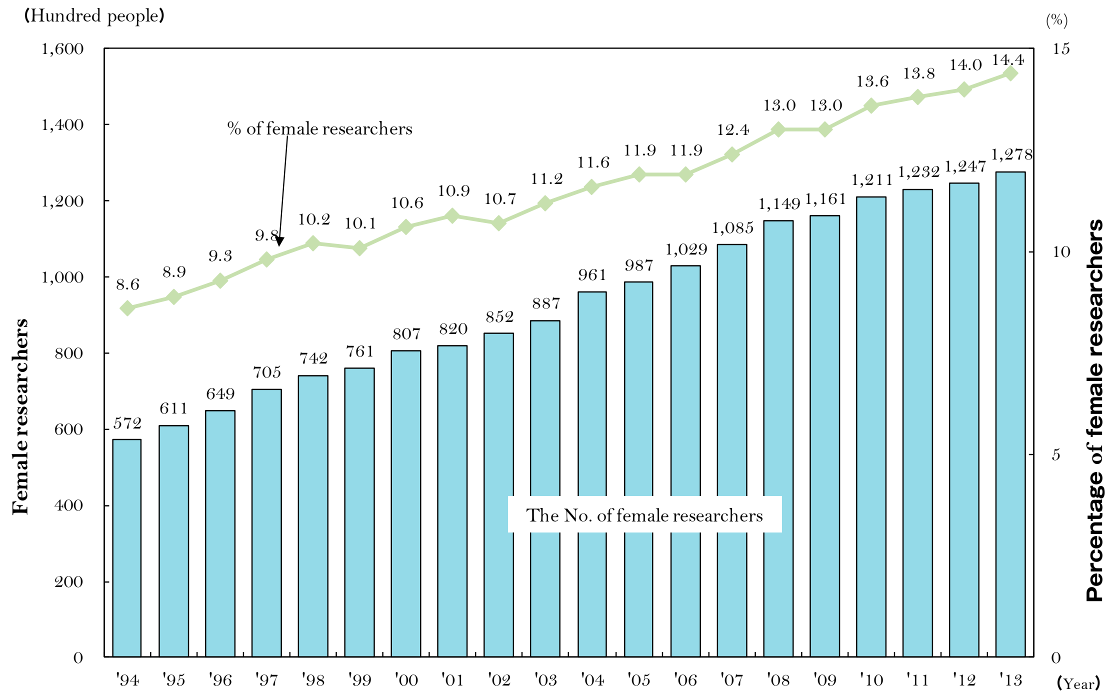
4 Opportunities for Diverse Human Resources

(1) Female researchers in Japan

The Third Science and Technology Basic Plan (approved by the Cabinet on March 28, 2006) set the goal of increasing employment opportunities for female researchers. This basic plan has helped increase the number of appointments and opportunities for female researchers, resulting in a year-on-year increase in female researchers. As of 2013, the number of female researchers was about 130,000, accounting for 14.4% of all researchers in Japan (Figure 1-1-41). However, this percentage is still lower than those of other countries (Figure 1-1-42).

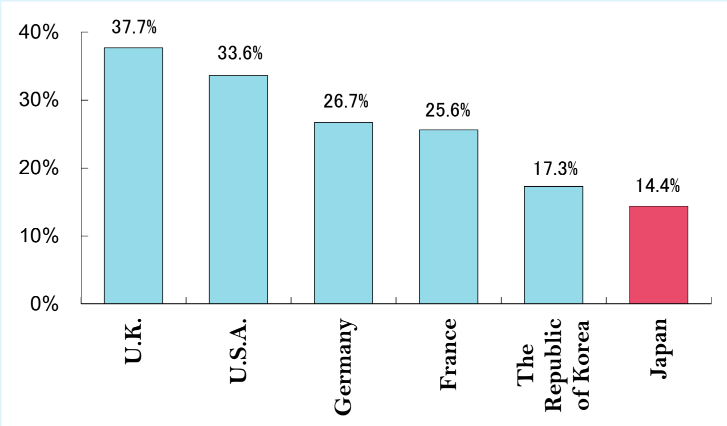
Figure 1-1-41 / Changes in the Number and Percentage of Female Researchers



Note: Until 2001, figures concerning enterprises, non-profit organizations and public research institutions are those for full-time researchers, and figures for universities are those for full-time and part-time researchers. In and after 2002, the figures represent head-counts by gender.

