THE CANON FRONTIER 2019/2020

Focus on Technology and R&D

Technologies Supporting Canon

Innovative Technologies that Support Lifestyles, Business and Industry

Professional digital SLR cameras

Digital cinema cameras

Diagnostic ultrasound systems

Ophthalmic equipment

X-ray angiography systems

Broadcast equipment

Professional

X-ray CT diagnostic systems

Digital radiography

Professional digital video camcorders

MRI systems

Interchangeable lenses

Professional displays

Professional inkjet printers

Image scanners

Digital compact cameras

Compact photo printers

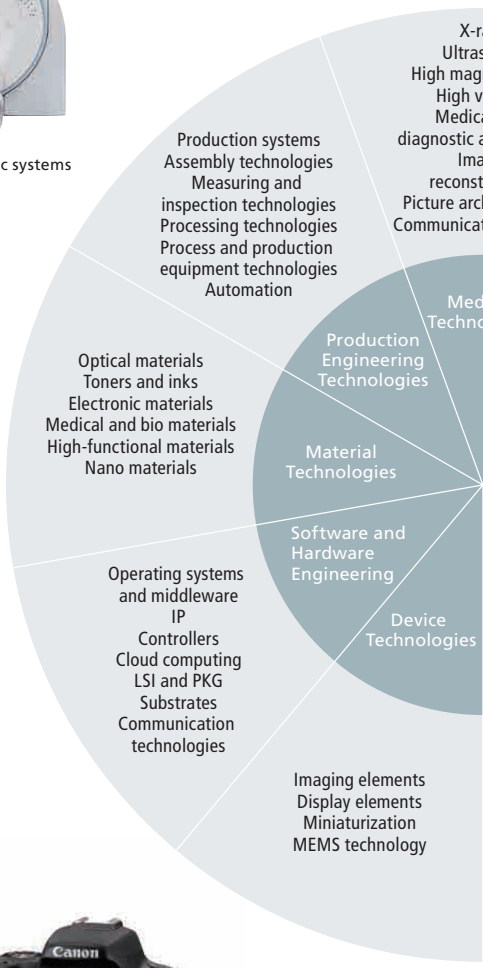
Digital SLR cameras

Home

Mirrorless cameras

Inkjet printers

Digital video camcorders



Over the course of Canon's more than 80 year history, prioritizing technology has been a part of Canon's corporate DNA and represents the source of Canon's innovative technologies. The unique core technologies that the company has cultivated over the years have led to the creation of nine fields of R&D, which include optical technologies and image communication technologies. The company is engaged in business activities for products and services in four major areas of use: Professional, Home, Office and Industry. With the aim of developing new, one-of-a-kind technologies and products, Canon combines the creativity of its engineers with the company's core technologies to create never-before-seen value.


Large format inkjet printers

Cloud-based document services


Business inkjet printers


Office multifunction devices


Document scanners


Laser multifunction printers


Toner cartridges

Office


Multimedia projectors


Facsimile machines


Solution software


Business inkjet multifunction printers


Laser printers


Network cameras


Calculators

Optical design
Optical measurement
Optical elements
Optical theory
Optical analysis

Optical Technologies

Machine and Control Technologies

Mechanical design
Mechanical control
Precision equipment operation and control
Mechatronic devices


3D machine vision systems


Die bonders


Commercial photo printers

Image Communication Technologies

High-quality image processing
Image processing and editing
Image coding
Image information processing


Digital continuous feed press

Printing Technologies

[R&D fields]

Image-formation processes
Optimal design of modules and systems

[Core technologies]


Organic LED (OLED) panel manufacturing equipment

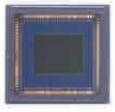

Semiconductor lithography equipment


Industrial cameras

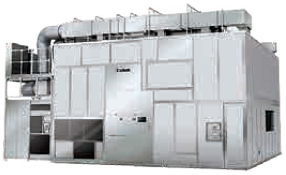

Color label/
Color card printers

Industry


Components


CMOS Sensors


Multi-purpose cameras

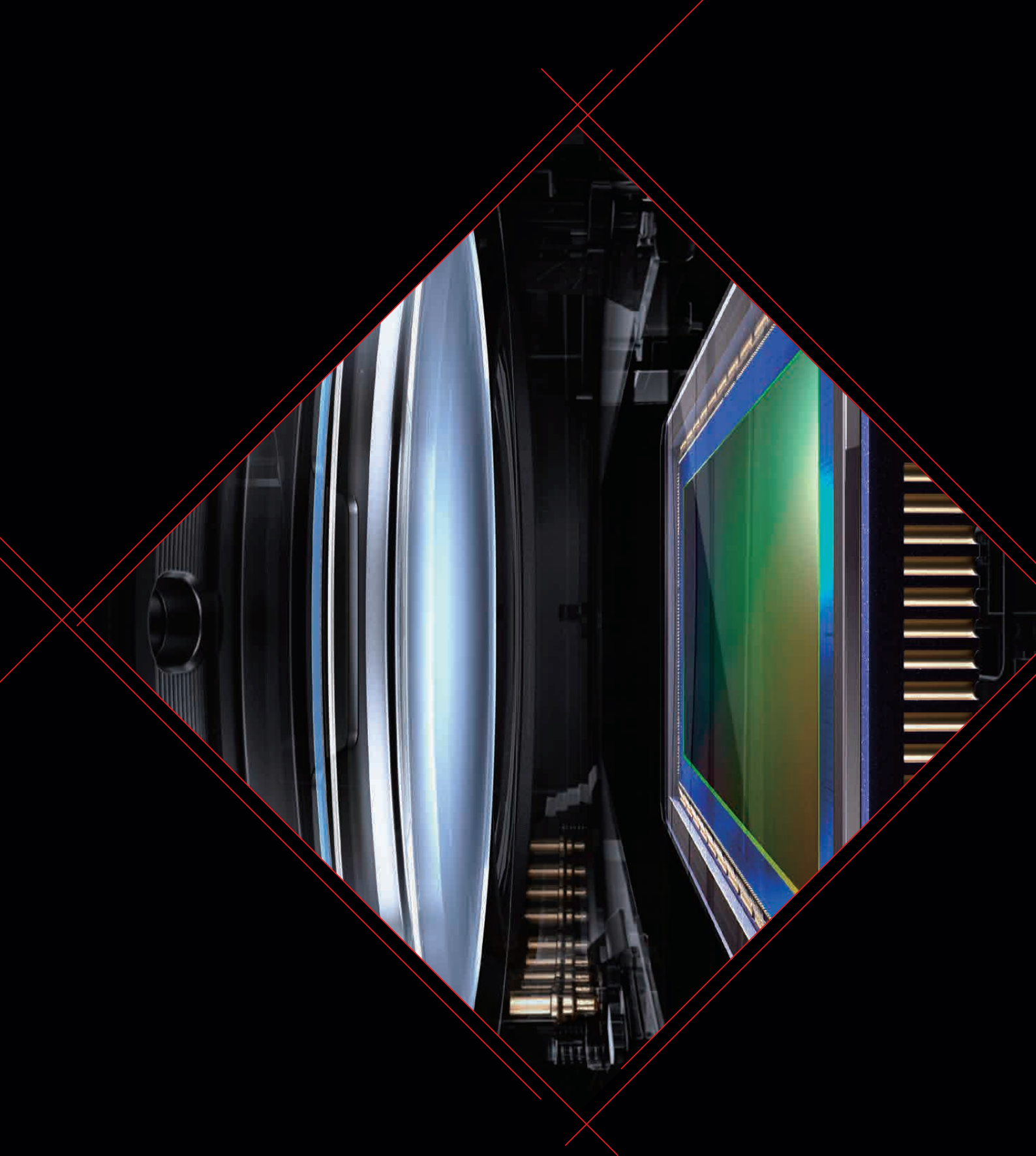

Flat panel display (FPD) lithography equipment


Mixed reality (MR) systems


Vacuum thin-film deposition equipment


Handy terminals


Digital sheet-fed press



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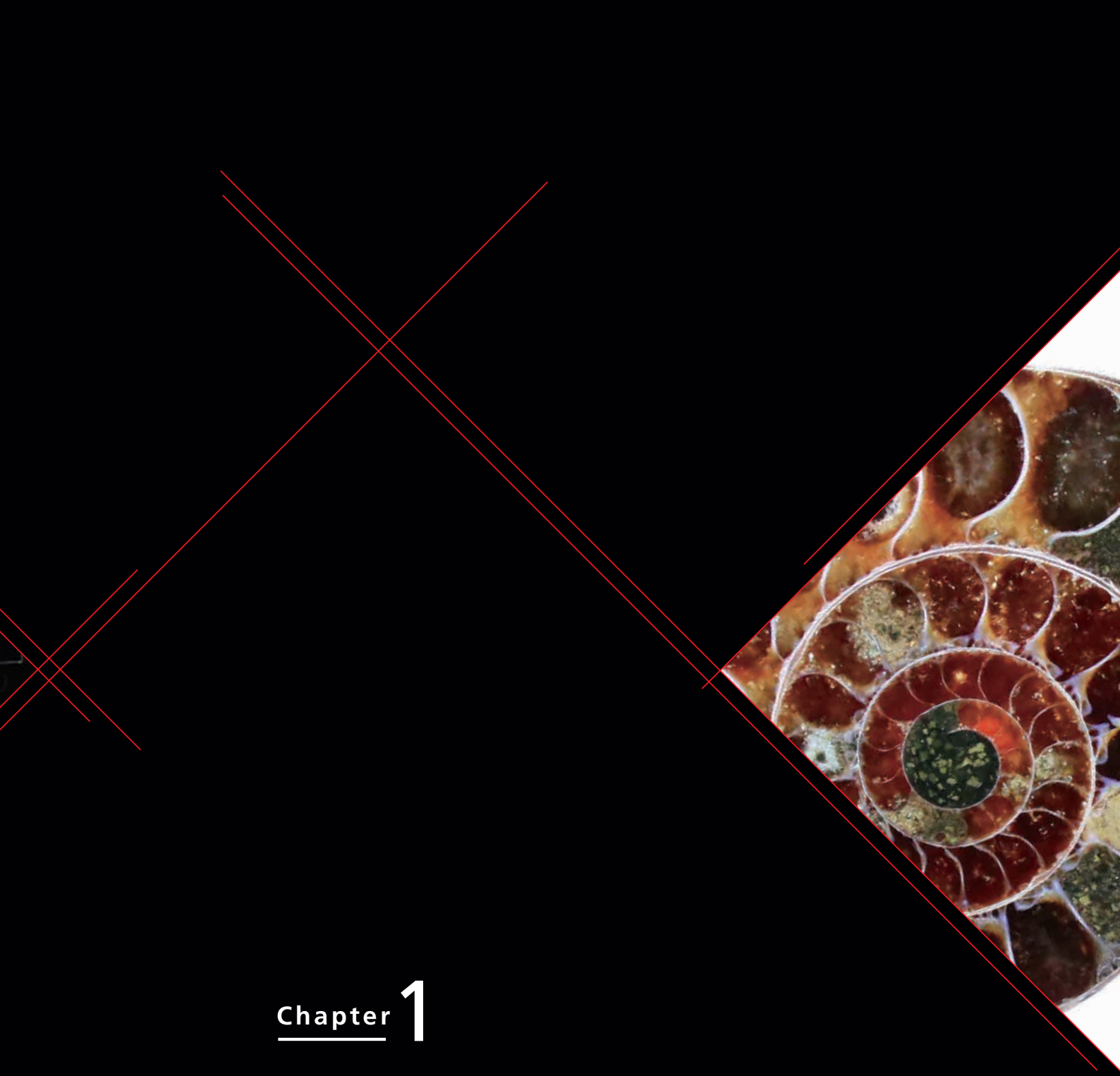
About the Cover

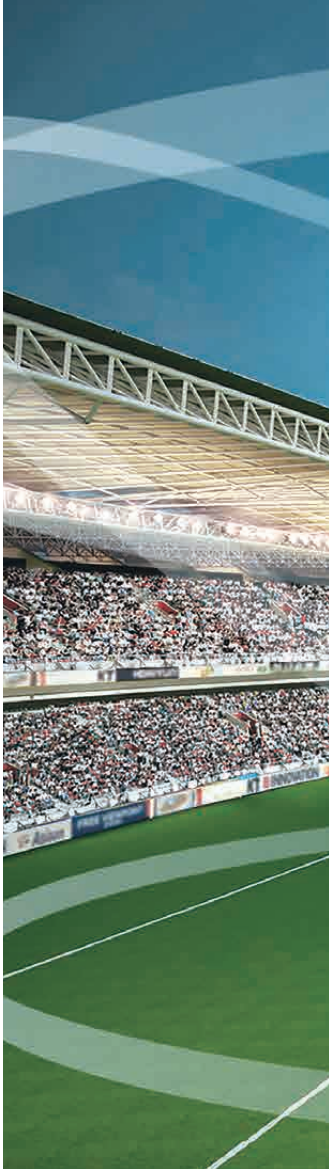
The EOS R System's RF lens mount makes possible incredibly high image quality (see P. 7)



Chapter 1

Inspiring Innovation

Imagine making the "invisible" visible.
Canon merges ideas and technologies to create products, services, and solutions that have never existed before—things people could only wish were possible before.
To resolve issues facing society, we will continue pursuing avenues and territories as yet unexplored.



