2. Survey results in “Electronics”

2.1. Trends in noteworthy domains

In 1996 sales by Japan’s electronics industry amounted to more than 21 trillion yen, of which semiconductors, computers and household electrical appliances accounted for about one third. The growth in sales of the first two over the past few years has been remarkable. We divided the overall field into the following four classifications based on industrial scale and potential for future development, and drew up forecast topics using a table listing various technological levels from the discovery of new phenomena to the widespread use of the technology.

(a) Microelectronics

(b) Optoelectronics

(c) Molecular, sensor and bioelectronics

(d) Storage and display electronics

Here we shall review each of the domains, and look behind the formulation of forecast topics in the future.

(Ken-ichi Iga)

2.1.1. Microelectronics

(1) Basic technology

Electronic devices that incorporate microelectronics technology are growing smaller and smaller, and the ultimate destination in this quest for minuteness is the atom, the smallest unit of substance, molecule and cell. Very rarely do they display the necessary functions for electronics by themselves, but the development of extreme technology that can observe, measure and manipulate these units of substance, and research aimed at incorporating mezoscopic singular phenomena into electronics by making full use of these technologies is a dream of researchers and engineers who explore the extremes. And the progress in scanning probe microscopes (tunneling microscope, interatomic microscope, etc.), lithographic technology and materials and processing technology over the past five years has served to further fuel their enthusiasm. “01: Development of technology capable of manipulating single atoms and single molecules” is a fairly typical example of such technology. Topics such as “02: Practical use of quantum-phase devices” and “03: Practical use of LSIs using single-electron transistors” represent this technological dream, and do not necessarily indicate the direction we expect this kind of technology to proceed. Rather, we wanted to gauge the thoughts of respondents as to whether this could become one of the courses along which science and technology will travel. Similarly, we included “04: Artificial realization of the mechanism by which single-cell organisms etc. respond to external stimuli” as one technological dream of basic biosensor elements. At times technological innovation and new discoveries push basic microelectronics technology well beyond our expectations, but until this technology becomes highly reliable and can be incorporated stably within systems, we look forward to a range of challenging elemental technology leads, and to the efforts of experts who tackle the verification of such leads with far-reaching vision.

(Koji Kajimura)

(2) Highly integrated, high-capacity, ultra-small, large-scale

Semiconductor integrated circuits are the “nervous system” of our information-based society, and miniaturization has enabled the industry to increase both their density and speed. Design rules are such that size decreases by a factor of ten every 15 years. A size of 10µm in 1970 became 1µm in 1985. In 1995 it became 0.35µm, so we can expect it to become 0.1µm in 2000. Considering 0.04µm devices are in operation today, it is believed there are no physical limitations at least, but there are doubts as to whether lithographic technology in the post-0.1µm era lends itself to mass production.

Therefore forecasting the realization time of “05: Practical use of technology which allows mass processing of 10nm patterns” is crucial to the semiconductor industry.

As for increasing density, in DRAM a fourfold increase every three years has been maintained: 1Kb in 1970 was 64Kb in 1980, so 64Mb in 1995 can be expected to be 1Gb in 2001. So whether topic “06: Practical use of VLSI with as much as 256 Gbits of memory per chip” can be achieved at the forecasted time is a critical point.

As for wafer size, 50mm in 1970 increased to 125mm in 1980, so 200mm in 1995 can be expected to increase to 300mm in 2001. In this light, it is important to have a feel for when the topic “07: Widespread use of wafers one meter in diameter,” as basic semiconductor technology, will be realized.

EEPROM, a type of nonvolatile memory, began at 4Mb in 1992 and shifted to a 64Mb mass-production structure in 1996. Consequently, the realization time, including usage, of topic “08: Practical use of non-volatile random access semiconductor memory with more than 100 Gbits capacity” is important.

(Kazuo Tsubouchi)

(3) Low power consumption, user-friendly, high productivity

The rapid progress of semiconductor technology continues to hasten the advent of a multimedia world. This is a world crisscrossed by information networks offering an array of services, accepted by society and designed to make the life of the individual and the group richer and more fulfilling. And in leisure, art and other aspects that form the essence of human life, new and vivid cultures will take shape.

Most information transmission, storage and processing is done through semiconductors. So in this sense, semiconductor technology forms the very foundations upon which our information society grows and prospers. History to date has shown us that each step semiconductor technology takes forward is accompanied by the emergence of new information services. We can say that the progress of semiconductor LSI has two sides: 1) the development of chip architecture, and 2) the cultivation of more minute and faster domains through the introduction of new structures and new materials.

The aim of R&D in microelectronics technology is to “readily produce user-friendly high-performance LSI,” and in this light, we set topics 17–30.

Topics 17, 18 and 19 tackle microelectronics from an energy perspective. Demand for LSI processing function as a tool for information processing and transmission continues to rise, so if we are to maintain its ease of use, we have to improve the degree of integration while significantly reducing its energy consumption, and from this viewpoint, we set topic “19: Development of processor LSIs with 10 GIPS performance and power consumption of 10 milliwatts or less.”

Topics 20–25 asked how close the superior capabilities of semiconductor LSIs can get to human functions. We set several topics with different levels of human-like functions, such as voice recognition, automatic interpretation, housekeeping, and understanding emotions.

Topics 26–30 took up the theme of LSI productivity. While there may be some concern that topic “28: Practical use of systems in which LSI chips are produced automatically from LSI design data,” which looks at the possibility of producing LSI chips from advanced design technology and especially top conceptual designs, may be a little too general, the topic asks experts whether they believe the dreams of present-day SiLSI engineers can be realized.

The following are some comments about the survey results.

Interest in solar cells as a substitute for fossil-based energy is high. The extent of interest in “18: Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence” and “30: Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt” is an indication that respondents are looking to electronics technology to contribute to the development of clean energy, and through this, play an important role in the fight against global warming. Both topics set concrete targets, and both are expected to be realized between 2010 and 2012.

A similar interest can be seen in energy in topic “19: Development of processor LSIs with 10 GIPS performance and power consumption of 10 milliwatts or less.” This reflects the respondents’ awareness that as tools for information processing and transmission, semiconductor devices have to be portable. But considering the substantial gap between the high target in the topic and current LSI performance, the topic's realization is not expected until 2014. Additionally, quite a few respondents indicated that it would not be realized at all.

We believe the level of interest in "24: Widespread use of a portable multimedia wireless terminal which can be used throughout the world" can be put down to the mobile communication boom over the past few years and its enormous impact on our life culture. "Following the telephone is the image," and against this technological catch-phrase, expectations of wireless terminals that can be used over a wide area are high. And in the forecasted realization time of 2011, we can see the optimism with which the respondents view this technology.

As for application of SiLSI, while some skepticism could be seen in forecasts about technology that could bring LSI functions close to human functions as a total system, as seen in topics dealing with artificial intelligence (topic 21), housekeeping robots (topic 25) and the like, respondents did forecast the early realization of personal aids with limited functions, such as voice recognition (topic 22) and automatic translation systems (topic 23).

(Hiroyuki Abe)

(4) High speed, super-paralleling, high sensitivity, high performance

Fifty years have passed since the transistor was invented, and throughout this time, the pursuit of higher speeds and higher frequencies has been an enduring theme. There is no application significance in the speed of simple basic gate circuits alone, so we focused on LSI speed in topic "09: Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less." As for frequency, we set topic "10: Practical use of wide-band solid-state amplifiers operated at high frequencies of around 100-1,000GHz," which differs little from the previous survey.

Developing new devices that can take over from transistors in the next era is a crucial challenge facing the microelectronics industry, and in this light, we set topics "11: Development of super-conducting three-terminal devices with amplification capabilities" and "12: Development of high-speed, highly-integrated devices that switch by the movement of a single atom."

Microprocessor performance is improving in rapid strides, and is forecasted to reach 1,000–2,000 MIPS (mega-instructions per second) in 2000. The greater speeds and performance that advances in microprocessor technology have given to computers and various other systems have impacted enormously on our socioeconomic lives, and forecasts here are important, so we set topic "13: Practical use of TIPS (tera-instruction per second) level microprocessors." As for improvements in sensitivity and resolution, we set topic "14: Development of X-ray microscopes capable of 10-100nm resolution," which differs little from the previous survey.

From the viewpoint of high performance, high function, system integration and intellectual integration, we assumed a neuron scale that enables high-level recognition, and set topic "15: Practical use of semiconductor neural network chips on the order of one million neurons." And regarding the effective use of high-temperature superconducting materials, we set "16: Widespread use of high-temperature superconducting materials in passive circuits for millimeter-wave communication systems."

Topics 13 and 09 are ranked 5th and 8th in importance to Japan among the 74 topics in this field, and at 95%, the assessment regarding their contribution to socioeconomic development is extremely high. Topic 13 is forecasted to be realized in 2018, and has the highest response rate. For leading country assessment, the USA is well above the other countries and regions with 93% (Japan is around 50%), indicating the USA's dominant position in this domain. As for measures, the government first has to "foster researchers, engineers and research assistants," and the higher the level of expertise of the respondents, the greater the demands for increased government research funding. As for topic 09, the forecasted realization time is 2015, Japan and USA are at roughly the same level in leading countries with about 80%, and the government has to "foster researchers, engineers and research assistants." For topics 14 and 12, highest expectations among the respondents are in "expansion of intellectual resources," and realizations times are, respectively, 2015 and 2018.

(Tetushi Sakai)

2.1.2. Optoelectronics

This domain began with the appearance of the laser in 1960. Various types of lasers covering a broad spectrum from infrared to ultraviolet through various media have been produced, and from this have emerged a range of technologies and industries. In 1995 the output of Japan's optoelectronics-related industries amounted to four trillion yen.

