1. Survey results in "Materials and processing"

1.1. Trends in noteworthy domains

In the fifth technology forecast survey we identified four domains expected to draw attention in this field: 1) Structural control and computer simulation at the atomic/molecular level; 2) interface control and function manifestation; 3) state-of-the-art materials and compounding and hybrid design; and 4) chemical processes. For this survey we have identified the following four items.

1) Precision synthesis and structural control through the manipulation of atoms and molecules

2) Incorporation of high-level computer science into materials and processing design

3) Elucidation of biofunctions and their incorporation into the development of highly functional materials and processes

4) Development of materials and processes connected with global problems

Since precision synthesis at the atomic/molecular level has at last come into a realistic field of vision, we have positioned it as the most important theme. And accompanying steady advances in computer science are growing expectations about the simulation of material functions, and elucidation of catalytic action, biofunctions and solid state functions and operations. So in recognition of their importance, we have separated them into two distinct items. At the same time, advances have been seen in the elucidation of biofunctions, so the biomimetic approach has become a concrete theme. We have taken up these as noteworthy domains with the understanding that the materials and processing field has a vital role to play in the increasingly urgent issues of the global environment, resources and energy.

1.1.1. Precision synthesis and structural control through the manipulation of atoms and molecules

The concept of controlling the structure of materials at the atomic/molecular level has been rapidly taking shape since it was highlighted as the most important issue in advanced materials in the 21st century in a briefing at the CHEMRAWN VI world conference of the International Union of Pure and Applied Chemistry (IUPAC) at Tokyo in 1987, and has been taken up in recent years as the basis of numerous national projects.

Especially since silicon devices are not able to increase their degree of integration above present levels because of optical wave length limits, a breakthrough in a new and different concept became necessary. From this, attempts were started on the development of new devices operated at the atomic/molecular level. One is the quantum functional device that uses the quantum effect of the super lattice, started as a ten-year project by the Ministry of International Trade and Industry (MITI) in 1991. The following year saw the start of the atom technology project, aimed at the ultimate device. This was an attempt to develop ultimate_electronic devices through the development of technology for self-organization and reciprocal control that manipulates single atoms and single molecules and creates nano-scale structures collectively while recognizing chemical species. These days we are now able to manipulate this kind of atom/molecule through advances in tunneling microscopes, and the possibility of molecular devices is growing rapidly. Topics 75, 76 and 81 tackle this kind of development.

Research into precision high polymer began in 1994, and from 1996 an industrial and academic research structure began to take shape as a major pioneering research project into highly functional materials by MITI. This research is aimed at developing new high-performance polymer material through the rigid control of the primary structure of polymer at the atomic/molecular level, and the higher order structure, and through this, drawing out new functions. Topics 29–32 deal with precision polymer. Achieving the precision control of high polymer structures would boost the possibility of high-polymer superconductors and organic ferromagnetic substances, and with this in mind, we devised topics 14, 15 and 18. Moreover, if the supra-molecular structure of high polymers can be controlled, it will open the door to the subtle functions seen in organisms, such as self-organization and physiological activity. Precision control at the atomic/molecular level is also an important theme in ceramics and metals, so in this light, we set topics 40, 45, 46 and 60 dealing with the control of mezo- and nano-structures. Elucidation at the atomic and molecular level is also necessary for the development of post-silicon devices, such as diamond and cubic boron nitride devices. As for precision control of composite materials, we devised topics 90, 92 and 94 dealing with control of nano-structure. Topics 98–103 also deal with precision control. In synthetic chemistry, advances are being made in the elucidation of reaction points at the molecular level, and coupled with the elucidation of the nature of catalysts, this is bringing the atomic/molecular control of highly selective solid catalysts, molecular catalysts, etc. into the realm of possibility. Topics 24–28 were set against such a backdrop.

1.1.2. Incorporation of high-level computer science into materials and processing design

Advances in computer science make various kinds of simulation possible. By calculating the first-principle electron condition, we can elucidate the behavior and function of atoms and molecules, determine stable structures in atomic and molecular groups, and understand the characteristics of electrons. This enables us to understand the behavior of atoms and molecules in dynamic phenomena such as crystallization and chemical reaction through molecular dynamics simulation and Monte Carlo simulation. The powerful computer systems required for such large figure calculations are being realized, but we need more efficient computer methods that go beyond the Car-Parinello method and parallel computing technology. This theme is raised in topics 73 and 97.

Computer technology has come to play a vital role in the development of various materials, chemical processes and biotechnology. In material design, advances have been seen in the finite element method and various kinds of computer simulation. Progress has also been seen in the compilation of a S&T materials database, and in computer-aided material design and process design support systems. Topics 95 and 96 are related to this theme. Advancement in computer chemistry has made the design of molecular structures and the low molecular substances that act on those molecules possible, rationalizing to a significant degree the screening of drugs and agricultural chemicals. Combinatorial chemistry is a new technology that has grown around peptide synthesizing technology using the solid-phase method, and is an efficient screening system (high through-put screening system: HTS) in which tens to tens of thousands of compounds are synthesized at once through the combining of various blocks of chemical synthesizing processes under the principle of permutations and combinations. Moreover, it is being automated through robot technology, facilitating the development of a drug producing system with a high processing capability.

1.1.3. Elucidation of biofunctions and their incorporation into the development of highly functional materials and processes

Synthetic chemistry has delivered to the marketplace a diverse range of synthetic compounds that do not appear in nature, such as various kinds of plastics, synthetic fibers, and synthetic rubber. These synthetic products are still very much in the infant stages compared to the subtle mechanisms of living bodies. Conversely though, by learning the mechanisms of living organisms we may develop highly functional materials and synthesizing processes. But our insufficient understanding of biofunctions has made the realization of such advanced synthesizing technology extremely difficult. Recently though there have been major advances in the biomimetic approach, and we are beginning to see an opening for the skilled incorporation of the subtle mechanisms of living organisms. Expectations in this area can be seen in topics in the biotechnology domain, including “01: Muscle-like material,” “02: Artificial organs,” “03: Protein synthesizing,” “04: Materials that promote development of biological tissues,” “05: Missile drugs” and “06: Membranes similar to those in living bodies;” in the organic polymer domain, including “21: Self-healing polymers” and “22: Control of protein aggregates;” in ceramics, including “40: Self-organizing materials” and “42: Self-repairing turbines;” and in electronics and composite materials, including “71: Materials that incorporate sensor functions,” “72: Nerve function of transmitting information,” “91: Materials with self-diagnosis and self-repairing functions” and “92: Organic hybrid materials.” Meanwhile, human genome analysis projects have been moving ahead, and with this, information about human genes is beginning to accumulate rapidly, enabling researchers to steadily identify genes associated with specific diseases. Technology to elucidate the functions of genes that have to date been unknown has also been developed. So if researchers can specify the genes to be targeted by drugs, they will be able to highlight those genes and develop new bioassay systems for them.

1.1.4. Development of materials and processes connected with global problems

It has already been a quarter century since the Rome Club pointed out in 1972 the finite nature of the earth, and warned that the population explosion and the economic expansion of developed countries could plunge the world into a serious crisis. Unable to put the brakes on the exploding population and the massive expansion of economic consumption, we have seen over these past 25 years the irreversible emergence of various global-level problems. To tackle resource, energy and environmental issues, a range of chemical processes is necessary, as are various kinds of high-performance and highly functional materials. Put in another way, resolving various global problems is highly dependent on materials and chemical processes. There is growing support for mandatory recycling of resources to make their use more effective and ease some of the load on the environment, but discarding used goods and materials has always been the cheaper option. Recovering resources seeks to reduce the growing entropy from the laws of thermodynamics, so it requires more energy, and naturally it costs more. That is, we must understand that from an economics viewpoint, recycling generates a negative added value.

In the materials and processing technology forecasts, the development of energy materials has traditionally been one of the major topics, but topics dealing with ways of resolving various global problems have increased considerably. This has gone hand in hand with a much greater recognition of the importance of this theme compared to other themes. As well as topics 84 and 85 dealing with solar cells, we set numerous topics that covered energy, such as “107: Generation of hydrogen through water decomposition by sunlight” and “59: Hydrogen cars,” and global environmental issues, such as “33: Biodegradable plastics,” “34: Plastic recycling,” “35: Waste disposal,” “36: Biomass,” “108: Carbon dioxide fixation” and “109: Desert afforestation.” This theme accounted for 10% of all topics.

One point that has to be examined in relation to global environmental problems is the biodegradability of synthetic polymers. Various kinds of synthetic polymers, especially the plastics we use today, are produced as a part of the petrochemical processes, so they are not biodegradable and are therefore causing a major problem in the global environment. The world’s oil reserves are finite, so it is important to develop processes by which environment-friendly general-purpose polymers can be produced from non-oil resources. The general line of thinking is that precision polymerization technology developed through a biomimetic route would be useful for this. Moreover, we are reaching the stage where we can develop new microorganisms and enzymes that can break down synthetic compounds that do not exist in the natural world through technology that accelerates the evolutionary process. The development of chemical processes that generate less waste and use less energy in industrial production is attainable, and it is believed that we will begin to see advances in such evolutionary molecular engineering technology from now on.

In conclusion, in many cases the forecasted realization times for topics in this survey are five years or more later than those for corresponding topics in the fifth survey. This signifies that as research becomes more tangible, respondents are coming to the understanding that realization of the various topics in the domains highlighted above is much more difficult than originally thought, and also indicates just how hard reading the future of developmental research in materials and processing technology can be. The sudden realization of a ceramics superconductor in the previous survey is a good example of this. Technological development, however, forges its own path, and by following the locus formed by a series of developments, we should be able to make a more accurate forecast of realization times. In the light of the above trends, the topics in the highlighted domains will be realized between 2010 and 2030. These technologies include advanced materials, molecular devices, biotechnology and chemical processes revolving around developments at the atomic/molecular level, and technological developments connected with new energy and global environmental issues. It is forecast that we will see almost a simultaneous blossoming of these technological innovations, peaking around 2030. But we are approaching a fairly critical period, and there is some concern about whether these technologies will be realized in time to resolve the various global issues we are facing.

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1.2. 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 1.2-1 Forecast Topic Framework for Materials and Processing Field

Objective \ Domain	Biological	Organic and high polymer	Ceramic	Metal	Semiconductor and electronics	Composite	Other
High performance		11 12	37 38 39	51 52		88 89 90	
Functionality	01 02 03 04 05 06	13 14 15 16 17 18 19 20 21 22	40 41 42 43 44	53 54	61 62 63 64 65 66 67 68 69 70 71 72	91 92	
Analysis, measurement and simulation	07	23	45	55	73 74 75 76		95 96 97 98 99 100 101 102 103 104
Chemical processes	08	24 25 26 27 28 29 30 31 32	46 47 48	56 57 58	77 78 79 80 81 82 83	93 94	105 106
Global-scale problems, environment, resources and energy	09	33 34 35 36		59	84 85		107 108 109
Processing methods, devices and systems	10		49 50	60	86 87		

* Figures appearing in the table represent topic numbers.

1.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 58.1 for topics in the materials and processing field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Notably, as many as 8 topic featuring in the top 20 related to the environment.

