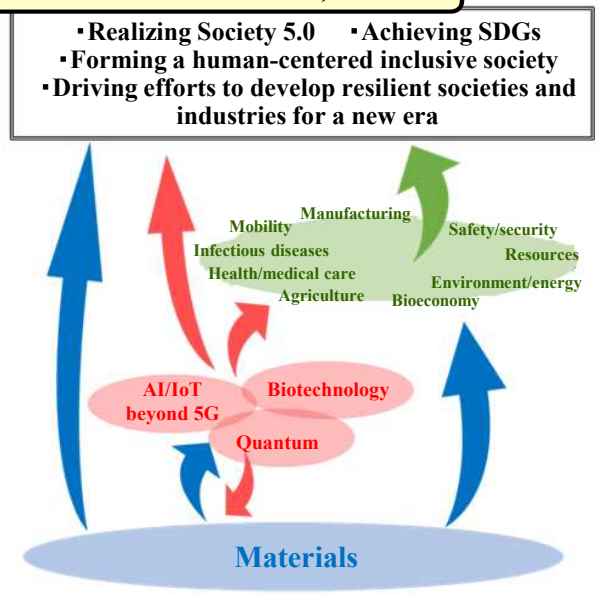
Toward Government Strategies for Enhancing Material Innovation Power (Report Compiled by the Strategy Preparation Meeting) 【Summary】

History of discussions

- ◆ In February 2020, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Economy, Trade and Industry (METI) started discussions on the strategies, establishing **a panel of experts for enhancing material innovation power**.
- ◆ In April 2020, MEXT and METI inaugurated a Preparation Meeting for Formulation of Strategies for Enhancing Material Innovation Power (chair: Hideo Ohno, President, Tohoku University) to accelerate discussions. In June 2020, after additional discussion based on the outbreak and expansion of the novel coronavirus disease, **"Toward Government Strategies for Enhancing Material Innovation Power (Report Compiled by the Strategy Preparation Meeting)"** was formulated and released.
- ◆ With a view to **the Integrated Innovation Strategy 2020** and **the Sixth Science and Technology Basic Plan**, this report presents basic stances toward **the formulation of government-wide strategies** for enhancing material innovation power and directions of future efforts.

1. Need for formulating strategies: Why are we taking up materials (including substances and devices) now?

- ○ Material innovations that support digital innovations are indispensable for realizing **Society 5.0**.
- ○ Material innovations are decisively important for **enhancing** artificial intelligence, biology, quantum and other **advanced technologies**, for achieving United Nations Sustainable Development Goals (SDGs) and for **resolving social challenges**, such as the realization of a safe, secure society. Materials R&D will also contribute to **addressing the novel coronavirus disease**.
- ○ Given U.S.-China trade disputes and the global novel coronavirus pandemic, Japan is required to innovate materials to **make its supply chains more resilient** from the viewpoint of economic security.
- ○ **Data-driven R&D** employing digital tools **has globally made progress**. Japan could exploit materials for leading global industries and innovations by strategically collecting and using good-quality materials data in Japanese industry, academia and government sectors.
- ○ The novel coronavirus disease is leading human values and behavior to change, creating **opportunities to accelerate the digital transformation of materials R&D and manufacturing fronts in industry, academia and government sectors.**
- ○ After making numerous achievements to produce material innovations, Japan has **great strengths**. The current situation in which materials are becoming even more important provides a great opportunity for Japan. On the other hand, Japan has faced the **risk of losing its strengths**.



Materials hold the key to industries and innovations

"Materials for All"
"Materials for Society"

Based on its strengths, Japan is urgently required to formulate government strategies for enhancing material innovation power (the power to create material innovations) under common visions for industry, academia and government sectors.

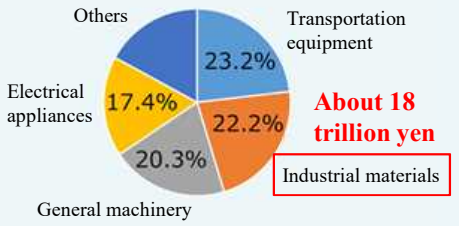
2. Current situation assessment – Strengths and risks of Japan's material innovation power

Viewpoint of industries

○ **Representing Japan's export-oriented industries are materials** and automobiles **(each accounting for more than 20% of total exports in value)**.