Optical fiber communication has been the engine driving research and technological development in this domain, and for 20 years from 1970, the bulk of international communication through land-line and submarine cable depended on optical fiber networks. In the 1992 survey the practical use of submarine cables exclusively for optical relay was forecasted at 2007, but it was completed by 1996. Technological development to produce greater capacities and faster speeds surged ahead from about 1996, and studies into clock speeds of 10 Gbits/s (gigabits/second) and multiplexing 100 channels or more led to the realization at the research level of a transmission capacity equivalent to more than 2 Tbits/s (terabits/second) through a single optical fiber. Also from about 1996 optoelectronics technology made its way into computers, and from here important advances have been seen in optical interconnecting technology that allows transmission speeds of more than 1 Gbits/s at a lower cost.

Optical memory achieves the largest sales in the optoelectronics industry. Compact disks began kicking analog records off the shelves from about 1984, and from here, the small size and light weight of digital technology found its way into portable electronic devices and automobiles. And through a linkage of GPS and the optical fiber gyroscope, a booming market for automobile navigation systems had been created. It is well known that large analog optical disks are used for *karaoke* music, but in the latter half of 1996, development work into the digital videodisk (DVD) was for the most part completed, and the commercialization of this new technological application began. Contributing to this has been the practical application of red semiconductor lasers. From 1996 research into blue semiconductor lasers gained momentum with a view to higher capacity optical disks, and with this we have begun to see the possibilities for gallium nitride materials. Thus we set several topics in expectation of the emergence of what is perhaps best described as the file electronics domain whose key is the high-capacity optical disk. GaN blue LEDs and green LEDs have already been put to practical use, and from 1996 they began to be applied in large panel displays and traffic lights. And considering their high efficiency, we have now entered an era in which we can realistically look at semiconductors for lighting, and we have included related topics to reflect this.

Another major domain is optoelectronics equipment, such as laser printers and copiers, and improvements in the performance of computers and their ever-increasing reach are expanding the market, and generating demand among users for faster speeds. In 1996 multi-beam systems using surface light-emitting laser arrays were looked at for the first time, and research into memory based on optical interconnection became more active, so we set topics to reflect this.

Sensing and control technology using light is one domain that shows tremendous promise. Though the market is still only quite small, there is no doubt that it will expand and achieve considerable reach. Optical operation is also an interesting theme, so we included a related topic in this survey as well. But we are not sure how this will change once devices that apply this technology appear in the market. There are numerous other domains, such as the medical application of light, optical processes, energy development, and display and art, but looking at industrial scale, we did not include a large number of topics in this survey.

(Ken-ichi Iga)

2.1.3. Molecular, bio, sensor electronics

(1) Molecular electronics

Research interest in the molecular devices proposed in the beginning of the 1980s faded for a while because of a lack of a way to access individual molecules, but advances in scanning tunneling microscopes and interatomic microscope in the mid 1990s are beginning to provide the access means, and once again research in this area is gathering pace. Over the past couple of years, research institutions in Europe and the U.S. in particular have been locked in fierce competition to be the first to gain access to single molecules, an achievement that would lay the first block in the construction of molecular electronics, and international conferences are being held frequently.

In Japan, molecular devices are being approached from two angles. The first is to functionally replace the current inorganic material, making effective use of the flexibility of molecules and their size adaptability, while the other is to realize ultra-high performance devices, focusing on the functions of single molecules. In this survey there are eight topics dealing with molecules, while in the previous survey there were only three, indicating a growing awareness about the importance of molecule-related technology. Three topics cover the first approach — “35: Practical use of lasers, optical switches, and other devices by means of solid organic materials,” “69: Practical use of high-efficiency light energy converters utilizing organic materials” and “71: Development of super-large-scale flat panel displays utilizing organic materials”; and five cover the second approach — “01: Development of technology capable of manipulating single atoms and single molecules,” “12: Development of high-speed, highly-integrated devices that switch by the movement of a single atom,” “51: Development of logic LSIs and memory LSIs in which the basic switching element is a single molecule,” “58: Practical use of biosensors capable of identifying single molecules” and “66: Development of a storage system in which one atom or molecule corresponds to 1 bit.”

Among these, topics 01 and 12 are ranked in the top five in degree of importance regarding the expansion of intellectual resources, and topic 69 is in the top three regarding the resolution of global problems, which backs up the high expectations of molecular electronics as the next paradigm to follow the present semiconductor electronics. To realize these research topics, “foster researchers, engineers and research assistants” (topic 58) and “ increase government research funding” (topic 66), are in the top five in degree of importance as effective measures the government should take, indicating a recognition among respondents that measures to promote research are essential in this area.

(Yasuo Wada)

(2) Bioelectronics

In the early 1980s the concepts of molecular devices, bio-devices and biocomputers attracted the S&T spotlight around the world, and since then the three bioelectronics domains of 1) molecular and super-molecular structures, 2) cells and cell tissue, and 3) brain and nervous system have evolved independently at their own levels.

R&D on biodevices made up of molecular and super-molecular structures is closely linked to that on molecular devices, but biodevices are highly distinctive in that protein is the main structural element. Although there were various problems along the way, an important turning point came in the early 1990s with the mass production as practical devices of biosensors designed to give full play to the electronics functions of proteins. And the future looks bright for R&D in the construction of biodevices by artificially altering proteins through protein engineering and other pioneering technologies.

Rapid progress is being made in R&D into the construction of biodevices using cells or cell tissue, and though expectations are high, there is still much to do. Attention is being drawn to conceptual R&D into technology to access life functions by applying advanced electronics technologies or optoelectronics technologies, such as scanning probing microscope methods, to cell structures.

In brain and nervous system bioelectronics as well, a major goal of R&D is to design technologies that allows us to access brain functions.

We set ten topics (50, 52, 54, 55, 58, 59, 62, 63, 64 and 65) to reflect these developments.

(Masuo Aizawa)

(3) Sensor electronics

Sensing technology is absolutely crucial in various industries, basic science, disaster prevention, the environment and various other areas, and its principles are indeed diverse, including photonics, superconductors, semiconductors, and quantum effect. Therefore, the production of individual sensor types or sensing technologies is not always in large volumes, and the industrial scale is comparatively small. Technology-intensive and expensive sensors in particular are more often than not produced only in small amounts. In this light, it is not easy to select topics that strike a good balance across the entire technological domain. In this survey we leaned toward the molecular, bio and sensor electronics area, so most of our topics cover these technologies. However, we also gave consideration to topics connected with sensor electronics in the microelectronics and optoelectronics domains.

The importance index for the molecular, bio and sensor electronics domain is lower than for other electronics domains, and we can probably attribute this to its relative low economic effect because of the demand factors mentioned above. In fact a look at the assessment of expected effect shows that while "contribution to socioeconomic development" ranks highest in the other domains, in molecular, bio and sensor electronics, "response to people's needs" is at the top. Among the items classified by objective, expectations of "expand intellectual resources" is quite high in the "high sensitivity and high resolution" item, which consist mainly of sensing-related topics over the entire electronics field. This can also be put down to the above-mentioned factors in the sensing domain. And in fact, topic "40: Development of high-sensitivity sensing technology using technology to control the quantum condition of light" assumes gravitational wave detection technology.

In any event, sensing technology is vital in a wide range of technological fields, and the technology-intensive high-sensitivity sensing technology in particular is essential in fields that are not necessarily talked about only in terms of economic effect, such as space and aviation, disaster prevention, and environment. Topic "60: Practical use of multiplexed sensing methods for materials with self-diagnostic capabilities" is one example of this. Sensor electronics is one domain where measures to promote R&D, such as injecting public funds into research as necessary, should be considered. If we look at the topics by objective, it is worth noting that the United States is dominant in "high sensitivity and high resolution," and also that voices calling for the government to "increase government research funding" are quite strong among the respondents.

(Kazuo Hotate)

2.1.4. Storage and display electronics

(1) Storage electronics

The development of magnetic memory technology for external memory use in computer systems did not always go smoothly in the 1980s, and memory capacity per unit area roughly doubled every five years. But advances over recent years have been remarkable to say the least, with capacity at least doubling every year, and now the per-bit cost of magnetic memory is less than one hundredth that of semiconductor memory. The 2.5-inch and 3.5-inch magnetic hard disks used in personal computers have a memory capacity of 1–5 Gbits and high access speed, and are highly reliable, so they are used for housing system software. Currently a magnetic memory density of 10Gbits per square inch is within reach, and topic "67: Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch" is forecasted to be realized around 2017.

The ubiquitous floppy disk has been a popular removable memory device, but of late it is beginning to be replaced by the IC memory card, which uses flash memory technology.

These days almost all personal computers are equipped with CD-ROM drives, so the production of optical disk memory is now around the 50 million a year mark. The DVD, which was developed in Japan, has about seven times the memory capacity of the CD, and if blue laser diodes can be used, it jumps to more than 25 times as great. Currently DVDs in the ROM form are used for replaying movies and in computer ROM devices, but in the future with the development of writable DVD-RAM, the scope of their use will expand enormously to such areas as music, digital broadcast recording, *karaoke*, films, and games, so world demand is projected to be around the 120 million mark in 2000. And realization of topic "68: Practical use of optical memories with recording density of 10^{11}b/cm^2" is expected around 2016.

While technology for parallel storage devices that arrange tens of small magnetic disk or optical disk storage devices is already being used in the construction of highly reliable high-capacity computer memory systems, topic "70: Practical use of small read/write optical filing systems with at least 1 terabyte capacity per system" is forecasted to be realized around 2012. (Ken-ichi Mori)

(2) Display electronics

The Cathode Ray Tube (CRT) has maintained its importance, and in 1996, 45 million units were produced earning 1.7 trillion yen. High-definition CRT with 1600×1200 and even 7680×4320 resolution for work stations and computer terminals have been developed, and with this, screens are becoming larger, and demand is shifting from 14-inch to 15- and 17-inch screens.

LCD technology is advancing rapidly. Full-color TFT-LCD has been developed, and its use in notebook computers has pushed production up to very close to the trillion yen mark. With the development of polysilicon TFT, the scope of small displays suddenly expanded, and have found a wide range of applications, such as viewfinders, digital cameras, NC, computers, and PDA. In the same way that Sony's Walkman brought to users a mobile concert hall, these small displays look as though they could bring mobile offices and mobile photo galleries to reality. Projection displays, too, are now finding greater use in electronic presentations and teleconferences.