Table 1.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
84 Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	91	2016
85 Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	91	2011
34 Establishment and practical use of plastic recycling technology.	91	2007
62 Development of memory capacity of 1 terabit per chip.	86	2013
107 Practical use of processes for water decomposition by the sunlight.	85	2017
108 Practical use of carbon dioxide fixation technology necessary for protecting global environments.	84	2016
44 Development of superconductive materials with a transition temperature around room temperature.	83	2020

Topic	Degree of importance index	Forecasted realization time (year)
20 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82	2011
05 Widespread use of signal-responsive missile drugs capable of efficiently reaching targeted parts such as tumor cells.	81	2011
33 Biodegradable plastics will account for 10% of all plastics.	76	2009
35 Practical use of composite systems capable of garbage disposal based on the high-temperature methane fermentation technology and of waste combustion disposal.	76	2008
82 Development of innovative single crystal silicon manufacturing technology.	75	2011
41 Construction of large-scale structures (bridges, high-rise buildings, etc.) using concrete (cement and fibers, steel bars, etc.) whose strength deterioration is predictable.	75	2009
49 Widespread use of industrial electric machines which employ superconductive materials having a critical temperature of liquid nitrogen (77 K) or more.	72	2014
59 Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys exceeds 10% of the total automobile production.	70	2017
25 Development of selective catalytic cracking technology for naphtha.	70	2010
65 Practical use of semiconductor UV lasers.	66	2010
55 Development of diagnostic technologies, which enable in-situ estimation of remaining life of metallic materials structures and components depending on service conditions, by non-destructive inspection for fatigue.	65	2010
72 Elucidation of the information transmission structure of sensory nerves.	65	2015
22 Development of technology which create the desired functions through the complete control of two- and three-dimensional structures of protein complex.	64	2018

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

1.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

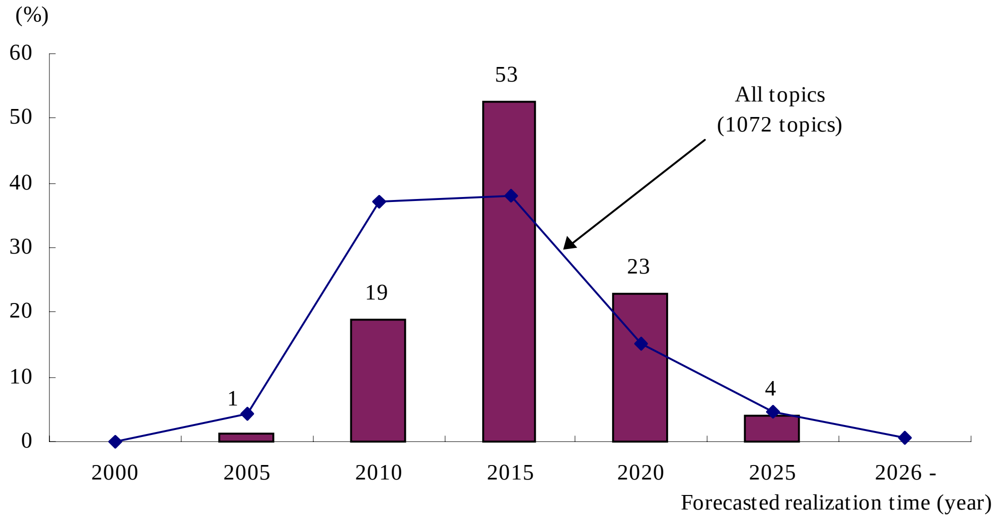


Fig. 1.4-1 Trends in Forecasted Realization Times

With more than half the topics in the materials and processing field forecasted to be realized between 2011 and 2015 and none before 2005 or after 2021, the distribution of forecasted realization times exhibited a sharper peak than the general trend covering all the topics included in the latest survey. The earliest forecasted realization time was 2007, which was given to the following 3 topics: 07. Practical use of non-invasive monitoring of blood components, 26. Development of mass-synthesizing technology for fullerene carbon compounds and 34. Establishment and practical use of plastic recycling technology. The latest forecasted realization time was 2020, which was given to the following two topics: 44. Development of room temperature superconductors and 106. Development of technology to produce materials of a condition in which single-lattice bonding is fused ($sp^{2.5}$, etc.).

1.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by 72.6% of the respondents, the U.S. ranked No. 1 in the materials and processing field as a whole, followed by Japan (63.7%) and the EU (24.9%), with virtually no other country or region chosen.

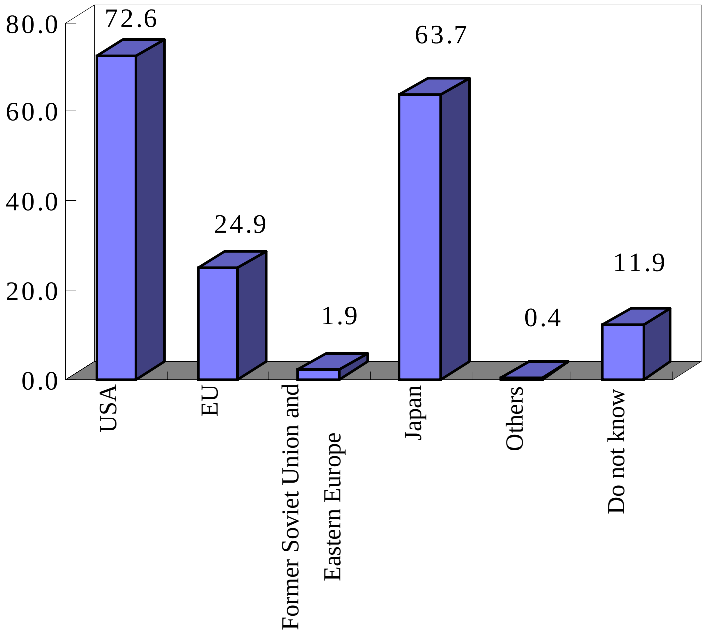


Fig. 1.5-1 Current Leading Countries etc. (%)

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

Of the 109 topics included in the latest survey, 51 (47%) were identical to the previous survey, 20 (18%) were modified, and 38 (35%) 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.

Degree of importance index scores rose for 11 topics, fell for 38 topics and remained the same for 2 topics. 20. Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter saw the greatest jump in the degree of importance index score, up 19 points, while 23. Practical use of devices that enable real-time X-ray structural analysis of supramolecular-biopolymer crystals saw the greatest drop, down 32 points. Incidentally, Topic 23 belonged to the particles field in the 5th Survey, so, among the topics already included in the materials and processing field in the previous survey, the fall was greatest with 01. Development of artificial muscle-like material that responds to stimuli reversibly (15 points).

Forecasted realization times were all pushed back from the 5th Survey, except for 2 topics , one brought forward and the other remaining unchanged. In particular, 67. Development of microwave cathode elements able to operate at 7 A/cm^2 for a life-time of one year saw its forecasted realization time pushed back 11 years.

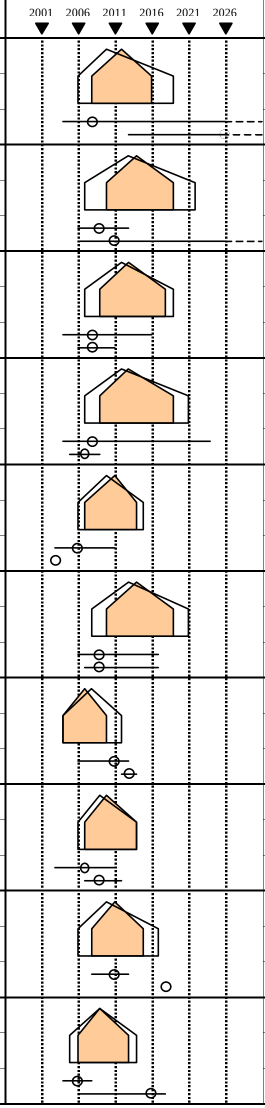
Table 1.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
01 Development of artificial muscle-like material that responds to stimuli reversibly.	51/2012	66/2014
02 Practical use of hybrid artificial organs in which cells are immobilized on materials such as high polymer plastics.	64/2014	71/2007
04 Practical use of artificial materials that promote development of biological tissues and organogenesis	60/2013	66/2006
06 Practical use of membranes that are similar to those in living bodies, and which have an active transport function and receptors for signals.	53/2014	55/2009
07 Practical use of non-invasive monitoring of blood components.	53/2007	53/2004
10 Practical use of supersmall-sized medical accelerators with an energy of 200 MeV and a diameter of less than 5 m.	53/2009	57/2003
14 Development of organic superconductor having a transition temperature higher than 77 K.	58/2018	70/2009
16 Practical use of high-polymer materials offering a coloring and luminescence when supplied with energy and sustaining for at least 3,000 hours.	60/2009	51/2005
17 Practical use of organic materials with the photo-sensitivity and resolution of silver chloride.	53/2012	58/2007
19 Practical use of high-polymer ferroelectrics whose piezoelectric constant is as high as PZT.	47/2012	48/2007
20 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82/2011	63/2008
23 Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	49/2011	81/2005
35 Practical use of composite systems capable of garbage disposal based on the high-temperature methane fermentation technology and of waste combustion disposal.	76/2008	66/2001
37 Development of Si_3N_4 sintered material having robustness at least equivalent to cast iron at room temperatures.	53/2009	57/2007
42 Development of ceramic materials for high-temperature gas turbines (1,400°C or higher), which have a self-repairing ability for damage (e.g., preventing cracks, corrosion, etc.) in a combustion atmosphere.	57/2016	63/2016
44 Development of superconductive materials with a transition temperature around room temperature.	83/2020	92/2017
45 Practical use of non-destructive testing technology which is detectable minute cracks of less than 10 μm in ceramics.	55/2008	63/2003
46 Development of a technique enabling solid-phase sintering process using ultra fine particles at temperatures around 800°C to produce SiC-based or Si_3N_4 -based heat-resistant ceramics.	48/2010	52/2004
47 Practical use of a technique producing cBN (cubic boron nitride) tools using vapour deposition coating.	48/2008	52/2001
48 Development of technology for manufacturing diamond fiber.	48/2013	51/2009
49 Widespread use of industrial electric machines which employ superconductive materials having a critical temperature of liquid nitrogen (77 K) or more.	72/2014	83/2008
50 Practical use of a plastic forming technology for processing of structural ceramics (e.g., alumna, zirconia, silicon nitride, and silicon carbide).	53/2013	59/2005
51 Widespread use of super-heat-resistant intermetallic compounds for mechanical components such as aircraft, engines, turbines and etc..	61/2012	59/2005
53 Development of magnetic materials of which maximum energy product exceeds 70 Mega-Gauss Oersted (MGSOe). (Current maximum value of Fe-Nd-B alloy : 64 MGSOe)	54/2009	62/2002

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
54 Development of bulky magnetic materials of which magnetic saturation density exceed 3 Tesla. (Current maximum value: 2.4 Tesla.)	51/2012	61/2003
55 Development of diagnostic technologies, which enable in-situ estimation of remaining life of metallic materials structures and components depending on service conditions, by non-destructive inspection for fatigue.	65/2010	75/2004
56 Development of economical manufacturing process for ultra-high purity steel with 6-N (99.9999%).	48/2013	46/2006
57 Development of new titanium refining process lowering the manufacturing cost on a par with that of aluminum.	55/2015	63/2009
59 Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys exceeds 10% of the total automobile production.	70/2017	64/2011
60 Practical use of processing technology for super-smooth-surface finished metal with the level of nano-meter surface roughness. (Current limit : 0.1 μ).	49/2010	55/2003
61 Development of high performance switching elements made of nonlinear optical material of the third order.	63/2010	61/2003
67 Development of microwave cathode elements able to operate at 7 A/cm^2 for a life-time of one year.	53/2016	46/2005
70 Development of photo-refractive material that can change its photo-refractive index by more than 0.1.	53/2013	60/2005
71 Development of intelligent materials which incorporate sensor functions, programming functions and effector functions.	59/2014	63/2010
73 Practical use of computer simulation technology for growing thin films according to the first principle computation.	50/2008	59/2004
75 Development of technology for controlling the structures and properties of solid interfaces at the atomic level.	62/2011	75/2005
77 Development of a technique for manufacturing of p-n junctions of diamond.	53/2010	56/2005
78 Development of a heteroepitaxial technology for growing any semiconductor material on silicon substrate.	62/2010	67/2004
79 Development of the technology to fabricate large-area (inch order) compound semiconductor single crystal film on glass substrates.	58/2011	60/2005
80 Development of heteroepitaxial technology for growing large-area (inch order) diamond thin films on hetero-substrates.	55/2011	61/2004
81 Development of technology for embedding impurities, and repairing defective crystallized silicon surfaces by STM-associated technology.	54/2008	59/2003
84 Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	91/2016	91/2010
85 Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	91/2011	86/2004
86 Development of X-ray free electron lasers with a wave-length of a few dozen Å.	52/2012	60/2004
89 Practical use of oxidation-resistant carbonfiber reinforced carbon composite materials.	55/2010	58/2004
93 Practical use of a bonding technology of ceramics and metals which resists to the repetition of temperature change over 500°C.(So far less than 400°C)	57/2010	66/2003
95 Practical use of computer-aided material design of solid catalysts with specified composition, organization, and physical properties.	52/2013	66/2008
96 Development of computer simulation technology enabling the precise prediction of structures and physical properties in an isothermal equilibrium state, provided element compositions are given in materials made more than one element.	55/2014	67/2011

