Expert Group under the EU-Japan Enhanced Dialogue on Advanced Material Recommendation

Advanced materials are a key field driving industrial competitiveness in both Japan and Europe, while also serving as a foundation for enhancing economic resilience and open strategic autonomy. Based on this background, the European Commission and the Cabinet Office, Government of Japan announced the launch of the EU-Japan Enhanced Dialogue on Advanced Materials in April 2024. The EU-Japan Enhanced Dialogue on Advanced Materials aims to build on the success of EU-Japan collaboration in research and innovation in material sciences, by establishing a platform for the exchange of policy developments and identification of opportunities to pursue collaborative research in areas of mutual strategic interest.

As part of this dialogue, an expert group consisting of material science experts from both sides was established. The mandate of this expert group was to identify shared research and innovation needs of the EU and Japan in the field of advanced materials, providing technical input and recommendations for mutual benefit, fostering collaboration between the EU and Japan. This group took into account the Communication on Advanced Materials for Industrial Leadership by the European Commission, as well as Japan's Materials Innovation Strategy. The members of the expert group are listed in the annex at the end of this document.

This document presents recommendations of the expert group to the European Commission and the Cabinet Office based on the outcomes of their discussions. The views expressed herein reflect the independent perspectives of the expert group and do not represent the official positions of either the European Commission or the Cabinet Office. These recommendations are intended to be a strategic foundation for the planning and implementation of collaboration activities between the EU and Japan.

The expert group focused on five key domains: Construction, Energy, Mobility, Electronics, and Data-Driven R&D (incl. Autonomous Experimental Systems), addressing critical needs, complementarities, and opportunities for collaboration.

The European Commission and Cabinet Office, Government of Japan would like to express their sincere gratitude to the experts for their dedicated work within the group.

Summary of EU – Japan Expert Meeting on Advanced Materials

The EU-Japan expert meeting focused on the exploration of potential pathways in five key domains of advanced materials application, namely a) construction, b) energy, c) mobility, d) electronics, and e) data-driven R&D (autonomous experimental systems). The discussion addressed critical needs, complementarities, and opportunities for collaboration. The main points of the expert meetings are summarized as follows:

Construction

Critical needs: The development of long-lifespan sensor materials, eco-friendly construction materials, self-healing materials (i.e. concrete) and climate-resilient materials seem to be the most urgent needs, considered by both EU and Japan experts. The use of nanotechnology and smart coatings to enhance targeted properties (e.g., self-cleaning, hydrophobicity) of building materials is also under consideration. **Complementarities**: EU's strength in scientific research and Japan's expertise in practical applications may create synergies for material innovation, resource recycling, and cultural heritage preservation. **Collaboration opportunities**: Bio-based, smart functional materials and advanced manufacturing technologies for sustainable construction are key-elements for EU-Japan collaboration actions.

Energy

Critical needs: Materials for large-scale hydrogen storage (e.g., containers, adhesives), high-efficiency materials for batteries and PVs, and materials for CO_2 valorization have been proposed as immediate needs to be addressed. **Complementarities**: Japan's strong manufacturing capabilities in hydrogen and battery technologies can be coupled with EU's leadership in advanced energy materials. **Collaboration opportunities**: EU's and Japan's attributes may pave the way for the collaborative development of solid-state batteries, energy-harvesting materials, and hydrogen storage infrastructures.

Mobility

Critical needs: Lightweight materials and effective battery recycling technologies have been identified as key areas of research. Recyclability of automotive parts and materials for hydrogen powered vehicles are also considered as areas of research interest. **Complementarities**: EU's expertise in advanced polymeric and smart functional materials aligns with Japan's strengths in industrial applications and materials processing. **Collaboration opportunities**: EU and Japan may together invest in design and production of shape memory alloys, and generative AI for material design towards next generation mobility applications.

Electronics

Critical needs: Sustainable, high-performance materials for electronics, low-waste productions processes, and recycling of rare metals have been pinpointed as key research objectives by EU and Japan experts. High-purity silicon alternatives for next generation semiconductors are also highly considered. **Complementarities**: Japan leading in high-precision manufacturing and semiconductor materials, while EU excelling in material sustainability and process optimization, may facilitate joint innovations in the field of electronics. **Collaboration opportunities**: Materials for AI and quantum computing (e.g., SiC, 2DMs), recycling of rare metal components, and biocompatible materials for implants and medical devices.