Source: MEXT based on MIC, *Report on the Survey of Research and Development*

Figure 1-1-42 / Percentage of Female Researchers by Country

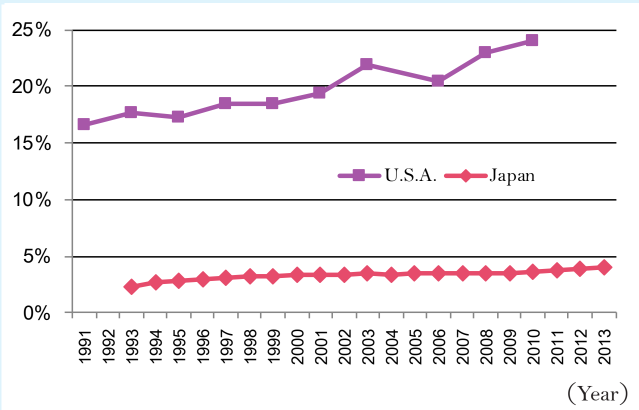


Note 1: Data used are those as of 2010 for the USA, as of 2011 for the U.K., Germany, France and South Korea, and as of 2013 for Japan.
Note 2: Regarding the USA, data on scientific professionals (i.e., holders of a bachelor's/master's/doctoral degree in science or engineering, engaging in a science-related profession) are used instead of data on researchers. "Science" includes the social sciences.
Source: MEXT based on MIC, *Survey of Research and Development*, OECD, *Main Science and Technology Indicators*, and NSF, *Science and Engineering Indicators 2014*

(2) Foreign researchers in Japan

Foreign nationals account for 3-4% of all key faculty members at universities in Japan, although this share has been gradually increasing. In the USA, foreign nationals account for 20%, and the figure continues to increase, although the data for the USA pertain only to foreign nationals in science, engineering and the social sciences (Figure 1-1-43).

Figure 1-1-43 / Changes in the Percentage of Foreign Faculty Members

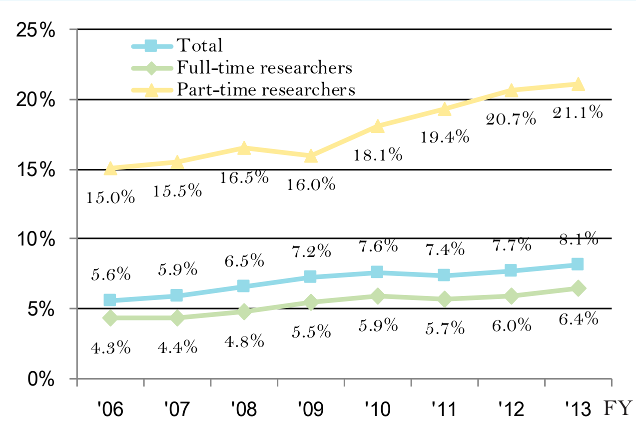


Note 1: The figures for the USA for the years 1991 through 2003 are those of senior and junior faculty members combined. For the years 2006 through 2010, the figures are those of full professors, associate professors, assistant professors and instructors combined.
Note 2: For the USA for the years 1991 through 2003, the figures are those of foreign nationals in the physical sciences, mathematics, computer science, the earth, atmospheric and ocean sciences, the life sciences, psychology, the social sciences, and engineering. For the years from 2006 through 2010, the figures are those for the physical sciences, mathematics and statistics, computer and information sciences, the life sciences, psychology, the social sciences, and engineering.

Source: MEXT based on *the School Basic Survey* and NSF, *Science and Engineering Indicators*

In contrast, foreign researchers account for a higher percentage of researchers at independent administrative institutions specializing in R&D than in academia and that percentage has been increasing recently, although it is still lower than the percentage at American universities (Figure 1-1-44).

Figure 1-1-44 / Changes in Foreign Researchers as a Share of All Researchers at Independent Administrative Institutions Specializing in R&D



Note: These figures pertain to 25 institutions out of the 37 institutions listed in an appendix to The Act on Enhancement of Research and Development Capacity and Efficient Promotion, etc. of Research and Development, etc. by Advancement of Research and Development System Reform (Act No.63 of 2008). These 25 institutions had been established as independent administrative institutions by FY2006. (The National Museum of Nature and Science and Japan Oil, Gas and Metals National Corporation are excluded because research expenses account for only a small percentage of the total expenditures for these two institutions; The Japan Science and Technology Agency, the Japan Society for the Promotion of Science, and the New Energy and Industrial Technology Development Organization (NEDO) are also excluded because these institutions mainly disperse funds to other organizations.)