○ **There are numerous Japanese materials products that command global market shares above 50%.**

Breakdown of exports value (8.1 billion yen) in 2018



(Source) Ministry of Finance trade statistics

▲ **Japan's market shares are falling for storage batteries and other combination products.**

▲ **Growth** in materials-related **ventures is sluggish. The development of innovation ecosystems and the leadership in rulemaking are insufficient.**

▲ Future **raw material supply risks are growing.**

Viewpoint of basics

○ Japan's materials domain has greater international competitiveness than other domains, represented by **world-level research centers and high-quality researchers**.

○ Japan has **research facilities and equipment among the best in the world, as well as good-quality materials data**.

▲ Japanese materials-related **academic papers' share of the global total is falling in terms of quality and quantity**. At universities and other R&D fronts, **there is a shortage of young human resources**.

▲ **Japan has failed to fully utilize materials data** in industry, academia and government sectors.

Trends in Japan's share of global materials-related academic papers

	<2005~07>	<2015~17>
<Chemistry>		
Total number of papers:	8.4% (3rd)	→ 5.1% (4th)
Top 10% papers:	7.9% (3rd)	→ 3.6% (6th)
<Materials science>		
Total number of papers:	9.6% (3rd)	→ 4.0% (5th)
Top 10% papers:	7.5% (3rd)	→ 2.4% (9th)

(Source) National Institute of Science and Technology Policy

Viewpoint of fusion

○ **The materials domain sees Japanese firms' more proactive utilization of human resources and knowledge at Japanese universities** than other domains.

○ Numerous **Japan-developed materials**, such as lithium-ion batteries and blue light-emitting diodes, have **driven social innovations**.

▲ Japan has **lagged behind** major foreign countries **in exploring fusion and emerging fields**.

▲ Japan has **failed to fully put numerous findings into social practice**.

3. Future visions to be pursued

Citing three future visions to be pursued -- **"a country that would take advantage of materials for driving industries and demonstrating leadership in the world," "a country that would attract excellent researchers with attractive materials"** and **"a country that would contribute to the world by exploiting materials for creating new values and industries,"** the report proposes four initiatives to be promoted in the immediate future for a decade (to 2030).

4. Directions of future initiatives

(1) Developing data-based materials R&D platforms

○ **High-quality materials data** for **data-driven R&D** are decisively important for **improving the efficiency, speed and quality of materials R&D**.

○ Shared facilities among the most advanced in the world, **excellent human resources in industry, academia and government sectors, and mature industry-academia-government cooperation relations are among Japan's greatest strengths regarding materials**.

○ Japan is required to accelerate **the digitalization and the remote, smart and on-demand use** of overall materials R&D and production fronts.

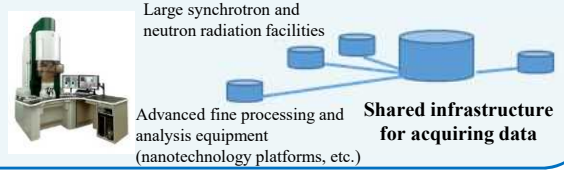
Based on its strengths, Japan should quickly develop **materials digital transformation (DX)** platforms for the whole of the country to **sustainably and effectively create, share, store, distribute and utilize data in industry, academia and government sectors**, should realize **the dominant improvement of productivity** in creating R&D achievements and should establish **Japan models for the effective utilization of data**.

Developing a common guideline for handling industry, academia and government materials data

- The development of common data structures (including data formats) and rules for export control regarding data distribution and rights regarding data should be considered.
- The development of databases for patents and other open information for AI learning should be promoted.

Developing or upgrading shared facilities allowing data to be created and utilized

- Shared cutting-edge facilities and equipment should be utilized to develop and enhance shared infrastructure for creating high-quality data and data structures, and to nurture and secure data experts and engineers.
- Next-generation research instruments should be developed, upgraded and introduced.