Controlling

Perspective and Time

Using Canon's unrivaled imaging technologies, the Free Viewpoint Video System provides a video experience like never before.

Technologies for Visual Expression Create a Brand-new Viewing Experience

The 2016 finals match for a Cup of J.LEAGUE marked the start of a new era of visual solutions. Conventional stadium systems use fixed cameras and cable-suspended cameras, which provide video feeds from limited viewpoints. Meanwhile, for the first time ever, the new Canon system allows the viewer to see the action on the field from any position or any angle in the stadium. You can view the same scene from various angles, changing to the perspective of an athlete on the field or any number of alternate viewpoints. Additionally, viewers can control both viewpoint and game time at will. For example, viewpoint can be changed while watching the scene in slow motion. This revolutionary technology dramatically changes how sports are viewed, and this match was the moment it became reality.

The means by which video is generated may very well be considered the future of video capture. Visual data is captured by high-resolution cameras installed around the stadium, then converted into 3D data and stored on servers. When the user sets or moves the position of the virtual camera, the video they see is generated from the 3D data to show video from the desired camera angle. This video data can then be output for viewing.

In addition to optical and visual technologies consistently developed since its founding, the Canon Group develops cutting-edge technologies in such fields as network transmission and user interface. Such technologies have the power to completely transform the workflows of video production and broadcasting.

Canon's project to develop its Free Viewpoint Video System involved selecting engineers from various divisions to work together and combine their specialized engineering skills.

An immersive viewing experience just like being there in person.

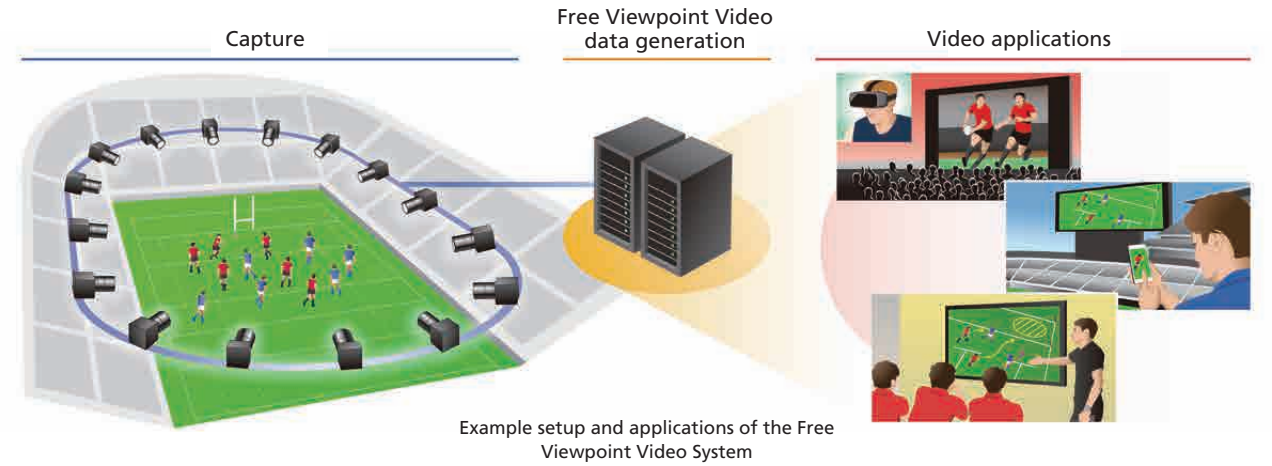
The Free Viewpoint Video System creates an immersive experience, placing the spectator into the middle of the action

Cutting-Edge Systems that Anticipate Advances in Society and Technology

The Free Viewpoint Video System is currently being tested for such sports competitions as soccer and rugby. In order to generate accurate 3D data, every camera must start shooting at the exact same time. If the timing is off for even one camera, the data cannot be generated correctly. Developers were aware of this issue from the design phase, and accordingly developed algorithms to control and completely synchronize the start of shooting for multiple cameras.

An additional challenge is the need to process enormous amount of data instantaneously in order to generate Free Viewpoint Video data. Efforts are underway to generate high-definition images at faster speeds through such means as parallel distributed processing.

Canon will continue to build systems designed for cutting-edge technologies and emerging trends.



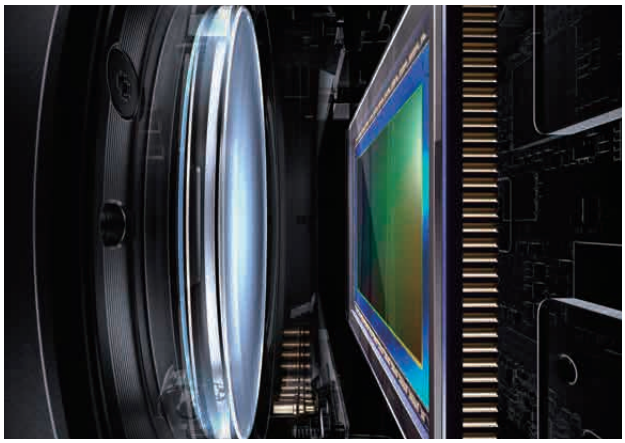
Example setup and applications of the Free Viewpoint Video System

Expanding

Photographic Freedom

The new EOS R System with a new lens mount to extend boundaries of photographic expression.
With high-resolution imaging that meets modern standards, the system opens up new possibilities for visual expression.

EOS R System
Redefining the world of imaging



A large-diameter mount and short back focus helps expand photographic expression

The EOS R body is both lightweight and durable.

SLR Cameras: Thirty Years of Change

In 1987, Canon introduced the first EOS series single-lens reflex (SLR) camera, with a fully electronic mount. Over the next three decades, the world of SLR cameras has been swept by successive waves of change. Perhaps the biggest paradigm shift has been the transition from film to digital photography. Now, in addition to prints, it is commonplace for people to view photos on electronic displays and to share and publish photos online.

The boundary between still photography and videography is also becoming blurred, and users' needs, priorities and the environment in which they pursue visual expression are continuously diversifying and evolving. Amidst these changing times, Canon announced in 2018 a new camera system—the EOS R System—developed to encourage the next revolution. The "R" represents the development concept of "Reimagine optical excellence," signifying Canon's strong commitment to redefining the world of imaging.

The RF Mount—Realizing Optical Ideals

The project to develop the EOS R System was a cross-department effort involving optical, mechanical and electrical engineers working with specialists in cinema production and network cameras. The team began by reevaluating the strengths of the EOS System. Canon's existing EOS SLR cameras are loved by photographers all over the world, from beginners to professionals. The team decided to reexamine why. The answer that emerged was the high-performance lens mount that enables sophisticated communication between the camera and lens.

Instead of the existing EF mount, the EOS R System employs the newly developed RF mount. In order to realize the ideal lens, Canon adopted the same large diameter as the EF mount (54 mm) but with a shorter back focus distance. This allows the rear of the lens to be positioned closer to the CMOS sensor.

The new mount offers a much greater degree of freedom in lens design, and accordingly, significant advantages including higher spec image quality, higher performance and compact, lightweight designs.

Canon's Bold Spirit of Endeavor Leads to Innovative Technologies

The RF mount also offers improved communication between the lens and the camera body. The fully electronic mount controls autofocus and aperture with high precision, continuing the EOS System philosophy of speed, comfort and high image quality.

The RF mount incorporates a 12-pin electronic contact system—an increase over the 8-pin configuration of the EF mount—to improve communication speed and enable storage of all optical information and optical correction data in the RF lens. The data is communicated in real time to help realize high image quality.

This high-speed transmission of data is useful for such operations as assigning control of settings including aperture, shutter speed, ISO speed or exposure compensation to the control ring of RF lenses. Additionally, it has enabled Canon to include Digital Lens Optimizer function that maximizes image quality.

Such new features are made possible by the new mount system. Throughout the development of the new mount, major themes included the ability to respond to changing needs and laying the groundwork for further advancements in anticipation of new technologies.

The engineers who led the development of the EOS R System spent countless hours discussing the form it would take. Their wish—to offer new value in visual expression to customers by extending their creative possibilities.

However, the journey has only just begun. Canon engineers will continue to study the needs of users and the marketplace, and strive to create products that surpass expectations.

Ultimately, the source of their motivation is the smile on users' faces when they pick up a camera emblazoned with the Canon logo.

Leading

The Future with Big Data

Multifunction devices using big data are becoming the linchpin of the smart office.
As the world of IT evolves, Canon is revolutionizing working styles and supporting new ways to work.

Using Big Data to Become the Linchpin of the Smart Office

To cope with a constantly changing IT environment, including the increasingly ubiquitous IoT, many companies are taking advantage of cloud computing and big data. They are actively incorporating these technologies into products and services that improve operational efficiency and provide new services. Such advances have led to the emergence of the smart office.

Canon has swiftly adapted to the changing environment by designing Office Multifunction Devices (OMDs) to take advantage of industry innovations. Over one million Canon OMDs in more than 100 countries and regions are connected to the cloud. In addition to copying and scanning, these cloud-connected devices collect and store data in secure online networks for use around the globe.

Big data gathered from OMDs all over the world is analyzed by Canon—data such as the timing for replacing consumables and the occurrence of breakdowns—in order to greatly reduce equipment downtime.

A Global R&D System to Support the Evolution of Multifunction Devices

Canon's OMDs are also contributing to more efficient document management through such features as directly uploaded scanned documents to the cloud, and batch management of documents. However, there are also new challenges to be addressed. For example, Canon is working on technology that enables OMDs to digitize scanned files for efficient upload and storage to the cloud by reducing noise in high-quality images, compressing files without loss of image quality and ensuring files resemble the original image as closely as possible.

Strengthening security has also become a critical point. When a multifunction device connects to the outside world through an external network, there is an increase risk that it might become the target of a cyber-attack. To protect against such possibilities, Canon employs the latest industry-standard encryption methods for communications between OMDs and the outside world, as well as redundant security measures such as technology that detects tampering with the device's firmware.

Canon's global development system supports the evolution of OMDs. One example is the development of OCR (Optical Character Recognition) in conjunction with I.R.I.S., the Belgium-based Canon Group company. This technology makes it possible to search for and within scanned documents.

In addition, the Canon Group company NT-ware in Germany is developing uniFLOW Online software for OMDs that uses cloud-based infrastructure to offer expandable features that facilitate smooth sharing of information and improve operational efficiency. Collaboration with such overseas Group companies speeds up development and brings new perspectives to Canon.

Office Multifunction Device evolution is transforming business and workstyles.

Working Style Reform and a Future Empowered by Data

Cloud use by OMDs is also effective in changing the way people work. With Japan facing a declining and aging population, there is significant demand for workplace improvements that enable employees to work while also balancing such home responsibilities as childcare or nursing care. Improvements are also needed to boost white collar productivity. Cloud use allows people to work as usual not only when in the office, but also from home or on the go—whether parenting, caregiving or on a business trip—helping to boost productivity.

Additionally, based on usage data from the devices, it is possible to schedule automatic deliveries or stock replenishments of consumables before they run out. Usage analyses also help determine the ideal times to perform maintenance operations, thereby greatly reducing downtime.

By analyzing the enormous amount of data gathered in real time from Canon's OMDs connected globally via the Internet, we can provide products and services that support workplace and a variety of work style innovation as the IT environment evolves.

Canon's all-in-one OMDs have set the standard with a single green start button to enable simple operations. This "green button" culture of simplification embraces new possibilities in working styles and ways of doing business.

Data is collected in real time from Canon's OMDs around the world

The operating panel enables direct access to the cloud.

Capturing

Fast-Moving Subjects, Distortion-Free

Canon has developed CMOS sensor technology from the ground up for its digital SLR cameras.
Bringing greater convenience and safety to the world by making visible that which could not be seen before.

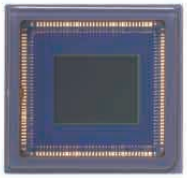
String movement can be captured without distortion using a global shutter

CMOS Sensor Featuring a Global Shutter

CMOS Sensor Captures Fast-Moving Subjects without Distortion

An issue facing conventional CMOS sensors, which sequentially expose pixels one row at a time, is that fast-moving subjects can become distorted in the image produced.

