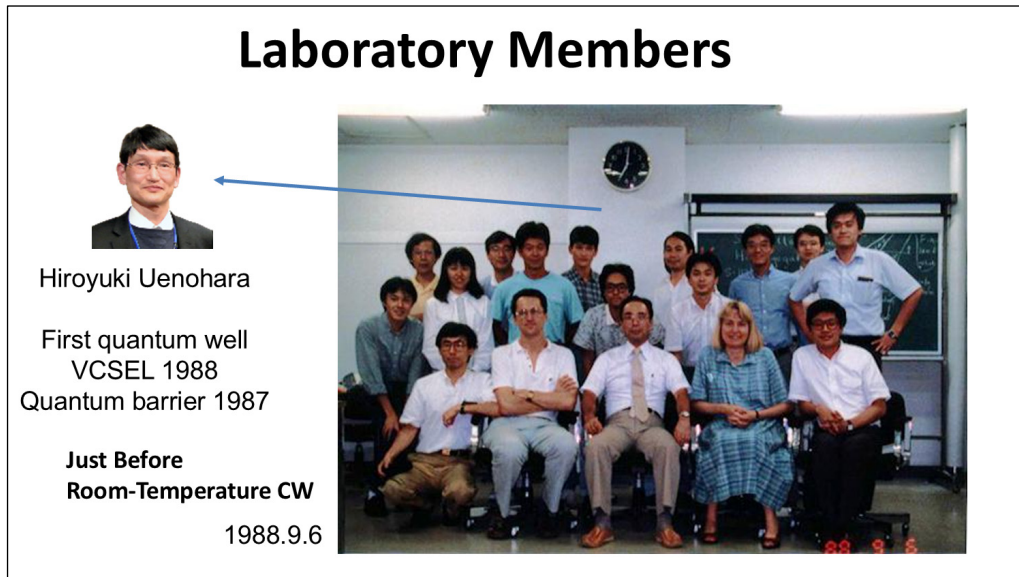


Fig. 15

〈Fig. 15〉 This photograph shows the members of our laboratory at that time. Among them is Hiroyuki Uenohara, who is now a professor. He conducted the first experiments using a quantum well structure in a surface-emitting laser. The concept involves confining electrons within an extremely thin layer.

Furthermore, we expanded this research to propose the concept of a "quantum barrier" to reflect electrons. This is, in a sense, the opposite idea of the quantum tunneling effect, for which the Nobel Prize was awarded. This idea has since been applied to technologies such as ultraviolet LEDs and also holds the potential to increase the power output of surface-emitting lasers. We have also obtained a U.S. patent for this technology.



Fig. 16

〈Fig. 16〉 Next, I would like to discuss the second condition: a "monolithic structure" that can be fabricated collectively on a wafer. The wafer I showed you earlier is a gallium arsenide (GaAs) crystal with a diameter of 15 centimeters. As I mentioned in a book I wrote in 2021, approximately 10,000 such wafers were being produced annually even at that time—an average of about 30 wafers per day.

A single wafer contains approximately one million surface-emitting lasers. While the dots shown in the diagram are markers and not the lasers themselves, this gives you an idea of the vast number that can be produced at once. Today, wafer sizes have increased from 6 inches to 8 inches, further advancing the scale of mass production.



Fig. 17

〈Fig. 17〉 This photograph was taken by Dr. Genichi Hatakoshi's group at Toshiba, who were developing red surface-emitting lasers at the time. It captures the characteristics of the beam very clearly. I believe this light is exactly as I had originally imagined it.

■ The Mission to Achieve Consistent Wavelengths

Wavelength Reproducibility

That's impossible from the engineering point of view.

Fig. 18

〈Fig. 18〉 The third condition is whether we can consistently produce the same wavelength. As shown here, some might say, "That's impossible from the engineering point of view." In other words, creating identical objects is considered impossible from an engineering perspective.

Take automobiles, for example. At first glance, they appear identical, yet each one is slightly different. It is impossible to make something that is perfectly the same. However, the essence of engineering lies in taking on that very challenge.



Fig. 19

〈Fig. 19〉 This is a photograph of the chamber orchestra that I direct. [At this point in the lecture, a short recording of the performance was played.] In this picture, I am playing the contrabass on the far right. The reason I am showing you this is that in an orchestra, many

different instruments come together to create harmony, but their fundamental tones must be perfectly aligned. We call this process of aligning the fundamental tones "tuning."

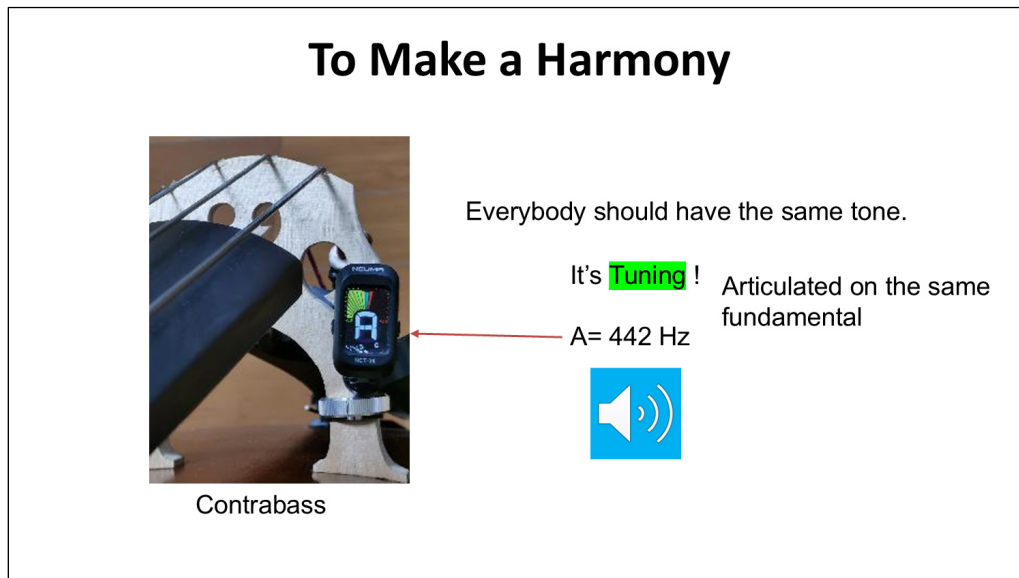


Fig. 20

〈Fig. 20〉 In practice, each instrument aligns itself to a reference pitch using a tuner, as shown here. Nowadays, a frequency of 442 Hz is commonly used. While the time signal on analog radio is 440 Hz, we establish a standard like this to ensure everyone is in sync. The entire orchestra then performs a collective tuning.