Source: MEXT based on the Cabinet Secretariat, *Survey Regarding R&D Corporations (Subcommittee on Reform of Independent Administrative Institutions)* and the Cabinet Office, Government of Japan, *Summary of S&T Activities of Independent Administrative Institutions and National University Corporations*

(3) Research administrators in Japan

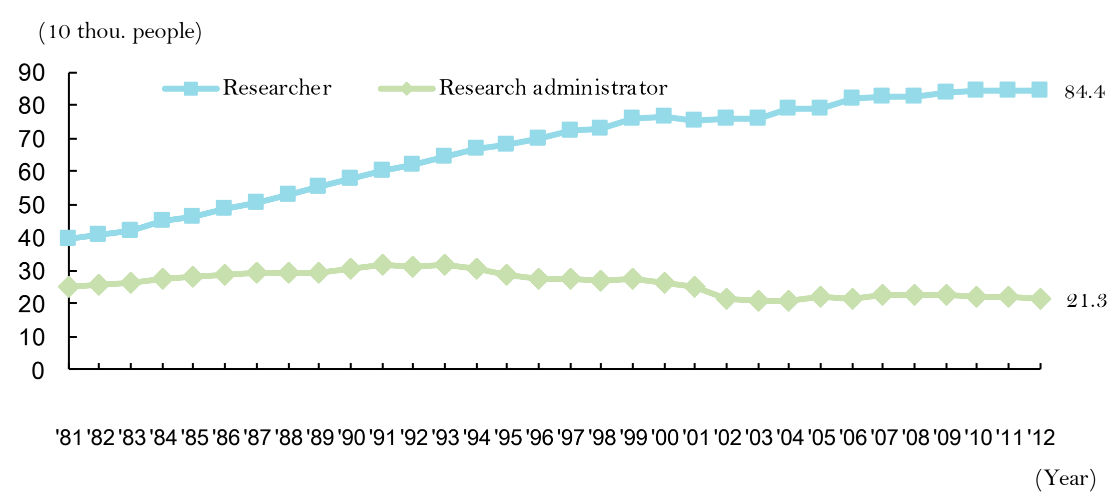
Technical experts support the maintenance and operation of R&D equipment and facilities that are indispensable for R&D projects. As R&D equipment and facilities have become increasingly sophisticated and complex, these technical experts need to have a high level of technological skill and even research capability in some situations. A large-scale biotechnology experiment, for example, is implemented by a team that is led by researchers and that is based on mutually beneficial partnerships among team members. Such a team is called "an ecosystem[1]," and it is supported by various human resources, including lab technicians.

With the growing significance of external funding, such as competitive research funds at universities and research institutions, there has been an increased need for research administrators[2] who support the acquisition and management of research funds and the operation of projects, including those that involve industry-university-government collaboration.

However, research support personnel including research administrators have been decreasing in number, even though the number of researchers in Japan has been increasing in the past three decades (Figure 1-1-45). Additionally, the number of research support personnel per researcher is 0.25, far smaller than in other major countries (Figure 1-1-46).

1 This is an ecological system in which researchers interact with various persons concerned.
2 These are human resources collaborating with researchers at universities in taking responsibility for formulating research plans, raising and managing research funds, and managing intellectual property.

Figure1-1-45 / Changes in the Number of Support Personnel in Japan



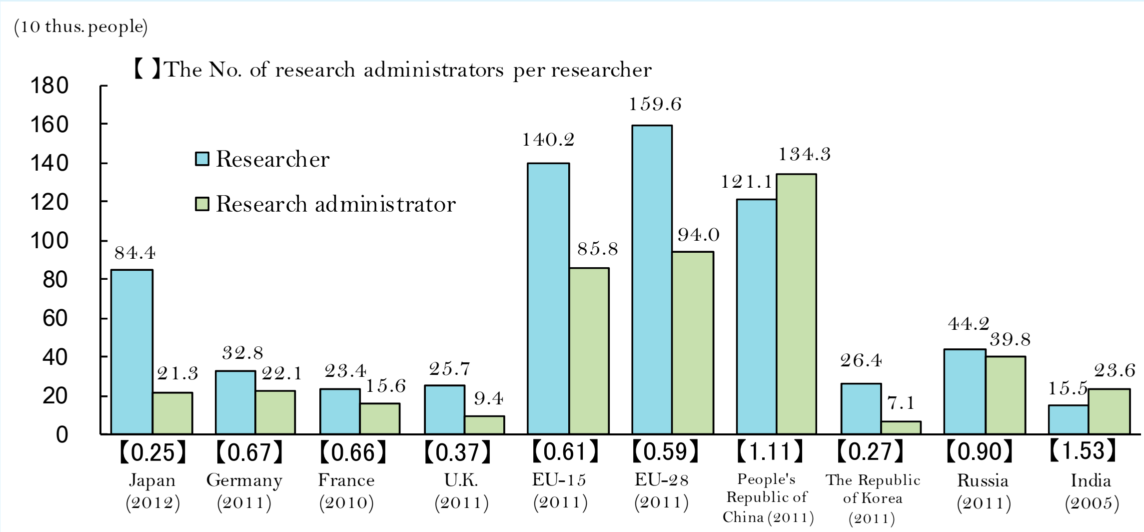
Notes: 1. Humanities and social sciences are included, and the figures are those as of March 31 each year except for the years up to 2001, for which the figures are those as of April 1.