To that end, Canon has implemented a newly developed scanning method that exposes all of the sensor's pixels at the same time. This makes possible the capture of distortion-free images even when shooting fast-moving subjects, which is required for such industrial applications as product inspection. Although there were initial concerns about the power consumption necessary to achieve a high frame rate of 120 frames per second with a full-frame readout, a low power consumption was achieved using proprietary Canon circuit technology. What's more, as less heat is generated by the sensor, the camera body doesn't need to be made larger to accommodate a heat sink, allowing for more compact camera designs. The sensor has strong potential for use in cameras that inspect parts on belt conveyors at factories and for aerial cameras mounted on drones.



3U5MGXSC

Photo taken with rolling shutter

Photo taken with global shutter

Ultra-high-Sensitivity 35mm Full-frame CMOS sensor

A CMOS Sensor Capable of Clear Color-Image Capture by the Light of a Crescent Moon

From surveillance to observing natural phenomena, there is a growing need to capture video in the dark. By increasing size of the sensor's pixels, allowing them to capture more light, Canon has developed an ultra-high-sensitivity sensor capable of Full HD video capture in color with reduced noise, even in low-light environments where subjects would be difficult to discern with the naked eye.

This CMOS sensor features pixels measuring 19 µm (µm=micron, one millionth of a meter) square, which is more than 7.5-times the surface area of the pixels on the CMOS sensors incorporated into Canon's top-of-the-line EOS-1D X Mark II and other DSLR cameras.

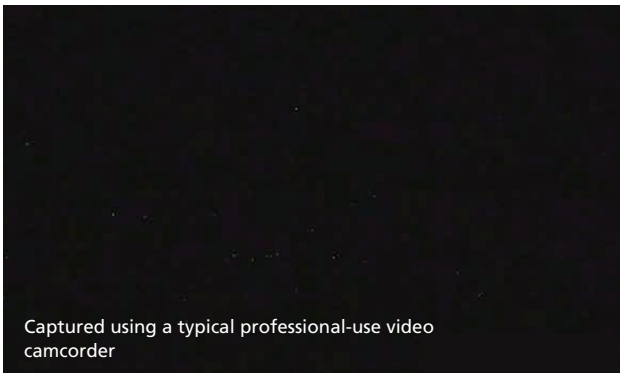
The sensor makes possible video capture with as little as 0.001 lux of illumination, roughly the equivalent of starlight, and was even used to successfully capture footage of a rare phenomenon known as a moonbow, a rainbow produced by moonlight.

The sensor is expected to be used for such applications as astronomical observation, monitoring natural disasters, crime prevention and the observation of microorganisms in low light, as well as for wildlife photography and video production.

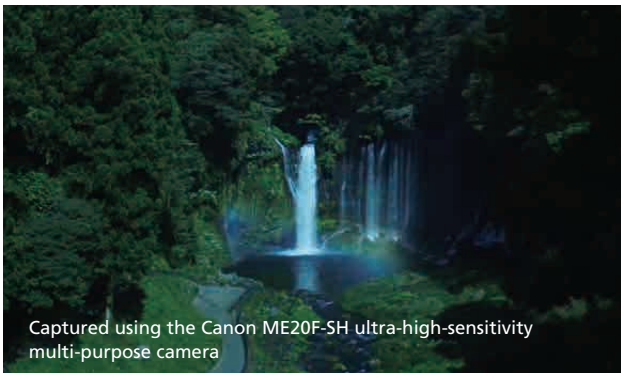
ME20F-SH

Scan to access a special video and learn more about Canon's cutting-edge CMOS sensors.

Comparison of images captured under identical conditions



Captured using a typical professional-use video camcorder

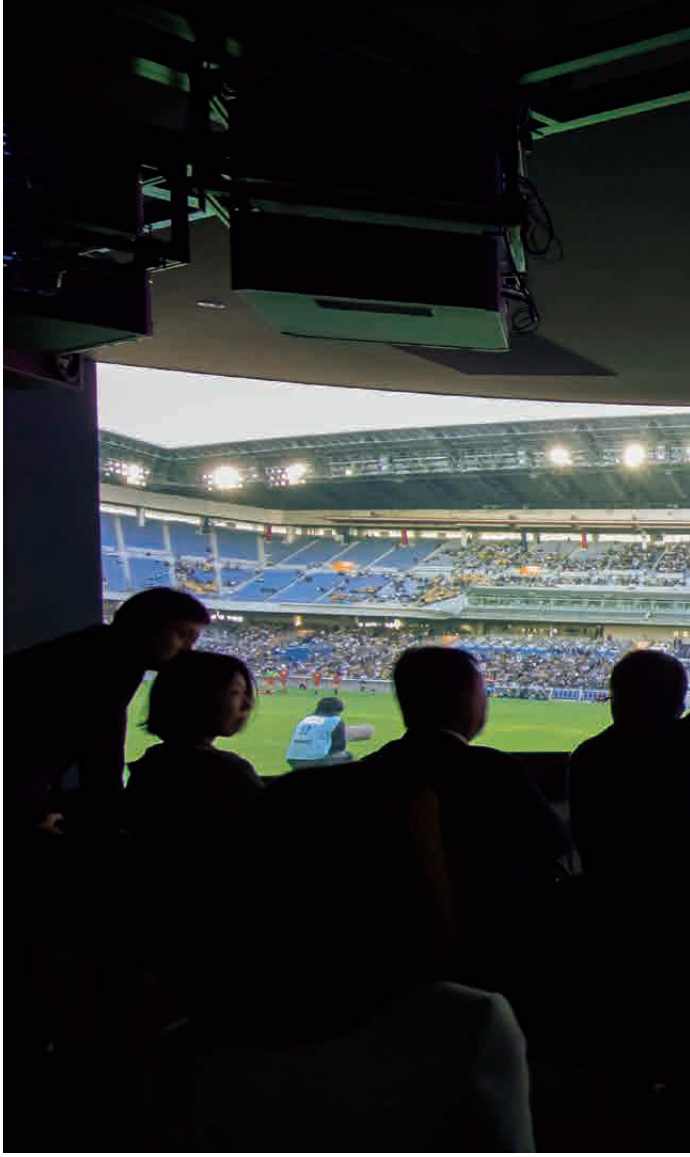


Captured using the Canon ME20F-SH ultra-high-sensitivity multi-purpose camera

Awe-inspiring

Fidelity, As If You Are Really There

The ultra-high resolution and high image quality of Canon's 8K technology makes viewers feel as though they have been transported to a distant location to watch the action live. Beyond sports and events, 8K imaging can also allow for closer observation in scientific fields.



8K Video Transports the Viewer to the Scene

Higher resolution with less distortion. Canon's video technology developers have striven to deliver realistic video that feels as though you are seeing everything unfold before you with your own eyes.

At the 2015 Canon Expo—an exhibition held every five years to showcase the Company's latest technology and upcoming developments—Canon screened an 8K video, which contained roughly 16 times the amount of information in a Full HD video. The many people seeing 8K video for the first time were in awe of the rich expressive power afforded by its high resolution. Canon's 8K visual solutions continue to evolve and now, more than simply something to be looked at on a high-resolution screen, deliver an experience so immersive that one has a sense of actually being there, allowing viewers to savor the excitement of seeing an event unfold before their eyes.

8K Lenses, Cameras and Displays Developed without Compromise

Canon is one of the few manufacturers in the world that can develop lenses, cameras, and displays covering 8K video production from input to output. The tenet of putting technology first encoded in Canon's corporate DNA has accelerated the development of high-image-quality 8K technology to win over video production professionals.

Harnessing our expert command of optical technology, we re-examined every facet of optical design to create a lens that thoroughly minimizes aberrations and achieves high-resolution, high-contrast imaging across the entire focal length range, to deliver sharp 8K video from the center of the image to the periphery.

Because an 8K camera generates a much higher volume of data, a conventional image processor was insufficient to process it all. To that end, Canon worked to develop a system that could process massive amounts of data at high speed by making use of a state-of-the-art programmable IC (integrated circuits that can be programmed to carry out various functions). This system made it possible to shoot ultra-high-resolution video with low noise and a wide dynamic range.

Through their capacity to process visual expression with ultra-high resolutions surpassing that of the human eye and proprietary backlight control, 8K displays produce brighter highlights while maintaining deeper blacks to output images with three-dimensionality and textures close to the real thing.

8K immersive live viewing at Canon's HQ

8K Visual Solutions Fundamentally Change How Video is Produced and Enjoyed

In sports broadcasting, it has long been difficult to capture video that shows both the facial expressions of the athletes and an overview of the entire field.

Canon conducted two live-video transmission tests in October 2018 for an international rugby match held in the city of Yokohama.

In the first test, video shot with Canon 8K cameras and lenses was transmitted to the company's Tokyo headquarters using such conventional equipment as fiber optic cables and a 4K broadcast van. The live footage was projected in 8K using four 4K/HDR projectors and screened in 8K on Canon's 8K/HDR display, resulting in impressive 8K footage with faithful reproduction down to the finest details.

In the second test, ultra-wide-angle video was captured using an 8K camera equipped with a fisheye lens, converted in real time to correct for distortion, and transmitted from the stadium. The video was received at the Canon headquarters and projected onto a large curved screen using multiple 4K projectors. The impressive live video fully encompassed the audience's field of vision, creating the feeling of being at the stadium watching. These tests accelerated the development of technologies for the practical implementation of ultra-realistic live viewing solutions.

Beyond just sports viewing, 8K visual solutions have already begun to show their true value for applications in other fields. The 8K display developed by Canon has been used in the field of geobiology to view and analyze cross-sectional images of fossils contained in rock formed in the ocean in prehistoric times. This system makes it possible to see subtle color differences and microscopic marks that had not been observed before, even presenting the chance to discover unknown forms of life.

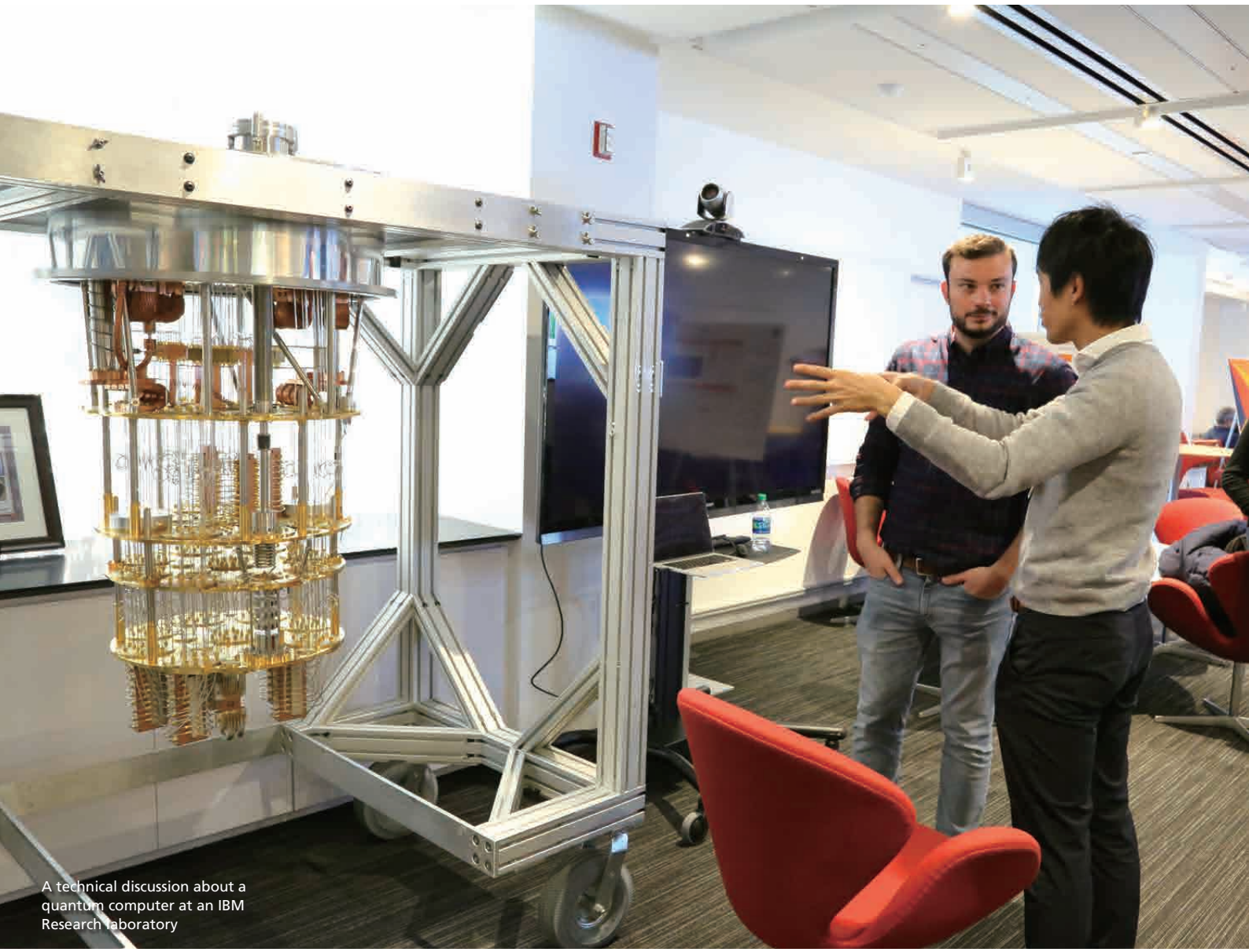
Going forward, Canon will continue to improve upon current 8K video technology and develop wide-reaching 8K visual solutions, including never-before-seen visual experiences that transport viewers to distant places and scientific applications.