One technology that has been attracting attention of late is the plasma display (PDP), and following on from the marketing of 20-inch displays are plans for large-screen PDP of 40 inches and larger. As for large outdoor screens, with the development of high-resolution blue LED, full-color LED display (2.56x1.92 meters) are now being put to practical use.

Among new trends are the FED, which utilizes electrical field discharge, and MMD, which utilizes micro-mirror arrays. Research into 3D displays, especially those that do not require the viewer to wear special glasses, is progressing, but the technology is still a long way off.

One point about future developments in this area that is raising interest is just how large screens can become. We have already seen large screens in Jumbotron and the LCS projection system, but the keys to the success of this technology is low cost, light weight and shallow depth. For example, it would be interesting to know whether we will ever be able to enjoy TV with an entire wall as the screen as if we were in a theater, or hold a TV conference in which participants feel as though they are actually at the conference site. As long as glass is used, there will always be limits as to how light screens can become. One solution to this could be organic polymer displays. The future promises to be exciting.

It is also interesting to travel to the other extreme, and find out just how small and highly defined screens can become. As an ultimate, and perhaps somewhat scary, feature, one topic asked whether an imaging system incorporated into glasses that directly projects images on to the retina can be realized, and its forecasted realization time is quite early.

(Hajime Ishikawa)

2.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 2.2-1 Forecast Topic Framework for Electronics Field

Objective \ Domain	Microelectronics	Optoelectronics	Molecular, sensor and bioelectronics	Storage and display electronics
Pursuit of new scientific principles, new phenomena and new devices	01 02 03 04	31 32 33 34 35	50 51 52	66
High integration and high capacity	05 06 07	36	53	67
Miniaturization and expansion in size	08		54 55	68
High speed	09 10 11 12 13	37	56	
Super-parallel processing		38 39		
High sensitivity and high resolution	14	40	57 58 59	
High performance, high functionality, systems integration and knowledge accumulation	15 16	41 42 43	60 61 62 63 64	69 70
High efficiency, high output and low power consumption	17 18 19	44		
Large scale and wide area		45 46 47		71 72
Intelligence, flexibility, ease of use, human interface and portability	20 21 22 23 24 25	48	65	73 74
High productivity, high reliability, low price, and rationalization of design and testing	26 27 28 29 30	49		

Figures appearing in the table represent topic numbers.

2.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 67.7 for topics in the electronics field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index) are listed in the table below. While the top 20 were dominated by semiconductor-related topics, two relating to manufacturing technology were also included. As many as 4 topics were given a degree of importance index score of more than 90. The topic with the lowest degree of importance index score was ì74. Practical use of miniature file devices that fit inside a pair of glasses (46 points).

Table 2.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	94	2014
30 Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	93	2012
05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	93	2013
18 Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	92	2010
13 Practical use of TIPS (Tera Instruction Per Second) level microprocessors.	89	2018
08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	88	2017
49 Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	88	2009
09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps	87	2015

Topic	Degree of importance index	Forecasted realization time (year)
or less.		
19 Development of processor LSIs with 10 GIPS performance and power consumption of 10 miliwatts or less.	87	2014
24 Widespread use of a portable multimedia wireless terminal operated on the order of 100 Mbits/sec., which can be used throughout the world.	84	2011
32 Practical use of ultraviolet, blue, and green, semiconductor lasers.	84	2004
67 Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch.	83	2017
38 Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber.	83	2014
68 Practical use of optical memories with recording density of 10^{11} b/cm^2.	82	2016
28 Practical use of automated production systems in which LSI chips are produced automatically by giving LSI design data.	82	2015
37 Widespread use in homes of 10 Gbits/sec. optical subscriber-type systems.	79	2015
03 Practical use of LSIs using single-electron transistors.	78	2015
70 Practical use of small read/write optical filing systems with at least 1 tera bite capacity per system.	78	2012
23 Practical use of portable automatic translation systems with a single-chip LSI.	77	2013
59 Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm.	77	2012

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

2.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. With more than half the topics forecasted to be realized between 2011 and 2015, the peak of the distribution of forecasted realization times in the electronics field roughly coincided with that of the general trend covering all topics, although it was sharper. The proportion of topics forecasted to be realized before the peak was smaller than the general trend. The earliest forecasted realization time was 2004, which was given to “32. Practical use of ultraviolet, blue, and green, semiconductor lasers”, while the latest realization time was 2024, which was given to “21. Development of an “artificial intelligence chip” capable of understanding and sharing human emotions.”

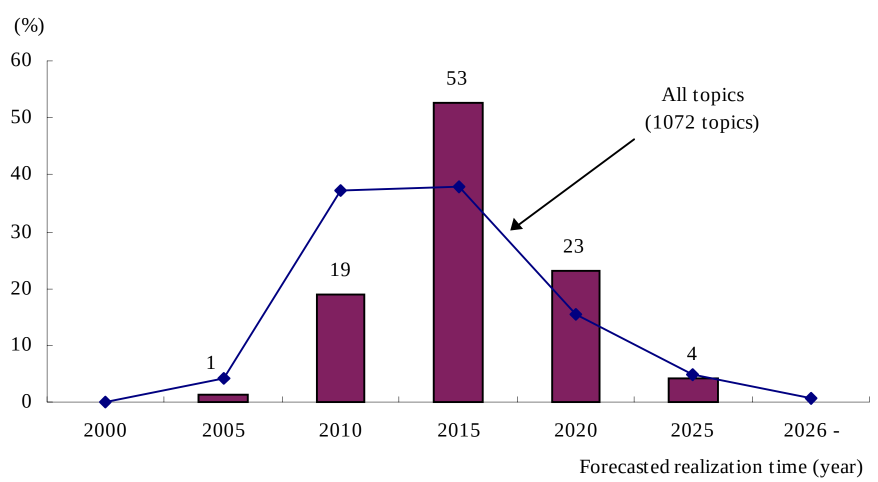


Fig. 2.4-1 Trends in Forecasted Realization Times

2.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by 75.2% of the respondents, the U.S. ranked No. 1 in the electronics field as a whole, closely followed by Japan (69.0%). The score of the third-ranking EU was a little less than a quarter of Japans.

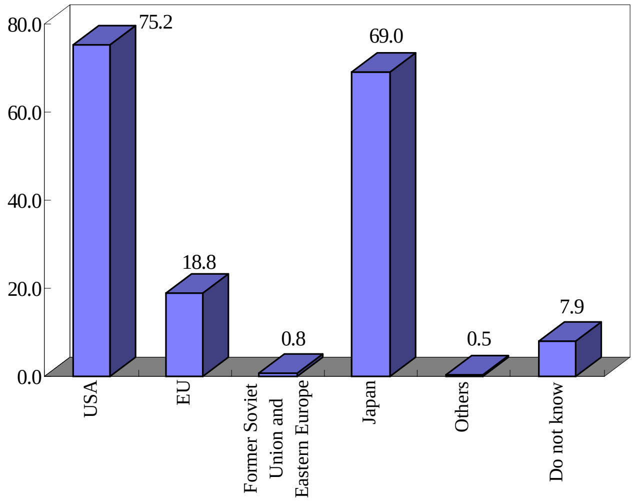


Fig. 2.5-1 Current Leading Countries etc. (%)

2.6. Comparison with the 5th Survey (previous survey)

Of the 74 topics included in the latest survey, 6 (8%) were identical to the previous survey, 18 (24%) were modified, and 50 (68%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

There was a major procedural change in the latest survey in that the <information and electronics> field in previous surveys was broken down into <electronics> and <information> fields.

Degree of importance index scores rose for 4 topics, fell for 1 topic and remained the same for 1 topic. The only topic which experienced a drop was “65: Development of sensors that could be substituted for human sensation, capable of directly stimulating nerves” down 2 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all but one topic (i.e. those from the electronics domain of the former electronics and information field in the case of the 4th Survey). Likewise, from the 5th to the 6th Survey, all 6 identical topics were pushed further into the future. In particular, “09: Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less”, “17: Practical use of heat-resistant logic ICs useable in high-temperature environments up to 500°C” and “26: Development of technology capable of continuous LSI production on semiconductor substrates in a sheet form” saw their forecasted realization times pushed back 10 or more years.

Topics from other fields in the 5th Survey included one which was identical to a topic from the electronics field in the 6th Survey. For this topic (from materials field), the degree of importance index score fell by 1 point, and the forecasted realization time was pushed back 9 years.

