MATERIALS 2030 MANIFESTO

Systemic Approach of Advanced Materials for Prosperity – A 2030 Perspective

7 February 2022

Vision

Materials, especially advanced materials, are the backbone and source of prosperity of an industrial society. In the context of the radical transformational changes of the 21st century, it is precisely these advanced materials that will play a decisive role.

Against this background, and based on a roundtable discussion with Mariya Gabriel, European Commissioner for Innovation, Research, Culture, Education and Youth, the undersigned are engaging with the widest possible group of stakeholders to strengthen our collaboration, scale the use of advanced materials, and work towards the following vision:

A strong European Materials ecosystem drives the green and digital transition as well as a sustainable inclusive European society through a systemic collaboration of upstream developers, downstream users and citizens and all stakeholders in between.

Mission

Reaching climate neutrality, circularity, healthy food-systems and sustainability in agriculture, transportation, construction, packaging, electronic appliances, as well as completing the transition to renewable energy sources are among the greatest challenges humanity is facing today. Scientific evidence shows that action on climate change must have an interconnected and systemic response and this is exactly where advanced materials can and must deliver solutions.[1] To achieve these solutions, Europe must maximise the sustainability features of new advanced materials and their visibility using advanced digital technologies. Sustainable advanced materials are a key driver for innovation, creating new opportunities on multiple dimensions and sectors. Our vision to enable the EU's twin green and digital transitions is anchored in good design principles combined with synergies between advanced materials, circularity, digital and industrial technologies. Europe must support the evolution of materials research underway, specifically in the following:

- **Uniting Digital and Material capacities and competences** – high performance computing, big data and AI revolutionise the digital modelling, simulation and screening of materials properties, materials development and production processes, unlocking the merge of computational and experimental material science, which in turn drives e.g. communication (5G and 6G) and edge computation. This will lead to new safe and sustainable products / systems by design, which utilise smart and advanced materials with targeted functionalities and physical properties.

[1] EC Group of Chief Scientific Advisors Scientific Opinion – A systemic approach to the energy transition in Europe (June 2021) and EC Group of Chief Scientific Advisors Scientific opinion – Adaptation to health effects of climate change in Europe (June 2020)

- **Combining technology push and market pull** – discovery-led research should be connected with developments along the value chain and scaling up processes led by start-ups and industry.

- **United EU** – all 27 Member States should contribute to the efforts towards levelling up advanced materials development whilst no one is left behind. A united approach is essential in order to benefit from Europe's strength and profits. In this process, harmonised standards and norms create common grounds and act as a global standard setter, which is crucial to strengthening Europe's sovereignty.

New forms of inclusive cooperation across the entire value chain will be necessary to overcome the current fragmentation of Europe's R&D&I production environment and the ever-increasing complexity of developing new materials and processes. **Working together is vital for success.** Boosting interdisciplinary activities to harvest smart and coherent development of advanced materials can tremendously benefit when all forces are aligned. These new forms of collaboration should bring together:

- Materials and life, social and computer scientists, designers, engineers, material producers, converters, recyclers and users (Business2Business and Business-2Clients), end-users and associations representing citizens, enterprises and society.

- Experts from the aforementioned sectors to work together closely from the **early concept stages all the way to product end-of-life scenarios** and across value-chains whilst considering the entire process.

We call for a systemic approach to develop the next generation solution-oriented advanced materials which will offer faster, scalable and efficient responses to the challenges and thus turn them into opportunities for Europe's society, economy and environment today and in the future. We recognize that "Blue sky research" and applied research both play an integral part in this approach.