Fossil cross-section examination at Hokkaido University using an 8K display

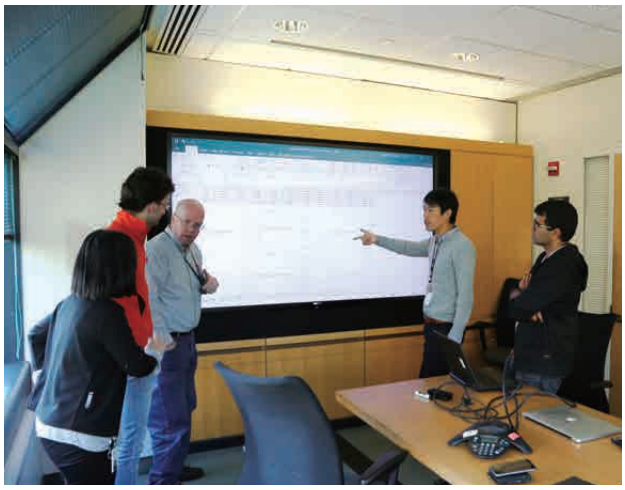
Transcending

Conventional Ideas

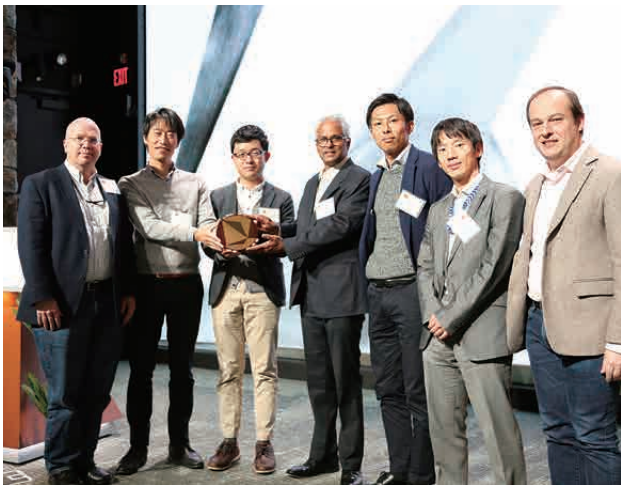
Canon is engaging in open-innovation-based research and development with research organizations internationally, covering such broad themes as quantum computing.
When combined with Canon technologies, the results of this R&D generate new value for society.



A technical discussion about a quantum computer at an IBM Research laboratory



Neuromorphic device development team design meeting



IBM's project leaders and Canon's development team at a meeting to announce their results at the IBM Thomas J. Watson Research Center

Incorporating Cutting-Edge Technologies through Open Innovation

Vast resources are required to be an early adopter of such complex, state-of-the-art technologies as AI, IoT and quantum computing towards tackling the issues facing society. It is unrealistic to expect any single entity to explore everything by themselves. Hence open innovation is becoming an important strategy for companies to strengthen their R&D capabilities.

Artificial Intelligence (AI) is a technology with great potential, and ambitious AI research is being pursued around the world. Open innovation is an effective way to obtain research results quickly and combine them with Canon technology to provide new value to society. Additionally, since one company is limited in its ability to collect the vast amount of data required to train AI, collaboration is crucial.

Quantum computing, with its ability to process vast amounts of data at ultra-high speeds, is another area of great interest. Through engaging in open innovation, Canon is taking steps towards creating unprecedented, new products and services that utilize these cutting-edge technologies.

Merging Canon Technologies with the Results of Open Innovation

An initiative with the IBM Research Frontiers Institute (RFI) is just one example of the open innovation initiatives that Canon is currently pursuing. The RFI works with partners in various industries and fields all over the world, and conducts basic research that leads to business innovations 10 or 15 years down the line. Canon sends young engineers to RFI where they engage in R&D work with the ultimate aim of commercialization. We examine their results and strategize how to cross-fertilize the ideas with the many technologies possessed by Canon to create completely new products and services.

Neuromorphic Devices to Solve Problems with Using AI

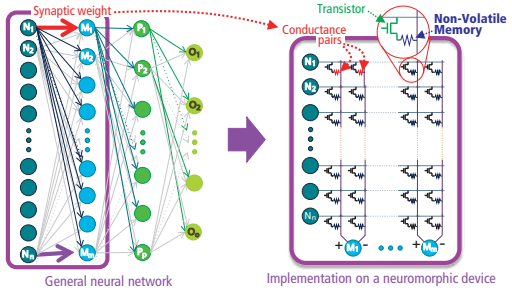
One area of Canon research at RFI is neuromorphic devices. The further utilization of AI is expected for such applications as language processing and video processing in cameras. However on conventional architectures, these AI applications consume high compute and power. The solution is a neuromorphic device that imitates the structure of the brain. By building analog non-volatile memory (memory that can retrieve stored information even after the power is turned off) into the device, low power consumption can be achieved for large-scale parallel operations.

A paper about neuromorphic device research in RFI was published in Nature, Vol. 558 Issue 7708, 7 June 2018. The paper demonstrates the feasibility of a highly power efficient neuromorphic device that can perform as many as 28,065 billion operations per second at 1 watt. The results of demonstrating the future potential of these neuromorphic devices are considered to be a big step for AI technology which will process a large amount of data in the future.

This research is being conducted at IBM Research—Almaden in San Jose, California, a research laboratory that brings together hundreds of researchers from companies and research institutions around the world. The research group has experts in diverse fields. Meetings are for everyone to freely express their opinions, and new ideas emerge from the interaction of researchers from multiple disciplines.

Through these new collaborations in research and development, Canon will accelerate its efforts to address societal issues.

Synaptic weights in a neural network are implemented with simple conductance pairs that are compact and achieve low power consumption on a neuromorphic device.



Implementation of general neural network on a neuromorphic device which the Nature papers* are based.

* Nature Volume 558 Issue 7708, 7 June 2018

Pursuing

New Possibilities for Materials

Material science drives the development of colorants, lenses and more; it is indispensable to product competitiveness.
Canon is creating new materials with unprecedented performance that will contribute to a sustainable world.

> High-Color-Performance Xanthene-Based Dyes

Vivid Red that Doesn't Fade

In most cases, since printer manufacturers do not develop original colorants in-house and instead procure commercially available dyes from suppliers, it is difficult for them to differentiate their colors from those of competitors. Canon, however, focused its development efforts on xanthene-based dyes, which boast superior coloration properties, to create a magenta dye capable of producing high-visibility reds. Although finding a practical application for xanthene dyes was considered difficult due to challenges related to robustness (light colorfastness), the Company's research efforts paid off with the successful development of a new magenta dye that enables the printing of reds that are both vivid and robust.

Employing Proprietary Molecular Design in Search of Improved Robustness

Canon began developing new dyes in the 1980s and has now amassed more than 10,000 types of dyes in its Canon Materials Bank. The bank represents a database of a diverse variety of technological know-how that, in addition to information on the synthetic and physical properties, includes data on the mechanisms behind the breakdown of dyes when exposed to such stimuli as external light and ozone gas. During the development of xanthene dyes, Canon introduced repeated simulations, molecular designs, synthesis, evaluations and analyses, arranging specific substituents in optimal locations to achieve both desired coloration performance and robustness. The result was the birth of new dyes.

It was 2012 when a proprietary dye was first used in the ink of the cartridge. A second-generation dye with further improved performance was later (2017) used in the ink cartridge, which contributed to improved print quality.

Moving from the Lab to Mass Production

One challenge that needed to be addressed following the creation of xanthene-based dyes in the lab was mass production. Unlike the compact 300-milliliter reaction vessels used in laboratories, those used in mass production, with capacities exceeding one ton, are of an altogether different scale. For inkjet printers in particular, because ink ejection must be controlled at the picoliter level, even the slightest amount of impurities arising during synthesis could cause the ink nozzles in the print head to clog. Accordingly, R&D division and business group conducted joint research aiming at reducing impurities to less than one part per million. The collaborative efforts paved the way for commercialization by ensuring consistent ink quality during mass production.

> Ceramic Materials for 3D Printers

Accurately and Consistently Producing Even Parts with Complex Geometries

Today, it is becoming commonplace to use 3D printers to prototype and manufacture a variety of parts in small lots using such raw materials as resin and metal.

However, many existing ceramic materials for 3D printers contain resins and the items produced using these materials can shrink during the post-annealing process, making it difficult to produce ceramic parts

with high accuracy. To that end, Canon has developed alumina-based ceramic materials that does not shrink. Using 3D printers, Canon has succeeded in consistently producing ceramic parts with such complex geometries as hollow and porous structures, which are difficult to achieve through ordinary metal molding and cutting processes.

This technology is expected to be used in industrial equipments and meet prototyping and high-mix, low-volume production needs for a wide range of fields, including the healthcare industry.

> Lead-Free Piezoelectrics

Developing Piezoelectrics with Low Environmental Impact

Piezoelectric materials, which are essential for producing motors and sensors, have the ability to transform electrical energy into mechanical energy. Most piezoelectric materials, however, contain lead as a principal component, which has a negative impact on the environment, posing a challenge within the industry. In addition to continuing efforts to eliminate lead from lenses and solder, Canon is trying to eliminate lead from piezoelectric materials towards the goal of launching products that feature lead-free materials.

Top: Ceramics parts made with ceramic material and parts manufacturing technology newly developed for 3D printers
Bottom: Preparing samples of lead-free piezoelectrics for analysis by sintering mixed raw particles

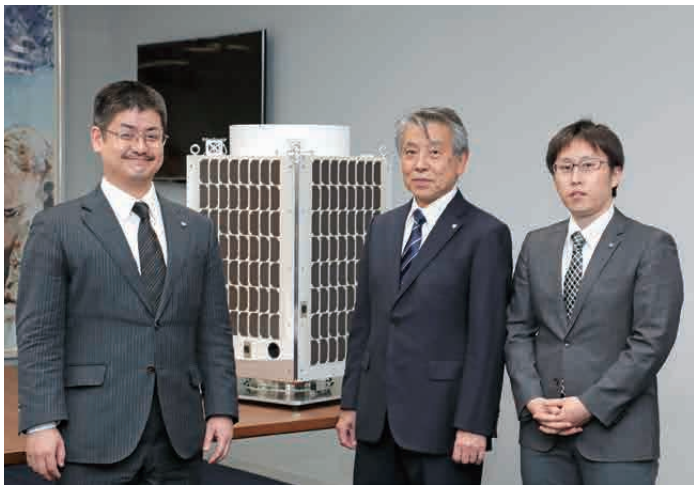
Reaching

Space

The Canon Group is fully mobilizing its technologies with Canon Electronics Inc.'s entry into the micro satellite industry.
We are steadily hitting milestones towards exploring the final frontier that is outer space and leading humanity to a new stage.

Image of the Phoenix Sky Harbor International Airport in Arizona captured with a CE-SAT-I micro satellite from 500 km above the Earth

The further miniaturized CE-SAT-III measures 100 mm x 100 mm x 300 mm



With the CE-SAT-I satellite

Nobutada Sako (left)
Group Executive Satellite Systems Laboratory
Canon Electronics Inc.

Tsumori Sato (center)
Senior Managing Executive Officer & Group Executive Future Technology Research Laboratory
Canon Electronics Inc.

Yoshito Niwa (right)
General Manager
Development Div.2
Satellite Systems Laboratory
Canon Electronics Inc.

Toward the Next Frontier

In 2017, a rocket carrying the CE-SAT-I micro satellite, developed by Canon Electronics, was launched from a space center in southern India. At 17 minutes and one second after liftoff, the micro satellite entered space, successfully reaching its scheduled orbit. This tiny satellite, measuring only 500 mm x 500 mm x 850 mm, was a major step forward for Canon Electronics.