2. "Researchers" means full-time researchers up until 2001.(Note: In the category "universities and other," "researchers" includes part-time researchers).

3. "Research support personnel" refers to assistant research workers, technicians, clerical staff members and others concerned with research activities.

Source: MEXT, *Indicators of Science and Technology*

Figure 1-1-46 / The Number of Research Administrators in Major Countries



Notes: 1. The number of research administrators per researcher was estimated by MEXT by using the number of researchers and research administrators in each country.

2. The humanities and social sciences are included.

3. Research administrators assist researchers, provide technical services and engage in clerical work necessary for research. In Japan, "research support personnel" refers to assistant research workers, technicians, clerical staff members and others concerned with research activities.

4. Figures for Germany are preliminary and provisional.

5. Figures for the U.K. are provisional.

6. Figures for the EU are either provisional or are OECD estimates.

7. Figures for India are preliminary.

Source: MEXT, *Indicators of Science and Technology*

Recently, project managers have been appointed for many large-scale projects financed by competitive funding. Such managers are responsible for the effective implementation and operation of research projects based on their strong awareness of the need to solve research questions and to apply the research results. Project managers propose topics of research, organize research teams and achieve great results by coordinating and facilitating the work of the project team. The role of project managers will grow in importance in the future.

Column 1-4

One Result from the Funding Program for World-Leading Innovative R&D (FIRST)

- Development of a Real-time Tumor-tracking Proton Beam Therapy System for Enabling Sustainable Advancement of Therapies -

A real-time tumor-tracking proton beam therapy system
Courtesy of Hokkaido University

Hiroki Shirato, a professor at the Hokkaido University Graduate School of Medicine, developed a radiotherapy system that utilizes real-time tumor-tracking radiation technology.

Prof. Shirato succeeded in developing the Real-time Tumor-tracking Proton Beam Therapy (RTPBT) system by combining real-time tumor-tracking radiation technology and spot-scanning proton beam technology. The former technology is able to accurately irradiate tumors in motion from breathing and heartbeat; the latter technology is used for precisely irradiating tumors by adjusting the proton beam position. When applied to cancer treatment, this therapy system is more effective and causes fewer side effects than conventional X-ray therapies. The Proton Beam Therapy Center of Hokkaido University opened in March 2014 to provide cancer therapies by utilizing the RTPBT system. Plans for exporting this system have progressed, with three world-leading cancer centers overseas choosing the system. Toward international standardization of real-time tumor-tracking proton beam therapy, a proposal regarding standards has been submitted to the International Electrotechnical Commission. Various initiatives have been taken to promote Japan's medical equipment industry.

5 Current Situation and Issues Regarding Human Resources in Science, Technology and Innovation

(1) Summary of the current situation regarding human resources in science, technology and innovation

The current situation regarding human resources in science, technology and innovation can be summarized as follows (Figure 1-1-47):

○ The number of Japanese researchers is reaching a plateau. Significantly more doctoral degrees are awarded per fiscal year than 30 years ago, but the number has been gradually declining recently and it is smaller than in other countries.

○ Postdoc positions have become established as a career path, and fixed-term appointments of young researchers have been increasing at universities and public research institutions. This situation has helped enhance the mobility of young researchers.