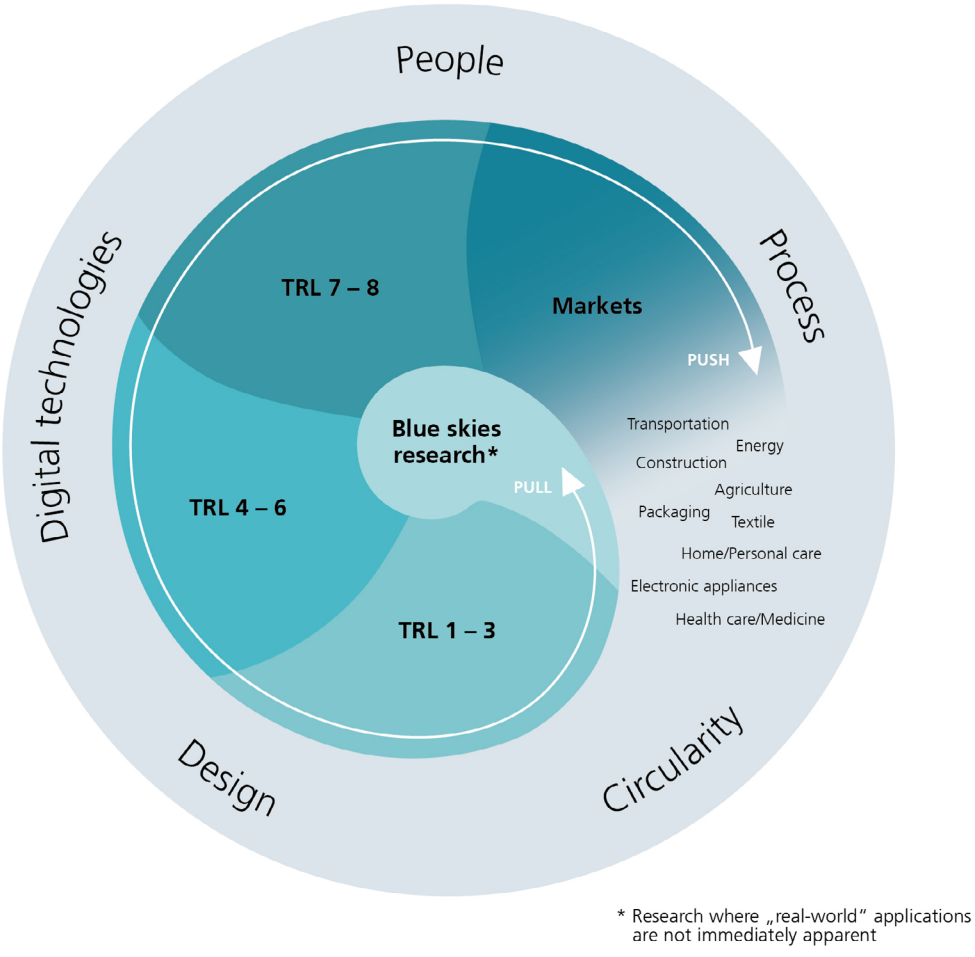

Figure 1 *– Systemic Approach to Sustainable Advanced Materials Solutions 2030*

Challenges and Opportunities

The Green Deal[2] and the Digital Decade[3] address societal challenges through establishing high-priority policies for Europe. 70% of all technical innovations are directly or indirectly attributed to advanced materials.[4] Yet, advanced materials often contribute to the dominant share of the cost of technologies. Therefore, smart advanced materials' developments are indispensable and provide game-changing solutions driving the twin green and digital transformation. We believe that dovetailing upstream R&D and downstream applications development is fundamental to operating at the necessary speed, scale, and efficiency, thus offering strong solution-driven value creation.

Historically Europe is the place of inventions and has created many of the greatest breakthroughs for humanity. Critical to R&I is discovery-led research as ultimately it feeds directly or indirectly into end-user applications and industry. In short, there is no applied research without fundamental research in the long-run. Hence, it is critical for Europe to create a world-wide unique ecosystem that connects discovery-led low TRL research with application-orientation and links it synergistically with industry, including small and medium-sized enterprises.

Herein we outline **four fundamental pillars** that generate the basis for the development of **advanced materials**. The following four fundamental pillars should be pivotal to the vision of scientists and materials designers when they innovate:

a) Safeguarding Europe's technology leadership;
b) Reducing the environmental footprint by using advanced materials;
c) Securing strategic autonomy; and,
d) Targeting advanced materials innovation markets.