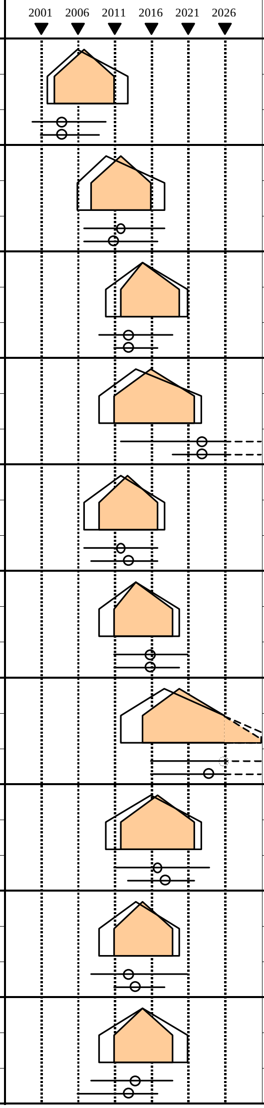
Table 2.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	87/2015	80/2005
17 Practical use of heat-resistant logic ICs useable in high-temperature environments up to 500°C.	51/2015	50/2005 52/2006*
22 Practical use of single-chip voice recognition integrated circuits which incorporate learning functions capable of identifying different speakers.	70/2011	64/2003
26 Development of technology capable of continuous LSI production on semiconductor substrates in a sheet form.	66/2017	57/2007
59 Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm.	77/2012	77/2005
65 Development of sensors that could be substituted for human sensation, capable of directly stimulating nerves.	55/2013	57/2008

* Identical topic from materials field

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Microelectronics	1	Development of technology capable of manipulating single atoms and single molecules.	1	290	12	38	50	71	48	42	10	0	62	6	7	75		1	4	85	26	0	63	0	9	60	40	45	5	53	1	1	8	2	8	2
			2	258	12	34	54	71	46	46	7	0	62	2	1	79		1	3	92	22	0	69	0	3	64	36	47	2	55	0	0	5	2	6	2
			X	30	100	0	0	91	83	13	3	0	67	3	0	93		0	3	100	37	0	77	0	0	80	47	47	0	63	0	0	0	0	0	0
	2	Practical use of quantum-phase devices that control the phases of, for example, electron waves.	1	236	10	39	51	65	36	49	14	0	74	4	3	52		6	6	86	28	1	71	0	6	55	47	43	2	48	1	1	2	2	5	2
			2	226	9	34	57	64	34	52	14	0	77	2	1	56		6	4	90	23	0	76	0	3	62	42	41	1	49	0	1	1	1	3	1
			X	21	100	0	0	77	57	38	5	0	86	5	5	71		10	0	100	19	0	90	0	0	67	67	33	0	48	0	0	0	0	0	0
	3	Practical use of LSIs using single-electron transistors.	1	275	13	40	47	74	53	34	12	0	86	11	6	43		9	7	79	34	3	80	0	4	56	47	44	1	52	0	0	2	3	4	1
			2	247	11	38	50	78	60	32	7	0	87	5	2	47		6	4	83	31	1	84	0	2	61	44	44	1	53	0	0	1	2	2	1
			X	28	100	0	0	91	82	18	0	0	100	11	0	61		14	0	86	32	4	96	0	0	61	57	32	0	61	0	0	0	4	0	4
	4	Elucidation of the mechanisms by which single-cell organisms etc. respond to external stimuli, and realization of such mechanisms artificially.	1	103	5	14	82	61	30	55	15	0	40	11	42	68		2	10	70	34	3	41	0	18	52	43	38	29	43	5	0	18	5	33	0
			2	108	3	11	86	61	29	58	13	0	31	8	37	75		2	9	76	31	1	39	0	14	63	39	34	24	43	5	0	15	5	38	0
			X	3	100	0	0	100	100	0	0	0	33	33	67	67		0	0	100	67	0	100	0	0	100	67	33	33	33	0	0	0	0	33	0
	5	Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	1	296	25	38	38	87	75	23	2	0	92	10	10	29		0	3	76	16	1	90	3	2	47	51	53	1	50	1	0	3	1	4	2
			2	267	24	34	42	93	86	13	0	0	96	6	6	22		0	1	75	10	0	92	1	1	47	50	58	1	54	0	0	2	2	1	1
			X	63	100	0	0	98	95	5	0	0	97	8	5	32		0	0	79	19	0	97	0	0	52	44	48	2	65	0	0	3	2	0	2
	6	Practical use of VLSI with as much as 256 Gbits of memory per chip.	1	281	25	37	38	89	79	20	0	1	95	8	16	15		3	4	62	4	1	92	16	1	45	50	45	1	52	3	1	2	3	9	1
			2	251	24	35	42	94	88	11	0	1	95	3	10	11		3	1	61	2	0	96	15	0	44	51	48	1	56	2	0	0	2	6	2
			X	59	100	0	0	97	95	3	0	2	98	7	17	14		5	0	64	0	0	97	25	0	44	56	44	0	69	0	0	0	0	5	2
	7	Widespread use of wafers one meter in diameter.	1	257	18	35	47	53	29	35	27	9	80	13	5	6		39	15	43	6	0	75	3	9	25	30	32	1	35	2	3	6	2	2	1
			2	236	17	32	51	55	27	43	23	6	87	7	4	3		39	14	44	3	0	83	2	7	26	33	38	1	44	1	3	4	1	1	1
			X	40	100	0	0	64	45	33	10	13	85	8	3	5		40	5	58	5	0	88	3	0	23	40	38	0	53	3	3	3	0	3	3
	8	Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	1	272	21	35	44	84	71	26	2	1	92	10	16	15		5	5	71	8	0	88	7	2	46	44	37	1	49	2	1	3	2	7	1
			2	244	22	31	47	88	78	20	1	1	93	5	9	10		4	4	72	3	0	89	6	2	48	48	36	1	52	2	0	0	1	5	1
			X	53	100	0	0	94	91	8	0	2	96	9	11	23		8	0	81	2	0	94	11	0	53	53	30	0	60	0	0	0	0	4	2
	9	Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	1	266	23	38	39	81	65	30	5	0	92	9	15	27		10	9	80	15	1	79	0	6	52	47	38	2	48	2	2	3	2	4	1
			2	237	22	35	43	87	74	25	1	0	95	3	8	19		7	4	84	11	0	83	0	3	60	49	37	1	52	1	0	1	0	2	1
			X	52	100	0	0	95	90	10	0	0	100	8	19	21		10	0	92	19	0	90	0	0	67	50	29	0	58	0	2	0	0	2	2
	10	Practical use of wide-band solid-state amplifiers operated at high frequencies of around 100–1,000GHz.	1	242	19	39	42	70	47	41	11	1	88	9	15	20		5	14	77	27	2	61	0	10	56	41	31	1	46	3	0	4	2	3	1
			2	224	18	38	44	77	57	38	6	0	91	4	13	18		2	8	86	22	0	72	0	5	64	46	28	0	52	2	0	1	0	1	1
			X	41	100	0	0	88	76	24	0	0	98	7	17	22		2	0	90	39	0	85	0	2	66	49	20	0	68	2	0	2	0	5	0



(Note) See page 7 for the interpretation of the graphs.