○ However, despite the fact that the number of doctoral graduates has substantially increased since the late 1990s, the number of positions available to young researchers has been decreasing, because an increasing percentage of positions are taken by senior researchers. Additionally, career paths available to young researchers are limited due to the lack of opportunity to gain employment at private companies. It has therefore become more difficult for young researchers to obtain tenured positions. For these reasons, young researchers are facing an unstable employment situation, and some of them have no choice but to take multiple postdoc positions. Under the circumstances, students in master's courses are unwilling to go on to doctoral programs.

○ In contrast, fixed-term appointments have not been increasing with regard to the employment of senior researchers, and the mobility of senior researchers remains low. This situation has caused a decrease in the number of positions available to young researchers, resulting in the extremely high mobility of young researchers. This problem can be understood in terms of "a generation gap in mobility" between young researchers and senior researchers working at universities and public research institutions.

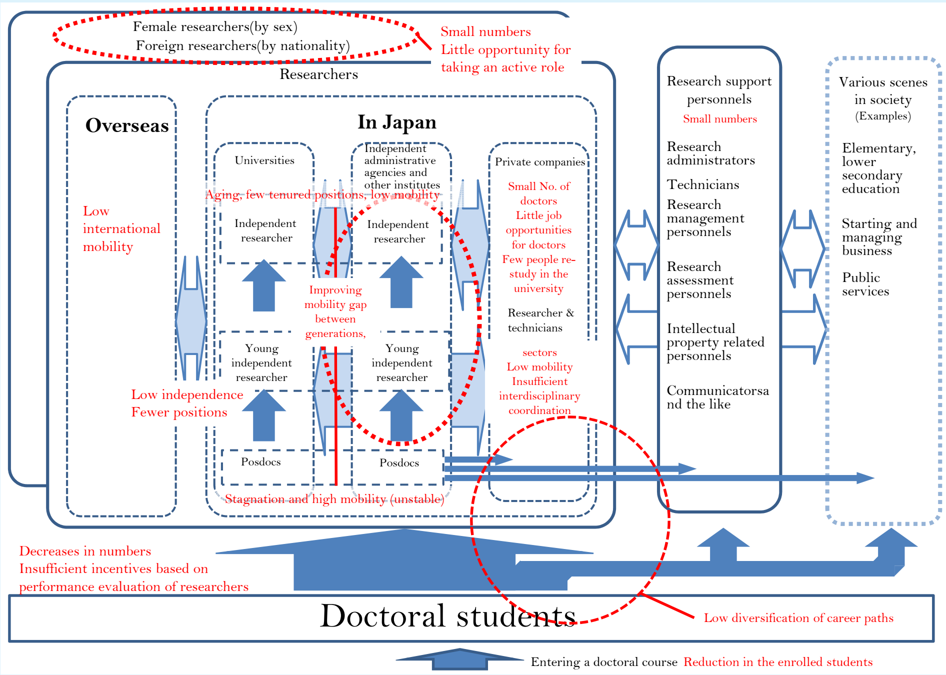
○ The performance of researchers is being evaluated, but the evaluations are not adequately utilized for proper treatment of researchers because it is difficult to change the positions of researchers with poor performance evaluations due to inflexible pay systems.

○ Due to the low cross-border mobility of Japanese researchers, networking with international researchers is not yet sufficient in Japan; thus, Japan is in danger of being left behind in the global trends of research.

○ It is difficult for young researchers to establish themselves as independent investigators; the numbers of female researchers and researchers from abroad have not been increasing and ample opportunities have not been generated for diverse human resources to conduct research. The number of research support personnel is insufficient to support the diverse human resources.

○ The mobility of researchers between sectors remains low, and researchers have not been able to flexibly modify or expand their research areas in response to the changes in social and industrial needs. Private companies are not sufficiently open to the recruitment of young researchers, and mature researchers are not motivated to return to school to pursue a degree. Accordingly, adequate systems are not in place for flexibly responding to changes in socioeconomic demands and for creating value and knowledge.

Figure 1-1-47 / The Current Situation Regarding Human Resources in Science, Technology and Innovation



Source: MEXT

(2) Future issues

As previously summarized, socioeconomic changes (Section 1) are affecting science, technology and innovation in Japan. It is increasingly important to foster and secure human resources in science and technology and promote their activities, to secure wide-ranging knowledge, viewpoints and ideas, to build international networks of researchers, to utilize and secure highly specialized professionals and to address changing approaches to the creation of value and knowledge.