a. Safeguarding Europe's Technology Leadership

The overarching challenge featured in this Manifesto is to preserve and leverage our technology leadership by reinforcing and focussing our advanced materials' R&I efforts through new, modern approaches. In a globalised and competitive innovation-driven environment, European industry needs to get access to more performant, cost-competitive and sustainable advanced materials, whilst mastering their integration into technologies for European strategic value chains. For instance, digital (e.g. microelectronics), energy and mobility technologies will steadily become more complex, surfacing the need to deliver on shorter and agile development cycles. This will require intensive efforts in advanced materials' development and new modern approaches to reduce cost-to-market and time-to-market loops. For instance, silicon is reaching its fundamental physical limits in semiconductor manufacturing. Demands for ever-smaller, faster integrated circuits have pushed the silicon's efficiency about as far as it can go. The need to develop new materials will become vital for the semiconductor industry. With Europe lagging behind (see Figure 2[5]) in various key industries, defending and further building our strategical position in "Advanced Materials" will be a core asset when combined with our leadership in manufacturing industry capacity and competency (automobile, aeronautics…).[6]

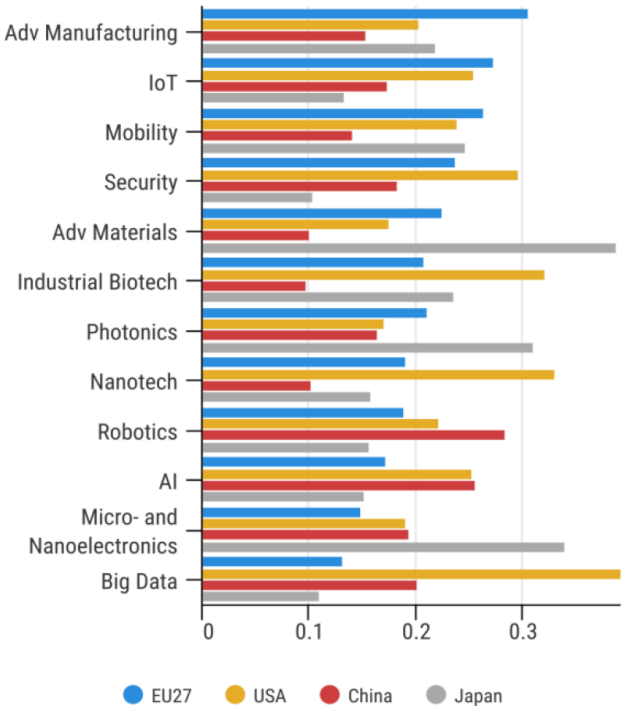

***Figure 2** – The graph provides a ranking of performance in key technologies in of technology generation, start-up creation and skills comparing EU with US, China and Japan[7] (source: EC SWD (2021) 352). This graph highlights key industries in which Europe is lagging behind, e.g., Security, Industrial Biotech, Nanotech, Robotics, AI, Micro-and Nanoelectronics, and Big Data. With Advanced Materials playing a pivotal role in all of these areas, Europe must build on its strength by creating suitable ecosystems that allow to overcome this weakness.*

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2 COM 2019/640
3 COM 2021/118
4 SETIS Magazine February 2015 - Materials for Energy
5 EC – SWD (2021) 352 final
6 SETIS Magazine February 2015 - Materials for Energy
7 Detailed methodology available under https://ati.ec.europa.eu/reports/eu-reports/advanced-technologies-industrymethodological-report

b. Reducing the Environmental Footprint by using Advanced Materials

Considering the triple challenge of satisfying an increasing demand for new materials and products, complying with the Green Deal ambitions (reducing net GHG emissions by 55% by 2030 and reaching climate neutrality by 2050), and ensuring responsible and ethical sourcing, will require new technological and smart approaches. Circular strategies using less (scarce) materials, new production technologies, re-use & re-purposing and dismantling, recycling & refining, will have to be developed and combined with modern digital technologies such as tracking and tracing or digital twins that are integrated in advanced materials solutions. Overall, enhanced circularity and responsible practices will not only provide a good solution to reduce the environmental impact generated by materials, but also boost economic growth and reduce local dependencies on imported raw materials.

c. Securing Strategic Autonomy

The COVID-19 pandemic impacted on Europe's value chains and demonstrated their fragility and weaknesses. It highlighted Europe's dependency on other regions and stressed the urgent need to accelerate the twin transition and to address the vulnerability of our value chains. Furthermore, the OECD[8] estimates that the global consumption of resources will grow by up to 40% by 2040 and close to 90% by 2060[9]. Since most of the key raw materials needed by European industry are produced outside Europe, European industry experiences a rapidly increasing global competition when securing access.