The endeavor began with an order from the president of Canon Electronics, Hisashi Sakamaki: "In the future, a top company will be one that can master space. Let's be a trailblazer that sparks a dream in the minds of young people."

The Canon Electronics Inc. Future Technology Laboratory, currently in charge of the effort, is led by Senior Managing Executive Officer & Group Executive Tsumori Sato, who says he was initially quite surprised by Mr. Sakamaki's declaration. However, Canon Electronics already had the technological foundations needed to develop a micro satellite—the motor technologies for attitude control of the satellite, lens technology ranging from macro to zoom and miniaturization technologies for eliminating wasted space. In addition, Canon Electronics could leverage the electronic, mechanical, optical, materials and other technologies of the Canon Group to make the satellite development possible.

The result was the CE-SAT-I. In a small chassis, the company fit such components as a digital single-lens reflex (DSLR) camera with a catadioptric optical system and a compact camera for wide-angle image capture. Using the DSLR camera, the imaging system can provide a 0.9 m ground resolution from a 500 km orbit within a 5 km x 3 km frame size, making possible the identification of individual cars on a road. The compact camera can capture wide-angle shots within a 740 km x 560 km frame.

Currently, CE-SAT-I is operating smoothly and sends image data to Earth every day.

Space: A Different Environment

Canon Electronics had confidence in its manufacturing capabilities, but developing a micro satellite was no easy task. Ground and space are two entirely different environments. "We had real difficulties in three technical areas," says Nobutada Sako, Group Executive, Satellite Systems Laboratory, Canon Electronics Inc. "One was the absence of gravity; two was the vacuum environment; and three was the unrelenting radiation in space."

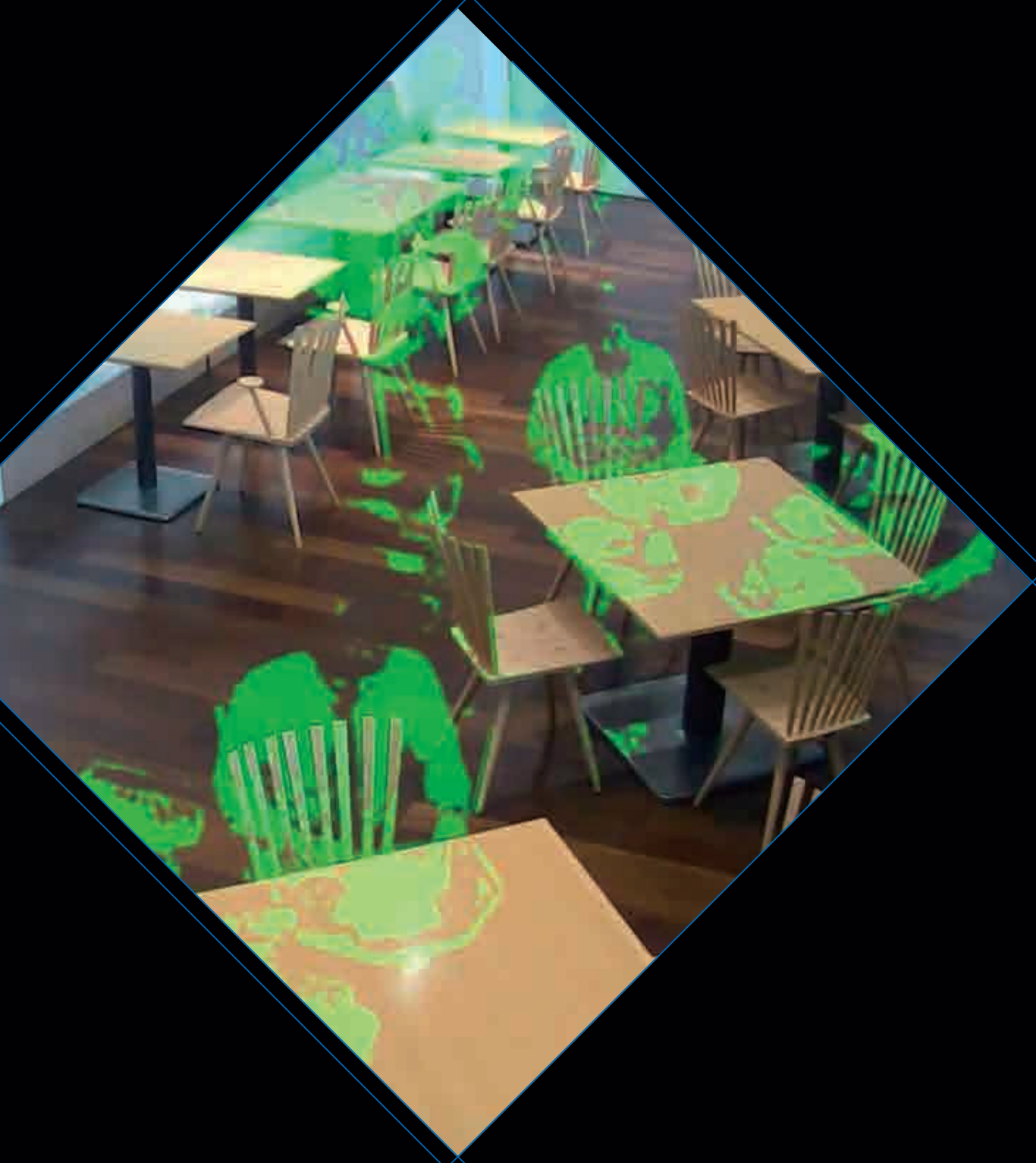
The challenges of radiation and operating in a vacuum were particularly difficult to overcome. We eventually solved the problem of heat dissipation by devising a clever radiative cooling method that uses metal to conduct heat away from where it is generated, even in a vacuum. Radiation presents the risk of causing system stoppages or malfunctions. The development team overcame this issue by testing a large number of semiconductor chips, and eventually found a moderately priced, commercially available chip that was resistant to radiation.

Semi-Customizing the Satellite

Canon Electronics' micro satellite project is proceeding smoothly, but designing an optimal business model for micro satellites is still a major hurdle to overcome.

Currently, the company plans to generate revenue through sales of micro satellites, sales of parts for micro satellites, and sales of the visual data recorded by the satellites.

However, according to Yoshito Niwa, General Manager, Development Div. 2, Satellite Systems Laboratory, Canon Electronics Inc., "Sales of micro satellites alone will not help us reach our goal. The key to expanding this business is the sales of visual data." The high-resolution images captured from space contain information that is valuable in many ways. At present, however, Canon is searching for clients who might require such data. What kind of information can be obtained, and who can use it? Going forward, Canon will work to improve its image analysis technologies with the goal of finding the perfect customer match for this information.



Chapter 2

Accelerating the Development of New Canon Businesses

Canon is making new advances in healthcare technology, security, and industrial equipment. Canon is advancing new businesses with purpose and speed while staying on top of the latest technological and societal trends towards the realization of a richer world of greater convenience where people can live with peace of mind.

Advancing

Society

Network cameras are increasingly being used in a range of fields beyond security, such as management and marketing.
IT integration and advanced video analysis will lead to a safer, more secure world and bring higher productivity to businesses.

High-Resolution Network Camera Systems Meet the Needs for Enhanced Security

Canon's network camera systems, which combine cloud services and image analysis technologies, have a key role in our business growth. Their use is expanding into a broad range of fields, from security systems for factories, warehouses and retail outlets to business solutions that analyze flows of people and physical objects for marketing research or productivity improvement.

JAL Engineering Co., Ltd., which handles aircraft safety and quality control, adopted a Canon network camera system for the company's hangar and facilities at Haneda Airport in Tokyo, Japan. Routine aircraft maintenance is conducted in the hangar, along with inspections carried out on an aircraft in the short period of time between its landing and next takeoff. Emergency repairs are also carried out there if a malfunction occurs. Previously, a monitoring system with 60–70 cameras was utilized in the hangar with a constant traffic of people, vehicles, and aircrafts. However, due to increased security needs, they decided to upgrade to a system that offered higher resolution. Ko Misawa, in charge of the project, explains what his company needed in a new security system.

"To establish a higher level of safety management, we placed top priority on a system that would produce clear, sharp images. However, due to wiring issues, we couldn't install cameras in some places in the hangar. To cover every part of the very large hangar, we needed advanced camera functionality that would be able to easily control the zoom, change the direction of the lens and also produce clear images at night. We were impressed with models that could produce distinct images even in the dark, and cameras that could capture ultra-wide-angle shots, even in cramped spaces. Only a camera manufacturer, I felt, could offer such capabilities."

The combination of lens and video technologies cultivated by Canon over its history makes it possible to create network cameras that provide high-definition, high-resolution images while maintaining a wide angle of view. The cameras also adjust for optimal shooting day or night, producing clear images from corner to corner.

Solutions Optimized for a Given Location through IT Integration

At the introduction stage of the new system, Canon's team of engineers repeated on-site verification and numerous meetings with the client. "JAL Engineering had objectives and key locations to improve monitoring. We explained these to the Canon team, and they set about designing a plan."

Further progression was made to the high-capacity data management system, according to Mr. Misawa.

"Thanks to cutting-edge data compression technologies, it is now possible to store video for long periods of time. If a problem occurs, we can now go back in time and verify video in chronological order to thoroughly troubleshoot the issue."

Canon has created a monitoring system that reduces strain on the network even when transmitting high-quality video, thanks to an image compression system that realizes high image quality with a high compression ratio. High compression

Canon network cameras are installed in the JAL hangar at Haneda Airport in Tokyo, Japan.

reduces the hard disk drive capacity requirements and makes the long-time video recording possible, allowing for a high volume of footage from multiple cameras to be stored.

Overcoming On-Site Challenges to Improve Operations—the Expanding Possibilities of Network Cameras

"When the completed system began operating, we witnessed improvements on the hangar floor," says Mr. Misawa.

Before, a late arrival of an aircraft, in spite of numerous exchanges made with the aircraft, resulted in lost time waiting at the hangar. After the system was introduced, it became possible to monitor the aircraft coming in or leaving in real-time via the system. Additionally, we are able to now visually check the progress of work using the cameras."

The primary mission of maintenance crews is to precisely complete the work without any error in the limited time available.

"At JAL Engineering, we coined the term 'Zero Zero 100' to represent our goal of zero irregular operations, zero in-flight malfunctions and 100% on-time departures. I feel that the system renewal has allowed us to achieve improvements in both security and productivity."

Canon's network camera system watches over and helps improve business operations for the aircraft maintenance floor. Using the power of cutting-edge technologies, Canon will strive for the contribution to safety and security in a range of various fields.

Canon's Video Content Analysis Solutions Are Generating New Value from Video

Canon's high-precision, high-resolution network cameras offer even greater value when used in combination with software to provide video content analysis solution.

The People Counter video content analysis software developed by Canon can count the number of people in an area or the number of people that cross a specified line.

Canon's Moving Object Mask video content analysis software can render a moving object as a silhouette. It enables monitoring the availability of seats at a venue, overcrowding, while protecting privacy.

Canon will continue to commercialize video content analysis software for marketing and other applications, adding value to network camera video.


People Counter with silhouettes

Reducing

Dose for Patients

Canon Medical Systems has developed technology that uses deep learning to produce high-resolution CT images at a low radiation dose. The technology reduces risk for patients while providing high-quality images to healthcare personnel for accurate diagnosis.

The Relationship Between CT and X-Ray Dose

X-ray Computed Tomography (CT) equipment has a significant role in providing clinicians with the tools for diagnosis and treatment planning.

CT image quality is closely related to radiation dose. High image quality can be obtained with greater dose, but that means increased X-ray exposure for the patient. A low radiation dose reduces exposure to radiation, but the trade-off is lower image quality.

To solve this problem, Canon Medical Systems (Canon Medical) has been developing various innovative technologies to produce high-resolution images without compromising on radiation dose. One is AIDR 3D (Adaptive Iterative Dose Reduction 3D), which reduces exposure by 75%. Another is FIRST (Forward projected model-based Iterative Reconstruction SoluTion), which further reduces exposure and improves image quality. Such technologies produce high-quality images while reducing patients' radiation dose. These new technologies greatly expand the practical uses for CT to applications such as perfusion and dynamic movement.

AiCE, a CT Imaging Technology Using Deep Learning

Canon strives to continue to reduce radiation dose on patients to improve their quality of life. In April 2018, Canon released a high-resolution CT system equipped with AiCE (Advanced Intelligent Clear-IQ Engine), CT imaging technology using deep learning.

AiCE is a state-of-the-art technology designed to reduce noise found in CT images through deep learning while producing high-quality images. The clearer images allow for a more accurate diagnosis at the low radiation dose level no different from that of a normal chest X-ray. AiCE offers exceptional noise reduction while eliciting details in the CT image.