Topic	Degree of importance index/forecasted realization time (year)	
	6th survey	5th survey
102 Practical use of online processing technology systems capable of forecasting and controlling size and shape with an accuracy in the order of 10Å.	61/2012	60/2004
107 Practical use of processes for water decomposition by the sunlight.	85/2017	80/2009
108 Practical use of carbon dioxide fixation technology necessary for protecting global environments.	84/2016	87/2008

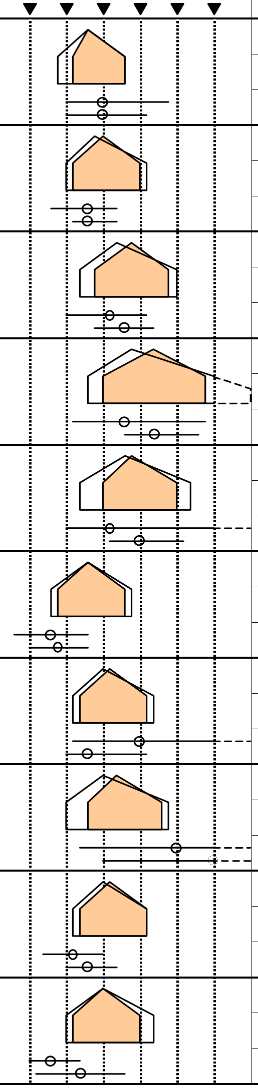
Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.



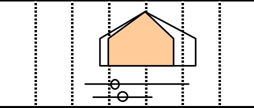
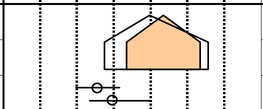
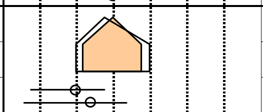
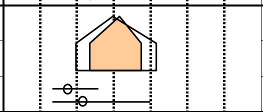
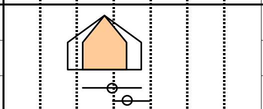
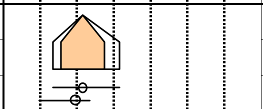
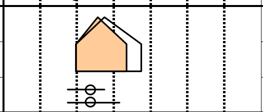
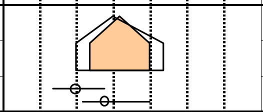
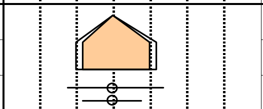
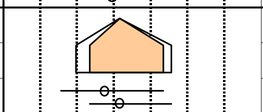
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%): High	Degree of expertise (%): Medium	Degree of expertise (%): Low	Importance (index, %): Index	Importance: High	Importance: Medium	Importance: Low	Importance: Unnecessary	Expected effect (%): Socioeconomic 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
Biological	1	Development of artificial muscle-like material that responds to stimuli reversibly.	1	171	2	24	74	56	20	64	16	0	34	6	88	16		3	8	57	14	2	40	0	29	53	48	17	6	46	1	1	3	10	20	5
			2	146	2	21	77	51	11	72	17	0	28	1	92	9		1	5	66	6	1	44	0	25	62	53	10	6	55	1	1	3	14	35	3
			X	3	100	0	0	33	0	33	67	0	33	0	100	0		0	33	67	33	0	100	0	0	33	67	0	33	67	0	33	0	0	0	0
	2	Practical use of hybrid artificial organs in which cells are immobilized on materials such as high polymer plastics.	1	140	4	16	80	66	39	50	10	1	24	3	96	7		3	7	71	18	0	39	0	21	53	50	15	13	41	13	0	4	19	48	3
			2	118	3	14	83	64	33	55	12	0	19	3	97	2		0	8	78	9	0	41	0	15	66	51	8	10	47	7	0	3	19	67	2
			X	4	100	0	0	69	50	25	25	0	25	0	100	0		0	0	100	25	0	75	0	0	50	75	25	0	50	0	0	0	0	50	0
	3	Development of biomimetic systems that synthesize proteins using natural and non-natural amino acids.	1	104	8	19	73	52	19	52	26	3	42	42	38	26		2	5	65	26	2	36	0	21	46	33	19	24	35	4	0	30	9	21	2
			2	89	4	19	76	51	14	64	23	0	42	40	42	16		0	7	74	18	1	42	0	20	60	35	13	22	40	2	0	40	8	19	0
			X	4	100	0	0	50	0	100	0	0	0	25	100	0		0	0	100	25	0	50	0	0	100	50	0	0	0	0	0	50	0	0	0
	4	Practical use of artificial materials that promote development of biological tissues and organogenesis	1	128	4	21	75	61	31	53	14	2	23	2	88	9		3	9	61	15	1	33	0	24	44	46	21	13	38	5	0	6	12	29	4
			2	115	3	15	83	60	26	63	12	0	23	3	94	4		3	6	70	9	0	37	0	20	51	50	14	10	43	3	0	3	20	44	2
			X	3	100	0	0	100	100	0	0	0	100	33	100	0		0	0	100	33	0	67	0	0	100	100	0	0	100	0	0	33	33	100	0
	5	Widespread use of signal-responsive missile drugs capable of efficiently reaching targeted parts such as tumor cells.	1	136	3	18	79	77	57	39	2	2	27	1	96	6		0	4	75	24	0	49	0	14	38	49	19	21	42	13	1	3	13	14	4
			2	116	1	15	84	81	63	34	3	0	27	0	94	2		0	3	81	16	0	59	0	10	39	63	10	16	42	9	1	2	22	18	3
			X	1	100	0	0	100	100	0	0	0	0	0	100	0		0	0	100	100	0	100	0	0	100	100	0	0	100	0	0	0	0	0	0
	6	Practical use of membranes that are similar to those in living bodies, and which have an active transport function and receptors for signals.	1	99	6	15	79	52	20	53	24	3	35	27	74	10		3	8	61	21	0	46	0	18	53	39	24	7	39	4	0	3	10	9	6
			2	82	4	16	80	53	18	57	25	0	32	23	79	7		2	4	68	16	0	61	0	12	62	44	15	4	39	1	0	2	16	13	2
			X	3	100	0	0	83	67	33	0	0	0	67	33	0		0	0	100	33	0	100	0	0	67	67	33	0	33	0	0	0	0	0	0
	7	Practical use of non-invasive monitoring of blood components.	1	60	8	22	70	55	23	55	18	3	28	3	92	5		2	12	60	17	0	43	0	23	32	48	17	17	30	10	0	0	17	12	5
			2	49	4	22	73	53	16	65	16	2	20	4	96	6		0	8	78	14	0	53	0	10	33	65	4	12	43	8	0	0	24	10	2
			X	2	100	0	0	75	50	50	0	0	50	0	100	0		0	0	100	0	0	0	0	0	50	100	0	0	50	0	0	0	0	0	0
	8	Practical use of highly selective oxidation processes using biomimetic catalysts (modeled after enzymes in biochemical reactions)	1	116	6	31	63	56	21	61	16	2	48	63	15	18		0	8	53	28	2	45	1	21	51	34	20	6	41	1	1	16	3	3	5
			2	92	3	33	64	55	16	72	12	0	49	71	9	14		0	4	71	22	1	62	0	14	60	39	13	3	45	0	0	22	3	1	4
			X	3	100	0	0	50	0	100	0	0	100	67	0	33		0	0	100	33	33	100	0	0	100	0	33	0	100	0	0	0	0	0	0
	9	Practical use of biodesulfurization technology.	1	110	2	24	75	57	29	48	18	5	25	88	13	4		3	8	43	16	2	45	0	25	30	37	18	13	43	7	2	32	5	1	4
			2	83	1	18	81	61	30	54	14	1	19	93	6	2		0	5	52	8	1	63	0	20	39	43	8	8	59	4	1	40	4	1	0
			X	1	100	0	0	100	100	0	0	0	0	100	0	100		0	0	100	0	0	100	0	0	100	0	100	0	100	0	0	0	0	0	0
	10	Practical use of supersmall-sized medical accelerators with an energy of 200 MeV and a diameter of less than 5 m.	1	98	5	19	76	54	20	56	21	2	28	9	88	8		1	5	67	34	6	45	0	10	24	41	32	1	47	9	1	7	23	6	3
			2	75	5	13	81	53	18	58	25	0	24	3	93	7		0	5	80	31	1	59	0	9	27	48	32	0	52	7	0	5	39	1	1
			X	4	100	0	0	100	100	0	0	0	50	0	75	25		0	0	100	0	0	50	0	0	0	100	25	0	50	25	0	0	25	0	0

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

Table of Contents

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time	Will not be realized (%)	Do not know (%)	Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026			USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	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	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Organic and high polymer	11	Development of heat-resistant polymer capable of continuous use at temperatures of up to 450 °C.	1	243	14	37	49	62	32	52	15	1	81	40	14	12		4	9	72	25	4	44	0	17	52	47	25	4	46	0	2	30	6	1	4
			2	202	9	39	51	60	28	59	13	1	86	36	13	9		3	4	79	15	2	50	0	14	59	48	17	3	52	0	2	41	4	0	3
			X	19	100	0	0	68	39	56	6	0	89	63	11	5		0	0	95	16	0	79	0	0	68	47	21	0	63	0	0	26	0	0	0
	12	Development of polymeric fiber with a tear resistance of 40% of the theoretical value and a modulus of 90% of the theoretical value (the theoretical values are assumed to be 20 GPa for resistance and 250 GPa in modulus of elasticity).	1	185	15	37	49	60	28	59	11	2	82	24	19	16		4	6	69	28	3	49	1	16	50	40	27	6	49	1	2	19	4	3	4
			2	154	11	34	55	57	23	62	14	1	86	22	16	10		5	2	79	17	1	55	0	12	58	42	19	2	59	0	1	27	3	2	3
			X	17	100	0	0	78	56	44	0	0	88	41	12	18		6	0	82	41	0	82	0	0	59	41	29	6	82	0	0	12	0	0	0
	13	Practical use of polymer materials with electrical conductivity and resistance to the environment equal to copper at room temperature.	1	226	12	31	58	59	31	49	18	3	75	45	11	22		17	12	57	26	3	43	1	27	50	42	23	3	38	0	3	18	3	2	6
			2	190	8	31	62	58	27	52	19	2	75	45	9	16		17	6	62	20	2	50	0	23	58	41	18	2	44	0	3	23	3	1	4
			X	15	100	0	0	77	53	47	0	0	87	80	13	7		7	7	93	40	0	87	0	0	80	53	27	7	60	0	0	20	0	0	7
	14	Development of organic superconductor having a transition temperature higher than 77 K.	1	205	7	33	60	60	32	46	19	3	65	48	10	44		14	11	68	36	5	55	0	16	58	39	25	5	46	0	1	12	4	2	5
			2	169	5	34	62	58	27	54	17	2	69	44	7	41		15	12	68	27	3	59	0	18	62	37	19	4	46	0	3	19	4	0	4
			X	8	100	0	0	63	25	75	0	0	63	63	0	50		13	25	75	38	13	88	0	13	50	50	38	0	63	0	0	13	13	0	0
	15	Development of superconducting materials of conjugated polymer.	1	182	13	29	58	54	24	48	25	3	65	40	10	40		9	16	66	34	4	50	0	19	58	40	21	4	45	0	1	12	4	3	4
			2	149	9	30	61	53	18	57	23	1	68	38	7	38		7	15	74	30	3	60	0	13	65	39	19	3	47	0	1	22	3	1	3
			X	14	100	0	0	64	29	71	0	0	71	43	0	43		0	21	93	36	7	79	0	7	64	43	7	0	71	0	0	21	7	0	0
	16	Practical use of high-polymer materials offering a coloring and luminescence when supplied with energy and sustaining for at least 3,000 hours.	1	180	14	28	58	62	33	51	16	1	83	26	22	16		2	6	66	28	1	67	1	14	52	50	18	3	39	1	2	14	3	3	6
			2	151	11	26	62	60	27	60	13	1	83	20	22	13		0	7	72	20	1	72	0	9	56	54	13	1	45	0	1	21	2	1	5
			X	17	100	0	0	69	41	53	6	0	88	24	18	12		0	6	71	24	0	94	0	0	71	82	6	6	47	0	0	6	0	0	0
	17	Practical use of organic materials with the photo-sensitivity and resolution of silver chloride.	1	155	10	21	69	54	24	47	27	2	77	28	19	10		12	8	61	23	1	55	0	23	39	46	19	3	35	2	1	17	5	2	5
			2	122	8	21	70	53	21	52	25	2	83	29	16	8		8	7	70	20	1	66	0	17	48	47	15	2	34	0	2	26	2	1	3
			X	10	100	0	0	68	40	50	10	0	90	30	10	0		30	20	80	20	0	70	0	10	50	60	10	10	50	0	0	10	0	0	0
	18	Development of organic ferromagnetic substances.	1	182	4	27	69	50	19	47	32	2	71	23	13	36		8	13	57	24	14	49	1	20	53	44	18	3	45	1	1	9	5	2	3
			2	152	3	19	78	48	14	51	34	1	76	16	11	35		5	12	66	19	9	57	1	12	57	43	13	3	48	0	0	16	1	1	3
			X	5	100	0	0	60	40	20	40	0	60	20	20	40		0	20	100	60	0	40	0	0	60	60	0	20	60	0	0	0	0	0	0
	19	Practical use of high-polymer ferroelectrics whose piezoelectric constant is as high as PZT.	1	166	5	35	60	49	13	60	27	1	80	20	16	22		7	9	59	22	4	47	0	21	43	45	17	3	43	1	1	10	2	2	5
			2	136	7	29	64	47	7	69	23	2	83	17	11	19		4	11	64	14	1	55	0	18	51	44	13	1	47	0	1	19	1	1	4
			X	9	100	0	0	53	11	78	11	0	89	33	33	44		11	11	78	33	0	67	0	0	44	33	11	0	67	0	11	0	0	0	0
	20	Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	1	157	8	28	64	79	61	34	3	1	75	69	25	8		6	6	66	30	2	64	1	11	44	56	21	3	52	3	2	22	4	3	5
			2	133	5	24	71	82	65	32	3	0	78	65	23	5		4	6	74	18	0	72	0	9	47	57	14	2	56	2	4	28	2	1	5
			X	7	100	0	0	86	71	29	0	0	86	71	29	0		0	0	71	29	0	100	0	0	71	57	0	0	57	0	0	0	0	0	14