This competition puts Europe's strategic autonomy at risk in key technologies for the green and digital transitions, advanced materials and critical raw materials (CRMs). Although, the European Union has been implementing a new policy on CRMs (namely metals and minerals) to mitigate this risk, an action plan addressing the strategic importance of advanced materials for strategic value chains is still missing. Here again, the above-mentioned circular strategies in conjunction with new digital tracking and tracing technologies is the way forward towards creating and implementing digital solutions, e.g. a digital passport.

d. Targeting advanced materials innovation markets

Innovation markets are the industrial perspective to address societal needs and challenges. Value chains addressing these markets have to be sustainable and use collaborative business models, which will stimulate an open engagement by industry. The primary focus is therefore to develop new materials, processes and products based on people's needs and expectations in line with scientific evidence that suggests putting people at the centre of the transition [10]. To achieve societal buy-in in the broadest sense R&D&I must contribute to meeting citizens' expectations for smart, safe and sustainable materials and products that are fully compliant with a circular economy. A people-centric innovation will impact existing markets and create new ones including new business models, with huge opportunities for Europe to take the lead. The development of new advanced materials for prosperity must start with a long-term vision as regards the value chain, contributions to society, and ethics.

Reaching the Vision with Advanced Materials

Advanced materials are key to providing solutions for many applications that address the challenges mentioned above. A selection of system critical applications is summarised in Figure 3. Their classification follows nine selected innovation markets, presents "market pull", and considers the European Green Deal and other policies that demand a change of the materials portfolios and the creation of new value-chains. These applications are listed according to a colour-code in order to demonstrate that there is a significant share of similarity in the materials' challenges across the nine selected markets thus inspiring the community by way of connectivity and potential collaboration and further exchanges.

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8 OECD, Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences (OECD Publishing, Paris), 2019. https://doi.org/10.1787/9789264307452-en

9 Compared to 2017 values

10 EC Group of Chief Scientific Advisors Scientific Opinion – A systemic approach to the energy transition in Europe (June 2021)

To show the relevancy, each application is tagged according to the value it generates through the following four categories:

i) circularity of materials,
ii) zero pollution and non-harmful,
iii) transparency, and,
iv) traceability and climate contribution.

These four categories are at the heart of environmental policies, and broadly discussed in the sustainability arenas. Two significant crosscutting enablers are coming to the fore, as depicted in Figure 3: new technologies and innovations (green band) and new polices (blue band). In order to unlock the full potential of advanced materials, digital innovations must be applied within materials development, as well as creating a harmonised understanding on how to measure, quantify and benchmark the sustainability performance of new materials.