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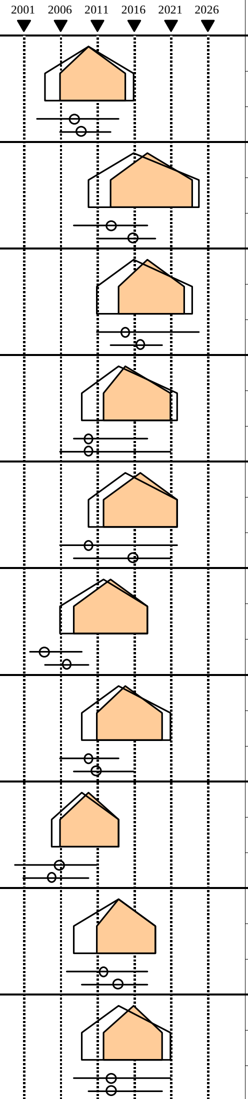
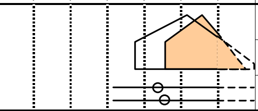
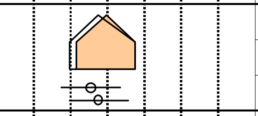
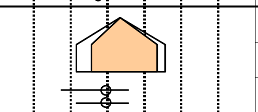
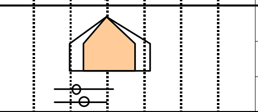
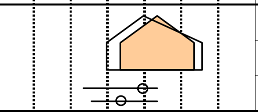
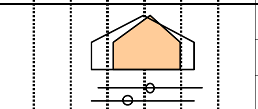
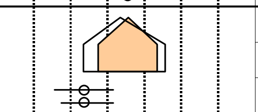
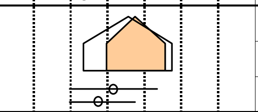
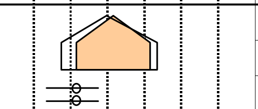
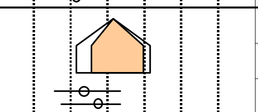
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time: Will not be realized (%)	Forecasted realization time: Do not know (%)	Leading countries (%): USA	Leading countries: EU	Leading countries: Former Soviet Union and Eastern Europe	Leading countries: Japan	Leading countries: Other countries	Leading countries: Do not know	Measures the government should adopt (%): Foster human resources	Measures: Promote exchanges among industrial, academic and government sectors and different fields	Measures: Upgrade advanced facilities and equipment	Measures: Develop a research base	Measures: Increase government research funding	Measures: Adjust regulations (relax/toughen)	Measures: Others	Potential problems (%): Adverse effect on the natural environment	Potential problems: Adverse effect on safety	Potential problems: Adverse effect on morals, culture or society	Potential problems: Other adverse effects
Microelectronics	11	Development of super-conducting three-terminal devices with amplification capabilities.	1	209	9	32	59	51	19	50	27	4	71	14	5	39	5	16	65	29	4	71	0	9	54	42	31	2	44	1	1	2	0	3	1
			2	196	9	25	66	49	13	56	29	2	74	7	1	45	3	11	69	25	3	78	0	7	64	41	28	2	48	1	1	1	0	2	2
			X	17	100	0	0	56	24	53	24	0	82	12	0	47	6	6	59	29	0	94	0	6	59	65	41	0	53	6	0	0	0	0	6
	12	Development of atomic-scale, high-speed, highly-integrated devices switching by the movement of a single atom, such as to atom relay transistors.	1	224	9	29	63	64	38	42	17	2	67	7	5	58	16	13	72	27	2	49	0	16	57	39	34	1	43	0	0	1	1	2	3
			2	204	8	25	67	63	35	47	16	1	73	3	3	62	15	12	80	23	0	53	0	13	66	41	32	1	46	0	0	0	0	1	1
			X	17	100	0	0	85	71	29	0	0	88	0	0	65	12	6	88	35	0	76	0	6	71	59	18	0	59	0	0	0	0	0	0
	13	Practical use of TIPS (Tera Instruction Per Second) level microprocessors.	1	211	13	29	58	86	73	24	2	0	93	13	19	20	6	6	89	10	0	46	0	3	52	45	27	1	48	1	1	1	4	4	1
			2	196	12	24	64	89	79	18	3	0	95	8	14	16	4	3	93	5	1	48	0	3	66	47	21	1	54	1	1	0	3	4	1
			X	23	100	0	0	91	87	4	9	0	96	17	17	22	4	0	96	9	0	57	0	4	78	35	13	4	83	0	0	0	4	9	4
	14	Development of X-ray microscopes capable of 10-100nm resolution.	1	170	8	25	67	56	28	43	26	3	53	2	10	69	11	19	58	31	4	41	0	21	53	32	35	2	44	1	1	5	4	1	1
			2	162	7	21	72	55	24	51	22	2	52	1	6	82	6	13	70	27	1	50	0	17	67	28	36	1	52	0	0	3	5	0	1
			X	11	100	0	0	82	64	36	0	0	36	0	9	100	0	0	91	27	0	64	0	0	55	18	45	0	73	0	0	0	0	0	0
	15	Practical use of semiconductor neural network chips on the order of one million neurons.	1	176	9	24	67	63	35	51	13	2	85	6	26	35	10	14	76	20	1	59	0	10	55	50	19	1	48	2	1	1	2	11	1
			2	174	7	25	68	64	33	59	9	0	90	5	21	33	7	7	86	19	0	64	0	7	68	56	14	0	53	1	0	1	2	6	1
			X	13	100	0	0	79	62	31	8	0	92	15	23	46	8	0	92	31	0	69	0	0	69	54	15	0	85	0	0	0	8	8	8
	16	Widespread use of high-temperature superconductive materials in passive circuits for milimater-wave communication systems.	1	218	13	26	61	54	23	50	25	2	78	10	12	19	11	17	72	30	4	59	0	12	47	43	27	0	41	5	1	2	2	2	1
			2	202	12	25	63	54	19	59	20	2	86	6	11	17	10	12	79	26	0	64	0	8	59	50	21	0	46	4	0	1	2	0	1
			X	24	100	0	0	74	50	46	4	0	96	8	29	8	4	4	96	25	0	58	0	4	67	63	21	0	54	8	0	0	17	0	0
	17	Practical use of heat-resistant logic ICs useable in high-temperature environments up to 500°C.	1	212	11	29	60	50	19	46	31	3	70	26	15	19	9	14	67	19	5	44	0	18	49	40	25	3	40	2	2	4	1	1	2
			2	192	12	26	62	51	17	56	25	2	82	20	14	16	7	10	76	19	2	54	0	13	58	46	18	2	47	1	0	2	1	1	1
			X	23	100	0	0	72	43	57	0	0	87	30	35	9	0	4	83	17	0	74	0	0	65	65	9	0	61	0	0	0	0	0	4
	18	Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	1	243	8	33	59	86	73	25	2	0	59	88	21	5	2	6	65	23	2	86	1	7	40	48	27	1	56	11	1	12	1	3	2
			2	219	7	28	65	92	84	15	1	0	60	89	15	2	0	3	68	16	0	91	1	4	47	53	20	0	63	10	0	8	0	1	1
			X	15	100	0	0	97	93	7	0	0	73	93	33	0	0	0	93	27	0	100	7	0	67	73	20	0	73	7	0	0	0	0	0
	19	Development of processor LSIs with 10 GIPS performance and power consumption of 10 miliwatts or less.	1	204	20	30	50	81	64	32	3	0	92	28	23	10	5	10	88	14	0	62	0	3	56	44	26	1	45	0	0	3	2	4	2
			2	188	17	32	51	87	74	24	1	1	96	25	17	5	3	9	91	8	0	66	1	3	66	46	20	1	54	0	0	2	2	2	2
			X	32	100	0	0	94	88	13	0	0	100	31	22	13	3	0	94	16	0	75	0	0	94	44	19	0	72	0	0	3	3	3	3
	20	Practical use of multi-processor systems with advanced self-restoration capabilities.	1	190	12	26	62	72	46	48	6	0	89	6	24	19	3	8	86	21	2	36	0	8	63	47	23	2	42	0	1	2	3	6	2
			2	179	9	23	68	71	44	53	3	0	94	2	22	12	2	6	92	16	2	40	0	6	71	55	16	1	44	0	0	1	2	3	1
			X	17	100	0	0	88	76	24	0	0	94	6	12	18	0	0	94	29	0	76	0	0	88	53	6	0	76	0	0	6	6	6	6

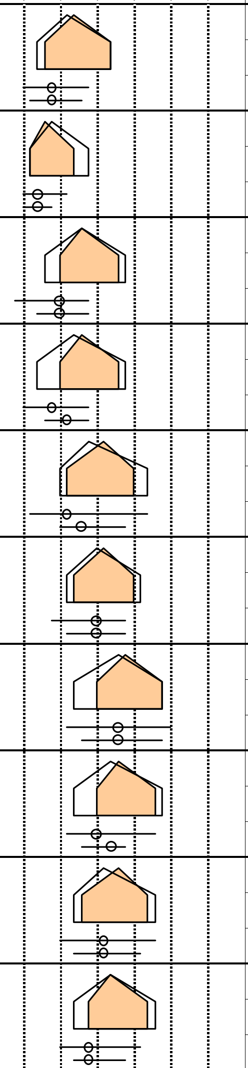


(Note) See page 7 for the interpretation of the graphs.

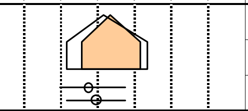
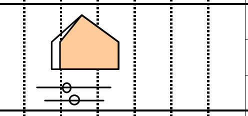
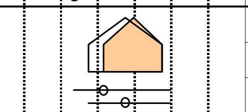
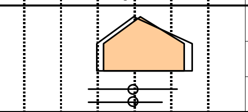
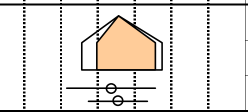
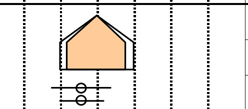
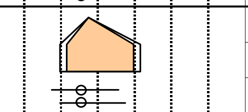
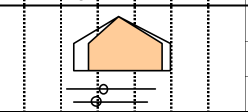
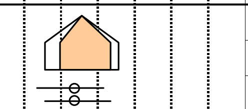
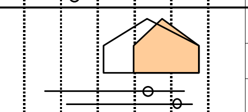
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Medium	Low	Importance (index, %): Index	High	Medium	Low	Unnecessary	Expected effect (%): Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Microelectronics	21	Development of an "artificial intelligence chip" capable of understanding and sharing human emotions.	1	170	8	18	74	66	42	42	14	2	67	3	72	37		21	15	71	20	2	36	0	20	60	41	20	9	39	1	3	0	15	42	1
			2	162	6	15	79	64	34	54	10	1	59	0	75	36		22	10	80	15	1	36	0	16	70	43	11	6	41	1	1	0	10	50	1
			X	10	100	0	0	89	78	22	0	0	80	0	80	30		10	0	100	40	0	50	0	0	90	70	30	10	50	0	0	0	10	40	0
	22	Practical use of single-chip voice recognition integrated circuits which incorporate learning functions capable of identifying different speakers.	1	233	9	22	69	71	45	49	7	0	81	1	78	11		1	8	77	19	0	71	0	12	56	55	18	4	36	2	1	1	18	12	1
			2	217	7	19	74	70	41	56	3	0	79	0	85	8		1	3	81	10	0	76	0	8	62	60	12	1	40	1	0	0	17	7	1
			X	16	100	0	0	91	81	19	0	0	75	6	88	13		0	0	81	19	0	81	0	0	56	63	25	0	44	0	6	0	6	6	6
	23	Practical use of portable automatic translation systems with a single-chip LSI.	1	236	9	22	69	76	55	39	6	0	84	5	69	9		4	5	66	22	0	76	0	11	52	56	22	4	39	1	1	1	7	15	1
			2	224	8	21	71	77	56	41	3	0	84	4	79	5		3	3	68	15	0	82	1	8	55	61	16	2	46	1	0	1	5	15	1
			X	17	100	0	0	97	94	6	0	0	88	12	88	18		6	6	88	41	0	94	0	0	53	59	35	0	71	0	0	0	6	6	6
	24	Widespread use of a portable multimedia wireless terminal operated on the order of 100 Mbits/sec., which can be used throughout the world.	1	255	12	31	57	79	61	33	5	0	96	9	60	7		3	5	91	34	0	72	0	2	42	45	19	2	33	29	4	2	24	15	1
			2	237	12	27	61	84	69	30	1	0	93	4	69	2		0	2	93	30	0	75	0	1	47	48	11	0	34	30	3	1	26	11	1
			X	28	100	0	0	96	93	7	0	0	96	21	71	4		0	7	89	46	0	89	0	0	54	50	14	0	46	32	4	4	25	14	4
	25	Widespread use (one in every household) of "housekeeping robots" capable of cleaning, laundry, etc.	1	199	4	16	80	51	21	43	32	3	45	4	91	3		11	9	47	11	2	54	0	27	26	45	13	2	23	6	3	2	13	26	2
			2	197	3	14	83	50	18	49	30	3	41	1	94	1		11	7	50	6	0	66	0	21	30	55	8	1	28	5	4	2	11	30	2
			X	6	100	0	0	79	67	17	17	0	50	0	83	0		0	0	50	0	0	83	0	0	50	50	17	0	33	0	0	0	17	33	0
	26	Development of technology capable of continuous LSI production on semiconductor substrates in a sheet form.	1	216	17	26	57	63	40	36	19	5	82	15	12	4		20	14	45	7	2	52	1	25	43	40	25	1	30	1	0	5	1	3	1
			2	201	15	26	59	66	42	42	13	3	90	9	9	1		24	10	49	2	0	63	0	21	47	45	20	0	34	1	0	3	0	0	1
			X	30	100	0	0	70	57	17	20	7	80	23	13	3		37	3	57	3	0	67	0	13	50	40	17	0	33	0	0	3	3	0	3
	27	Practical use of virtual factory technology, in which high-performance LSI with several hundred K gates or more can be designed automatically by giving the required specifications on the system level.	1	179	13	30	57	72	49	42	8	1	89	6	9	11		3	4	85	13	0	42	1	8	65	45	21	1	36	1	2	3	1	4	2
			2	172	10	27	63	76	55	40	4	1	95	2	6	6		2	4	88	7	0	50	1	5	66	48	18	1	41	0	1	1	1	2	2
			X	18	100	0	0	97	94	6	0	0	100	6	11	0		6	0	89	17	0	67	0	0	72	61	17	0	56	0	6	0	0	6	6
	28	Practical use of automated production systems in which LSI chips are produced automatically by giving LSI design data.	1	196	13	29	58	76	56	36	7	0	89	7	8	8		5	5	80	9	1	58	2	9	47	43	26	2	32	1	2	3	2	2	2
			2	186	12	24	63	82	66	32	2	1	94	3	5	3		5	5	86	4	1	64	1	4	54	53	20	1	37	0	1	2	1	1	2
			X	23	100	0	0	98	96	4	0	0	96	9	9	4		9	0	83	9	0	57	0	0	65	52	17	0	52	0	4	4	0	0	4
	29	Practical use of device which directly detects LSI signals from an area of less than 10 nm dimension.	1	190	15	27	57	58	27	52	21	0	75	4	3	41		2	11	75	26	1	65	0	11	59	40	31	1	35	0	1	1	2	3	3
			2	175	14	29	58	57	22	62	16	1	82	2	2	40		1	6	80	22	1	70	0	7	64	40	26	1	34	0	0	1	1	1	2
			X	24	100	0	0	74	50	46	4	0	96	4	8	42		4	0	79	33	0	92	0	0	83	54	13	0	38	0	0	4	0	0	4
	30	Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	1	207	12	25	64	89	79	19	2	0	60	89	23	4		1	10	65	17	2	82	1	6	38	49	26	2	57	17	1	19	3	2	2
			2	197	9	25	65	93	87	12	1	0	60	90	19	2		1	7	65	11	1	90	2	3	41	51	18	1	68	13	2	16	2	1	1
			X	18	100	0	0	97	94	6	0	0	61	94	22	0		0	0	89	22	0	94	11	0	56	50	22	0	83	11	6	11	6	0	0