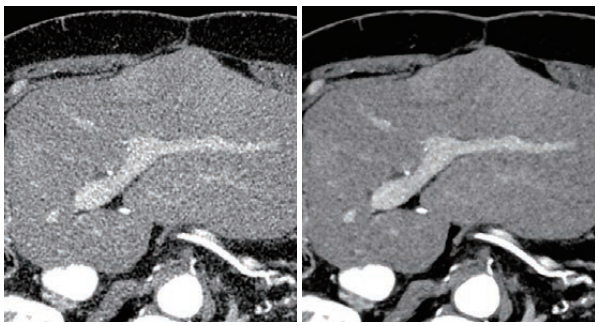
Also, with conventional CT systems, the image processing used to produce high-resolution images generally takes a lot of time. AiCE harnesses the computational power of deep learning neural networks (a network structure patterned after the connectivity of neurons in the human brain) to reduce noise, resulting in faster image output that contributes to improved workflows in the healthcare field.

Canon Medical's CT scanner

Global Collaboration with Leading Hospitals

Canon Medical actively promotes product development through joint research with clinical doctors. In working to make AiCE clinically available to the market, our global development team collaborated with the doctors and engineers at institutions providing state-of-the-art medical care to enable the system's commercialization in the short period of about a year.

Looking ahead, we will continue to actively promote product development that employs deep learning and other cutting-edge technologies to improve the quality of life for patients and provide medical professionals with the best tools to help their patients.



Conventional technology (left) vs. AiCE imaging (right)

Aiming to Benefit More Patients and Medical Institutions

The development of AiCE started with a strong desire to create a system that would help patients and doctors. My team and I believed in the power of AiCE and wanted to make this product available to the market ahead of other companies. In the end, we were able to achieve commercialization in the short period of just a year, thanks to the collaborative efforts of overseas research labs and doctors in medical clinics. The clinical doctors we worked with rated the AiCE system highly, calling it "indispensable to diagnostic imaging." I was very happy to work on the development and commercialization with my team. We will continue to improve and update AiCE, taking into account the latest trends in technology, so that we may further improve image quality and reduce radiation dose. Pooling our experience, we will strive to employ this technology in medical devices beyond CT to help clinical doctors and patients around the world.

Naruomi Akino
Deputy Manager of CT Systems
Development Dept. System Group
Canon Medical Systems

Developing

New Medical Technology

Canon is working with the leading medical institutions within the United States to further develop medical imaging technologies.
This technology will provide a more accurate diagnosis and help advance medical treatment that exist today.

Ultra-miniature fiber endoscope is currently under development with the goal of commercialization.

Ultra-Miniature Fiber Endoscope

Extremely Thin Endoscope Will Offer New Diagnostic Possibilities

At the Healthcare Optics Research Laboratory (HORL) in Boston, Canon is leveraging their technological strengths in areas such as micro-optics fabrication technology, diffraction optics simulation, and optical design technology with a goal to develop an ultra-miniature fiber endoscope. This endoscope will be less than 1 mm in diameter and will be significantly thinner than conventional devices. It consists of a micro-lens with a diffraction grating attached to the end of the optical fiber attaining a higher resolution endoscope. When commercialized, the device will enable real-time observation inside joints and sinus cavities for the first time, facilitating early treatment and new forms of diagnostics for patients.

Development of an ultra-miniature fiber endoscope for commercialization

Needle-Guiding System

Image-Guided Navigation Software and Robot for Accurate Needle Insertion

Today, a physician will typically view the CT or MRI images outside of the operating room. They try to confirm the location of a cancerous site and decide where to position the needle. With this needle-guiding system being developed by HORL, the software will help angle the position for the needle to be inserted into the abdominal or chest cavity. This will provide a more accurate target of the cancerous site for the physician.

In today's environment, physicians rely on their intuitions and skills during ablation and biopsy procedures. In creating a prototype of the needle-guiding system, Canon has been developing motors and sensors that can operate in an MRI environment. This system aims to bring greater speed and accuracy to such procedures.

The ultra-miniature fiber endoscope and needle-guiding system are being developed for commercialization in collaboration with Massachusetts General Hospital and Brigham and Women's Hospital. They are both teaching hospitals of Harvard Medical School, in Boston, Massachusetts.

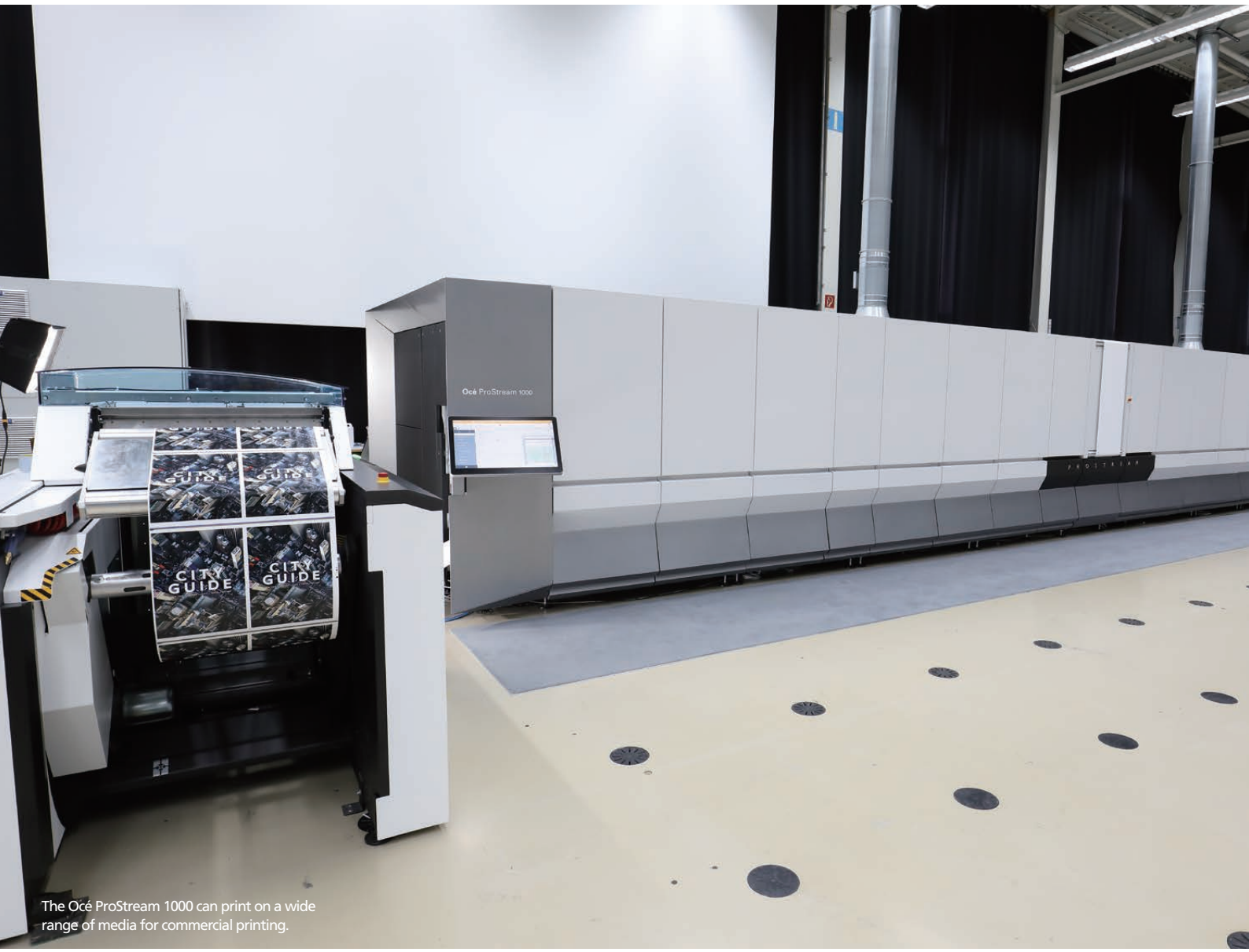
The needle-guiding system is being developed jointly with HORL and hospitals

The needle-guiding system is composed of an image-guided navigation software and a needle guidance robot

Transforming

the World of Digital Commercial Printing

Achieving unprecedented high image quality for a wide range of print media. Digital printing enables a variety of output that can only be achieved digitally to meet diversifying commercial printing needs.



The Océ ProStream 1000 can print on a wide range of media for commercial printing.

Meeting the Printing Industry's Growing Need for Short-Run Production for a Broad Range of Applications

The need for short-run production for a broad range of applications is growing rapidly for commercially printed materials such as books, brochures, direct mail and catalogs. In direct mail, for example, the conventional practice was to send the exact same message to a large number of customers. Recently, however, digital marketing is utilizing data to customize printed messages according to each person's interests, resulting in higher customer satisfaction.

Offset printing has thus far been a mainstay of commercial printing and is advantageous for printing high volumes of the same content. However, because it employs thin printing plates made of aluminum etched for printing, it is not cost-efficient for short-run production and does not easily handle individual print jobs.

Digital printing has risen to the fore to address such concerns. Since digital printing does not require printing plates, it is better suited to short-run production with quick turnaround time and variable printing that requires changes to the printed content for each sheet. Canon is meeting various needs in the digital printing market with high quality, productivity and reliability.

New Technologies Adopted to Ensure High-Resolution 1200 dpi Printing

Canon and the Canon Group company Océ* have expanded their product lineups to provide optimal solutions tailored to customers' objectives. One such product is the Océ ProStream 1000, the company's latest continuous feed press (for high-speed printing on roll paper) developed for the graphic arts market, where high image quality is required for high-quality catalogs, premium direct mail and other published materials.

This press features ColorGrip, a media-pretreatment applied before ink is printed onto media to prepare the paper surface and prevent the ink bleeding.

This technology enables the press to print on a wide range of media including conventional offset coated media which was considered difficult with prior technology. Océ's proprietary polymer-based pigment ink (ink containing a polymer component that forms a durable film when heated and cured) enhances abrasion resistance and creates vibrant colors. It is also effective for accurate ink droplet positioning and detail sharpness, and together with the latest print head, the press supports high-resolution 1200 dpi printing, which is comparable to offset printing.

The air floatation non-contact drying technology, which dries the ink using an "air flotation" dryer system without the need for a paper conveyor belt, minimizes paper stress and produces high-quality printing on various media. Océ's proprietary ColorGrip solution and air floatation non-contact drying technology produce high-quality output without compromising the paper's texture.

* Océ joined the Canon Group in 2010. The Dutch company has a history of more than 140 years, and has earned a high market share for such commercial printers as continuous feed presses and large-format printers.

The Diverse Technologies in Canon Printers

Canon also manufactures many other printers for commercial printing to meet a broad range of needs, including digital continuous feed presses and sheet-fed presses that print books, manuals and transactional application at high speed, and large-format inkjet printers for producing blueprints, posters, signages, etc.

Another of Canon's strengths is in proprietary UVgel ink (gel-like UV-curable ink with excellent color gamut and environmental performance) that offers high image quality, high durability, productivity and support for a wide range of media. Canon also excels in such technologies as elevated printing that can even reproduce textures. Going forward, we will continue to deepen our group synergies and meet the world's diversifying needs for digital printing.

Océ's Elevated Printing Technology Recreates 3300-Year-Old Decorations from an Ancient Egyptian Pharaoh's Tomb

The tomb of the 19th Dynasty pharaoh Seti I was discovered in the Valley of the Kings, where the ancient Egyptian rulers sleep. The tomb, considered the valley's most grand, has been deteriorating since its discovery in 1817. To reconstruct this cultural heritage of ancient Egypt, in 2016, Océ partnered with an NPO, as part of the company's social contribution activities, to use 3D photographic data taken inside the tomb to print large molds used to create life-size reconstructions of the tomb's walls, pillars and sarcophagus. Océ's unique elevated printing technology was able to print reliefs up to 15 mm thick by stacking layers of UV curable ink, faithfully reconstructing the tomb decoration.

