

Section
2

Reinforcing Technology Base

1 Necessity of Reinforcing Technology Base

As the security environment surrounding Japan becomes increasingly severe, it is necessary to ensure technological superiority by effectively utilizing Japan's advanced technological strength in order to protect the lives and property of Japanese people in any situation. Particularly in recent years, with the rapid advances in technological innovation, it is forecast that we will see the operationalization of so-called game-changing technology that will completely transform combat aspects in the future, and the United States and other countries are proceeding hastily with research and development.

Q See Part I, Chapter 3, Section 1 (Trends Concerning Military Science and Technology)

Thus, as a nation, strategically working on ways to ensure technological superiority and ensuring advanced technology base are important from the perspective of creating superior defense equipment and ensuring Japan's security. Also, the

strengthening of the technology base is a pressing issue. The state-of-the-art military technologies in each country are sensitive technologies that must not be easily shared with other countries. From the perspective of Japan, for the areas which should strategically maintain their domestic technology base, it is necessary to promote research and development domestically. In the cases of defense equipment and technology cooperation, such as equipment procurement and international joint development, it is important to maintain the leading role by owning important cutting-edge technology (key technology). This requires not only research and development by the MOD, but also the promotion of research and development by both the public and private sectors together.

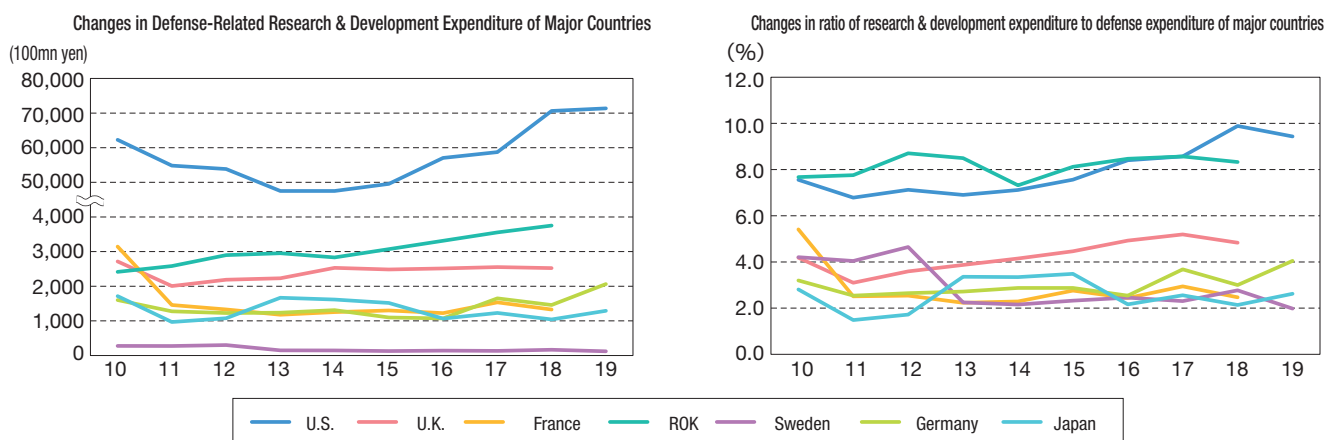
Q See Fig. IV-2-2-1 (Current Status of Research & Development Expenditure)

2 Defense Technology Strategy and Related Documents

For the purpose of ensuring Japan's technological superiority, inventing as well as delivering advanced equipment in an effective and efficient manner, and dealing with various policy issues pertaining to defense and civilian technologies, taking account of the National Security Strategy and the 2013 National Defense Program

Guidelines (NDPG)¹, the MOD formulated the Defense Technology Strategy in 2016, which presented the specific direction for various measures that should be addressed strategically. Based on this strategy, the MOD promotes various measures.

Fig. IV-2-2-1 Current Status of Research & Development Expenditure



Source: "OECD: Main Science and Technology Indicators"

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"SIPRI Military Expenditure Database ©SIPRI 2020"

(Note) For the calculation of Defense-Related Research & Development Expenditure of Major Countries, the ratio of research & development expenditure to defense expenditure of major countries from the "OECD: Main Science and Technology Indicators" data was used. However Chinese data was not published.