Data-driven R&D (autonomous experimental systems)

Critical needs: Japan and EU concluded that the employment of AI for enhanced material discovery and design is a primary need, followed by the international standardization of respective datasets. **Complementarities**: Experimental automation is one of Japan's key-attributes, which can be successfully combined with EU's advanced computational material research. **Collaboration opportunities**: EU and Japan can collaborate in the areas of laboratory automation to accelerate research cycles, and AI-based predictive modeling towards material discovery.

Conclusions: EU-Japan first expert meeting highlighted strong potential for collaboration, identifying potential pathways for synergies in sustainable, high-performance materials. By leveraging their respective strengths, both areas can accelerate innovation in critical sectors such as construction, energy, mobility, electronics, and AI-driven material science, fostering advancements that address global challenges in sustainability and technology.

EU-Japan Dialogue on Advanced Materials for **Construction**

The EU-Japan expert meeting focused on the exploration of potential pathways in five key domains of advanced materials application, namely a) Construction, b) Energy, c) Mobility, d) Electronics, and e) Data-driven R&D (autonomous experimental systems). Regarding the field of **Construction**, the main points are summarized as follows:

Critical Needs for Advanced Materials

The development of long life – span sensor materials for continuous measuring of structure durability, eco-friendly materials (e.g., low-carbon cement, thermally efficient insulation), new coatings and composites for harsh environments, and self – healing materials (e.g., concrete) seem to be the most urgent needs considered by both EU and Japan experts.

The use of nanotechnology and smart coatings (e.g., self-cleaning, pollution reduction) to enhance targeted properties of building materials are also under consideration.

Both expert sides seem to converge also on the need for preservation of historical buildings, which dictates the study and development of innovative materials towards heritage conservation.

Circular economy principles are also seriously regarded in both Japan and EU expert groups. To employ or enhance the presence of these principles in the Construction sector, carbon – neutral materials are in scope, along with sustainable production coupled with digital transformation.

EU – Japan Complementarities

EU – Japan collaboration can be based on the research-driven scientific approaches employed by either or both EU or Japan for each issue, and the strength in practical applications and technology development presented by each. This synergy can foster innovations in material design and research, resource recycling and cultural heritage preservation.

In the frame of heritage conservation, EU and Japan can complement each other, since EU specialized in masonry heritage, while Japan focuses on wooden heritage. Both sides can cooperate by drawing on their respective experiences in the preservation of cultural heritage modern buildings such as reinforced concrete buildings.

Japan and EU can also complement each other in view of the material recycling and carbon-neutrality, which are critical aspects of the Construction sector. In particular, Japan possesses expertise in the efficient resource utilization, while EU focuses on sustainable material innovation.

EU – Japan Collaboration Opportunities

EU – Japan can collaborate on the design, development, and durability evaluation of smart functional materials for Construction (e.g., self-cleaning, shape-changing). Bio-based polymers and composites also create a common ground towards enhancing sustainability and reducing environmental footprint in this sector.

Advanced concrete techniques may also be bilaterally developed (e.g., self-repairing coatings), coupled with nanotechnology elements in overall building materials, which can lead to the creation of depolluting, self-cleaning, hydrophobic building components.

EU-Japan Collaboration on Advanced Materials for **Energy**

The EU-Japan expert meeting focused on the exploration of potential pathways in five key domains of advanced materials application, namely a) Construction, b) Energy, c) Mobility, d) Electronics, and e) Data-driven R&D (autonomous experimental systems). Regarding the field of **Energy**, the main points are summarized as follows:

Critical Needs for Advanced Materials

Materials for large-scale hydrogen storage (e.g., containers, adhesives), high-efficiency materials for batteries and PVs, and materials for CO_2 valorization have been proposed as immediate needs to be addressed. Next – generation battery materials are also considered a research domain that needs immediate focus. These materials can feed the development of either solid-state or sodium-ion type batteries for high-efficiency, and long-life storage. Currently, major requirements cover both mobility applications (e.g. electric vehicles) but also more-and-more energy storage applications (e.g. to guarantee grid-stability). On top of battery materials, the corresponding battery design & architecture is relevant for future applications.