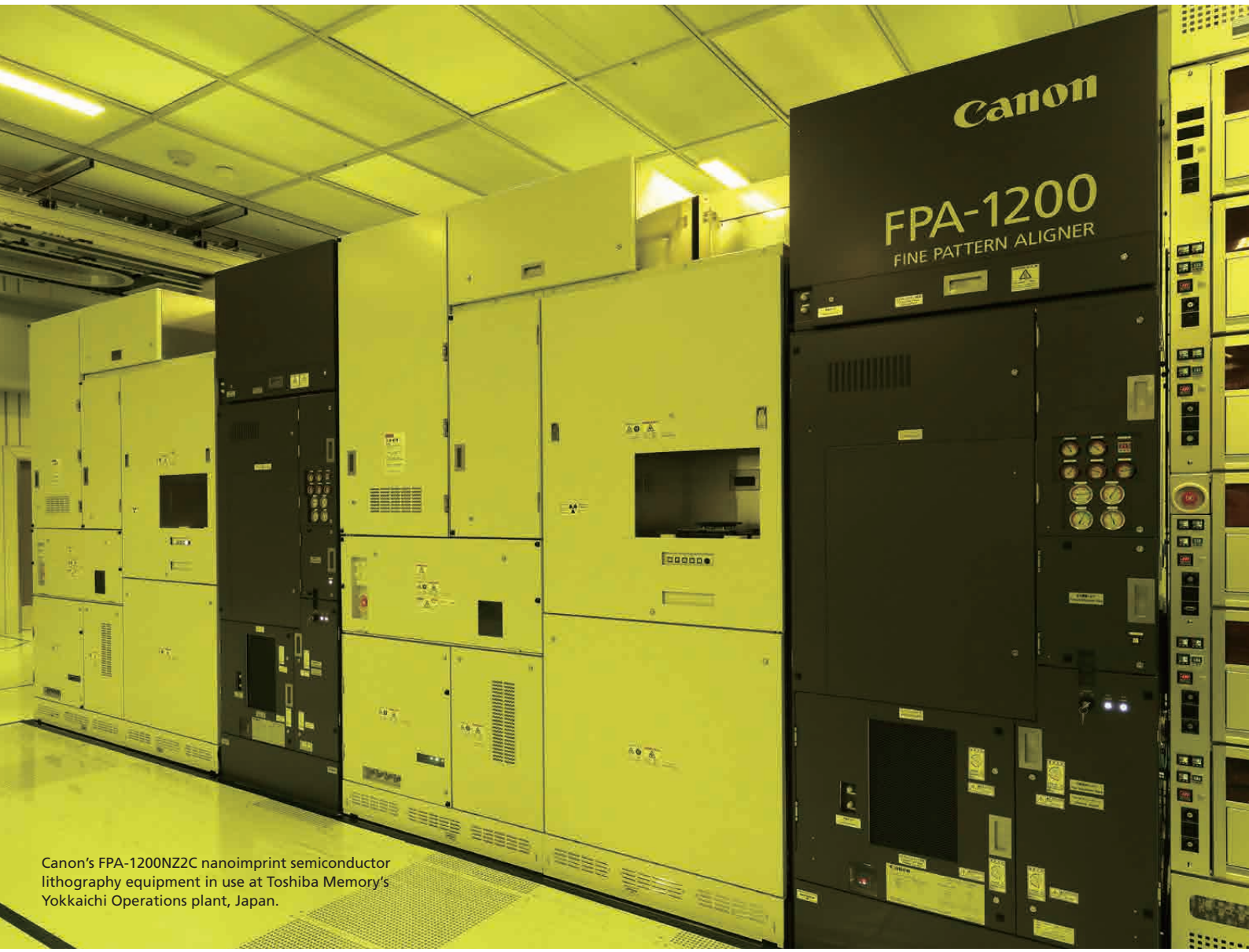
Walls and pillars printed with the reconstructed reliefs

Relief reproduction using elevated printing technology

Exceeding

the Limits of Miniaturization

Semiconductor lithography equipment is used to transfer circuit patterns onto a semiconductor chip.
By making further miniaturization possible at low cost, Canon's nanoimprint lithography technology is about to trigger a revolution in semiconductor manufacturing.

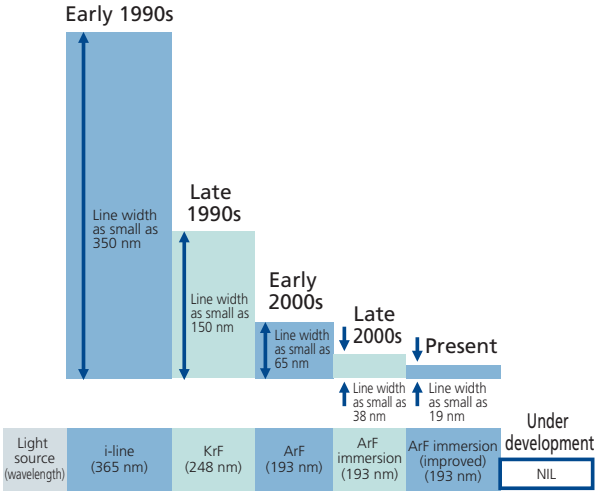


Canon's FPA-1200NZ2C nanoimprint semiconductor lithography equipment in use at Toshiba Memory's Yokkaichi Operations plant, Japan.

Nanoimprint Lithography: The Ultimate Microfabrication Technology

The evolution of semiconductor chips correlates directly to the history of circuit miniaturization. The key to this miniaturization has been the shortening of light-source wavelengths and advances in lithography technologies. In the early 1990s, Canon introduced its i-line 365 nm wavelength (nm = nanometer, one billionth of a meter) steppers, making 350 nm resolution possible for a variety of imaging applications. In the late 2000s, new shorter-wavelength light sources were developed, leading to the creation of an argon fluoride (ArF) immersion lithography system capable of 38 nm-resolution patterning. At the time, it was believed that miniaturization had reached its technological limit.

As the industry looked for further breakthroughs, including extreme ultraviolet (EUV) lithography, Canon sought alternatives to shorter wavelengths, establishing a new approach to circuit miniaturization. That approach was nanoimprint lithography (NIL), which exceeds conventional lithographic limitations and does so at lower cost. Capable of achieving line widths of under 15 nm using a simple process that lowers manufacturing costs, NIL is poised to revolutionize the semiconductor industry.



While line widths have halved roughly every five years, progress has stalled since the late 2000s

Overcoming Numerous Technological Challenges

Unlike conventional lithography technology that uses light to expose circuit patterns, nanoimprint lithography fabricates nanometer-scale patterns by transferring the nano-pattern mask (mold) onto the coated resin on the wafer surface to form circuits. Because the process involves no optical system, it enables the faithful reproduction of the mask's minute circuit patterns on the surface of the wafer. However, because the circuit patterns are formed using direct transfer, the process requires nanometer-level control technologies for accurately positioning the mask and wafer, eliminating particle contaminants and other operations. Through the comprehensive development of hardware, software and materials technologies, along with environmental control technologies to keep microscopic particles in check, Canon successfully overcame these numerous obstacles.

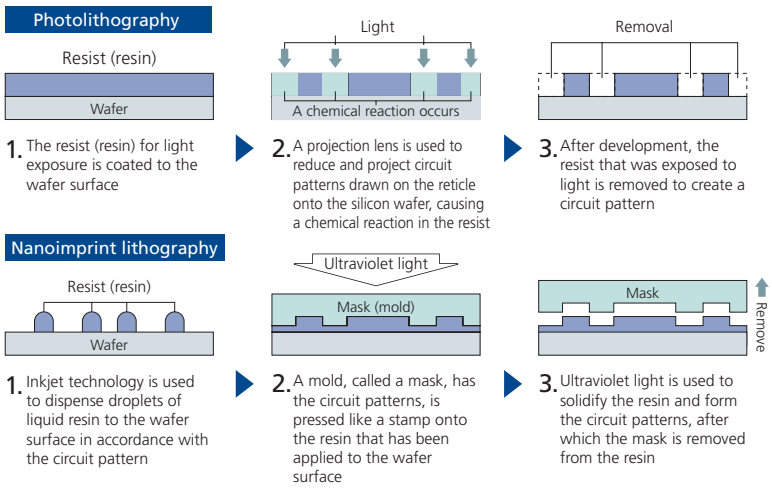
One of the technologies Canon developed for nanoimprint lithography controls the amount and positioning of the resin that is applied to the wafer surface. This technology precisely controls how much and where the resin is applied to prevent it from being squeezed out when the mask is pressed into the resin, while also ensuring the formation of a resin layer with a uniform thickness. Likewise, when the mask is removed from the wafer, their relative positions must be optimally controlled to prevent the deformation of the convex circuit patterns formed in the resin.

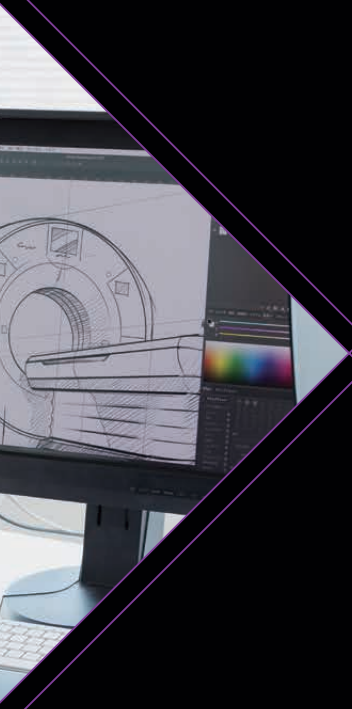
Generating Synergies from Different Cultures

With the aim of mass-producing nanoimprint lithography systems, Canon is collaborating with U.S.-based Canon Nanotechnologies, Inc. (CNT), which boasts some of the world's most advanced and unique technologies for microfabrication devices in the field of nanoimprint lithography. In addition to lithography system control and measuring technologies achieved through Canon's development of semiconductor lithography systems, Canon's service and support know-how will be merged with CNT's cutting-edge nanoimprint lithography technologies to break down the current barriers to miniaturization, once thought inviolable.

[How Canon Nanoimprint Lithography Works]

While photolithography has contributed to reducing the cost of semiconductor chips, further miniaturization required various workarounds that resulted in ever-larger and more expensive lithography systems. In contrast, nanoimprint lithography offers the simple approach of physically pressing patterns on a mask onto the resin. The simplified manufacturing process has the potential to significantly lower costs. Also, because this approach produces extremely sharp circuit patterns, it is expected to contribute to lower chip-defect rates.





Chapter 3

Canon Keeps Doing What Canon Does Best

Canon continues to stay true to itself.
Our highly original product design, robust intellectual property development and our societal and cultural support activities serve to build trust in the Canon brand.
Canon will continue to strengthen its foundation, driven by society's expectations.

Designing

Ease of Use

Canon provides high-quality design and new value through corporate activities that include the customer every step of the way.
Canon ensures the constantly evolving technology and functions featured in its products are easy to understand and easy to use.

User-Focused Design

Canon's business is expanding from consumer products including cameras and printers to such highly specialized fields as medical devices and industrial equipment. The role of design is also expanding from simply designing the product itself to ensuring that products are compatible with other devices and web services. Even with such major changes taking place both in the scope of our business and the roles therein, Canon maintains the same design philosophy we have held since our inception—to pursue design for the people who actually use our products.

The technologies and capabilities built into products are constantly evolving, but they must also be easy to understand and easy to use.

The user experience—when a customer engages with a company's products or services—links directly to the company's brand image. Making technology and its capabilities easy to understand and easy to use is an important role of design.

A Customer-Oriented Design Approach

Understanding the customer better is crucial for designing products for the people who will use them.

Before starting the design process, Canon conducts interviews with the people who the products and services are actually aimed at; investigating usage environments, monitoring user behavior and uncovering issues.

Designers and engineers work together to resolve issues. They ask questions from many different perspectives and gather ideas. Then they draw sketches and create product prototypes to turn ideas into visible, tangible things and see if their ideas will resolve the customer's issues. By repeating this series of steps, they get closer and closer to producing the ideal user experience for the customer.

Canon will continue to enhance brand value through the pursuit of design that combines aesthetic beauty with ease of use.

Study-Abroad Program for Engineers

As part of the company's R&D globalization efforts, Canon has offered a study-abroad program for its engineers every year since 1984.

The Canon Design Center also sends company designers overseas on this program, who leverage their international experience a great deal during the design development process.

Passing on

the Art of Antiquity to Future Generations

The Tsuzuri Project is an initiative that marries Canon's latest digital technologies with traditional artisanal works to create high-resolution facsimiles of precious works of Japanese art.
Using these facsimiles, rare cultural assets can be enjoyed by a wider audience while the originals are safely preserved in museums and other controlled environments.

High-Resolution Facsimiles as Close as Possible to the Originals Can Be Appreciated by a Wider Audience

The Tsuzuri Project was launched by Canon and the Kyoto Culture Association (NPO) in 2007 to create high-resolution facsimiles of precious Japanese cultural assets rarely shown to the public for wider public viewing using the latest digital technologies in combination with traditional artisanal works. A high- resolution facsimile is created by first photographing the work of art using Canon's latest digital SLR camera. The image data that is captured then undergoes Canon's proprietary color correction, and the processed image is printed in its original size using a Canon imagePROGRAF large-format inkjet printer. Master Kyoto artisans add various finishing touches as necessary, such as applying gold leaf and mounting the work.