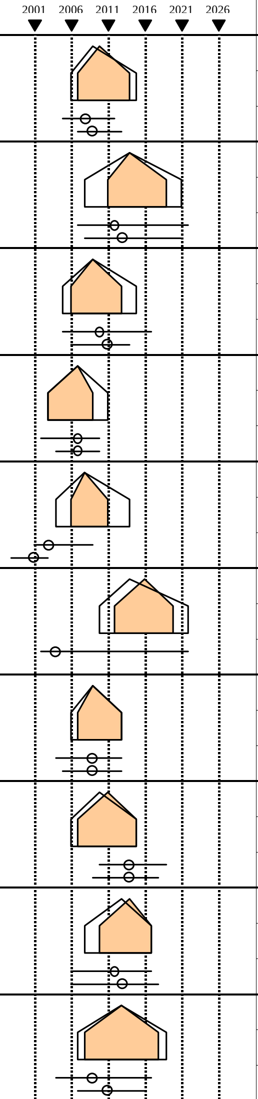
(Note) See page 7 for the interpretation of the graphs.

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
Organic and high polymer	21	Development of self-healing high polymers.	1	157	5	32	62	54	24	47	27	2	64	28	41	35		10	17	54	24	1	42	1	29	57	41	18	3	44	0	2	16	5	4	6
			2	135	4	27	68	51	15	62	22	1	63	16	44	33		9	15	65	15	0	50	0	23	67	46	13	3	47	0	1	24	4	1	6
			X	6	100	0	0	71	50	33	17	0	67	33	33	50		0	17	83	50	0	83	0	0	50	83	0	17	100	0	0	0	17	0	0
	22	Development of technology which create the desired functions through the complete control of two- and three-dimensional structures of protein complex.	1	106	8	26	66	65	38	47	15	1	62	34	37	49		11	8	74	40	1	46	1	15	56	34	24	20	41	1	0	20	6	16	4
			2	92	5	23	72	64	35	53	12	0	65	17	38	53		9	10	82	34	1	51	0	11	67	39	23	21	49	1	0	26	8	17	2
			X	5	100	0	0	90	80	20	0	0	60	0	60	60		0	20	100	80	0	80	0	0	40	80	20	40	40	0	0	0	0	0	0
	23	Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	1	163	7	23	71	52	19	51	29	1	37	9	26	69		2	7	65	37	3	50	1	17	41	37	39	10	48	1	1	7	5	4	6
			2	129	5	23	72	49	10	65	24	1	36	2	18	82		1	4	76	36	2	59	1	9	49	26	40	6	52	0	1	9	5	2	3
			X	6	100	0	0	50	17	67	0	17	50	17	0	83		0	0	100	67	0	67	0	0	50	17	50	17	67	0	17	0	0	0	0
	24	Use of catalytic oxidation and hydrogenation with much less by-production of inorganic salts in place of the majority of reagent oxidation and reduction reactions in the synthesis of fine chemicals.	1	96	10	29	60	57	27	49	22	2	55	64	11	22		2	7	60	50	4	51	1	20	58	42	17	4	42	1	2	16	1	0	5
			2	82	10	27	63	55	18	66	16	0	56	65	7	17		0	7	70	48	5	52	0	15	68	43	12	1	45	0	0	23	0	0	4
			X	8	100	0	0	75	50	50	0	0	38	88	0	63		0	13	88	75	13	100	0	0	75	63	0	0	88	0	0	0	0	0	0
	25	Development of selective catalytic cracking technology for naphtha.	1	89	11	33	56	67	44	40	15	1	58	76	8	12		1	3	76	36	3	54	0	10	48	52	25	1	54	4	1	15	1	0	4
			2	77	5	36	58	70	45	45	11	0	58	79	5	13		3	6	84	26	3	57	0	10	48	58	17	0	61	1	1	19	0	0	4
			X	4	100	0	0	88	75	25	0	0	75	100	0	50		0	0	100	25	0	75	0	0	75	75	0	0	100	0	0	0	0	0	0
	26	Development of mass-synthesizing technology for fullerene carbon compounds.	1	180	5	29	66	42	10	44	42	4	63	19	6	45		2	9	71	42	6	64	0	9	46	45	24	2	46	1	2	14	3	3	5
			2	151	3	26	72	40	5	48	44	3	66	9	3	51		1	11	77	34	3	66	0	11	48	44	19	2	44	0	1	17	1	1	4
			X	4	100	0	0	38	0	50	50	0	75	0	0	75		0	0	100	50	0	100	0	0	75	50	0	0	75	0	0	0	0	0	0
	27	Practical use of technology for direct synthesis of phenol from benzene.	1	92	15	25	60	51	19	52	27	2	59	53	7	17		1	10	57	43	7	49	0	20	42	51	17	1	45	1	1	12	1	1	3
			2	75	13	24	63	49	11	64	25	0	69	53	5	16		0	8	71	39	4	61	0	16	48	51	11	1	49	0	3	13	0	0	4
			X	10	100	0	0	60	20	80	0	0	80	70	0	40		0	0	70	60	20	80	0	0	50	60	10	0	60	0	10	0	0	0	10
	28	Widespread use of new organic synthetic processes using photocatalysts.	1	135	10	27	63	55	26	46	26	2	67	58	5	25		2	7	60	35	1	57	0	16	56	50	20	1	48	0	1	16	3	0	4
			2	109	6	24	70	50	14	59	26	1	67	61	2	18		1	6	69	23	1	65	0	15	58	54	14	1	44	0	2	18	1	0	3
			X	7	100	0	0	64	29	71	0	0	71	43	0	14		0	0	86	29	14	57	0	0	57	14	14	0	29	0	0	14	0	0	0
	29	Development of precision polymerization processes that can freely control stereoregularity, chain structure and molecular weight and its distribution of polymer in addition polymerization reactions.	1	128	23	33	45	65	37	49	13	2	76	26	13	42		3	5	77	45	1	70	0	8	60	45	21	2	52	1	1	9	1	1	8
			2	98	21	35	44	63	34	52	14	0	85	16	7	48		1	7	82	44	0	76	0	7	68	47	18	1	61	0	1	10	0	0	4
			X	21	100	0	0	85	70	30	0	0	90	14	10	62		0	0	81	52	0	81	0	0	76	67	38	5	62	0	0	0	0	0	0
	30	Development of technology that can freely control molecular weight and its distribution in condensation polymer.	1	129	20	28	52	60	30	53	16	2	73	19	11	39		5	5	68	39	1	61	0	14	62	40	20	2	49	0	0	8	2	1	5
			2	99	20	28	52	57	21	65	13	0	87	12	8	39		3	5	78	32	1	69	0	11	71	45	15	2	53	0	0	11	0	0	2
			X	20	100	0	0	78	55	45	0	0	85	15	15	35		5	5	65	25	0	85	0	0	75	50	30	5	65	0	0	5	0	0	0