[In the lecture, the pitch "A" was played.]

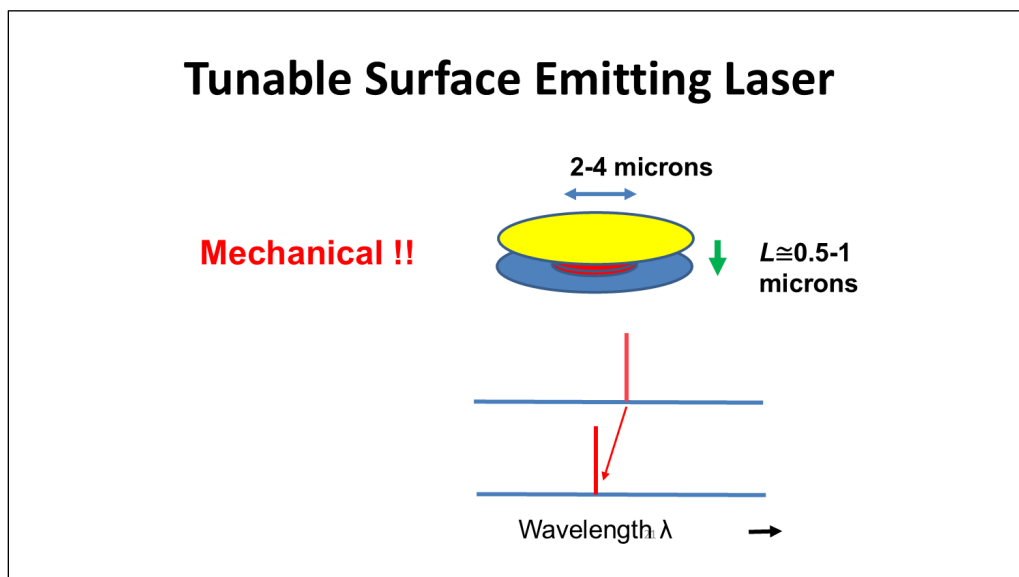


Fig. 21

〈Fig. 21〉 Similarly, tuning is indispensable for electronic devices. For instance, crystal oscillators, which are found in smartphones and computers, all undergo calibration. Tuning is an essential requirement for these components.

So, how do we address this in the case of surface-emitting lasers? While time constraints prevent me from going into great detail, the fundamental idea was that the resonant wavelength could be altered by slightly moving the mirrors. We attempted to achieve this through mechanical means.

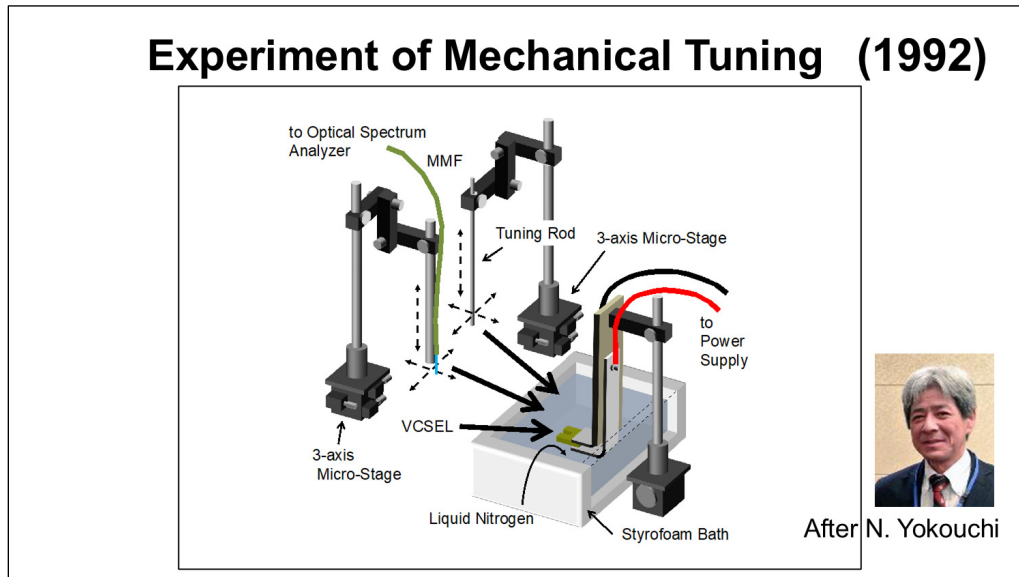


Fig. 22

〈Fig. 22〉 We conducted an experiment using a surface-emitting laser "engine" that was fabricated without a mirror on one side. This device was immersed in liquid nitrogen, and an external mirror was lowered from above and moved slightly using a micro-stage.

This experiment was carried out by Noriyuki Yokouchi while he was a doctoral student.