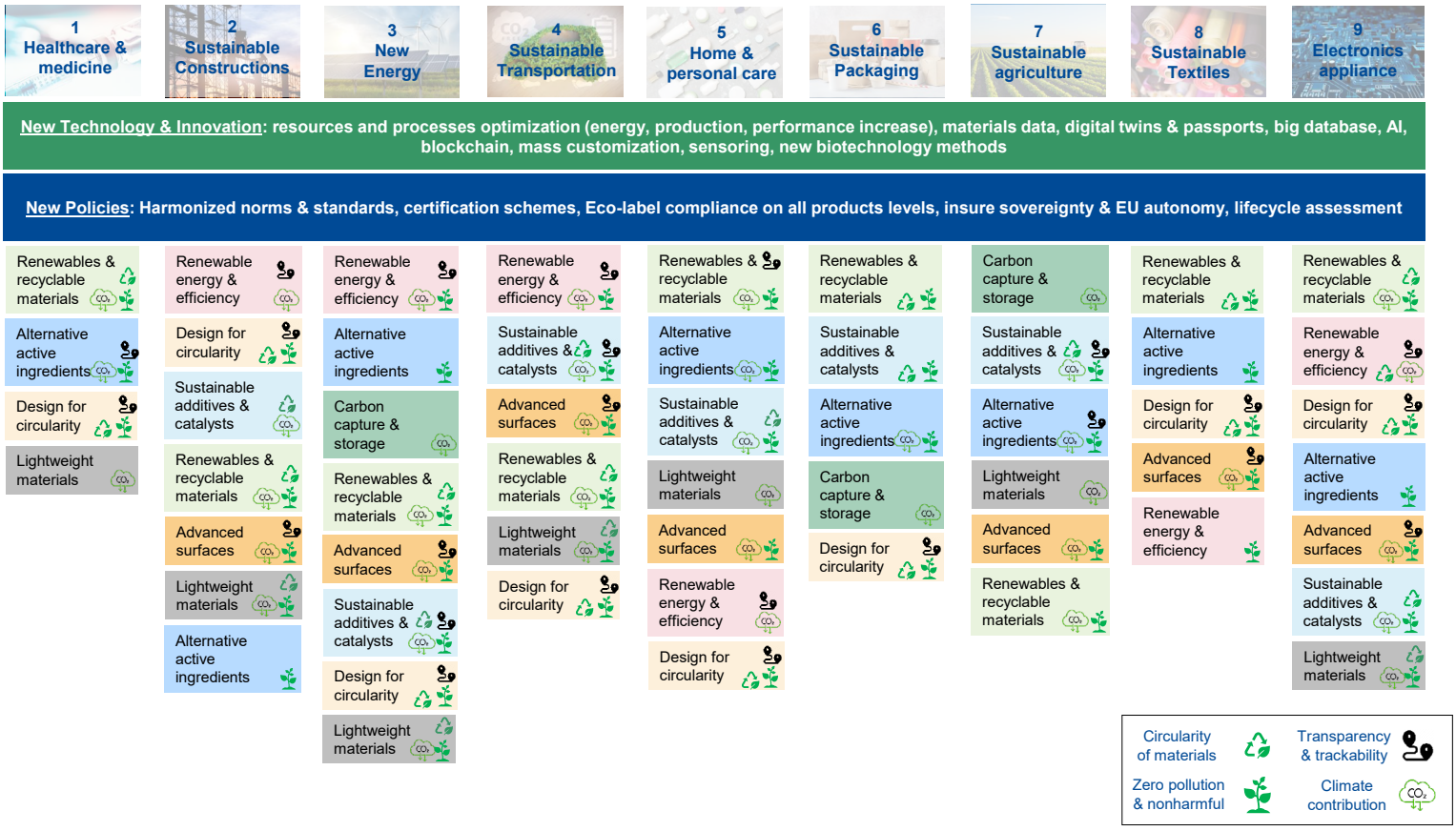

Figure 3 *– Advanced materials applications and cross-cutting challenges as relevant enablers for nine selected markets. This figure is not to be understood as an exhaustive research roadmap.*

Figure 4 gives a more detailed portrait of Figure 3 by providing more specific information on the material specifications level and their related innovation needs. Here the colour-code profoundly demonstrates the significant needs and challenges each cluster has as well as their similarities.