It was also shown that several challenges in Japanese employment practices interfere with the promotion of science, technology and innovation. Specifically, Japan's traditional employment system, which is characterized by lifetime employment, seniority-based promotion and lack of workplace diversity in terms of the gender and nationality of researchers, remains the status quo in society. Particularly with regard to universities and pubic research institutions, the mobility of researchers differs between generations, and a system for matching the right people to the right jobs is not in place. Thus, researchers with diverse abilities are not readily provided with opportunities to play active roles in research according to their abilities and motivation.

Recognition of the current employment situation regarding researchers leads us to conclude that "improved mobility," "increased opportunities for diverse human resources to play an active role" and "platforms for the co-creation of new knowledge and value" are the three key factors for the future, in view of the need to powerfully advance science, technology and innovation in response to socioeconomic changes (Table 1-1-48).

Universities and public research institutions are required to play an important role as international hubs of innovation. Toward making Japan "the Most Innovation-friendly Country in the World," it is urgently necessary for universities and public research institutions to reform their employment systems for researchers by taking these three key factors into account.

Table 1-1-48 / Summary of Issues Pertaining to Human Resources

		Issues regarding human resources for S&T innovation			
		In general (the number and working conditions)	Career paths for young human resources	Mobility	Increased opportunities for diverse human resources to play active roles
Items to be given more importance in S&T innovation in response to socioeconomic changes	Securing human resources Exhibiting capacity	Researchers are not increasing. Fewer doctoral degrees are granted. The population is aging, and positions for young researchers are reduced. Young researchers have little independence (insufficient utilization of the potential of young researchers)	Limited career paths → High mobility of posdocs (instability) → Reduction of students enrolled in doctoral courses	Few tenured positions for senior researchers Low mobility of senior researchers Insufficient incentives based on performance evaluations of researchers	Insufficient utilization of diverse human resources to play active roles
	Diverse knowledge and viewpoints Importance of new ideas	Independence of young researchers is low (insufficient utilization of viewpoints of young researcher)		Low mobility between sectors, resulting in a lack of diverse experiences Low international mobility	Insufficient utilization of knowledge and viewpoints of diverse human resources
	Importance of constructing global research networks			Little overseas research experience	Insufficient utilization of foreign nationals as researchers
	Importance of highly specialized human resources	Few doctoral degrees are awared.	Limited career paths → Little opportunity to play active roles in various settings		
	Changes in methods of creating knowledge and value		Few doctors doctoral degree holders at private companies ← Policy of companies: educating and training employees rather than hiring doctors	Insufficient enlargement and changes in the research area to respond to circumstances Low mobility between sectors → Inability to collect people with high competency Few people returning to university for new study	

Increased opportunities for diverse human resources to play active

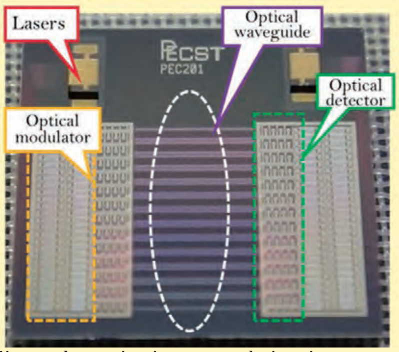
Improved mobility

New opportunities for the creation of value and knowledge

Source: MEXT

Column 1-5

One Result from the Funding Program for World-Leading Innovative R&D (FIRST) - Development of Photonics-Electronics Convergent System Technology -



Silicon photonics integrated circuit prototype

Courtesy of Photonics Electronics Technology Research Association

Professor Yasuhiko Arakawa, Director of the Center for Photonics Electronics Convergence, Institute of Industrial Science, The University of Tokyo, has been working on practical applications of silicon photonics integrated circuits featuring photonic-electronic convergence.

Data is transmitted via electrical wiring in LSI chips or between LSI chips. For higher-speed transmission of large volumes of data, a semiconductor integrated circuit is integrated with an optical transmission circuit on a silicon substrate. This technology is called silicon photonics. Practical applications of silicon photonics require the development of element technologies, therefore innovative element technologies were developed and system demonstration tests were conducted through nationwide industry-university-government cooperation. Element technologies, such as those of semiconductor laser elements, optical modulators and optical receivers, were improved, and system demonstration tests achieved the world's highest transmission density, allowing 30 terabits of data to be transmitted in 1 second per cm2 during the FIRST project period. In the demonstration tests conducted by using quantum dot lasers that operate at high temperatures, stable operation was verified at 125℃. Research is being continued toward realizing a baseball-sized supercomputer in 10 to 20 years.