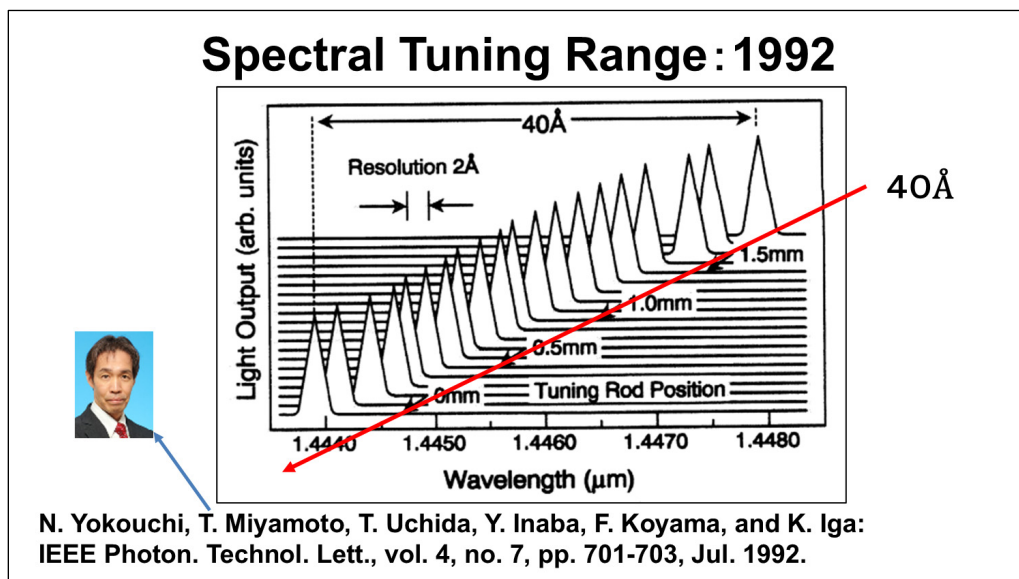


Fig. 23

〈Fig. 23〉 As shown in the introductory video before the ceremony, this experiment demonstrated

that the wavelength could be tuned continuously. In this team, Yokouchi was in charge of the experiments, and Tomoyuki Miyamoto, who is now a professor, was also a member of the same team, responsible for crystal growth using the Chemical Beam Epitaxy (CBE) system.

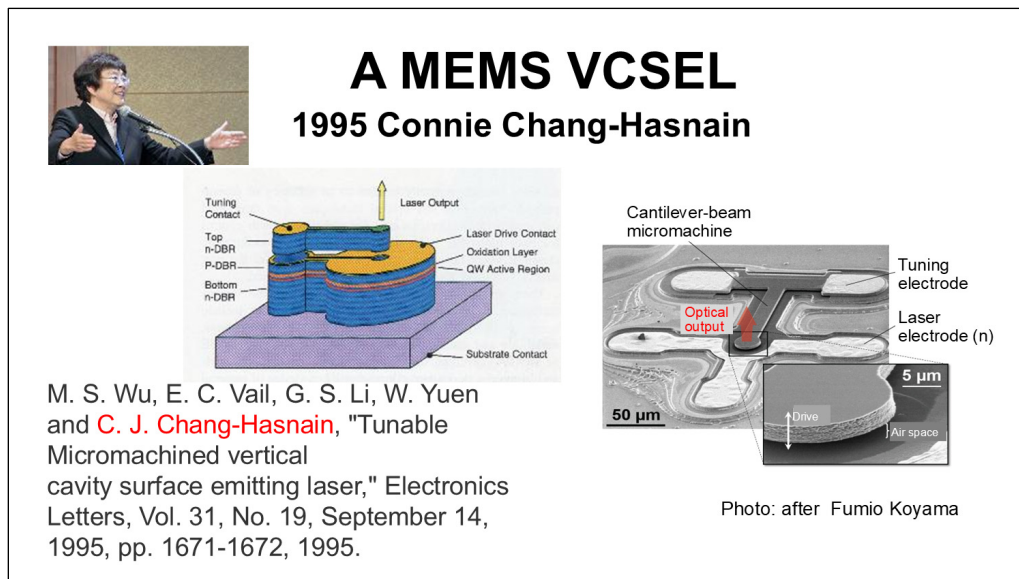


Fig. 24

〈Fig. 24〉 The experiments I previously mentioned took place in 1992. Subsequently, in 1995, Professor Connie Chang-Hasnain of the University of California, Berkeley, advanced this direction by utilizing MEMS. MEMS stands for Micro-Electro-Mechanical Systems, which are essentially micromachines.

Unlike handmade components, MEMS can be fabricated collectively, much like LSIs. As a result, it became possible to vary the gap of a cantilever to achieve continuous movement. The photograph on the right shows a device from the laboratory of Fumio Koyama at Science Tokyo. The introduction of MEMS successfully realized continuous wavelength tuning in these devices.

■ Has the "Dream Laser" been Achieved?

Has the dream laser been achieved?

- **Single Mode Operation +**
- **Monolithic Fabrication +**
- **Wavelength Reproducibility**

Maybe yes.

Fig. 25

〈Fig. 25〉 So, has the dream laser finally been achieved? We managed to achieve single-mode operation. Monolithic fabrication became a reality. Furthermore, through tuning, we were able to ensure reproducibility and consistency. Considering these achievements, I believe the answer is yes.

VCSEL IEEE Milestone Monument



Kenichi Iga, Stone Monument
At Yokohama Campus
Institute of Science Tokyo

Fig. 26

〈Fig. 26〉 As mentioned earlier in the guest congratulatory address by Professor Naoto Ohtake, this work was honored with the IEEE Milestone. The dedication ceremony took place just three weeks ago, on October 28. This recognition was awarded to the university, and a commemorative monument has been installed at our Yokohama Campus. It stands alongside the milestone for Prof. Issac Koga's crystal oscillator on the right and the monument for Prof. Yoshinori Ohsumi's Nobel Prize on the left. The VCSEL monument has been placed right in the center. It is located on the left side of the path leading into the campus, so I hope you will take a moment to see it.

■ The Evolution of Vertical-Cavity Surface-Emitting Lasers

Evolution to Industrialization

Fig. 27

〈Fig. 27〉 Now, let us take a brief look at how this technology has evolved since its inception.