(Note) See page 7 for the interpretation of the graphs.

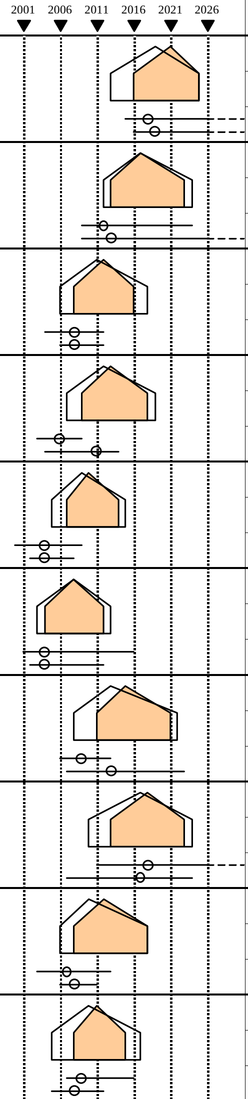
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Optoelectronics	31	Development of digital optical logic circuits which carry out binary operations.	1	226	19	32	49	56	26	47	24	3	77	3	7	28		3	8	79	31	3	71	0	8	55	38	30	1	43	0	0	1	1	4	3
			2	208	15	30	54	55	21	58	20	1	79	1	2	29		4	3	86	25	1	78	0	5	67	39	22	0	47	0	0	0	0	2	1
			X	32	100	0	0	59	34	34	28	3	75	0	0	34		6	0	94	44	3	97	0	0	56	53	25	0	47	0	0	0	0	3	0
	32	Practical use of ultraviolet, blue, and green, semiconductor lasers.	1	284	24	34	43	79	60	36	4	0	94	7	21	13		0	2	61	18	2	92	1	2	54	46	28	0	38	2	1	2	3	4	2
			2	257	21	35	44	84	69	29	2	0	96	2	21	9		0	1	55	12	2	95	0	2	62	50	22	0	37	2	0	2	2	2	1
			X	54	100	0	0	89	78	22	0	0	98	2	24	15		0	0	59	17	2	98	2	0	69	61	24	0	31	2	0	0	0	2	0
	33	Development of semiconductor lasers whose oscillation wavelength is independent of temperature.	1	245	26	28	46	62	34	48	17	1	81	2	7	22		9	16	61	18	0	76	0	12	54	37	26	1	34	1	1	2	1	2	2
			2	226	23	31	47	61	29	58	13	0	87	1	7	18		6	10	63	14	0	84	0	8	65	38	20	1	35	0	1	0	1	1	1
			X	51	100	0	0	73	49	45	6	0	84	0	10	24		4	6	69	22	0	98	0	0	75	55	22	0	35	0	2	0	0	2	0
	34	Development of semiconductor lasers with no threshold by, for example, controlling spontaneous emission.	1	230	27	28	44	55	26	44	28	1	76	5	4	32		14	15	62	17	0	73	0	11	50	30	28	1	33	0	1	1	1	2	2
			2	213	24	28	48	55	22	57	20	1	82	1	2	30		12	12	66	12	0	81	0	9	64	32	21	1	35	0	0	0	1	1	1
			X	51	100	0	0	71	45	49	4	2	84	2	2	43		14	2	82	22	0	98	0	0	80	43	22	0	33	0	0	0	0	0	0
	35	Practical use of lasers, optical switches, and other devices by means of solid organic materials.	1	209	21	33	46	54	23	49	26	1	85	5	9	22		7	9	63	32	2	56	0	13	52	41	24	1	37	0	1	2	0	2	2
			2	196	19	30	51	52	17	59	24	1	88	1	3	22		5	6	70	31	0	67	0	12	66	42	20	1	41	0	1	3	1	1	2
			X	38	100	0	0	69	42	50	8	0	87	5	3	34		5	0	84	50	0	74	0	3	76	50	21	3	55	0	3	0	3	3	0
	36	Widespread use of opto-electronic integrated circuits (OEIC) in which multiple optical elements and their wave guide connections are integrated on a semiconductor substrate.	1	267	31	31	39	69	43	46	10	0	93	5	15	10		4	6	79	31	1	86	1	3	49	51	29	1	43	2	0	1	2	4	1
			2	243	26	35	39	69	41	52	7	0	95	2	13	8		4	2	82	29	1	93	0	2	59	58	26	0	45	2	0	0	2	3	1
			X	63	100	0	0	81	65	30	5	0	98	5	21	8		2	3	84	41	0	98	2	0	63	62	27	0	56	3	2	0	5	5	3
	37	Widespread use in homes of 10 Gbits/sec. optical subscriber-type systems.	1	246	26	30	43	73	55	31	12	2	88	7	65	6		7	6	80	30	1	78	0	3	37	40	16	1	39	32	1	1	12	15	2
			2	229	24	31	45	79	64	26	8	2	92	4	67	2		5	4	83	25	0	82	0	4	39	45	11	0	45	32	1	0	7	15	0
			X	54	100	0	0	76	59	31	6	4	93	6	69	6		7	6	80	46	0	94	0	0	44	48	11	0	52	39	2	0	4	4	2
	38	Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber.	1	224	27	32	41	78	61	29	9	1	93	8	38	8		4	10	82	26	1	82	0	3	46	38	28	0	40	17	1	2	4	9	2
			2	217	23	31	46	83	69	23	6	1	95	5	38	2		4	8	82	19	0	86	0	4	54	41	21	0	49	16	1	0	3	7	1
			X	49	100	0	0	85	75	19	4	2	94	0	37	4		4	4	90	35	0	100	0	0	57	41	22	0	49	16	2	0	4	4	2
	39	Practical use of 1000 x 1000 surface emitting laser array, used in optical interconnections, for instance.	1	234	25	31	44	61	30	54	15	1	88	3	17	9		5	9	73	17	1	81	0	7	49	36	30	0	40	1	1	2	1	3	2
			2	215	25	28	47	61	29	60	11	1	92	1	15	6		5	5	75	13	0	85	0	5	60	39	27	0	47	0	1	0	0	2	1
			X	54	100	0	0	75	56	35	9	0	91	0	19	11		6	2	85	22	0	94	0	0	67	56	28	0	44	0	4	0	2	2	2
	40	Development of high-sensitivity sensing technology using technology to control the quantum condition of light.	1	188	20	26	54	56	24	55	21	1	64	9	13	53		2	16	76	31	2	52	0	15	61	35	28	2	39	1	0	1	2	5	3
			2	169	20	25	54	55	20	61	18	1	68	6	8	58		2	11	80	29	1	57	0	9	69	35	24	1	47	0	0	0	1	2	1
			X	34	100	0	0	68	38	56	6	0	71	9	26	53		0	9	88	38	0	74	0	6	76	56	21	0	62	0	0	0	3	0	3