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

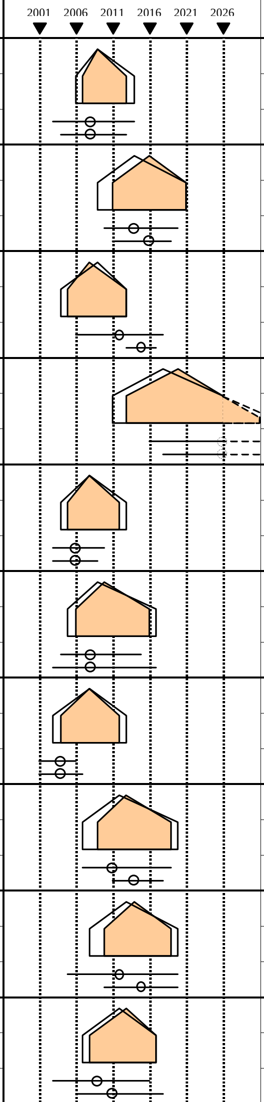
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%) High	Degree of expertise (%) Medium	Degree of expertise (%) Low	Importance (index, %) Index	Importance High	Importance Medium	Importance Low	Importance Unnecessary	Expected effect (%) Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	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
Organic and high polymer	31	Development of technology that can freely control the tacticity of polyvinyl chloride and polyvinyl acetate.	1	114	18	28	54	50	16	54	28	3	69	21	12	26	2	11	61	39	1	59	0	18	49	40	18	3	39	0	3	16	2	1	6
			2	91	15	27	57	50	12	63	24	0	78	13	8	27	1	13	75	32	0	70	0	11	63	44	14	1	44	0	3	25	0	0	3
			X	14	100	0	0	71	50	36	14	0	79	36	14	43	7	7	79	50	0	86	0	7	57	43	29	0	64	0	0	14	0	0	0
	32	Development of technology that can freely control the supra-molecular structure of polymers (higher order functional structure).	1	141	17	31	52	64	34	55	8	3	72	18	11	50	6	9	67	40	4	55	1	16	57	40	23	2	44	1	1	11	2	2	6
			2	117	14	32	55	60	24	68	6	2	83	13	7	56	5	9	76	44	2	68	0	11	70	45	22	3	53	1	0	19	3	2	3
			X	16	100	0	0	81	63	38	0	0	81	19	31	56	6	6	75	81	0	94	0	0	69	56	50	0	69	0	0	0	0	0	0
	33	Biodegradable plastics will account for 10% of all plastics.	1	213	9	23	67	71	48	41	9	2	44	89	21	6	6	4	58	59	1	57	0	11	32	42	16	6	42	28	3	46	3	4	2
			2	176	8	23	69	76	56	35	8	1	37	93	14	5	4	3	66	68	1	67	0	5	35	54	13	4	52	30	3	53	2	1	2
			X	14	100	0	0	75	57	29	14	0	29	100	21	7	7	0	64	79	0	64	0	0	21	57	14	0	57	29	0	21	0	0	0
	34	Establishment and practical use of plastic recycling technology.	1	259	11	26	63	85	72	24	3	0	51	92	17	4	0	3	46	64	1	52	1	11	31	51	20	5	46	34	2	37	4	7	3
			2	211	7	28	65	91	82	15	2	0	47	93	13	2	0	2	50	74	0	63	0	6	31	63	15	1	54	34	0	43	3	2	2
			X	15	100	0	0	100	100	0	0	0	73	93	20	7	0	0	67	87	0	73	0	0	27	67	13	0	53	27	0	27	20	0	0
	35	Practical use of composite systems capable of garbage disposal based on the high-temperature methane fermentation technology and of waste combustion disposal.	1	113	5	16	79	73	51	39	8	1	39	90	17	4	2	4	34	41	3	52	1	22	30	46	17	3	50	27	0	39	3	4	3
			2	96	2	14	84	76	54	39	6	0	32	93	14	4	0	1	31	38	2	70	0	18	25	59	13	0	64	27	1	51	1	3	1
			X	2	100	0	0	75	50	50	0	0	50	100	50	0	0	0	0	50	0	50	0	50	50	50	0	0	100	0	0	50	0	0	0
	36	Biomasses will exceed 10% of chemical materials.	1	114	3	19	78	59	33	42	23	3	36	92	12	7	8	11	52	39	4	32	7	22	37	34	15	8	44	23	3	33	0	4	3
			2	97	0	15	85	58	27	53	19	1	33	94	5	3	4	5	63	39	2	35	5	19	39	42	11	4	53	16	2	38	0	2	1
			X	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceramic	37	Development of Si_3N_4 sintered material having robustness at least equivalent to cast iron at room temperatures.	1	173	19	38	43	55	21	58	19	2	80	44	8	13	6	10	61	21	8	68	1	10	45	49	28	5	48	1	2	14	4	2	5
			2	149	16	34	50	53	16	63	19	1	84	32	8	7	6	7	59	11	4	77	1	7	52	56	19	3	56	1	1	19	3	1	3
			X	24	100	0	0	68	38	58	4	0	88	46	4	4	4	0	79	17	0	88	0	0	54	58	21	0	79	0	0	17	4	0	0
	38	Development of large-scale architectural window glass for which there is time enough to take prior safety countermeasures against a qualitative deterioration in strength.	1	135	14	34	52	50	17	55	24	4	56	20	59	6	2	11	59	21	1	54	1	17	36	48	14	4	35	11	2	7	22	3	6
			2	117	10	32	57	50	12	64	21	3	56	10	66	3	1	9	68	12	1	62	1	15	40	58	6	3	41	9	1	5	32	0	3
			X	12	100	0	0	66	36	55	9	0	50	17	92	0	0	0	75	17	0	92	0	0	83	75	0	8	67	0	0	0	33	0	0
	39	Practical use of power generator turbines made primarily from high-strength, heat-resistant ceramics.	1	198	16	34	50	65	37	49	12	2	58	76	8	7	5	8	65	30	4	67	1	11	43	55	27	4	54	2	2	11	10	1	4
			2	169	15	31	54	63	31	59	9	1	64	75	4	5	2	4	64	21	2	74	1	8	46	62	16	2	65	2	1	12	13	0	4
			X	25	100	0	0	73	48	48	4	0	68	88	0	0	0	0	88	16	0	72	0	4	48	52	12	0	84	8	0	12	12	0	0
	40	Development of inorganic materials which exhibit self-organization phenomenon with specific nano-scale structure/characteristics.	1	186	16	38	46	54	23	51	22	5	72	31	8	45	5	8	67	31	4	58	0	12	55	49	24	5	48	0	1	8	5	3	5
			2	154	14	35	51	51	16	60	20	4	75	24	7	43	4	6	69	20	2	68	0	11	65	47	19	3	56	0	0	13	6	2	3
			X	21	100	0	0	65	33	62	5	0	76	38	5	48	0	10	71	14	0	67	0	5	52	38	19	5	62	0	0	10	0	5	0

Forecasted realization time

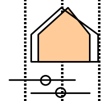
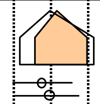
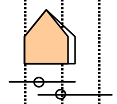
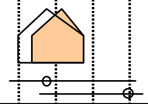
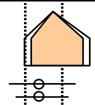
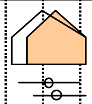
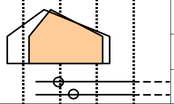
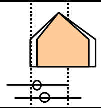
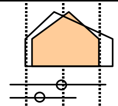
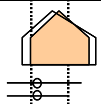


(Note) See page 7 for the interpretation of the graphs.