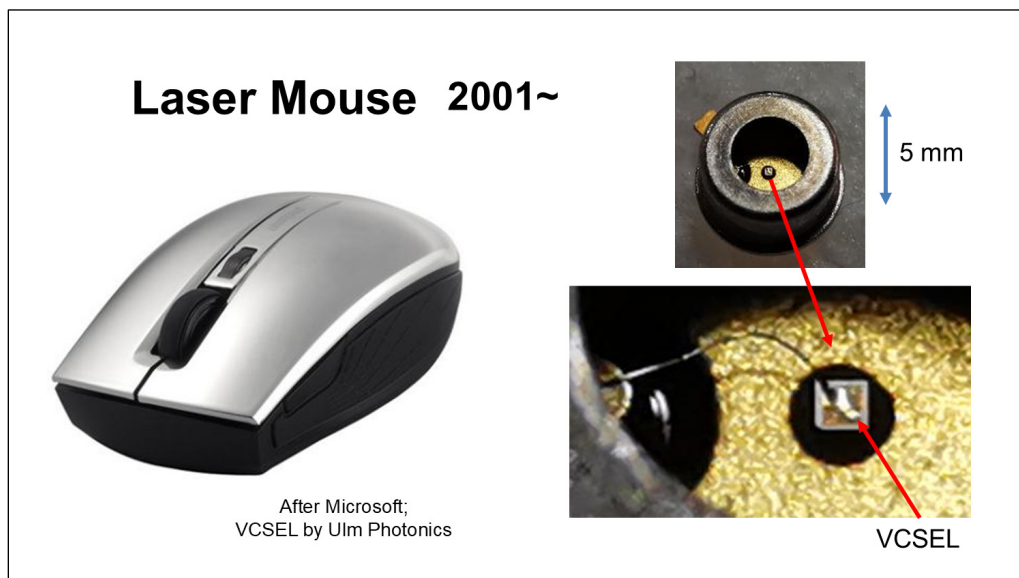


Fig. 28

〈Fig. 28〉 The first example is the computer mouse. In practice, an extremely small square chip is housed within a "CAN" package, which is about 5 mm in diameter. Light is emitted from an even smaller laser section within that chip to detect position and movement.

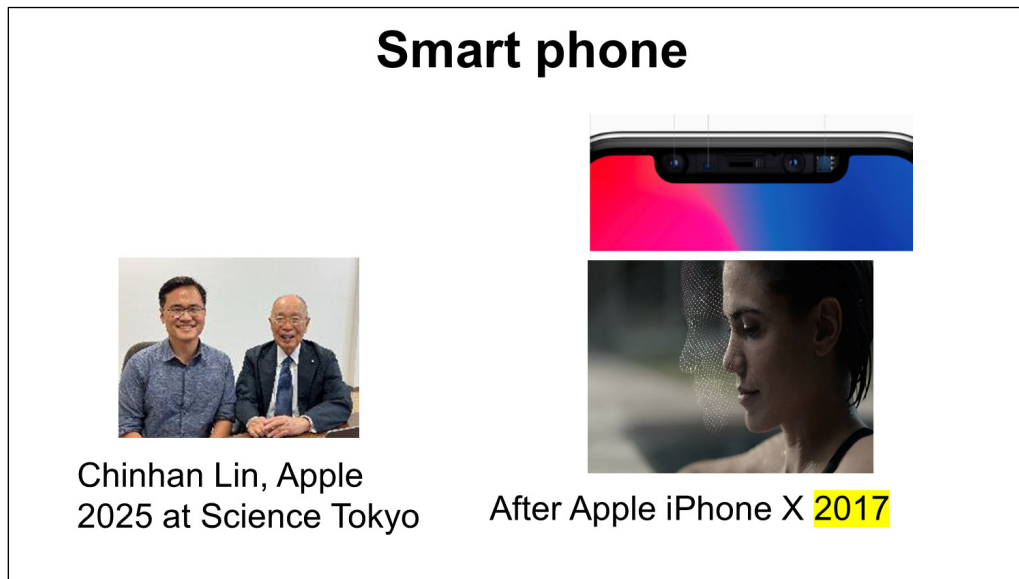


Fig. 29

〈Fig. 29〉 This is the iPhone X, which was released in 2017. The gentleman on the left is Dr. Chin-Han Lin, an engineer at Apple who developed and commercialized this 3D facial recognition system from the very beginning. This year (2025), he visited me, saying he wanted to meet the "Go-honzon" (the central figure or pioneer) of the surface-emitting laser.