(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Medium	Low	Importance (index, %) Index	High	Medium	Low	Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Optoelectronics	41	Practical use of semiconductor devices capable of emitting any wave-length of light by means of electric control signals.	1	241	26	32	43	66	38	51	11	1	88	3	12	29		10	12	66	24	1	72	0	11	57	41	26	1	40	1	0	1	1	3	2
			2	224	24	29	47	64	32	59	7	1	94	2	8	27		8	9	72	21	0	87	0	5	67	42	23	0	49	1	0	0	1	1	1
			X	53	100	0	0	74	49	47	4	0	96	4	9	32		4	4	60	25	0	92	0	0	74	43	17	0	47	4	0	0	4	0	0
	42	Practical use, in the field of optical communications and optical switching, of technology to convert the wavelength of a signal into another wavelength.	1	235	29	31	39	69	42	48	9	0	88	3	12	16		1	5	75	30	2	79	0	6	57	40	27	2	40	2	1	1	2	3	2
			2	215	27	33	40	70	42	52	6	0	96	2	8	14		0	4	87	27	1	90	0	2	67	44	22	0	51	2	0	0	1	2	1
			X	57	100	0	0	83	67	32	2	0	98	5	12	14		0	0	88	35	0	95	0	0	75	58	16	0	60	5	0	0	5	0	0
	43	Practical use of soft X-ray lasers oscillating at wavelengths in the order of 10/Å.	1	155	14	28	57	62	32	50	17	0	74	3	12	45		1	15	72	32	10	46	1	15	52	37	42	1	50	1	0	5	6	3	2
			2	146	13	23	64	58	23	63	13	0	75	2	7	51		1	16	84	31	8	53	1	10	66	30	37	1	55	0	0	2	4	1	1
			X	19	100	0	0	70	42	53	5	0	63	5	11	68		0	5	89	53	5	63	0	5	74	26	42	0	68	0	0	0	5	0	5
	44	Widespread use of semiconductor light sources for almost all types of lighting.	1	254	15	27	58	49	25	32	34	10	61	42	26	4		28	18	39	13	2	56	0	20	31	32	13	1	22	6	3	8	3	2	1
			2	229	15	28	58	49	20	42	32	7	69	41	27	3		27	14	43	11	0	70	0	14	43	39	9	0	28	4	2	7	2	1	0
			X	34	100	0	0	67	48	27	21	3	74	50	32	6		18	3	56	15	0	79	0	3	59	44	12	3	38	0	0	3	0	0	0
	45	Practical use of optical switches capable of connecting 10,000 video terminals.	1	193	20	28	52	67	43	44	12	2	85	5	42	5		3	9	74	23	1	74	0	7	38	35	17	2	30	17	0	1	6	11	2
			2	183	19	23	57	68	41	50	8	1	88	4	45	2		3	8	80	17	0	81	0	4	46	44	12	0	36	15	0	0	3	10	1
			X	35	100	0	0	87	77	17	6	0	89	6	46	3		0	0	83	40	0	100	0	0	46	43	11	0	46	11	0	0	9	3	0
	46	Practical use of optical communications between satellites.	1	201	19	23	57	52	22	46	31	1	73	21	9	7		3	9	83	25	9	45	0	6	40	33	22	0	45	6	1	2	4	3	1
			2	189	16	24	60	52	16	60	24	0	86	22	6	5		4	4	90	21	6	46	0	5	47	32	19	0	56	4	1	1	4	2	0
			X	31	100	0	0	71	48	39	13	0	87	26	16	3		3	0	94	29	0	77	0	0	68	35	26	0	58	6	0	0	6	0	0
	47	Practical use of optical soliton transmission for intercontinental undersea cables and other long-distance fiber communications.	1	201	25	31	44	65	37	52	9	2	88	13	14	10		6	11	76	20	2	83	0	4	44	34	25	1	44	7	1	2	3	3	1
			2	190	25	27	48	65	35	58	6	1	92	9	13	8		4	7	83	16	1	86	0	2	57	36	21	1	54	5	1	0	3	2	0
			X	47	100	0	0	72	49	43	9	0	94	9	17	4		4	9	83	30	0	89	0	0	62	45	23	0	57	2	2	0	4	0	0
	48	Practical use of devices capable of image recognition via optical operations.	1	222	17	32	50	59	30	51	17	3	78	3	32	16		6	12	73	22	2	60	0	13	51	36	25	1	35	1	1	0	5	3	1
			2	197	17	29	54	59	26	62	11	2	85	1	40	10		5	11	83	18	2	68	0	10	65	38	19	1	47	0	1	0	3	3	0
			X	33	100	0	0	75	52	45	3	0	88	3	42	9		3	6	91	30	3	79	0	0	82	48	24	0	45	0	0	0	3	0	0
	49	Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	1	233	29	28	42	83	68	27	5	0	90	5	61	3		2	6	69	23	1	82	0	4	32	35	18	0	27	23	3	0	5	10	1
			2	211	27	30	43	88	78	19	3	0	95	3	60	1		1	3	72	17	0	88	0	2	42	43	9	0	31	25	3	0	3	10	0
			X	57	100	0	0	97	95	4	2	0	93	7	61	4		0	2	72	26	0	91	0	0	49	35	12	0	33	23	5	0	7	4	0
Molecular, sensor and bioelectronics	50	Elucidation of the interconnective mechanism in the cerebral nervous system, and development of artificially functioning bio-nerve circuits with about 10,000 cells.	1	127	9	18	73	67	39	51	10	0	65	2	39	62		13	11	80	35	6	46	0	16	66	40	24	11	47	2	1	2	6	24	2
			2	123	5	18	77	64	33	59	8	0	64	0	31	66		11	7	88	30	2	46	0	8	73	41	15	6	59	0	1	1	3	28	2
			X	6	100	0	0	92	83	17	0	0	100	0	17	50		17	0	83	33	0	100	0	0	100	33	17	0	67	0	0	0	0	17	0

(Note) See page 7 for the interpretation of the graphs.

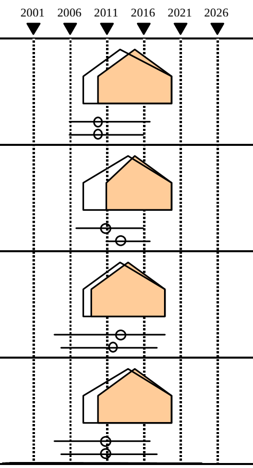
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Forecasted realization time (2001 2006 2011 2016 2021 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Molecular, sensor and bioelectronics	51	Development of logic LSIs and memory LSIs in which the basic switching element is a single molecule.	1	184	11	22	67	63	37	41	19	3	76	9	10	54		16	16	67	32	3	40	0	22	61	36	28	5	46	0	1	1	2	6	2
			2	166	11	16	72	61	31	51	18	0	80	4	7	49		13	13	75	27	2	46	0	16	68	37	17	2	54	0	1	0	1	4	1
			X	19	100	0	0	91	84	11	5	0	84	0	11	68		5	5	79	53	11	79	0	5	89	63	5	5	74	0	5	0	0	0	5
	52	Development of medical micromachine devices powered by the ATP etc. contained in blood.	1	85	7	18	75	69	47	37	14	2	51	5	85	31		14	15	61	22	0	36	0	21	53	40	19	7	44	6	1	4	9	20	2
			2	85	5	18	78	69	46	38	15	1	47	2	84	26		15	14	73	24	0	44	0	16	64	41	14	2	54	4	1	1	6	24	1
			X	4	100	0	0	63	50	0	50	0	75	0	75	0		25	0	50	25	0	100	0	0	100	50	0	0	75	0	0	0	0	50	0
	53	Practical use of devices which integrate sensors, controllers, and actuators, using micromachine technology.	1	208	9	27	64	68	42	47	10	0	78	10	62	10		2	5	78	31	2	70	0	8	49	58	33	2	46	2	0	1	5	7	1
			2	194	8	25	66	68	40	53	7	0	80	6	63	5		2	3	82	27	1	76	0	5	51	59	27	0	53	1	0	0	3	5	1
			X	16	100	0	0	91	81	19	0	0	94	13	75	0		0	0	88	56	0	88	0	0	44	63	25	0	63	0	0	0	0	6	0
	54	Practical use of micro medical devices for performing blood diagnosis and thrombus treatment.	1	118	8	25	68	72	47	47	6	0	44	0	92	6		1	8	80	30	2	58	0	13	58	53	19	8	51	6	0	1	11	16	3
			2	116	5	15	80	72	44	55	1	0	39	0	94	4		0	6	86	26	0	62	0	6	63	58	13	4	61	3	0	0	11	13	2
			X	6	100	0	0	83	67	33	0	0	83	0	67	17		0	0	83	33	0	100	0	0	100	50	0	0	50	0	0	0	33	33	0
	55	Practical use of ultra-small bio-sensors for use in medical and other applications, based on the utilization of biochemical reactions.	1	113	7	24	69	68	40	51	9	0	56	2	84	10		0	6	75	37	4	60	0	15	56	51	19	14	43	9	0	2	10	8	1
			2	105	9	16	75	68	38	60	3	0	52	2	89	4		0	2	87	31	2	73	0	6	67	55	8	10	50	5	0	0	12	6	1
			X	9	100	0	0	78	56	44	0	0	56	0	67	0		0	11	78	22	0	89	0	0	89	56	0	0	44	11	0	0	22	0	0
	56	Development of high-speed image recognition sensors capable of responding in real time to, for example, a baseball thrown by a pitcher.	1	174	14	24	62	54	23	45	32	0	71	4	51	14		0	6	65	17	2	61	0	17	47	42	26	1	32	0	1	1	5	5	2
			2	167	11	22	67	54	19	59	23	0	77	2	57	6		0	4	74	11	1	72	0	10	56	46	20	0	29	0	1	1	4	1	2
			X	19	100	0	0	69	44	44	11	0	89	5	58	0		0	0	84	21	0	79	0	0	68	37	21	0	42	0	0	0	5	0	5
	57	Practical use of various sensors (smell, taste, tactile) with levels of sensitivity comparable to those of humans.	1	158	10	20	70	62	34	48	18	0	61	10	78	13		4	10	61	33	3	53	0	20	52	47	16	13	39	1	1	1	5	12	1
			2	152	7	18	75	59	25	61	14	0	59	8	84	5		1	7	72	30	1	63	0	14	63	49	5	7	35	0	1	1	3	9	1
			X	10	100	0	0	75	50	50	0	0	50	10	80	0		0	0	80	10	0	100	0	0	70	40	0	10	20	0	0	0	10	0	0
	58	Practical use of biosensors capable of identifying single molecule.	1	96	9	19	72	58	28	49	23	0	60	8	50	32		7	16	65	33	3	34	0	20	57	36	22	9	41	1	0	2	1	2	2
			2	94	6	17	77	56	20	62	18	0	61	3	53	36		3	13	76	32	1	45	0	14	69	40	11	7	43	1	0	0	0	2	2
			X	6	100	0	0	75	50	50	0	0	83	0	33	17		0	17	50	0	0	50	0	17	83	17	0	0	50	0	0	0	0	0	0
	59	Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm.	1	96	13	21	67	74	53	37	10	0	42	1	78	45		0	8	78	34	5	52	0	14	51	39	29	3	54	3	0	1	18	18	1
			2	90	9	19	72	77	57	37	6	0	43	0	78	40		0	6	86	38	3	53	0	8	57	40	21	2	63	3	0	0	17	19	1
			X	8	100	0	0	100	100	0	0	0	88	0	88	25		0	0	88	63	0	75	0	0	88	50	25	0	63	0	0	0	25	13	0
	60	Practical use of multiplexed sensing methods which measure weight distribution from multiple points, for materials with self-diagnostic capabilities.	1	70	11	23	66	58	26	54	20	0	80	10	39	13		0	9	54	20	0	43	0	30	54	44	26	0	37	3	0	1	6	4	1
			2	64	11	17	72	57	21	62	16	0	83	6	31	6		2	3	67	14	0	58	0	20	63	50	19	0	33	2	2	0	3	2	2
			X	7	100	0	0	61	29	57	14	0	71	0	43	29		0	0	57	14	0	71	0	14	71	57	0	0	43	0	0	0	0	0	0