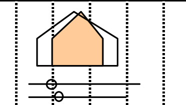
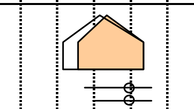
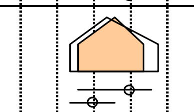
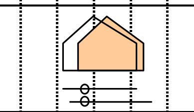
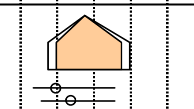
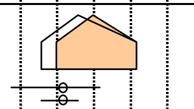
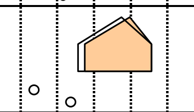
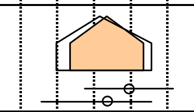
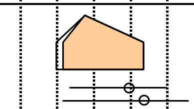
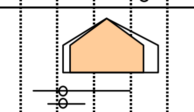
Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time		Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	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	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Ceramic	41	Construction of large-scale structures (bridges, high-rise buildings, etc.) using concrete (cement and fibers, steel bars, etc.) whose strength deterioration is predictable.	1	164	12	34	54	72	50	40	9	1	68	35	59	3	2	5	40	10	1	66	0	20	33	59	21	3	39	22	1	16	26	2	5
			2	140	7	34	59	75	55	38	7	1	78	24	59	4	1	4	46	6	1	79	0	15	27	71	16	2	49	19	1	14	36	1	4
			X	10	100	0	0	83	67	33	0	0	70	60	50	0	0	0	70	10	0	80	0	10	40	60	0	0	50	30	0	20	20	10	0
	42	Development of ceramic materials for high-temperature gas turbines (1,400°C or higher), which have a self-repairing ability for damage (e.g., preventing cracks, corrosion, etc.) in a combustion atmosphere.	1	175	19	35	45	62	31	55	13	1	61	66	13	11	13	10	61	23	2	58	1	18	50	51	25	5	51	1	1	10	7	2	3
			2	146	17	31	52	57	21	68	11	1	66	66	6	10	9	10	68	17	1	64	0	16	60	55	17	1	60	0	1	16	5	1	2
			X	25	100	0	0	68	36	64	0	0	64	80	0	8	20	0	76	24	0	68	0	16	60	36	8	4	64	0	4	4	8	0	0
	43	Practical use of fluoride glass fibers for optical communications.	1	158	9	27	64	60	29	54	15	1	91	19	23	7	3	9	66	20	3	71	0	13	42	45	25	3	37	4	2	11	10	2	4
			2	131	5	31	65	58	22	65	13	0	92	11	24	6	2	7	70	10	1	74	0	9	50	58	18	3	37	2	1	13	13	1	2
			X	6	100	0	0	63	33	50	17	0	100	0	50	17	0	17	83	33	0	67	0	0	50	67	17	17	50	0	0	0	0	0	17
	44	Development of superconductive materials with a transition temperature around room temperature.	1	220	9	32	59	80	65	28	7	1	83	69	9	49	12	28	74	48	10	67	0	12	55	41	32	6	51	0	0	12	7	3	4
			2	188	9	27	64	83	71	22	5	2	86	59	4	43	14	20	76	40	6	71	1	9	64	38	26	3	58	0	0	16	5	1	3
			X	16	100	0	0	83	75	13	6	6	88	69	13	44	13	25	81	44	19	63	0	0	56	38	44	0	63	0	0	13	6	0	0
	45	Practical use of non-destructive testing technology which is detectable minute cracks of less than 10µm in ceramics.	1	190	17	38	45	56	26	49	24	1	68	28	26	15	1	4	61	25	4	64	1	16	45	50	27	5	41	0	1	3	7	2	4
			2	162	14	35	52	55	19	60	21	0	78	22	23	9	1	3	69	19	1	74	0	14	52	59	20	2	43	0	1	2	10	0	4
			X	22	100	0	0	67	41	45	14	0	86	36	14	5	0	5	73	14	0	73	0	9	45	45	18	0	55	0	0	5	0	0	0
	46	Development of a technique enabling solid-phase sintering process using ultra fine particles at temperatures around 800°C to produce SiC-based or Si_3N_4 -based heat-resistant ceramics.	1	177	19	32	49	51	17	56	24	4	75	46	6	14	7	8	60	23	7	64	1	13	47	44	25	5	43	0	1	6	5	2	4
			2	146	14	32	53	48	10	65	23	2	86	37	5	9	3	4	70	14	3	71	0	10	57	45	14	3	51	0	0	7	4	1	2
			X	21	100	0	0	64	29	71	0	0	95	57	5	14	0	0	90	24	5	76	0	5	52	48	29	0	62	0	0	0	5	0	5
	47	Practical use of a technique producing cBN (cubic boron nitride) tools using vapour deposition coating.	1	161	17	27	56	49	16	49	34	1	83	19	8	7	1	5	57	25	12	66	1	13	39	48	24	3	37	0	2	4	3	2	6
			2	126	13	29	58	48	10	63	27	1	86	15	7	5	0	1	61	16	6	76	1	10	41	63	19	2	42	0	1	6	2	1	4
			X	17	100	0	0	60	24	71	6	0	82	41	12	12	0	0	82	18	12	100	0	0	53	71	35	0	53	0	0	0	12	0	0
	48	Development of technology for manufacturing diamond fiber.	1	158	13	26	61	51	20	44	33	2	82	18	11	21	5	20	53	20	11	44	0	24	43	40	27	3	40	1	3	5	4	2	4
			2	132	8	27	65	48	12	59	28	1	88	14	11	23	1	13	68	17	5	55	0	17	52	42	20	3	48	0	1	9	2	1	4
			X	10	100	0	0	48	10	60	30	0	60	50	10	40	0	20	80	30	20	80	0	0	90	40	20	0	60	0	0	10	10	0	0
	49	Widespread use of industrial electric machines which employ superconductive materials having a critical temperature of liquid nitrogen (77 K) or more.	1	208	9	32	59	72	48	44	7	2	84	66	13	12	3	8	72	37	6	72	0	10	43	56	24	4	53	4	0	8	5	4	2
			2	172	9	28	63	72	48	44	7	1	86	56	12	6	2	4	78	24	2	78	0	6	44	64	16	3	66	1	0	9	6	1	2
			X	16	100	0	0	81	69	25	0	6	94	69	19	6	6	0	88	25	0	94	0	0	50	69	31	6	69	6	0	0	6	0	0
	50	Practical use of a plastic forming technology for processing of structural ceramics (e.g., alumna, zirconia, silicon nitride, and silicon carbide).	1	176	19	32	49	57	26	53	19	2	82	31	11	15	3	7	56	24	4	68	0	14	48	49	29	5	48	1	0	5	4	2	4
			2	149	12	30	58	53	16	66	17	1	88	19	7	12	1	6	60	15	1	78	0	11	48	58	16	2	52	0	0	9	1	1	3
			X	18	100	0	0	69	44	44	11	0	83	50	6	22	0	6	67	17	0	83	0	0	56	56	17	6	56	0	0	6	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 (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)						Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	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	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Metal	51	Widespread use of super-heat-resistant intermetallic compounds for mechanical components such as aircraft, engines, turbines and etc..	1	163	17	34	49	63	34	50	14	1	73	58	9	5		5	7	82	33	8	58	0	9	44	44	26	6	48	4	1	12	10	2	4
			2	137	18	28	55	61	31	53	15	1	80	53	6	5		4	4	88	25	3	63	0	6	50	47	20	5	57	2	1	13	11	1	3
			X	24	100	0	0	70	46	46	4	4	75	67	4	0		8	0	96	8	0	67	0	4	50	46	29	13	42	4	0	13	8	0	4
	52	Development of heat resisting alloys which tolerate under the load of 150 N/mm^2 , at ambient temperatures of 1,050°C and beyond 1,000 hours for service.	1	137	20	33	47	60	29	56	14	1	70	59	11	6		6	9	72	28	12	50	1	12	52	45	30	7	56	2	1	11	7	1	4
			2	113	21	27	52	60	25	64	11	0	79	58	4	4		3	6	80	21	6	58	0	10	59	38	23	4	65	1	0	15	5	0	3
			X	24	100	0	0	71	42	58	0	0	88	63	0	4		4	0	79	17	0	75	0	4	63	29	29	8	67	0	0	21	0	0	0
	53	Development of magnetic materials of which maximum energy product exceeds 70 Mega-Gauss Oersted (MGSOe). (Current maximum value of Fe-Nd-B alloy : 64 MGSOe)	1	109	9	36	55	59	28	51	20	1	76	27	17	22		0	9	50	27	9	66	0	14	48	42	30	6	37	0	1	11	7	2	6
			2	85	7	33	60	54	14	73	13	0	86	18	12	18		0	8	60	20	6	73	0	11	59	44	21	4	39	0	0	14	2	0	4
			X	6	100	0	0	58	17	83	0	0	100	33	17	50		0	0	67	33	0	83	0	0	67	17	0	0	50	0	0	17	0	0	0
	54	Development of bulky magnetic materials of which magnetic saturation density exceed 3 Tesla. (Current maximum value: 2.4 Tesla.)	1	101	12	34	54	55	26	46	27	2	70	26	8	26		4	14	50	27	9	59	0	12	46	39	29	5	36	0	1	6	5	2	6
			2	76	8	30	62	51	15	62	22	1	84	16	4	20		0	9	64	22	4	74	0	4	55	36	20	3	38	0	0	8	0	1	7
			X	6	100	0	0	63	33	50	17	0	83	17	17	67		0	0	67	0	0	100	0	0	67	17	17	0	67	0	0	0	0	17	0
	55	Development of diagnostic technologies, which enable in-situ estimation of remaining life of metallic materials structures and components depending on service conditions, by non-destructive inspection for fatigue.	1	166	25	32	43	67	40	49	10	1	69	37	45	13		4	7	64	39	7	63	2	12	52	46	30	12	41	2	1	4	13	2	4
			2	140	21	28	51	65	34	59	7	0	78	31	41	4		1	1	70	24	1	76	0	8	56	54	20	9	44	1	1	3	13	1	4
			X	30	100	0	0	76	55	38	7	0	77	37	53	3		0	3	70	30	0	87	0	3	57	53	23	10	67	0	0	3	10	3	3
	56	Development of economical manufacturing process for ultra-high purity steel with 6-N (99.9999%).	1	129	15	26	59	51	19	49	30	2	76	24	8	35		5	16	32	25	8	62	1	21	43	36	33	6	47	2	1	6	3	2	7
			2	107	14	24	62	48	12	55	30	2	82	18	6	32		2	10	40	21	3	75	0	12	57	38	28	4	54	0	1	8	1	0	4
			X	15	100	0	0	61	29	64	0	7	80	27	7	60		7	0	40	40	0	87	0	0	60	33	20	7	67	0	0	27	7	0	7
	57	Development of new titanium refining process lowering the manufacturing cost on a par with that of aluminum.	1	128	14	23	63	60	29	52	17	2	84	42	20	13		14	16	57	21	11	46	1	25	48	40	27	6	38	0	2	11	8	2	5
			2	108	14	20	66	55	23	56	18	3	88	32	18	8		11	16	67	16	7	56	1	19	66	39	20	4	45	0	0	14	3	0	3
			X	15	100	0	0	58	33	47	7	13	87	33	0	20		27	7	67	7	20	67	0	13	73	33	13	7	53	0	0	27	0	0	0
	58	Development of molding technologies for making new alloys utilizing mechanical alloying technology.	1	126	16	30	54	48	13	54	31	2	75	29	7	18		2	10	62	28	6	57	1	16	50	41	28	6	38	0	2	6	6	3	4
			2	99	15	33	52	47	11	58	29	2	79	20	3	18		1	6	76	20	5	64	0	11	69	43	23	1	41	0	0	8	3	0	3
			X	15	100	0	0	55	27	47	20	7	80	40	0	13		7	0	80	13	7	67	0	0	67	40	13	7	53	0	0	13	7	0	7
	59	Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys exceeds 10% of the total automobile production.	1	184	7	18	74	70	47	40	13	0	54	92	15	6		8	10	55	34	3	59	1	20	28	54	21	2	49	22	1	18	17	2	3
			2	151	5	18	77	70	46	40	13	0	52	93	11	3		5	8	66	30	2	74	0	15	30	64	13	1	62	20	1	24	21	1	2
			X	8	100	0	0	91	88	0	13	0	38	75	13	0		13	13	75	13	0	88	0	13	50	63	25	0	63	0	0	25	25	0	0
	60	Practical use of processing technology for super-smooth-surface finished metal with the level of nano-meter surface roughness. (Current limit : 0.1μ).	1	158	10	32	58	52	21	46	33	0	80	9	11	25		5	3	53	28	4	61	1	16	49	41	37	4	41	3	3	4	4	2	3
			2	126	10	33	57	49	15	55	30	1	90	3	5	26		2	2	59	20	1	80	0	9	63	44	33	1	44	2	1	6	4	1	2
			X	12	100	0	0	54	25	42	33	0	92	8	0	25		0	0	67	0	0	83	0	0	67	33	50	0	33	0	0	8	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	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
Semiconductor and electronics	61	Development of high performance switching elements made of nonlinear optical material of the third order.	1	140	10	33	57	63	37	43	18	1	83	10	8	28		1	9	76	39	5	65	0	9	51	48	26	2	46	0	0	3	4	2	5
			2	117	9	31	60	63	32	53	15	0	85	8	8	23		0	8	84	33	0	68	0	7	58	56	20	2	55	0	0	3	5	1	2
			X	11	100	0	0	82	64	36	0	0	91	27	9	27		0	0	91	27	0	91	0	0	64	73	27	0	73	0	0	0	9	0	0
	62	Development of memory capacity of 1 terabit per chip.	1	142	11	29	61	83	69	25	4	1	92	13	20	21		3	6	75	9	0	82	2	5	46	54	36	1	52	2	1	2	3	8	4
			2	113	9	28	63	86	74	21	4	0	92	6	17	10		1	4	73	4	0	83	3	5	50	64	29	1	57	0	0	4	2	5	2
			X	10	100	0	0	95	90	10	0	0	100	10	30	0		0	0	90	0	0	100	10	0	40	90	30	0	50	0	0	0	0	10	0
	63	Development of radiation- and heat-resistant logic integrated circuits capable of use with nuclear reactors.	1	89	10	28	62	57	26	51	19	4	54	60	13	9		6	16	66	22	2	45	0	15	38	38	31	4	54	2	1	10	11	7	3
			2	75	8	23	69	55	19	63	18	0	55	75	11	5		4	11	81	11	3	47	0	11	39	43	24	3	69	0	1	12	15	4	1
			X	6	100	0	0	75	50	50	0	0	67	100	17	0		0	0	100	17	17	50	0	0	17	100	0	17	83	0	0	0	33	0	0
	64	Practical use of quantum-effect interferometer for flux measurement.	1	95	9	33	58	53	21	52	26	1	72	9	8	42		2	15	79	37	4	62	1	8	51	47	21	0	40	0	1	2	2	2	5
			2	77	9	22	69	50	12	65	23	0	77	5	3	42		3	10	86	34	1	70	0	4	68	58	13	0	44	0	1	1	0	1	4
			X	7	100	0	0	61	29	57	14	0	57	29	0	71		0	29	100	57	14	100	0	0	71	43	29	0	71	0	0	0	0	0	14
	65	Practical use of semiconductor UV lasers.	1	130	13	32	55	66	38	49	12	1	88	17	13	24		0	7	70	26	5	65	0	15	48	48	28	2	50	0	0	2	5	4	4
			2	105	16	27	57	66	36	57	7	0	95	10	10	19		0	5	80	17	2	72	0	8	57	59	22	0	54	0	1	4	3	1	2
			X	17	100	0	0	72	47	47	6	0	94	6	0	35		0	0	88	12	0	76	0	0	59	71	29	0	65	0	0	6	0	0	0
	66	Practical use of operational circuits comprising Josephson junctions.	1	119	8	30	61	55	27	45	23	5	80	11	10	25		4	7	71	29	2	69	0	6	42	45	26	2	52	0	1	1	2	2	4
			2	99	9	25	66	53	20	53	24	2	90	6	5	23		7	5	78	17	0	74	0	7	57	54	18	2	58	0	1	1	0	1	2
			X	9	100	0	0	64	33	56	11	0	78	0	11	11		11	0	89	11	0	89	0	0	56	33	11	0	67	0	0	0	0	0	0
	67	Development of microwave cathode elements able to operate at 7A/cm^2 for a life-time of one year.	1	45	2	24	73	51	19	50	29	2	84	16	16	11		0	27	69	24	0	49	0	16	36	44	16	4	47	0	0	0	2	2	11
			2	41	2	12	85	53	17	61	22	0	85	5	7	12		2	10	78	10	0	49	0	15	39	54	17	2	44	0	0	5	0	2	5
			X	1	100	0	0	50	0	100	0	0	100	0	0	0		0	0	100	0	0	100	0	0	0	100	0	0	100	0	0	0	0	0	0
	68	Development of PHB (Photochemical Hole Burning) memory devices.	1	136	10	28	63	59	29	49	19	2	87	10	12	24		8	9	71	38	4	65	1	10	43	47	25	3	49	0	1	2	2	3	3
			2	114	6	23	71	58	26	55	18	1	91	6	10	23		7	4	81	30	2	73	0	6	51	55	19	4	53	0	0	5	3	1	1
			X	7	100	0	0	75	50	50	0	0	100	14	0	29		0	0	71	57	14	100	0	0	71	57	43	0	71	0	0	0	0	0	0
	69	Development of elements (memory, magnetic heads, etc.) which utilize colossal magnetic resistance effect (variance of 10^{10} or more).	1	58	14	36	50	58	27	52	20	2	84	9	10	19		0	10	72	28	2	64	0	10	40	57	19	0	38	0	0	0	2	3	5
			2	47	11	30	60	53	15	66	19	0	83	6	9	13		2	9	77	11	2	62	0	11	43	60	15	0	43	0	0	6	2	4	2
			X	5	100	0	0	70	40	60	0	0	80	0	20	0		0	0	100	0	0	60	0	0	20	40	40	0	60	0	0	0	0	0	0
	70	Development of photo-refractive material that can change its photo-refractive index by more than 0.1.	1	106	9	30	60	55	22	57	19	2	84	8	12	33		3	17	63	32	3	57	0	19	47	44	20	2	44	0	0	1	2	4	5
			2	89	8	28	64	53	16	66	18	0	91	2	10	30		3	12	81	27	2	70	0	11	64	54	12	1	54	0	0	2	0	1	3
			X	7	100	0	0	71	43	57	0	0	100	0	14	14		0	0	100	14	14	100	0	0	57	71	0	0	57	0	0	0	0	0	0

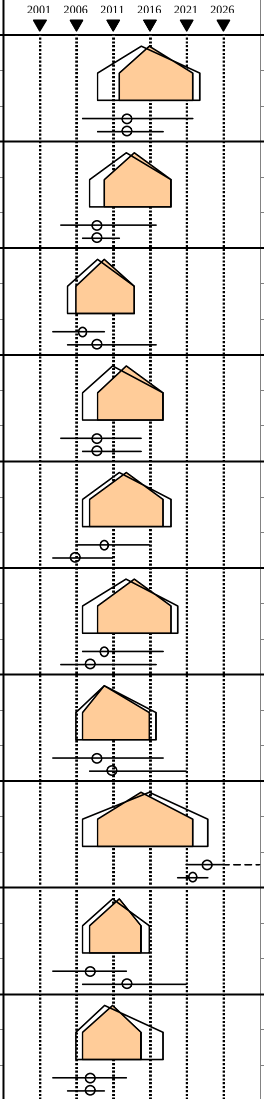
(Note) See page 7 for the interpretation of the graphs.