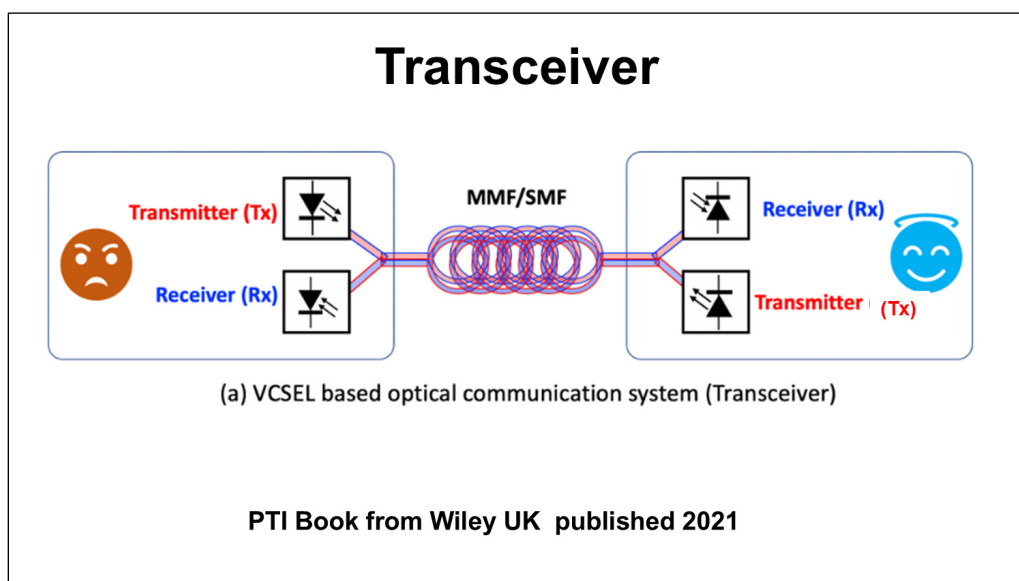


Fig. 30

〈Fig. 30〉 In data centers, vast amounts of optical fiber are used for data exchange. Data travels from a transmitter through the fiber to a receiver and is sent back via a separate path. A device that integrates both a transmitter and a receiver is called a "transceiver," and these pairs enable bidirectional communication. Surface-emitting lasers are used at the ends of these connections to power the data transmission.

VCSEL Transceiver 50m 400GBASE

ホーム / 光デバイス / InfiniBandネットワーク / 400G OSFP/QSFP12 ID / SKU:200963



Maximum power consumption 8.5 W

After Nobuhiko Nishiyama

タップまたはクリックで画像を拡大する

NVIDIA/Mellanox MMA4Z00-NS400互換
400GBASE-SR4 OSFPフラットトップ InfiniBand
NDR光トランシーバーモジュール(PAM4 850nm
50m DOM MPO-12/APC MMF ConnectX-7 HCA
用) Hot <

P/N:OSFP-SR4-400G FI SKU:200963

110,785円
100,714円 (消費税別)

6.6K 販売数 | 10 レビュー | 10 Q&A

Transceiver Models:

- MMA4Z00-NS400 1 400G SR4
- MMS4X00-NS400 1 400G DR4
- MMA3Z00-NS400 1 400G SR4
- MMS1X00-NS400 1 400G DR4
- QSFP117-FR4 400G 1 400G FR4
- QSFP117-XDR4 400G 1 400G XDR4

Compatible Brands:

- NVIDIA InfiniBand (1.6T)
- NVIDIA InfiniBand (800G)
- NVIDIA InfiniBand (400G)
- NVIDIA InfiniBand (200G)

Fig. 31

〈Fig. 31〉 In terms of actual products, the device is roughly the size of a toothbrush box. Optical fibers are connected to the black sections you see here. This is a 400 Gbps-equivalent transceiver capable of transmitting data over 50 meters, and it is priced at approximately 110,000 yen. These are currently available on the market and in practical use.

■ VCSELs and the History of Transceivers

VCSEL Transceivers



Chuck Mattera
From a lecture in Spain

"In 1977, Iga of Japan invented a structure combining chroma and hetero structures, and further improved it. Later, my colleague Julie Eng developed the VCSEL transistor and implemented it in the optical-fiber networks of data centers."

Chuck Mattera, Retired CEO of Coherent Corp.
2024.10.17 At Science Tokyo

Fig. 32

〈Fig. 32〉 Let's look back at the history of transceivers. Dr. Chuck Mattera, the former CEO of Coherent Corp., retired last year and visited me for the sole purpose of speaking with the "pioneer" of this technology.

In a publicly available lecture he gave in Spain, he recounts the history of the device: how I invented the VCSEL in 1977, and how Dr. Julie Eng—who could be considered one of my academic "disciples"—later developed the transceivers that are now supplied to data centers worldwide.

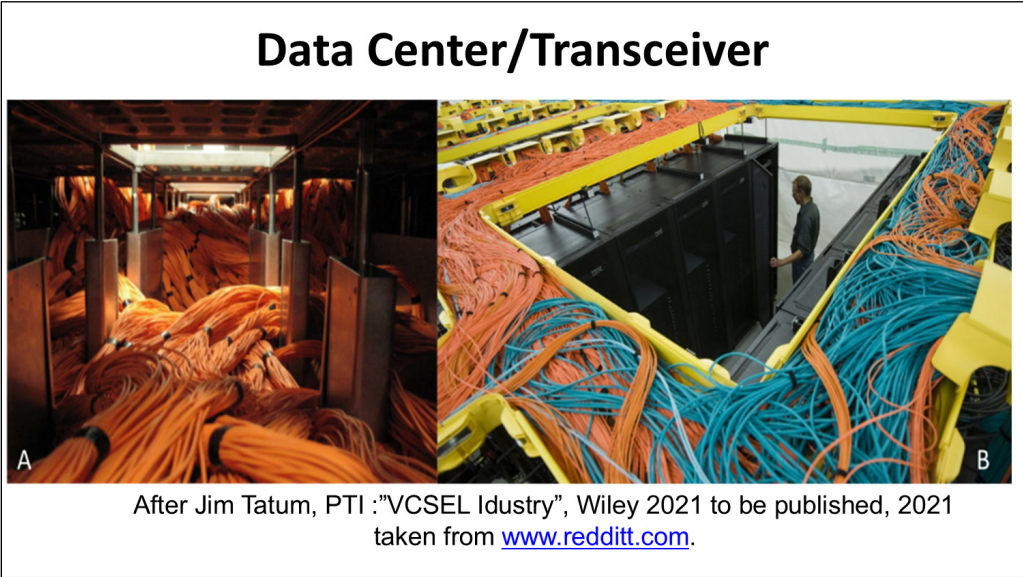


Fig. 33

〈Fig. 33〉 This image shows the interior of a data center, where a vast network of optical fibers is installed across the entire ceiling.