Promoting R&D projects to create and utilize data

- R&D projects to fuse data creation and utilization with theories, computation and tests should be implemented in key materials technology and social implementation domains, in which Japan has strengths.
- Smart laboratories to produce high-quality data should be promoted.

Developing materials data centers and networks

- Centers to accumulate and manage open materials data and data structures, and share closed ones, in a secure environment should be developed.
- These centers should cooperate and collaborate with existing data storage and control centers for technological domains featuring unique strengths.

Developing and standardizing common data formats for measurement and analysis instruments

- The development and standardization of common data formats for measurement and analysis data should be accelerated to promote the creation of high-quality data.
- Unified or integrated analysis on a platform should be enabled.

○ Japan should comprehensively promote the above specific initiatives to develop national materials DX platforms available for industry, academic and government materials researchers and users. This would **address R&D stagnation risks**.

○ R&D time and costs would be reduced, attractive R&D environments would be provided for young and other researchers, and industry-academia-government collaboration and fusion would be accelerated.

(2) Promoting important materials technology and social implementation fields strategically

○ **Technology domains Japan should promote truly** should be selected along with **social implementation domains (future picture) where these technology domains would bring about value**.

【Conceptual image of future **social implementation domains** (examples)】

Seven domains are proposed, including:

- **Realizing Eco-Society 5.0, driven through very low power consumption**
- **Transitioning effectively from a country dependent on overseas resources to a resources-producing country**
- **Realizing the world's most safe, resilient country**

【**Key technology domains** (examples)】

Ten domains are proposed, including:

- **Materials allowing high-level device functions to be performed** (power electronics devices, etc.)
- **Advanced materials recycling technologies** (Resources substitution technologies, resource consumption reduction technologies, etc.)
- **Ultimate functional materials** (Ultimate environment structural materials, lightweight high-strength materials, etc.)
- **Multi-material technologies** (Multi-material bonding technologies, three-dimensional lamination technologies, etc.)
- **Materials and device design/control technologies** (Surface/interface/grain boundary control technologies, new element function creation technologies, etc.)

【Promotion approaches】

○ **Leading projects** to realize the future picture should be promoted along with **the creation of R&D centers** to nurture key technologies.

○ For each domain, a system should be appropriately formed and promoted to step up industry-academia-government cooperation, interdisciplinary fusion, data creation and utilization, process technology enhancement, international cooperation, etc.

○ **Integrated projects** in which government agencies cooperate should be promoted for some technology and social implementation domains. Under governing boards, arrangements should be made for cooperation between **materials DX platforms** and **process innovation centers** to intensively support R&D agenda of data creation and utilization.

○ In addition to such **strategic research, emergent research** based on researchers' intrinsic motivation should be promoted to accumulate various excellent materials research findings.

(3) Developing material innovation ecosystems

○ Japan would **develop new innovation ecosystems** where various industry, academia and government stakeholders participate and fuse with each other to produce ventures and other new players.

○ Japan would further **pave the way for its companies to strategically win international markets**.

○ **Developing process innovation centers**

- Japan should develop centers that should have cutting-edge process foundries and analysis systems and accumulate, utilize and recycle industry, academia and government information and resources, including materials technologies and human resources.
- Centers should work based on the characteristics of regional industries.

○ Considering **how best to create ventures based on materials' characteristics** and to enhance universities' cooperation with the industry sector, and exploring and nurturing innovation seeds

○ Promoting the **international standardization** of materials **measurement methods and safety assessment benchmarks/approaches**

(4) Nurturing and securing human resources to support material innovation power

Industry, academia and government sectors should cooperate in implementing a comprehensive package for enhancing research capacity and supporting young researchers (as formulated by the CSTI) and in **nurturing and securing materials researchers and engineers sustainably**.

○ **Enhanced nurturing of human resources fusing materials and digital expertise**

- Nurturing data experts, materials researchers using data-driven R&D as a tool, and materials-related human resources with mathematical, data science, and AI expertise