1 See Part II, Chapter 3, Section 2.

1 Outline of Defense Technology Strategy

(1) MOD Technology Policy Objectives

The following two objectives of the MOD technology policy are designed to strengthen the technical capabilities, which serve as the foundation of Japan's defense capabilities, to make the foundation more robust:

- (i) Ensuring technical superiority
- (ii) Delivering superior defense equipment through effective and efficient research and development

(2) Specific Measures to be Promoted

The following three measures are promoted to achieve the objectives indicated in the previous paragraph.

(i) Grasping Technological Information

With regard to various scientific technologies that support defense technologies, the MOD grasps the current situation and trends both in and outside of Japan, including dual-use technology² in the public and private sectors and cutting-edge scientific technology. In addition, the MOD develops and publishes the Medium- to Long-Term Defense Technology Outlook (see Paragraph 2 below) to identify advanced technology fields, which have the potential to become game changers.

(ii) Development of Technologies

The MOD will promote research and development based on the "Research and Development Vision" (see Paragraph 3 below) that was formulated to promote medium- to long-term research and development. At the same time, the MOD also promotes research and development that serve as the foundation of defense force building and "Innovative Science & Technology Initiative for Security," which puts into perspective the identification and development of advanced technology expected to be used for technology exchange with relevant domestic/overseas agencies and for defense purposes, and technical research for application of the results to equipment, etc.

(iii) Protection of Technologies

The MOD implements technology control for proper technology transfer to prevent situations in which Japan's technology leaks without the country's intention, which would undermine the maintenance of peace and security in the international community or the ensuring of Japan's technological superiority. The MOD also establishes intellectual property management taking into account the transfer of defense equipment and promotes the utilization of intellectual property.

2 Medium- to Long-Term Defense Technology Outlook

The Medium- to Long-Term Defense Technology Outlook presents an outlook of the technologies that can be applied to equipment expected to be established in roughly the next 20 years, and indicates technology fields that need to be developed in order to ensure Japan's technological superiority. It is expected that making this Outlook public will facilitate the integration of superior civilian advanced technologies and the development of technologies outside of the MOD aimed at defense equipment applications. Review is now underway for taking a more strategic approach to important technologies, including technologies pertaining to new domains and other potentially game-changing technologies such as AI.

3 "Research and Development (R&D) Vision"

The "Research and Development (R&D) Vision" presents principles on R&D, technological challenges, and roadmaps on R&D of the technologies required for our future defense capability for the purpose of conducting advanced R&D systematically from a mid-to-long term viewpoint.

The MOD publishes R&D Vision, and shares them with the defense industry, with the aim of increasing predictability for relevant companies, promoting prior investment, and realizing more effective and efficient research and development by maximally exploiting the investment. So far, the MOD published the "R&D Vision on the Future Fighter Aircraft" in 2010 and the "R&D Vision on Future Unmanned Equipment: Focusing on Unmanned Aerial Vehicle" in 2016.

In August 2019, the MOD published the "Research and Development (R&D) Vision—Toward Realization of Multi-Domain Defense Force and Beyond" in order to contribute to the realization of Multi-Domain Defense Force and to achieve technological innovation necessary for further strengthening defense capability. The MOD will continue to promote research and development according to the roadmap of the R&D Vision while reviewing the R&D Vision, as well as establishing and publishing visions on new themes considering the direction of policy, operational needs, changes in technological trends and others.

² Technology that can be used for both civilian and defense purposes

3 Initiatives for Research and Development

Technological progress is about to fundamentally change how security should be managed, and major states endeavor to develop weapons that leverage cutting-edge technologies. Against this backdrop, the MOD is promoting focused research in promising technical fields in order to ensure technological superiority in strategically important equipment and technology fields through focused investment in technologies in new domains, potentially game-changing cutting-edge technologies such as AI, and other important technologies. Specifically, for R&D of AI, the MOD included in the FY2020 budget the expense for research on radio image identification technology using AI. The MOD also has been making efforts to greatly shorten the research and development periods of Hyper Velocity Gliding Projectile Intended for the Defense of Remote Islands, UUVs for long-term operation, standoff electronic warfare aircraft and other equipment through flexible and active use of new methods for stage-by-stage R&D of equipment, such as block approach and modularization. Research projects on new technologies, including UAVs and lasers, will include demonstrations that enable users to imagine how these technologies will be used. For equipment which is expected to need medium-term development, the ministry will develop a concrete image of future equipment by collecting and fully analyzing information on their technical feasibility from private companies and other parties at an early stage. Furthermore, the MOD efficiently and effectively conducts research on UUVs, etc. using dual-use technologies based on the “Basic Policy on the Relocation of Governmental Organizations”³ along with developing a new test and evaluation facility “Iwakuni Test Evaluation Facility (provisional name)” in Iwakuni City. The facility is also available for use by the civilian sector, including local institutions for higher education and research institutes.