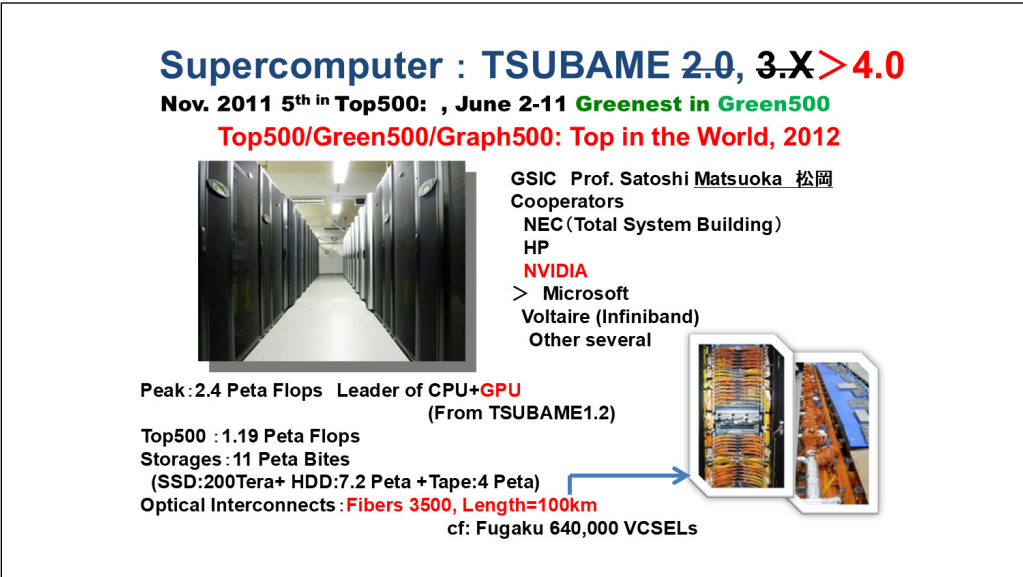


Fig. 34

〈Fig. 34〉 This is "TSUBAME," the supercomputer at the Institute of Science Tokyo (formerly Tokyo Institute of Technology). When I was the president of the university, it was version 2.0 or 2.1, but it has now evolved further to version 3.X. As you might expect, a massive number of optical fibers and surface-emitting lasers are utilized within this system.

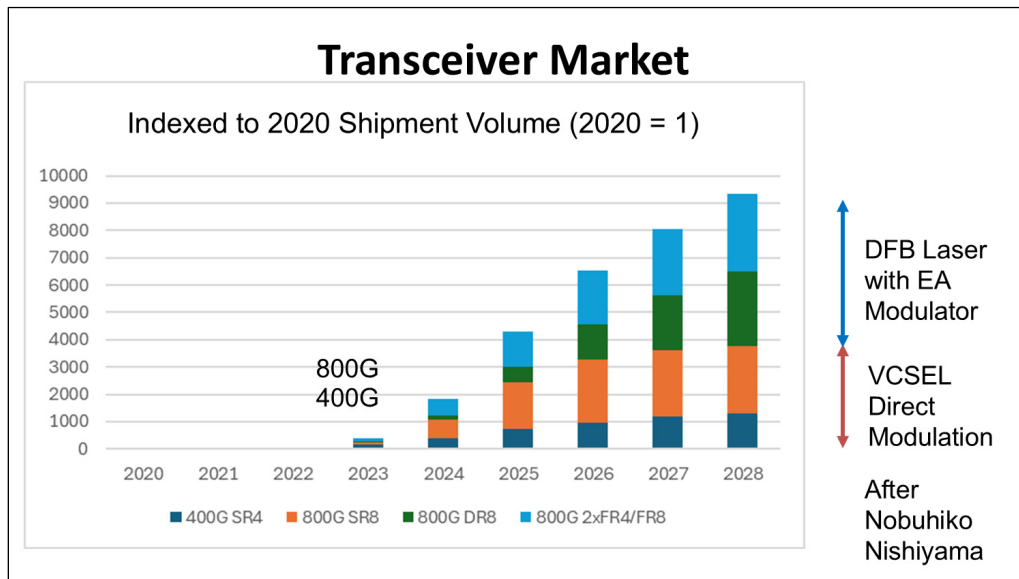


Fig. 35

〈Fig. 35〉 Looking at the transceiver market, we can see significant growth since 2020, with a particularly sharp increase starting around 2023. The two-colored bars at the bottom represent the direct modulation method using VCSELs, where digital optical signals are generated directly by the current. Meanwhile, the top two bars represent high-speed, long-distance systems using DFB-type lasers. These two technologies are evolving in parallel.

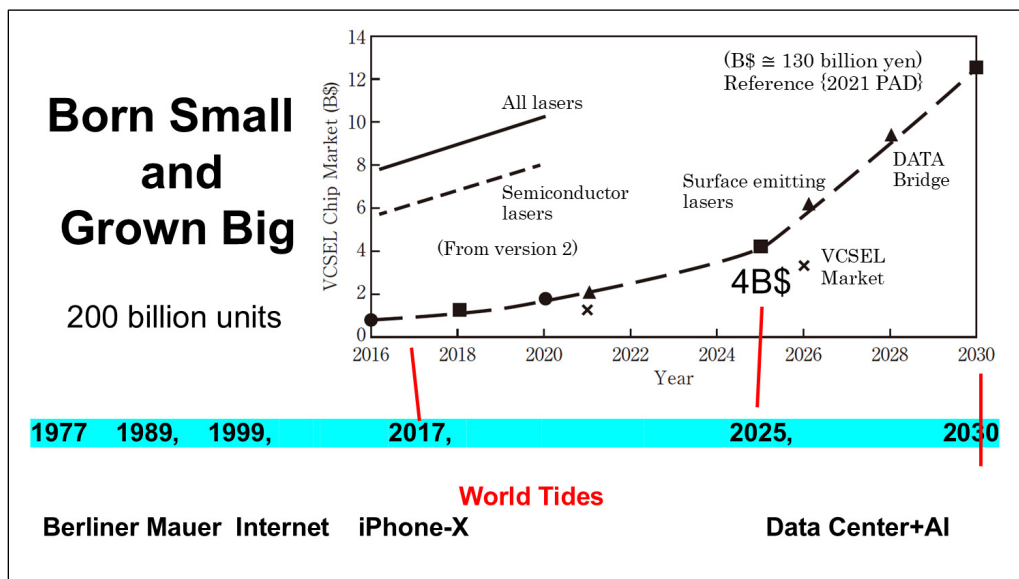


Fig. 36

〈Fig. 36〉 The market scale for individual VCSEL chips is projected to reach 4 billion dollars by 2025. It is estimated that approximately 200 billion units have been manufactured to date. In any case, these figures demonstrate that the technology is now being utilized on a truly massive scale.