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
Semiconductor and electronics	71	Development of intelligent materials which incorporate sensor functions, programming functions and effector functions.	1	156	10	29	61	61	32	50	15	3	81	17	36	24		8	10	64	24	2	54	1	21	58	54	24	4	57	1	1	6	6	4	3
			2	123	9	29	62	59	27	56	15	2	89	7	35	25		7	7	72	20	0	61	0	15	62	56	20	3	61	1	2	7	3	3	1
			X	11	100	0	0	82	64	36	0	0	91	9	27	36		9	0	82	18	0	82	0	9	45	91	18	9	55	0	0	9	0	0	0
	72	Elucidation of the information transmission structure of sensory nerves.	1	106	5	13	82	63	31	59	9	1	52	5	56	70		2	4	74	45	5	42	1	20	64	39	22	16	47	0	0	1	7	15	3
			2	89	2	11	87	65	33	61	7	0	54	2	60	69		1	1	84	49	1	42	1	16	79	43	16	11	58	0	1	2	3	22	1
			X	2	100	0	0	100	100	0	0	0	50	0	50	50		0	0	100	50	0	50	0	0	50	50	0	0	100	0	0	0	0	50	0
	73	Practical use of computer simulation technology for growing thin films according to the first principle computation.	1	139	16	29	55	51	21	45	32	3	63	11	4	60		2	8	76	30	4	55	1	14	50	38	24	12	47	1	0	1	2	3	7
			2	110	12	26	62	50	16	54	29	1	69	5	2	58		2	4	81	27	0	60	1	13	62	35	19	6	48	0	1	2	0	3	3
			X	13	100	0	0	75	54	38	8	0	62	31	0	69		0	0	100	62	0	92	0	0	77	38	38	8	62	0	0	0	0	8	0
	74	Elucidation of the crystallization growth mechanism using femto-second technology.	1	129	16	29	56	49	18	47	31	4	53	8	2	75		2	11	76	35	2	57	1	13	57	36	32	4	48	2	1	2	2	2	4
			2	104	13	26	62	48	14	50	34	2	49	1	0	81		3	6	86	26	0	63	1	11	63	40	27	2	55	1	0	2	0	1	1
			X	13	100	0	0	73	54	31	15	0	62	8	0	92		0	8	100	54	0	92	0	0	77	69	23	8	69	0	0	0	0	0	0
	75	Development of technology for controlling the structures and properties of solid interfaces at the atomic level.	1	213	26	27	46	65	38	50	12	1	76	15	8	62		1	4	76	41	3	66	1	9	56	47	35	4	54	0	0	2	2	2	4
			2	168	23	25	52	62	31	57	11	1	79	5	4	66		0	3	83	36	1	74	1	8	65	48	32	4	59	1	0	2	1	1	2
			X	38	100	0	0	80	61	39	0	0	79	8	3	61		0	0	82	53	3	89	0	3	63	53	32	8	66	0	0	3	0	0	3
	76	Development of technology to analyze the chemical species of solid surface atoms.	1	208	23	29	49	57	25	52	22	1	60	11	6	67		0	3	72	50	2	57	1	12	48	38	35	8	50	0	0	1	2	3	4
			2	165	22	25	52	55	19	62	17	1	65	4	3	72		0	2	85	44	1	67	1	8	56	38	30	6	59	0	0	2	2	2	2
			X	37	100	0	0	69	43	46	11	0	68	5	0	65		0	0	89	54	0	70	0	3	54	46	27	11	59	0	0	3	0	3	0
	77	Development of a technique for manufacturing of p-n junctions of diamond.	1	148	11	29	59	55	22	55	20	3	83	27	6	28		3	7	75	33	15	68	1	7	49	50	27	2	49	0	2	2	3	1	3
			2	113	12	27	60	53	15	67	17	1	87	19	4	28		1	4	86	25	7	81	1	4	54	58	21	3	54	0	0	1	2	1	1
			X	14	100	0	0	73	50	43	7	0	79	29	0	43		7	0	100	43	21	93	0	0	71	71	14	7	64	0	0	0	0	0	0
	78	Development of a heteroepitaxial technology for growing any semiconductor material on silicon substrate.	1	161	17	34	48	66	39	49	11	2	85	22	8	35		6	9	76	36	6	75	1	9	53	47	30	2	48	0	2	4	2	1	5
			2	126	17	29	54	62	29	60	10	1	94	11	3	33		2	9	81	28	1	83	1	6	63	51	24	2	51	0	0	6	0	0	2
			X	22	100	0	0	88	77	18	5	0	91	18	0	36		5	5	82	23	0	95	0	0	68	41	27	5	59	0	0	9	0	0	0
	79	Development of the technology to fabricate large-area (inch order) compound semiconductor single crystal film on glass substrates.	1	157	14	32	54	62	32	54	13	1	83	28	11	25		3	9	63	27	5	63	1	18	49	50	25	2	46	1	1	6	1	2	5
			2	126	14	27	59	58	22	66	10	2	90	15	10	21		2	6	71	21	1	73	2	13	60	62	18	3	54	0	0	6	0	1	2
			X	18	100	0	0	74	50	44	6	0	89	22	17	28		6	0	78	22	0	89	0	6	56	67	22	6	61	0	0	6	0	0	0
	80	Development of heteroepitaxial technology for growing large-area (inch order) diamond thin films on hetero-substrates.	1	157	13	32	55	58	25	58	16	1	83	22	8	27		2	8	71	28	12	67	1	11	50	50	31	1	43	0	1	2	1	3	4
			2	122	12	29	59	55	17	71	12	0	92	14	5	21		1	3	81	20	6	76	2	8	61	65	23	2	49	0	0	3	0	2	2
			X	15	100	0	0	73	47	53	0	0	87	27	7	27		0	0	93	33	0	87	0	0	73	73	27	7	53	0	0	7	0	0	0

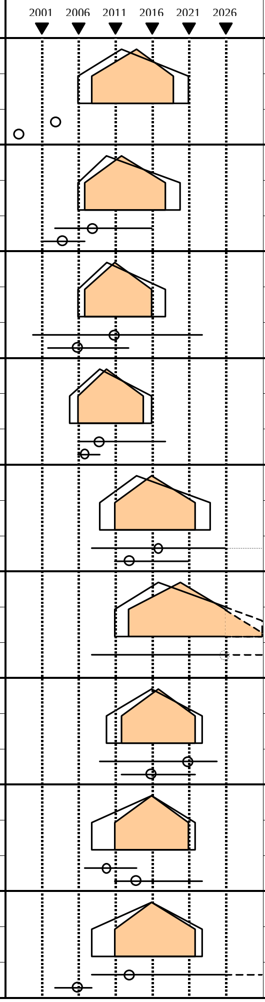
(Note) See page 7 for the interpretation of the graphs.