In addition, based on the MTDP, the MOD is working to actively leverage potentially dual-use advanced commercial technologies through such efforts as technology exchange



Standoff electronic warfare aircraft (conceptual drawing)

with relevant domestic and overseas entities, enhanced collaboration with relevant ministries and agencies, and use of the “Innovative Science & Technology Initiative for Security” program. In this regard, the MOD/SDF will strengthen and expand cooperation with countries who are making large-scale investments in game-changing technologies, such as the U.S. and special strategic partner countries, and promote mutually complementary international joint R&D. The MOD/SDF is also conducting studies to reinforce its structure aimed at early discovery of innovative, emerging technologies and fostering thereof by utilizing and creating think tanks that survey and analyze the latest foreign and domestic technological trends.

For F-X to succeed the F-2 fighter aircraft, a development project starts in FY2020, and “F-X Development Division” was established in the Acquisition, Technology and Logistics Agency (ATLA) in order to ensure efficient development. Furthermore, for improving technical reliability and reducing the development cost, the MOD is pursuing the best approach to realize Japan led development with international cooperation in sight.

Q See Part I, Chapter 3, Section 1 (Trends Concerning Military Science and Technology)

³ Decided at the Advisory Council on Vitalizing Towns, People and Jobs on March 22, 2016

Column Development of F-X

The Japan-led development of F-X to succeed the ASDF's F-2 fighter is scheduled to start in FY2020.

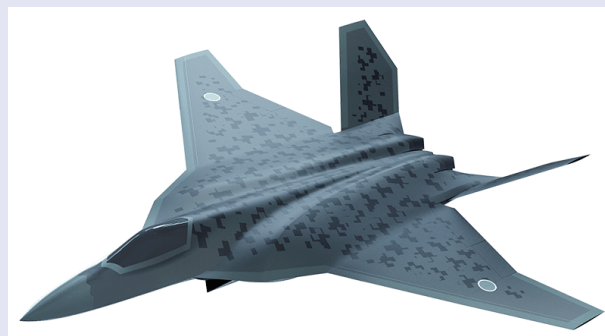
Over the years, Japan has built a fighter force structure comprising multiple types of fighter aircraft, as the MOD believes that deploying three types of fighter aircraft equipped with different combat systems makes it possible to effectively acquire and maintain air superiority. The MOD believes that it is necessary to ensure this structure into the future to acquire and maintain air superiority. While the F-2 is an important fighter that supports this fighter force structure, it is scheduled to start retiring around 2035. In order to maintain the structure by introducing the successor aircraft by that time, it is necessary to start developing F-X to succeed the F-2 now.

F-X will always have to exercise first-class capabilities against future threats. For the development of fighter aircraft with such capabilities, the MOD places priority on the following three objectives:

- (i) Acquiring freedom of modification and upgrade when needed
- (ii) Domestically accumulating in-depth technological knowledge and securing infrastructure for domestic maintenance and repairs with respect to aircraft systems and component systems.
- (iii) Reducing development cost and risks associated with development delays.

In order to achieve these objectives, Japan has been holding dialogues with the United States and the United Kingdom and it is scheduled to determine the basic framework, including partner countries, for international collaboration by the end of 2020.

Work processes associated with the development of F-X are wide-ranging, including a technical study on the aircraft sys-



F-X (Conceptual image)

tems, administrative work related to budget implementation, information security, management of intellectual property, and collaboration with foreign countries. To implement these processes efficiently, the “F-X Development Division” was established at the Acquisition, Technology & Logistics Agency Commissioner's Secretariat in April 2020, as a division dedicated to develop F-X in order to strengthen the organizational structure.

The development of F-X is an extremely large project compared to the MOD's previous aircraft development projects. In order to make this grand project a success, the MOD will proceed with the development while making maximum use of technological and human resources possessed by domestic companies by further strengthening collaboration between the companies.