Renewable energy production encompasses aspects such as the development of advanced composite materials and components (e.g., wind turbine blades) and highly efficient energy harvesting materials such as highly efficient perovskite solar cells. Recycling technologies for solar batteries and wind turbine blades are also important from a sustainability perspective. Regarding advanced energy materials, there is a need to develop AI designed energy materials (e.g. using ontologies to develop smart materials and semantic materials).

EU – Japan Complementarities

In the field of hydrogen technology, Japan possesses strong expertise in hydrogen storage and fuel cell technology. These attributes can be coupled with EU's leadership in advanced energy materials.

EU and Japan have expertise in lithium-based and beyond Lithium materials, and Japan developed significant expertise in solid-state battery research (e.g. based on solid oxides or sulfides), as well as advanced manufacturing and powder sintering processes. Development of single-atom nano catalysts for CO_2 valorisation into renewable energy products is also pursued in the EU.

Regarding materials for renewable energy applications, EU's strength in solar and wind energy harvesting materials complements Japan's advancements in efficiency, durability, and recycling.

EU – Japan Collaboration Opportunities

In view of an enhanced EU-Japan collaboration, joint efforts can be coordinated in the frame of infrastructure development for the realization of a hydrogen society for the stable production of clean hydrogen. In the field of batteries, collaborative research can be based on the development of solid-state batteries, Lithium-ion alternatives (e.g. sodium-ion) and efficient battery recycling processes.

Energy harvesting materials may also be a common topic, with special attention given to joint research on sintering processes for ceramic components, as well as the development of AI designed energy materials (e.g. use of ontologies for the development of semantic materials and catalysis). Recyclable, self-healing composites with dynamic covalent bonds are not only important for renewable energy wind turbine blades, but also for Mobility.

EU-Japan Collaboration on Advanced Materials for **Mobility**

The EU-Japan expert meeting focused on the exploration of potential pathways in five key domains of advanced materials application, namely a) Construction, b) Energy, c) Mobility, d) Electronics, and e) Data-driven R&D (autonomous experimental systems). Regarding the field of **Mobility**, the main points are summarized as follows:

Critical Needs for Advanced Materials

Both Japan and EU expert groups concluded that there is a pressing need to develop infrastructure materials that will pave the way towards the spread of hydrogen-powered vehicles. Battery recycling technologies with high-efficiency and low environmental footprint are also considered and ELV (End-of Life Vehicle) regulation requires innovation in plastics recycling technology.

Lightweight and high-performance materials are also highly regarded as means of boosting the Mobility sector. In detail, advanced composites, functionalized plastics, and shape-memory alloys can be used to reduce vehicle weight and increase efficiency.

Alternative and sustainable processes can also be considered towards realizing functional components for the Mobility sector. AM is an emerging technology, already established in the field of material research, and can be further expanded and coupled with design aspects (i.e., lightweighting) and post-treatment methods (e.g., plasma surface treatment, coatings). Rationalization of standard metallurgical processes is also an aspect to be developed in order to improve competitiveness and sustainability (e.g. process steps reduction, integration of alternative energy sources).

EU – Japan Complementarities

EU and Japan can complement each other in the field of automotive. EU leads in industrial applications of high-performance materials, while Japan specializes in advanced ceramics, semiconductors and functional materials integration.

Research and development of recycled parts and materials in battery and plastics is also highly regarded since it may foster the development of new materials and parts that do not downgrade in terms of quality following the recycling process.

EU – Japan Collaboration Opportunities

Japan and EU can collaborate in the frame of sustainable materials for vehicles by joint R&D actions for the recyclability of materials in battery and plastics but also the optimization of secondary aluminium and metals for structural components and the development of novel bio-based and biodegradable polymers by design in alternative to fossil-based plastics. The required performance of recycled parts needs also to be addressed in alignment with international standards.

AI-driven approached can also be bilaterally implemented in view of holistic component realization through optimized material selection, component design and generative design. This can also be coupled with mimetic materials that may enhance targeted component properties.