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
Semiconductor and electronics	81	Development of technology for embedding impurities, and repairing defective crystallized silicon surfaces by STM-associated technology.	1	166	17	30	53	56	25	50	23	1	78	9	4	41		4	5	75	38	2	66	2	8	52	43	38	1	43	1	0	2	1	2	6
			2	136	13	32	54	54	18	61	20	1	85	4	3	41		4	4	85	34	0	77	1	5	64	45	32	1	49	0	0	0	0	1	2
			X	18	100	0	0	63	33	50	17	0	78	11	6	50		6	6	100	56	0	94	0	0	67	50	39	6	50	0	0	0	0	0	0
	82	Development of innovative single crystal silicon manufacturing technology.	1	139	16	27	58	74	53	39	8	0	87	43	9	22		4	20	60	26	8	58	2	19	45	45	29	2	40	1	1	7	1	3	5
			2	117	12	29	59	75	56	34	10	0	91	33	3	18		1	14	73	21	4	72	2	10	56	56	25	3	48	1	1	5	0	1	3
			X	14	100	0	0	86	71	29	0	0	93	50	7	36		0	7	79	43	7	93	7	0	57	71	14	7	57	0	0	0	0	0	7
	83	Practical use of technology for constructing material through the employment of ions and particle beams with controlled characteristics.	1	159	14	31	55	56	24	54	20	1	88	16	8	33		3	9	72	37	6	61	1	13	47	44	39	4	45	0	2	4	2	2	5
			2	124	14	31	56	56	23	58	18	2	87	8	4	36		1	6	84	27	1	70	1	8	59	48	38	2	53	0	0	1	0	1	2
			X	17	100	0	0	72	50	38	13	0	88	24	6	35		0	6	100	47	0	82	0	0	59	65	41	6	53	0	0	0	0	0	0
	84	Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	1	177	10	24	66	84	71	25	4	1	67	88	19	16		13	14	67	30	5	71	1	10	42	53	32	4	51	7	1	12	2	4	4
			2	150	9	21	71	91	83	15	2	0	74	89	16	13		8	10	73	21	1	83	1	8	51	66	18	2	69	5	2	11	1	1	1
			X	13	100	0	0	100	100	0	0	0	54	100	23	8		0	0	92	46	8	92	8	0	69	92	8	8	69	8	0	23	0	0	0
	85	Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	1	183	10	25	65	84	70	27	3	0	64	86	19	10		3	7	63	27	2	78	1	8	39	54	27	4	50	8	1	10	1	2	4
			2	144	8	24	68	91	82	16	1	0	65	88	13	6		1	7	71	19	1	83	1	6	47	67	16	3	69	6	1	10	1	0	1
			X	12	100	0	0	86	73	27	0	0	50	92	17	8		0	0	75	25	17	83	0	0	42	92	17	0	50	8	0	17	0	0	0
	86	Development of X-ray free electron lasers with a wave-length of a few dozen Å.	1	98	6	20	73	57	28	45	26	1	67	17	2	56		1	16	78	33	10	43	2	14	47	44	30	3	50	0	1	8	8	2	2
			2	75	7	13	80	52	21	47	32	0	68	8	1	60		1	7	88	33	1	49	1	7	60	40	24	3	61	0	0	4	5	1	1
			X	5	100	0	0	88	75	25	0	0	60	40	0	80		0	0	100	60	0	80	0	0	60	100	20	20	80	0	0	0	0	0	0
	87	Practical use of industrial equipment that produces high-power excimer lasers in the order of 10kW.	1	88	7	16	77	53	17	61	21	1	81	17	5	22		0	14	73	42	8	51	1	9	38	52	28	3	44	1	1	6	8	2	2
			2	72	4	15	81	50	10	70	20	0	85	10	1	18		0	8	89	35	3	50	1	6	39	64	25	1	46	0	0	4	3	0	1
			X	3	100	0	0	75	50	50	0	0	100	33	0	33		0	0	100	67	33	67	0	0	33	100	0	33	67	0	0	0	0	0	0
Composite	88	Practical use of function-gradient materials that have undergone successive transformation from metallic to ceramic properties.	1	238	17	27	56	58	25	58	18	0	81	39	13	17		2	6	55	25	6	65	2	16	53	54	32	7	46	1	0	8	4	3	4
			2	198	15	26	59	56	20	64	16	0	87	32	7	12		1	6	58	16	3	80	1	11	62	61	23	2	50	0	1	9	3	2	3
			X	30	100	0	0	63	32	54	14	0	77	47	13	17		3	3	67	20	3	93	0	0	57	50	20	3	53	0	0	17	3	3	3
	89	Practical use of oxidation-resistant carbonfiber reinforced carbon composite materials.	1	184	22	27	51	58	27	51	21	1	84	40	14	14		3	8	65	23	4	61	1	11	47	49	27	5	49	0	1	9	4	3	3
			2	158	18	25	57	55	19	63	18	0	91	29	7	9		2	6	75	16	3	68	1	8	51	58	15	2	58	0	1	11	3	1	2
			X	29	100	0	0	69	42	50	8	0	83	48	7	7		7	0	83	24	7	66	0	0	52	52	24	7	59	0	0	17	7	0	3
	90	Practical use of organic and inorganic composite materials (nano-composites) with constituent parts in the order of tens to hundreds of Å.	1	224	15	38	47	54	19	60	21	0	83	23	16	30		3	5	63	32	3	65	1	14	50	53	29	4	49	0	1	6	3	3	4
			2	181	13	38	49	52	12	72	16	0	88	12	7	32		2	4	70	22	1	74	1	12	63	62	23	1	57	0	1	9	2	2	3
			X	24	100	0	0	59	18	82	0	0	79	21	8	33		0	0	79	29	0	83	0	0	63	54	21	4	50	0	0	13	0	4	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	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
Composite	91	Widespread use of intelligent materials which have the ability to perform self-diagnostics and repair.	1	226	16	28	55	61	31	53	14	1	81	30	39	23		10	10	64	24	1	61	0	17	54	54	23	5	49	1	2	6	7	4	4
			2	188	13	28	59	59	26	59	14	1	86	22	33	22		11	7	69	14	0	63	1	15	62	59	16	3	56	2	2	5	10	1	2
			X	24	100	0	0	70	46	46	4	4	92	17	38	38		8	4	71	17	0	79	4	4	46	46	25	0	63	4	0	0	8	0	0
	92	Practical use of organic hybrid composite materials of a controlled structure at the monomolecular level.	1	182	14	31	55	54	20	60	19	1	83	21	16	36		3	8	63	38	2	56	1	20	59	47	24	4	37	1	2	7	2	2	5
			2	145	12	32	57	53	13	72	13	1	83	14	7	41		3	1	69	30	0	63	1	19	68	55	16	1	47	0	1	8	1	1	2
			X	17	100	0	0	63	29	65	6	0	88	12	12	47		6	0	76	53	0	88	0	0	59	65	12	6	53	0	0	6	0	0	0
	93	Practical use of a bonding technology of ceramics and metals which resists to the repetition of temperature change over 500°C.(So far less than 400°C)	1	180	18	27	56	58	26	55	19	1	82	47	17	9		2	3	67	31	7	66	0	14	48	47	34	6	49	1	1	8	3	2	4
			2	149	15	26	59	57	21	65	14	0	86	35	11	5		1	5	73	17	2	69	0	11	52	49	23	3	55	0	1	9	2	1	4
			X	23	100	0	0	74	48	52	0	0	83	61	9	13		4	0	83	17	4	70	0	4	48	35	26	9	57	0	0	4	9	4	4
	94	Development of a technology to manufacture composite materials and products with nano-scale level structures, using the phase of super-plasticity.	1	136	18	26	56	51	17	55	26	2	86	22	7	23		3	9	65	29	5	63	0	14	46	48	29	4	44	1	1	5	3	1	6
			2	106	13	25	61	47	9	63	25	2	91	13	2	25		4	5	70	14	0	72	0	8	58	53	20	2	58	0	0	7	1	1	3
			X	14	100	0	0	54	21	50	29	0	86	21	0	21		7	0	64	21	0	79	0	0	57	43	14	7	50	0	0	0	0	0	0
Other	95	Practical use of computer-aided material design of solid catalysts with specified composition, organization, and physical properties.	1	138	9	24	67	59	26	58	14	2	75	33	7	38		7	7	72	38	3	49	1	17	54	43	22	28	41	0	1	6	2	1	5
			2	108	9	21	69	52	11	76	12	1	76	22	5	44		6	8	81	28	0	50	1	15	72	39	15	25	42	0	1	5	1	0	4
			X	10	100	0	0	58	20	70	10	0	60	20	20	80		0	20	90	50	0	90	0	0	60	60	10	40	60	0	0	0	0	0	10
	96	Development of computer simulation technology enabling the precise prediction of structures and physical properties in an isothermal equilibrium state, provided element compositions are given in materials made more than one element.	1	176	9	27	65	60	29	54	16	1	68	20	5	66		6	11	72	38	4	48	1	16	56	36	22	27	44	0	0	3	1	3	5
			2	140	3	29	68	55	18	67	15	0	71	11	2	71		3	9	81	29	2	52	1	14	74	36	17	24	51	0	1	1	0	1	4
			X	4	100	0	0	75	50	50	0	0	75	0	0	50		25	0	100	25	0	25	0	0	50	50	25	25	25	0	0	0	0	0	0
	97	Development of first-principle computer simulation technology (new algorithm) of 10,000 atom scale.	1	136	11	23	66	53	19	55	23	2	42	11	5	80		1	11	78	43	4	49	1	13	60	26	29	12	52	1	0	2	1	2	5
			2	111	4	21	76	49	11	64	24	1	49	6	3	82		1	12	83	28	2	45	1	8	70	20	23	12	54	0	0	1	0	1	5
			X	4	100	0	0	63	25	75	0	0	75	0	0	75		0	0	100	50	0	100	0	0	100	0	50	0	100	0	0	0	0	0	0
	98	Establishment of technology to detect a single nuclear spin.	1	80	11	16	73	45	14	41	39	5	28	5	3	88		9	19	66	38	3	31	1	16	54	30	24	6	43	3	0	3	4	4	5
			2	63	5	25	70	44	13	40	45	2	29	3	2	92		6	16	84	38	2	32	2	11	70	35	24	3	60	0	0	2	0	2	3
			X	3	100	0	0	50	0	100	0	0	67	0	0	100		0	0	67	0	0	33	0	33	100	33	0	0	100	0	0	0	0	0	0
	99	Practical use of equipment capable of ultra-micro-analysis up to the ppt level (in the order of 10^{-12}; e.g. oxygen, carbon and nitrogen).	1	143	7	25	68	57	26	53	21	1	64	22	6	55		4	4	69	52	3	54	1	13	48	41	35	8	41	1	1	3	2	3	4
			2	116	6	23	71	54	17	65	18	0	77	14	3	62		1	3	78	52	1	66	1	9	59	51	34	5	51	0	1	1	1	1	3
			X	7	100	0	0	82	71	14	14	0	71	43	0	71		0	0	86	43	0	57	0	14	86	43	43	14	43	0	0	0	0	0	0
	100	Development of technology for inducing and measuring ultra-high vacuums in the order of 10^{-14} torr.	1	139	12	27	61	57	26	49	24	1	63	6	4	67		1	9	69	42	2	50	1	14	55	40	34	4	49	1	1	2	2	3	5
			2	110	9	27	64	53	19	56	24	1	66	1	1	71		1	5	81	35	0	61	1	10	66	40	33	3	65	0	2	1	0	1	3
			X	10	100	0	0	70	50	30	20	0	80	0	0	60		0	0	70	30	0	70	0	0	80	30	30	10	60	0	10	10	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	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
Other	101	Establishment of technology to measure minute levels of force (10^{-19} neutons or less).	1	77	3	30	68	47	15	46	36	3	38	5	4	78	4	10	68	38	8	38	0	16	51	30	30	3	51	0	0	1	3	3	9
			2	56	2	38	61	46	11	50	39	0	43	2	2	82	2	5	82	39	2	43	0	11	64	36	32	4	63	2	0	0	0	2	5
			X	1	100	0	0	100	100	0	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	100	0	0	0	0	0	0	0	0	0
	102	Practical use of online processing technology systems capable of forecasting and controlling size and shape with an accuracy in the order of 10Å.	1	128	7	24	69	62	33	51	13	2	84	8	5	32	5	7	63	29	2	63	0	13	46	40	34	4	48	2	0	4	2	3	5
			2	99	5	19	76	61	30	52	18	0	86	3	2	33	4	5	71	18	1	77	0	10	60	44	24	4	57	0	0	2	0	1	3
			X	5	100	0	0	90	80	20	0	0	100	0	0	0	0	0	80	20	0	60	0	0	20	40	20	0	60	0	0	0	0	0	0
	103	Practical use of technology for identifying the morphology of solid configurations in the order of molecular level.	1	120	9	29	62	55	23	53	24	1	61	12	9	69	1	11	73	40	3	56	1	13	43	33	29	5	48	0	1	3	2	3	7
			2	101	8	19	73	52	16	59	25	0	64	3	6	77	0	10	85	32	1	67	0	9	61	33	25	5	57	0	1	1	1	1	6
			X	8	100	0	0	59	25	63	13	0	88	13	13	75	0	0	63	25	0	75	0	13	63	50	38	13	63	0	0	0	0	0	0
	104	Development of technology to control magnetic flux in super-conductors.	1	81	7	31	62	54	22	51	27	0	69	31	6	51	1	6	72	43	11	62	0	12	53	35	32	1	48	1	0	4	4	2	5
			2	56	7	29	64	52	16	61	23	0	73	21	5	57	0	7	79	36	5	63	0	13	63	32	25	4	45	2	0	0	2	0	4
			X	4	100	0	0	50	25	25	50	0	100	0	25	100	0	0	100	75	25	100	0	0	75	50	50	0	50	0	0	0	0	0	0
	105	Widespread use of technology to directly synthesize hydrogen superoxide from hydrogen and oxygen.	1	76	11	25	64	51	18	51	30	1	58	59	4	22	1	14	54	32	3	42	1	28	39	38	28	4	33	1	0	7	4	0	9
			2	61	8	26	66	50	11	66	23	0	66	57	2	16	0	13	62	23	0	49	0	25	46	51	20	3	46	0	2	8	0	0	7
			X	5	100	0	0	70	40	60	0	0	100	40	0	20	0	20	100	60	0	80	0	0	40	40	20	0	60	0	0	0	0	0	0
	106	Development of technology to produce materials of a condition in which single-lattice bonding is fused (sp2.5, etc.), in a terapascal-level (10 million atmospheres) or greater environment.	1	56	9	29	63	46	17	39	41	4	52	7	2	80	9	14	64	27	21	38	0	18	54	27	27	5	41	0	0	7	2	2	5
			2	39	0	26	74	41	8	42	47	3	49	3	0	79	5	18	74	23	15	44	0	18	62	26	31	3	51	0	0	3	0	3	3
			X	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	107	Practical use of processes for water decomposition by the sunlight.	1	163	8	26	66	79	63	30	5	2	50	90	13	20	6	12	55	33	4	55	1	20	47	38	27	3	52	2	1	14	4	2	4
			2	143	5	23	72	85	73	24	1	1	47	88	7	15	4	10	64	27	1	69	1	17	52	36	18	1	66	1	1	20	2	1	3
			X	7	100	0	0	100	100	0	0	0	57	100	0	14	14	0	71	43	0	100	0	0	43	71	43	0	86	0	0	14	0	0	0
	108	Practical use of carbon dioxide fixation technology necessary for protecting global environments.	1	189	8	24	68	78	61	33	5	2	42	95	10	11	6	11	52	39	2	56	2	23	46	42	23	5	60	10	2	23	1	2	3
			2	153	6	22	72	84	72	24	3	1	37	94	4	8	4	6	61	34	1	69	1	20	53	49	15	0	75	7	1	26	1	1	1
			X	9	100	0	0	75	63	13	25	0	33	100	11	33	11	22	67	56	0	100	0	0	33	56	22	0	78	22	0	11	0	0	0
	109	Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology.	1	167	5	11	84	62	38	34	27	1	39	94	16	7	2	8	41	24	5	39	5	32	46	39	18	8	59	6	6	30	2	2	3
			2	142	1	10	89	62	36	42	21	1	33	96	7	2	2	4	58	24	1	52	3	27	57	39	10	4	78	3	4	32	2	1	2
			X	2	100	0	0	100	100	0	0	0	100	100	50	50	0	0	100	100	0	100	0	0	0	50	0	0	50	0	0	50	0	0	0

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

Table of Contents