4 Active Utilization of Civilian Technology

1 Strengthening Technology Exchange with Relevant Domestic and Overseas Entities and Collaboration with Relevant Ministries and Agencies

The ATLA and domestic research institutions, such as universities and independent administrative institutions, proactively engage in research collaborations and technological information exchanges in order to ensure that advanced civilian technology is incorporated and efficient

research and development is conducted.

At the same time, in order to create excellent defense equipment through the utilization of advanced technologies and effectively and efficiently conduct R&D, the MOD will ensure cross-sectoral and substantial coordination at the Council for Science, Technology and Innovation (CSTI)⁴ and other control tower meetings⁵ based on the Integrated Innovation Strategy 2019 (Cabinet Decision on June 21, 2019). The ministry also actively participates in

⁴ One of the important policy meetings aimed at the planning and general coordination of comprehensive and basic science & technology innovation policies under the leadership of the Prime Minister and ministers in charge of Science & Technology policy, at a level higher than individual ministries.

⁵ The IT Strategy Headquarters, the Intellectual Property Strategy Headquarters, the Headquarters for Healthcare Policy, the Space Development Strategy Headquarters, the Headquarters for Ocean Policy, and the Geospatial Information Utilization Promotion Committee in addition to the CSTI

the Council for Integrated Innovation Strategy⁶ established for its promotion in order to further enhance collaboration with relevant ministries and agencies, national research and development agencies, industry, universities, and other parties. Furthermore, the MOD will further strengthen human exchange with research institutes, etc. in order to understand trends of civilian technologies for complementary and synergistic improvement of technological capabilities.

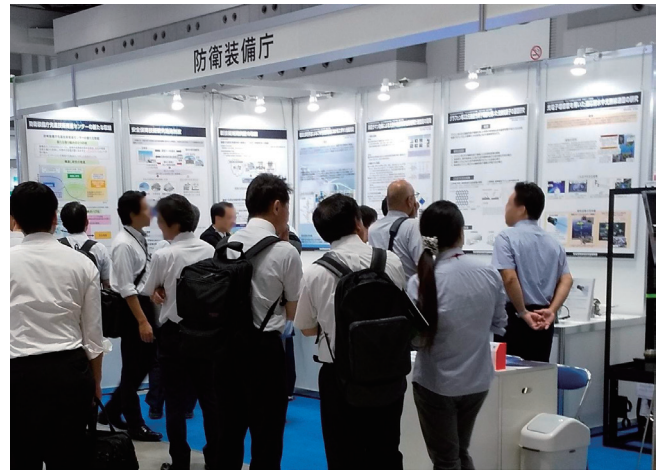
As international cooperative activities, the MOD will continue Japan-U.S. joint research and engineer exchanges, and continuously consider diverse possibilities through continued opinion exchange with other countries at various opportunities while closely observing their technology strategies, etc.

2 Innovative Science & Technology Initiative for Security and Its Utilization

In FY2015, the MOD launched a competitive research funding program called “Innovative Science & Technology Initiative for Security” to publicly seek and commission basic research on advanced civilian technologies, which are expected to contribute to future research and development in defense areas. A total of 74 research projects were awarded⁷ by FY2019, and this program was expanded in FY2017 in order to enable the awarding of larger-scale and longer-term research projects. The program will continue to run on a similar scale in FY2020 (total budget of about 9.5 billion yen).

In the basic research areas, free thinking of researchers leads to innovative and creative results. For this reason, it is necessary to assign maximum value to freedom of research when sponsoring research, so that, for example, researchers will be able to publish all of their research results to have a wide range of academic discussions. Hence, in this program, the MOD will neither restrict contractors’ publication of research results, nor designate research results as confidential, never providing any confidential data to researchers. In actuality, some research results have already been published through oral presentations, publications, etc.

Active utilization of advanced civilian technology through such programs is not only essential for securing the lives and peaceful livelihood of the Japanese people into the future, but is also beneficial for the development of Japan’s science, technology and innovation in non-defense areas as well, similar to how investment in innovative technology by the



At the Sensor Expo Japan 2019, exhibited the outcomes of the research utilizing the Innovative Science & Technology Initiative for Security (September 2019)

Defense Advanced Research Projects Agency (DARPA) of the United States facilitated advances in science and technology as a whole including civilian technology, such as the development of the Internet and GPS. From this perspective, the MOD intends to promote relevant measures and strives to raise awareness of this program that contributes to ensuring the freedom of study and its sound development.