■ VCSELs in Next-Generation Vehicles

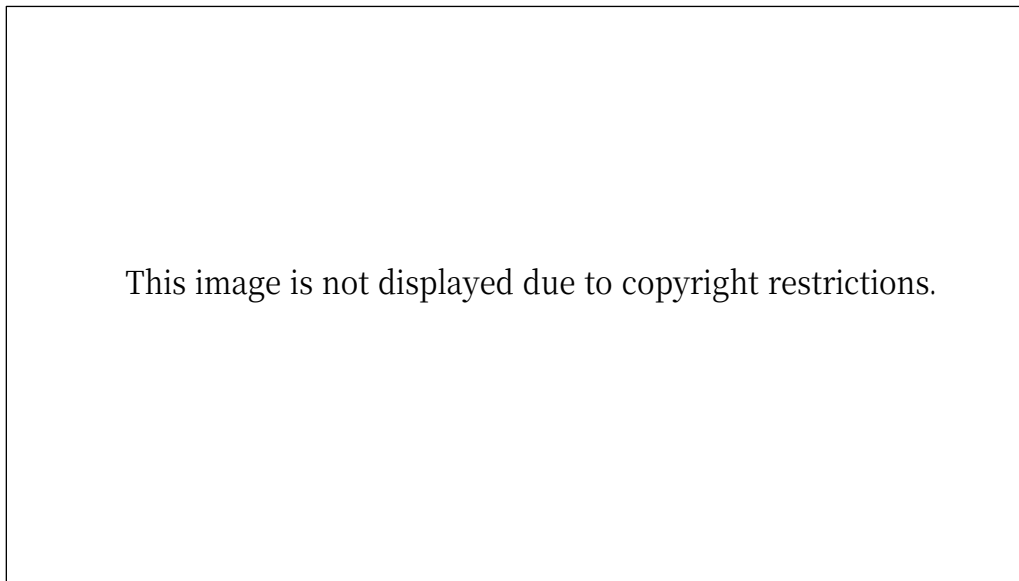


Fig. 37

〈Fig. 37〉 Surface-emitting lasers are also playing a vital role in next-generation automobiles. Autonomous driving requires LiDAR (Light Detection and Ranging) technology. In addition to cameras and microwave radars, optical LiDAR is becoming increasingly essential for safe and precise navigation. This image shows a model of an autonomous vehicle from the United States.



Fig. 38

〈Fig. 38〉 This is the fifth-generation Honda Legend. It was the first production car in the world to achieve Level 3 autonomous driving. I actually watched a 90-minute test drive review on YouTube by Mr. Yasutaka Gomi. It really makes you feel like you are in a self-driving car. However, this car is quite expensive. Even with the prize money from the Honda Prize, I'm afraid I still couldn't afford it! (Laughter)

Car Network : in-vehicle network standards

IEEE802.3cz 25•50G Quartz Multimode VCSEL 980 nm 40m



Yasuhiro Koike
GI-POF
VCSEL 850nm

Ryo Takahashi,
Masayuki Iwase,
Hiroyuki Tsuda :
IEICE Journal Vol.
107, No.2, p.127,
2024

表3 10 Gbit/s 以上の車載通信規格

信号	イーサネット				
	電気		光		
規格名	2.5/5/10G BASE-T1 IEEE802.3ch (Multi-Gig) 2020 年	25G BASE-T1 IEEE802.3cy (B10G) 2023 年	100G BASE-RH-c IEEE802.3bv (GEPOF) 2016 年	10G BASE-RH-c IEEE802.3dh (審議中) 2026 年目標	25/50G BASE-AU IEEE802.3cz (OMEGA) 2023 年
伝送速度	2.5/5/10 Gbit/s	25 Gbit/s	1,000 Mbit/s	2.5/5/10/25 Gbit/s	25/50 Gbit/s
物理メディア	メタル2線式 STP:シールドより線	メタル2線式 STP:シールドより線	STP:シールド (A4a:SI800) 光源 LED 波長 650 nm	GI-POF 光源 VCSEL 波長 850 nm (審議中)	石英 MMF (OM3:GI-50) 光源 VCSEL 波長 980 nm
構成	1対1	1対1	1対1	1対1	1対1
伝送距離	15 m 中継数 4	11 m	40 m 中継なし 15 m 中継数 4	15 m 中継数 3 (2.5-10 Gbit/s) 中継数 2 (50 Gbit/s)	40 m 中継数 4 (2.5-25 Gbit/s) 中継数 2 (50 Gbit/s)
変調方式	PAM4	PAM4	PAM16	NRZ	NRZ (2.5-25 Gbit/s) PAM4 (50 Gbit/s)
エラー訂正	RS-FEC	RS-FEC	RS-FEC	未定	RS-FEC

Fig. 39

〈Fig. 39〉 In modern in-car networks, the volume of data being processed has reached levels comparable to that of a typical office. The IEEE 802 standard defines a 40-meter communication link utilizing 980 nm wavelength VCSELs paired with silica glass fibers.

Another key development involves 850 nm wavelength VCSELs combined with Plastic Optical Fibers (POF). Thanks to the global promotional efforts of Professor Yasuhiro Koike of Keio University, this combination has become highly effective for short-distance communication. It is currently under deliberation for standardization in automotive applications.

■ Eco-Technology Around Us

Eco-Technology around us

Fig. 40

〈Fig. 40〉 Finally, I would like to show some examples of "Eco-Technology" that we find around us.