Many of Japan's valuable cultural assets are made of such fragile materials as paper, fabric, wood and lacquer. These works of art are fragile and easily damaged. While it is necessary to offer opportunities for the public to view such works of historical and scholarly value, they must also be protected from deterioration. To date, 38 valuable works have been recreated as part of the Tsuzuri Project (as of December 2018), including folding screens and sliding doors, and the facsimiles have been made available for public viewing. These include many national treasures, including "The Wind and Thunder Gods" by Tawaraya Sotatsu and "The Three Portraits of the Jingoji Temple," attributed to Fujiwara no Takanobu.

Exhibition of "Pine Trees" by Hasegawa Tohaku (high-resolution facsimile)

Joint Research Project with the National Center for the Promotion of Cultural Properties, Part of the National Institutes for Cultural Heritage

In 2018, Canon launched a joint project with the National Center for the Promotion of Cultural Properties, part of the National Institutes for Cultural Heritage. The project involves the creation of high-resolution facsimiles of important Japanese works of art using the technology employed by the Tsuzuri Project, as well as joint research and testing towards developing new applications for the technology. Due to the fragility of many Japanese cultural assets, art galleries and museums must impose strict limitations on displaying them to the public. To that end, the project produces high-resolution facsimiles of these works that are nearly indistinguishable from their originals for viewing and other potential applications. This effort aims to provide the public with more opportunities to view cultural assets and experience them on a more personal level.

High-resolution facsimile of "Tigers in Bamboo Grove," a 17th century painting on sliding doors by Kano Sanraku and Kano Sansetsu at Tenkyuin Temple. The original is housed at the Kyoto National Museum.

[Production Process]

1. Input

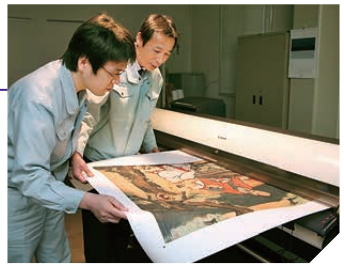
Segmented capturing of high-resolution data of a precious cultural asset

2. Color Matching

The captured image is color matched with the original on site

3. Output

The resulting image is output using world-class printing technology that reproduces fine textures



4. Gold Leaf, Gold Paint and Mica

The degradation of colors over time is reproduced through traditional craft techniques

5. Mounting

Works are mounted using the time-honored techniques of Kyoto master craftsman

Scan to access a special video and learn more about the Tsuzuri Project.

Protecting

Intellectual Property

Common refrains heard within Canon's research and development division include, "Read patent bulletins rather than research literature" and "Create draft patents rather than reports."
Intellectual property management protects proprietary technologies while expanding the number of technologies that Canon can access through such means as cross-licensing to enhance product development capabilities.

Canon in the Top 5 Among U.S. Patent Recipients for 33 Consecutive Years and Top Japanese Company for 14 Years

Canon believes that acquiring patent rights for its proprietary technologies is an essential aspect of expanding operations globally. Every year, Canon engineers submit more than 10,000 ideas with patent applications filed by country and region. In the United States, Canon has been the top-ranked patent recipient among Japanese companies for 14 straight years. Canon's intellectual property strategy consists of a defensive approach: protecting Canon's proprietary core technologies from being infringed upon by others, and an offensive approach: to create advantages for Canon's operations by acquiring valuable patents that other companies, not just Canon, need to use, and then negotiating licenses for their use. Canon strengthens its product development capabilities through both defensive and offensive intellectual property management.

Number of U.S. Registered Patents Figures tabulated by Canon

Year	Rank overall	Rank among Japanese companies	No. of patents
2018	3rd	1st	3,056*
2017	3rd	1st	3,285*
2016	3rd	1st	3,665*
2015	3rd	1st	4,134
2014	3rd	1st	4,048
2013	3rd	1st	3,820
2012	3rd	1st	3,173
2011	3rd	1st	2,818
2010	4th	1st	2,551
2009	4th	1st	2,200
2008	3rd	1st	2,107
2007	3rd	1st	1,983
2006	3rd	1st	2,366

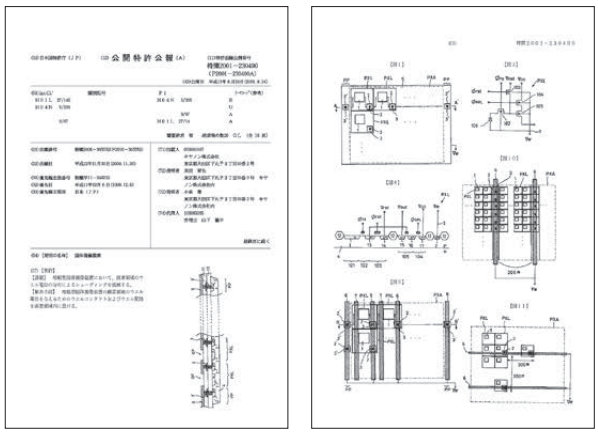
Based on annual information issued by the U.S. Department of Commerce

* Figures for 2016–2018 taken from IFI Claims Patent Services

Patent Strategy to Tackle Xerox's Monopoly

Canon's emphasis on intellectual property rights dates back to the 1960s, when the company entered the copying machine market.

In order to break through the airtight patent wall that U.S.-based Xerox had erected for its copying machines, Canon succeeded indeveloping the NP method, an all-new electrophotographic technology that did not infringe on Xerox's patents. Canon obtained a patent for the NP method. By protecting the differentiated proprietary technology, and also acquiring patents for peripheral technologies, Canon put itself in the position to be able to negotiate license agreements for other companies' technologies that Canon needed. This experience created the foundation for Canon's intellectual property strategy and has been passed down through the generations as part of Canon's corporate DNA.



Actual application submitted for patent bulletin publication (excerpt)

Engineers Work Closely with Patent Engineers to Cultivate Ideas

One major characteristic of Canon's intellectual property strategy is the active exchange of communication between development engineers and patent engineers, who are in charge of intellectual property. Some 300 patent engineers at Canon operation sites throughout Japan examine new ideas and the research results of engineers from various angles, searching for ways to maximize the number of inventions that can be generated.

Basic Policy of Canon Intellectual Property Activities

- Intellectual property activities are vital to support business operations
- The fruits of R&D activities are products and intellectual property rights
- Other parties' intellectual property rights should be respected and attended properly

Collaborations with Global Companies Boost Canon's Competitive Edge

In this day and age, it is becoming increasingly difficult for a company to protect its technologies on its own. In a move to assert the company's legitimacy and circumvent international patent disputes, Canon signed a cross-licensing agreement* with Microsoft in July 2014. In addition, six companies, including Canon and Google, established the License On Transfer (LOT) Network. As of November 2018, 318 companies have joined as members to protect approximately 1.36 million patents. In this way, Canon is working to coordinate with other companies to strengthen its competitive edge internationally through intellectual property.

* In a cross-licensing agreement, patent-right holders (companies, etc.) grant a license to each other permitting the use of a patent or patents held by the other party.

History of Awards for Canon Inventions

Several Canon inventions have been awarded Japan's National Commendation for Invention (sponsored by the Japan Institute of Invention and Innovation), presented in recognition of inventions of great merit in Japan. Additionally, Canon gives special recognition to the efforts of its own engineers and other meritorious individuals for their outstanding inventions through an Internal Invention Awards system.

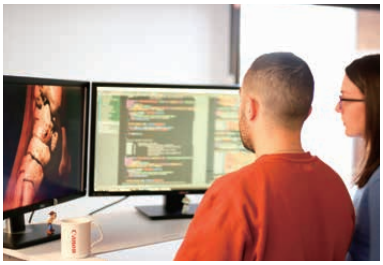
History of Canon's Receipt of Special Prize, National Commendation for Invention and Internal Invention Awards over the past 20 years

Name of Invention	Special Prize, National Commendation for Invention, sponsored by the Japan Institute of Invention and Innovation		Internal Invention Award	
	Year	Name of Award/Prize	Year	Name of Award/Prize
The development of an imaging sensor that realizes phase-difference autofocus on the imaging surface	2018	The Prime Minister's Award	2017	Invention Award of Excellence
Invention of ultrasonic diagnostic equipment utilizing differential harmonics from two fundamental frequency components and their second harmonic in diagnostic ultrasound apparatus	2018	The MEXT Minister's Award	-	-
Invention of shading-reduction technology for CMOS sensors	2015	The Prize of The Chairman of Japan Business Federation	2005	President's Incentive Award
Design of a compact, lightweight digital cinema camera with outstanding mobility	2014	The Prime Ministers Prize	2013	President's Award for IP Achievement
Invention of a printer using intermediate transfer member, without a cleaning mechanism	2013	The Prize of The Minister of Education, Culture, Sports, Science and Technology	2004	President's Award for IP Achievement
Box-shaped inkjet printer	2006	The Asahi Shimbun Prize	2005	President's Award for Excellence
Large-area sensor for real-time digital radiography system	2005	The Imperial Invention Prize	2001	President's Award for Excellence
Invention for a small-size optical system capable of high-speed zoom	2003	The Asahi Shimbun Prize	2004	President's Award for Excellence
Slim flatbed scanner design	2002	The Prize of The Chairman of Hatsumei Kyokai (JIII)	2001	President's Award for IP Achievement
Ozone-less charging method	1999	The Prize of Commissioner of the Japan Patent Office	1991	President's Award for Excellence
Invention of active type distance measuring device	1997	The Asahi Shimbun Prize	1996	President's Award for IP Achievement

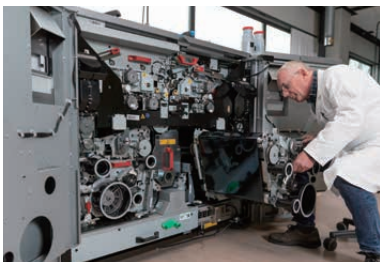
Global R&D

The Canon Group conducts business in more than 220 countries and regions around the world. Today, sales outside of Japan account for more than 80% of Canon's consolidated net sales. To ensure that the research work from Canon's global R&D locations expands into businesses, Canon's developers actively collaborate and engage in exchanges with external research institutes.

1. Canon Research Centre France S.A.S.
Rennes, France
Areas of focus: Development of network and communication technologies for transmission and connectivity to high-quality, high-volume video data; video data processing; and security camera systems and technologies



2. Canon Medical Research Europe Ltd.
Edinburgh, U.K.
Areas of focus: R&D of clinical decision support systems and AI automation



3. Océ-Technologies B.V.
Venlo, Netherlands
Areas of focus: R&D of large format commercial printers, medium and high speed printers for office use, consumables, etc.

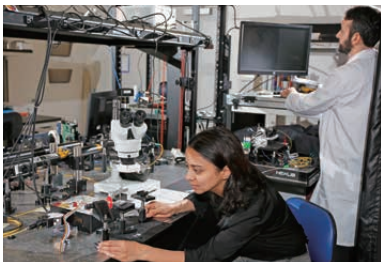
4. Milestone Systems A/S
Copenhagen, Denmark
Areas of focus: Development of video management solutions

5. Axis Communications AB
Lund, Sweden
Areas of focus: Development of network video solutions

6. BriefCam Ltd.
Modi'in, Israel
Areas of focus: Development of video analytics solutions for rapid video review and search, face recognition, real-time alerting and quantitative video insights

7. Canon Medical Systems Corporation
Otawara (Tochigi), Japan
Areas of focus: R&D of medical devices and systems, etc.

8. Canon Medical Research USA, Inc.
Illinois and Ohio, USA
Areas of focus: R&D of core system physics, data acquisition, and image reconstruction hardware and software for medical devices and systems



9. Healthcare Optics Research Lab. (Canon U.S.A.)
Massachusetts, USA
Area of focus: Development of novel minimally invasive medical devices for image guided diagnosis and therapies

Canon Inc.

Headquarters (Shimomaruko)		R&D Areas, Development of digital cameras, etc.
Yako Office		Development of inkjet printers, large-format printers and inkjet chemical products
Kawasaki Office		R&D Areas, R&D of production equipment and dies, R&D of semiconductor devices, etc., and Network camera development
Tamagawa Office		Development of quality management technologies
Kosugi Office		Development of medical devices
Hiratsuka Plant		Development of displays and next-generation devices
Ayase Plant		Development of semiconductor devices
Fuji-Susono Research Park		R&D of electrophotographic technologies
Utsunomiya Office	Utsunomiya Optical Products Plant	Development of semiconductor lithography equipment and FPD lithography equipment
	Optics R&D Center	R&D of optical technologies
Toride Plant		R&D of electrophotographic technologies

CANON TECHNOLOGY

The site presents a wide range of Canon technologies from various angles, providing easy access to the technology you want to learn about.

https://global.canon/en/technology/