Q See Fig. IV-2-2-2 (FY2019 Awarded Research Projects for the “Innovative Science & Technology Initiative for Security” Program)

⁶ Meeting of all ministers of state under the leadership of the Chief Cabinet Secretary for checking, sorting, and cross-sectoral and substantial coordination, and promotion of items that are included in the Integrated Innovation Strategy 2019 (Cabinet Decision on June 21, 2019) and that require coordination among the control towers related to innovation

⁷ For the research projects awarded under the Innovative Science & Technology Initiative for Security (a competitive research funding program), see the ATLA website (<https://www.mod.go.jp/atla/funding/kadai.html>).

Fig. IV-2-2-2 FY2019 Awarded Research Projects for the “Innovative Science & Technology Initiative for Security” Program

	Research Title	Brief Summary	Representative Institution for the Project
Large-scale research projects (Type S): Eight projects	Clarification of the mechanism for relaxing impact resistance using high-strength CNT* as a base material and creation of super-impact resistant materials	This research aims to: scholarly elucidate the mechanism of relaxing impact resistance through calculation analysis of a destruction-buffering phenomenon, measurement analysis of a destruction phenomenon at an experimental nano level and synthesis of composite CNT materials; and create next-generation, carbon-based super-impact resistant materials.	University of Tsukuba
	High throughput search for new solid-state lasers and characteristics by smart combinatorial lattice engineering technology	This research aims to establish a new R&D model which enables enhancement of the efficiency of exploration and prototype assessment through use of calculation-based estimation, combinatorial experimentation, and materials informatics to facilitate the search for laser materials and processes that are appropriate for lasing in specific wavelength bands.	SCT., Inc., Ltd.
	Neurofeedback psychotherapy: new methods for learning and regulating latent brain dynamics	This research aims to: develop AI ² technology that estimates latent brain dynamics to infer human's mental states and thereby achieve transferring skills from human to robots; clarify the relationship between external factors and latent brain dynamics underlying mental states and symptoms; furthermore, develop and optimize the neurofeedback method that controls the latent brain dynamics.	Advanced Telecommunications Research Institute International
	Basic studies on development of a marine soundscape monitoring system in coastal area	This research aims to: examine technology for categorizing a variety of sound sources under the sea on a real-time basis and technology for long-distance underwater communications; and thereby establish a method for making information on the distribution of sound sources obtained by multipoint observations visible and drawing it on a real-time basis.	Japan Fisheries Science and Technology Association
	Creation of highly-transparent and infrared reflectance members by controlling nanostructures	This research aims to: create resin with high durability and good reflection performance; and establish nano-layering technology for laminating multiple resin into hundreds of nanometer thickness layers in a highly precise thickness control with original layered layout design, thereby realizing components reflecting infrared rays over a wide range of bandwidths while keeping glass-like transparency.	Toray Industries, Inc.
	Development of light-weight, non-volatile secondary batteries with high-energy density for ships	This research aims to: establish technology for extending the life of secondary batteries by making use of nonvolatile substances at lower risk of leaking toxic substances outside of the batteries; and clarify the feasibility of the technology in applying it to energy storage systems which contribute to enhancing the performance and safety of ships.	Hitachi, Ltd.
	Research for miniaturization of large pulse power sources using high-performance SiC ³ power device	This research aims to conduct basic research on high-voltage switching devices using SiC with excellent characteristics in high dielectric breakdown field strength and high thermal conductivity to realize small and high-performance pulsed power supply.	Hitachi, Ltd.
Small-scale research projects (Type A/O): 13 projects	Basic research for enhancing the stability of small clock oscillators based on quantum interference	This research aims to enhance the stability of palm-sized, small clock oscillators with less power consumption so that the performance is equivalent to that of the clock oscillators on board positioning satellites.	Micromachine Center
	Detection of organophosphates by coordination polymers with extended pores	This research aims to find coordination polymers appropriate for detecting organophosphates. Spectral change of coordination polymers induced by exposure to organophosphates will be examined for three different spectroscopic methods. Each spectroscopic method will be validated as a new tool for detecting residual agricultural chemicals.	Osaka City University
	Materials research on gradient index lens	This research focuses on germanium-silicon mixed-crystals whose refractive index distribution is controllable, which are expected to dramatically improve the degree of freedom in designing infrared lenses, and aims to reveal optical constants, e.g., refractive indices, in order to obtain basic optical properties of the optical crystals; and establish a new method for crystal growth that control the radial-direction indices.	Japan Aerospace Exploration Agency (national research and development agency)