Institute of Science Tokyo Ecotechnology : Green Hills



2016.7.11 Photo by Kenichi Iga

Fig. 41

〈Fig. 41〉 This is the Ookayama Campus of Science Tokyo, introduced earlier by President and CEO Prof. Naoto Ohtake. During my tenure as president, we installed artificial turf on the sports ground. This was greatly appreciated by the students and also by the neighbors, as it eliminated the problem of dust clouds.

As you can see a train on the Oimachi Line passing by in the photo, just beyond it stands the building often called the "Gundam Building," though I personally prefer to call it "Green Hills" after the nearby Midorigaoka Station. This is an environmentally friendly building featuring 4,000 solar panels on its walls. It also utilizes fuel cells on the rooftop and a heat exchange system using 14°C groundwater for all its heating and cooling. I oversaw its construction as a model for "Eco-Buildings" during my tenure as President.

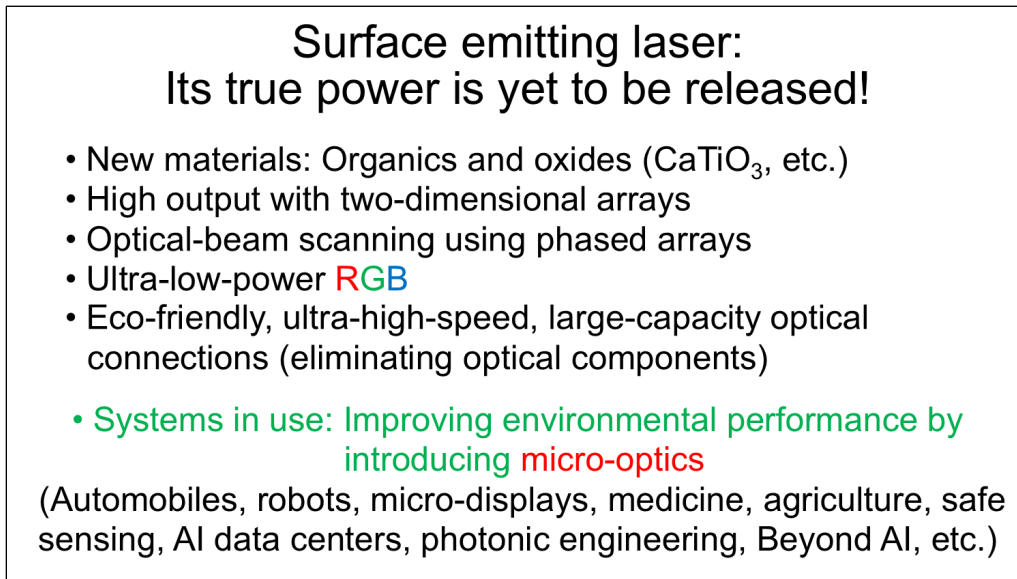


Fig. 42

〈Fig. 42〉 I believe the true potential of VCSELs is yet to be realized. While we currently rely on rare metals like gallium and indium, future candidates include organic and oxide materials.

If we can utilize an entire wafer as a laser source, it could become a high-power light source for industrial processing. There are still many challenges—such as beam steering via phase control, micro-RGB sources for AR, and ultra-low-power optical interconnects—but the possibilities are vast. To achieve this, "Microoptics" to support the lasers will be crucial. I envision VCSELs playing a vital role in fields like automotive, robotics, medicine, agriculture, AI data centers, and optical quantum engineering.

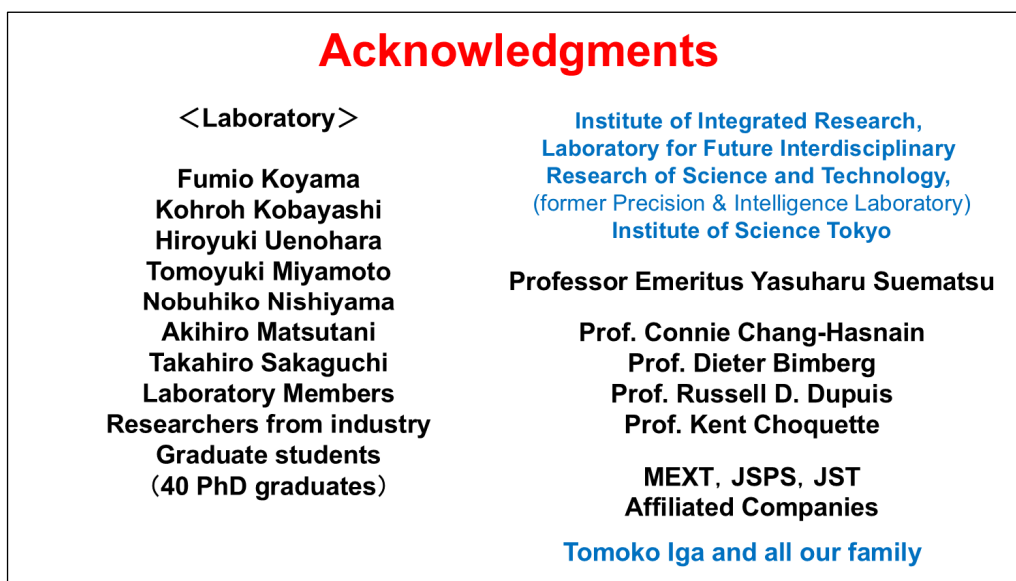


Fig. 43

〈Fig. 43〉 Finally, I would like to express my deepest gratitude to the many people who have supported my research and journey over the years.

Thank you very much for your kind attention.

- This report summarizes the Commemorative Lecture delivered at the Honda Prize 2025 Award Ceremony, held on November 17, 2025, at the Imperial Hotel Tokyo. This material is available on the Honda Foundation website. Unauthorized use for any purpose other than personal use is prohibited without the prior written consent of the Honda Foundation.

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