Materials design for additive manufacturing and emerging technologies for more efficient production (also including metallurgy) can also be considered for the introduction of lightweight components and shape-memory alloys, towards next-generation vehicles.

EU-Japan Collaboration on Advanced Materials for **Electronics**

The EU-Japan expert meeting focused on the exploration of potential pathways in five key domains of advanced materials application, namely a) Construction, b) Energy, c) Mobility, d) Electronics, and e) Data-driven R&D (autonomous experimental systems). Regarding the field of **Electronics**, the main points are summarized as follows:

Critical Needs for Advanced Materials

EU and Japan experts identified the components sustainability as a critical technology need. In detail, electronic technologies, components and materials need to be sustainable and maintain their performance (e.g., electrical, optical) following recycling processes.

Advanced materials research for flexible electronics, high-performance semiconductors connected to sustainable emerging technologies are also under consideration.

High-precision manufacturing and processes reliability are also considered key elements towards enhancing the advanced materials research for the Electronics sector. Low-cost, small-lot, high manufacturing technology that utilizes laser writing and printing methods is also considered.

EU-Japan Complementarities

In the case of semiconductors, Japan is leading in high-precision manufacturing, while EU specializes in design and fabrication. Japan is also expert in sensor-integrated materials, AI-driven material design, and quantum computing applications in materials science.

In the frame of circular economy and sustainable, EU contributes with driving eco-friendly electronics research, while Japan can contribute through its capacity in rare metal recovery and recycling.

Japan also leads in manufacturing process innovation and high-reliability materials, which aligns with the regulatory needs of the EU.

EU-Japan Collaboration Opportunities

The need for recycling of electronic components, while retaining their key functionality properties, is a common objective for both EU and Japan. The respective collaboration can be based on the establishment of key-performance requirements for recycled parts, coupled with international standardization of the recycling and reuse process.

Joint collaboration for sustainable semiconductor production exploiting emerging technologies is also a potential way to enhance the international standardization of the respective technology. Also, the deployment of semiconductors in the industry is of great importance.

A joint strategy to address the dependency on critical raw materials can also be implemented. By enhancing the recycling of critical raw materials (e.g., rare metals) many Electronic sector applications can benefit such as semiconductors, and battery components.

EU-Japan Collaboration on **Data-Driven Research & Development**

The EU-Japan expert meeting focused on the exploration of potential pathways in five key domains of advanced materials application, namely a) Construction, b) Energy, c) Mobility, d) Electronics, and e) Data-driven R&D (autonomous experimental systems). Regarding the field of **Data-driven R&D**, the main points are summarized as follows:

Critical Needs for Advanced Materials

Despite the fact that AI-based predictive modelling is already being implemented, there is a need to enhance data sets accuracy, normalization and standardization. Also, generative AI and deep learning need to be further expanded in terms of implementation in order to shorten time to market of innovative solutions.

Advanced materials research needs also the aid of data-driven approaches in view of more sustainable solutions. New materials need to fulfil environmental regulations along with the process technologies that create them.

To enhance the efficiency of autonomous experimental systems, there is a need for more delicate sensors and materials. In particular, very thin, light sensors are critical for operating robotic devices that in turn develop materials with high precision.

EU-Japan Complementarities

Experimental automation is one of Japan's key attributes, which can be successfully combined with EU's advanced computational-based material research.

Japan and EU can well complement each other in the synergy between Industry and Academia sectors. In fact, Japan demonstrates a strong industry-driven R&D approach in its employed research. On the other hand, the EU demonstrates an open data and collaborative academic research model, which can support this synergy.

EU-Japan Collaboration Opportunities

Japan and EU can collaborate in the field of AI/Data-driven materials discovery. In brief, both sides can complement each other in the development of machine learning-based material design and robots to accelerate discovery and testing.

Both sides can also cooperate towards creating standardized open data platforms. These will encompass normalization and integration of data sets, and reference data set for the different categories of materials.

EU and Japan can collaborate in the areas of laboratory automation to accelerate research cycles and hence innovation breakthroughs.

Annex: EU – Japan Expert Group on Advanced Materials

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Experts from EU:

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