	Development of super environment resistant high strength oxide ceramic composite material	This research aims to: establish basic processes for mass production of continuous zirconia fibers and coating technology appropriate for continuous zirconia fibers; realize composites with excellent material properties; and clarify the potential for application to jet engines via evaluation of high-temperature properties in simulated actual environment.	National Institute for Materials Science (national research and development agency)
	Basic research for the adhesion mechanism of insect legs and implementation of the mechanism to movable bodies	This research aims to: clarify the principle of insect legs that allow insects to walk on walls or in water and the structures of such legs; and thereby realize movable bodies capable of steadily moving on and staying at the surfaces of objects regardless of environmental changes.	National Institute for Materials Science (national research and development agency)
	Research for situation-adaptive swarm control taking advantage of machine learning and physics-based swarm intelligence	This research aims to: establish a swarm control technology in which many agents are able to cooperatively and appropriately take action even if situations are changing from hour to hour; and conduct basic research for optimization to minimize the gap between a real environment and a simulation environment as well as for machine-learning technology.	Cluster Dynamics Inc.
	Research for underwater optical wireless communication technology that achieves BL product ⁴ of 1Gbps x 100m	This research aims to: measure impacts on communications caused by the characteristics of underwater light propagation, the fluctuation of seawater and other factors; and examine a underwater optical wireless communication system taking into consideration such influences, thereby demonstrating a long-distance, large-capacity undersea optical wireless communication system which is excellent in disturbance tolerance and capable of providing stable communications for a longer time.	Trimatiz Limited
	Basic research for innovative underwater electricity transmission making use of self-excited bidirectional wireless power supply	This research aims to: clarify a principle of magnetic resonance systems in which an optimal oscillation condition is formed and wireless power supply is bidirectionally conducted at a highly efficient manner; and verify application of the principle to control of battery power sources.	Maxell, Ltd.
	Clarification of a rotation mechanism of soft wheels that cells have and application of the mechanism to movable bodies	This research aims to: analyze rotation motions of a wheel-like structure in ameba cells, which was discovered recently; manufacture prototypes of soft robots imitating the structure and demonstrate them, thereby conducting basic research for imitation of living organisms having a soft, wheel-like structure.	Yamaguchi University
	Development of a system for assessing collision frequency targeting ship traffic flows in ship-congested sea areas	This research aims to: establish a method for estimating the frequencies of multi-ship encounters by approximating ship traffic flows in ship-congested sea areas through a continuum approach and introducing computational grids into data on the target sea; and establish a system contributing to measures for forecasting frequencies of ship collisions and preventing ships from collision accidents.	National Institute of Maritime, Port and Aviation Technology (national research and development agency)
	Clarification of an impact-mitigation mechanism of the dilatancy phenomenon by making use of ionic liquid	This research aims to: create transparent dilatant materials consisting of ionic liquid and particles whose inside structures are visible; clarify the principle of the dilatancy phenomenon, in which liquid changes to solid if force is externally applied; and conduct basic research for realizing safe and secure shock absorbers by taking advantage of the outstanding environmental stability of ionic liquid.	National Institute for Materials Science (national research and development agency)
	Basic research for surface modification of oxide semiconductor gas sensors	This research aims to: modify the surfaces of oxide semiconductor gas sensors; and thereby conduct basic research for adding new functions capable of detecting desired gases in a selective manner.	National Institute for Materials Science (national research and development agency)
	Research on high-value added casting processes for Ni-based heat resistant superalloys	This study conducts basic research on a high-value added casting process that could provide an improved oxidation resistance, by: examining a casting making use of platinum coated molds; and understanding the effect of interaction between coated materials and molten metal on the distribution of element concentration after casting.	National Institute for Materials Science (national research and development agency)
Basic research for nanostructured interacting surfaces of novel polymer coating film having ultra-low friction property	This research aims to conduct basic research for clarifying a mechanism that develops coefficients of specific ultra-low friction by: analyzing nanostructured surfaces of polymer films dispersed with an ultra-low volume of carbon fibers having novel carbon crystalline structures.	GSI Creos Corporation	

*1. CNT: Carbon NanoTube
 *2. AI: Artificial Intelligence
 *3. SiC: Silicon Carbide
 *4. BL product: Product of transmission speed (B: Bit-rate) by transmission distance (L: Length)