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Expected effect Resolution of global problems	Expected effect People's needs	Expected effect Expansion of intellectual resources	Forecasted realization time (2001, 2006, 2011, 2016, 2021, 2026)	Will not be realized (%)	Do not know (%)	Leading countries (%) USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%) Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%) Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Molecular, sensor and bioelectronics	61	Practical use of biometric sensors which utilize retinal patterns or fingerprint patterns for individual verification.	1	147	8	24	68	63	33	56	10	1	73	1	67	7		1	7	69	20	2	54	0	18	44	41	18	10	28	16	1	1	44	16	1
			2	143	6	22	73	64	31	64	6	0	77	0	75	1		1	5	79	16	0	62	0	11	54	43	10	8	24	16	1	0	43	20	1
			X	8	100	0	0	75	50	50	0	0	88	0	63	0		0	0	88	13	0	88	0	0	63	25	0	13	0	0	0	0	75	50	0
	62	Practical use of biosensors utilizing antibodies.	1	67	12	24	64	68	42	48	9	2	42	6	78	16		0	3	75	34	3	52	0	12	49	34	16	25	31	4	0	9	18	4	0
			2	63	8	24	68	65	33	60	6	0	43	6	92	3		0	0	81	35	2	63	0	8	60	43	8	22	33	2	0	8	27	3	0
			X	5	100	0	0	80	60	40	0	0	60	0	80	0		0	0	60	60	0	60	0	0	60	40	0	0	20	0	0	0	0	0	0
	63	Practical use of diagnostics and treatment of medical conditions using devices implanted inside the human body.	1	85	8	8	84	68	44	45	9	2	40	0	92	9		0	13	68	25	1	33	0	25	41	46	18	18	39	13	0	1	28	19	0
			2	80	4	6	90	69	41	53	5	1	39	0	95	3		0	10	76	26	1	35	0	16	48	56	16	10	49	5	0	0	40	24	0
			X	3	100	0	0	83	67	33	0	0	67	0	100	0		0	33	67	67	0	67	0	0	67	33	0	0	33	0	0	0	0	0	0
	64	Development of DNA analysis system capable of processing 10,000 bases in a single day.	1	42	7	19	74	65	36	54	8	3	48	12	55	57		0	10	88	55	2	48	0	5	50	29	31	29	43	0	0	7	14	26	0
			2	41	7	5	88	63	29	66	5	0	51	5	49	46		0	5	90	44	0	59	0	0	66	39	15	20	44	0	0	2	12	37	0
			X	3	100	0	0	83	67	33	0	0	100	0	0	33		0	0	67	67	0	67	0	0	100	33	0	0	33	0	0	0	0	33	0
	65	Development of sensors that could be substituted for human sensation, capable of directly stimulating nerves.	1	59	8	20	71	54	26	40	30	4	44	3	83	17		3	14	66	25	3	32	0	24	49	41	20	7	36	3	0	3	22	27	0
			2	61	5	13	82	55	23	52	25	0	39	3	82	10		3	10	75	21	3	39	0	16	62	48	11	3	43	5	0	2	33	43	0
			X	3	100	0	0	100	100	0	0	0	67	0	100	0		0	0	67	33	0	67	0	0	67	33	0	0	33	0	0	0	0	0	0
Storage and display electronics	66	Development of a strage system in which one atom or molecule corresponds to 1 bit.	1	235	17	26	57	72	51	35	12	2	83	7	12	46		12	15	69	26	3	50	0	17	57	36	31	1	50	0	1	1	3	4	2
			2	210	15	25	60	76	57	34	8	1	88	5	9	47		12	12	76	24	1	59	0	13	67	35	25	0	60	0	0	0	1	2	1
			X	32	100	0	0	86	72	28	0	0	97	0	16	59		6	3	94	19	3	69	0	0	78	47	31	0	59	0	0	0	6	6	3
	67	Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch.	1	199	17	22	61	78	58	38	3	1	91	4	18	13		7	15	76	12	1	71	0	7	49	48	26	1	37	1	1	1	4	6	2
			2	180	17	24	59	83	67	32	1	1	94	4	17	10		5	9	82	8	0	78	0	2	56	49	22	0	41	0	0	0	2	5	1
			X	30	100	0	0	92	83	17	0	0	100	3	27	10		0	0	90	7	0	83	0	0	70	50	33	0	60	0	0	0	7	10	0
	68	Practical use of optical memories with recording density of 10^{11} b/cm^2.	1	206	18	32	50	77	57	37	6	0	87	7	24	16		7	14	68	17	0	75	0	5	53	48	25	1	43	1	0	0	5	7	1
			2	184	16	33	51	82	66	32	2	0	92	4	26	10		4	13	71	13	0	83	0	3	59	48	21	0	47	0	0	0	2	4	1
			X	30	100	0	0	97	93	7	0	0	97	7	27	20		0	7	77	10	0	93	0	0	63	73	13	0	57	0	0	0	10	10	0
	69	Practical use of high-efficiency light energy converters utilizing organic materials.	1	159	13	21	66	65	36	53	11	1	65	54	19	13		11	13	62	30	2	45	0	23	53	39	18	5	42	2	1	6	1	3	1
			2	146	9	18	73	66	36	57	7	0	71	54	16	9		9	12	65	24	1	55	0	16	66	40	16	3	43	1	0	4	0	1	1
			X	13	100	0	0	79	62	31	8	0	77	38	15	8		8	0	77	46	0	62	0	0	92	54	15	0	46	8	0	8	0	0	8
	70	Practical use of small read/write optical filing systems with at least 1 tera bite capacity per system.	1	193	17	33	51	72	48	45	7	0	91	5	26	11		1	9	73	12	1	79	0	5	50	49	25	1	34	3	1	1	9	7	1
			2	177	15	33	53	78	58	38	4	0	93	3	28	5		1	6	72	8	0	85	0	3	57	55	17	0	34	2	2	0	7	6	1
			X	26	100	0	0	91	85	12	4	0	96	4	23	15		4	0	65	19	0	88	0	0	69	65	8	0	46	4	0	0	15	12	4

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic development	Expected effect: Resolution of global problems	Expected effect: People's needs	Expected effect: Expansion of intellectual resources	Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%): USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Measures the government should adopt (%): Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Potential problems (%): Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Storage and display electronics	71	Development of super-large-scale flat panel displays (covering an entire wall, for instance) utilizing organic materials.	1	226	16	19	65	61	33	48	14	4	81	6	40	4		10	12	50	17	0	69	1	13	49	49	18	1	34	2	0	5	3	10	1
			2	197	14	17	69	62	31	57	10	2	90	2	47	4		7	9	52	13	0	76	1	12	60	55	15	1	39	1	0	4	3	9	1
			X	27	100	0	0	80	59	41	0	0	89	0	41	0		4	0	56	30	0	100	4	0	78	74	15	0	63	0	0	0	0	22	4
	72	Widespread use in homes of large flat-screen televisions with diagonal screen size on the order of 3 m.	1	247	14	23	63	49	21	42	30	7	72	4	46	3		17	9	39	7	0	83	0	6	39	39	13	0	23	4	2	4	4	12	1
			2	226	13	21	66	51	20	47	29	4	76	3	59	2		16	6	37	6	0	88	1	4	50	47	10	0	29	3	3	4	5	12	1
			X	29	100	0	0	74	52	41	7	0	90	0	55	0		7	3	41	14	0	97	0	0	76	59	21	0	41	3	0	3	0	17	3
	73	Development of roll-up type displays.	1	207	17	18	64	53	26	39	29	5	75	6	39	5		7	14	40	8	0	64	0	19	45	43	16	0	28	1	1	3	3	8	1
			2	189	14	21	66	54	23	50	24	3	77	2	53	3		6	11	39	5	0	74	0	13	60	53	8	0	31	1	1	2	2	6	1
			X	26	100	0	0	69	38	62	0	0	96	8	54	4		0	0	50	12	0	96	0	4	85	69	8	0	42	0	0	0	8	15	4
	74	Practical use of miniature file devices that fit inside a pair of glasses and make it possible, for example, to watch a movie anywhere and at any time.	1	213	13	21	66	45	15	44	35	6	76	2	49	4		13	10	56	6	0	62	0	18	43	42	15	0	22	4	2	1	15	23	1
			2	193	10	22	68	46	12	52	31	5	82	2	55	2		12	6	62	4	0	73	0	13	54	53	11	0	22	2	1	1	18	27	1
			X	19	100	0	0	65	39	44	17	0	95	5	58	11		0	0	84	11	0	95	0	0	84	58	11	0	47	5	0	0	32	42	5



(Note) See page 7 for the interpretation of the graphs.

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