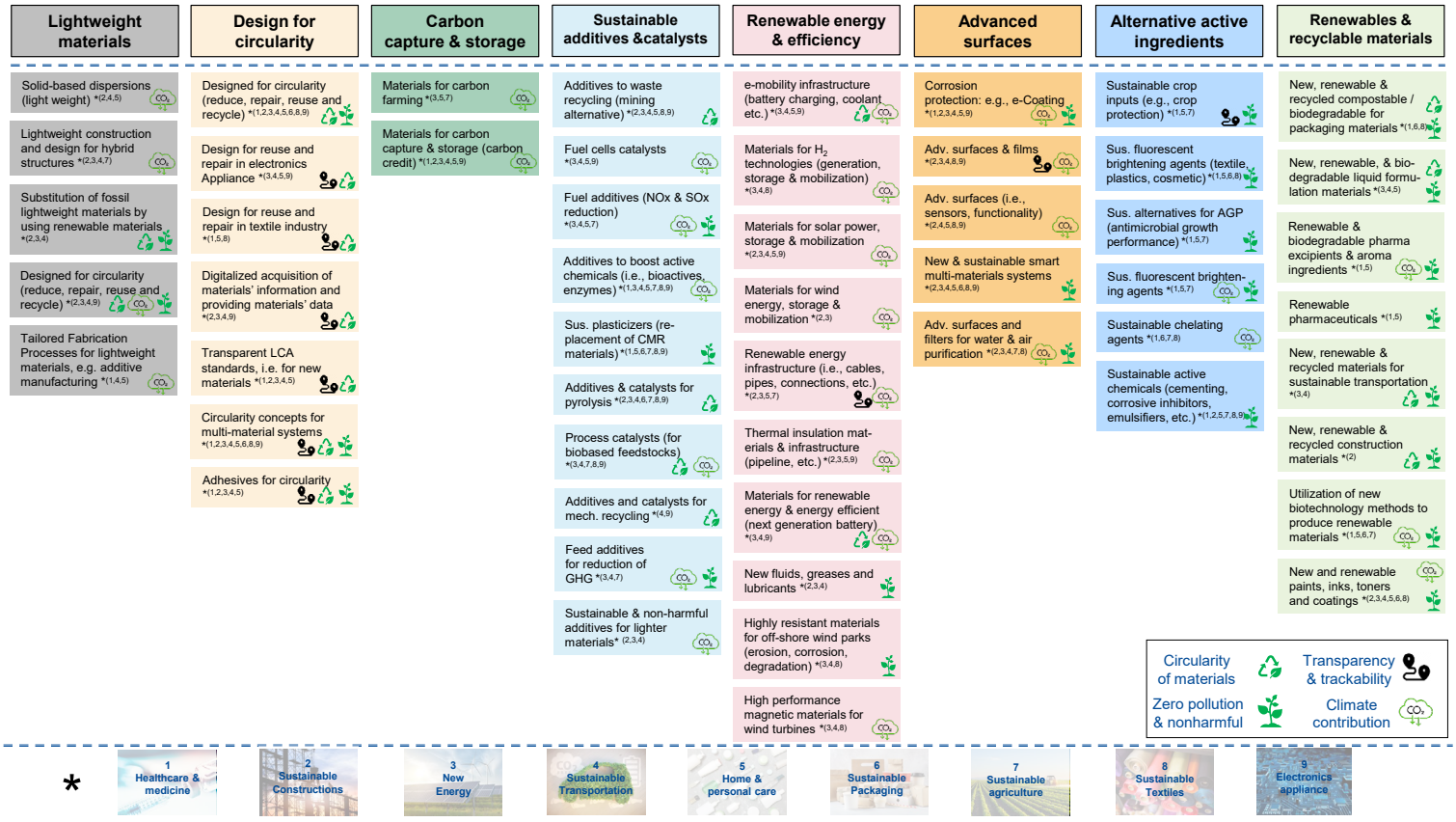

Figure 4 *– Secondary matrix detailing the materials specifications and the related innovations needs in the aforementioned material clusters in Figure 3. This figure is not intended to be exhaustive.*

Modern approaches for design and development of advanced materials will contribute to building the EU's leadership in this field, improving the EU's strategic autonomy, and providing more sustainable and responsible solutions to today and tomorrow's challenges. Therefore, we need:

- **game changers in the initial concept, process and end result of advanced materials development,** where not only citizens see and acknowledge how new technologies change their daily life to the better, but also where environmental policies can come to life, while bearing in mind environmental boundaries. It should go hand in hand with an economical boost and the creation of new job prospects. Technological game changers should offer a clear potential and pathway for speed, scale and efficiency, delivering together on environmental, societal and economic values.

- **action to enable innovation in the broad field of advanced materials' development,** e.g. digital twin, big data (see green banner in Figure 3) enabling research across the spectrum and bridging from blue skies and discovery-led to applied research. Furthermore, the innovation markets have to be prioritised with regard to low hanging fruits and long-term impacts to the overarching transformation goals. We acknowledge that there is already a series of identified policy initiatives ongoing in many of the innovation markets, but the role of advanced materials should be emphasized.

- **the European Commission, Member States, industry and research, and citizens to leverage collaboratively the interplay between advanced materials,** digital technologies and circular strategies in order to accelerate the development, and reducing the cost and complexity of developing tomorrow's solutions for the twin green and digital transitions. It will avoid fragmentation amongst the different players in the Horizon EU programme, therefore enabling the EU to implement the green and digital transitions.

Call for action

To establish the modern approaches for design and development of advanced materials comprehensively in the short term and to move forward regarding the needs mentioned above, we propose the following three actions:

1) **Establish a consolidated strategic roadmap in the short term (3-4 months);**

2) **Launch an agile and inclusive governance of advanced materials at EU level (6 months);**

3) **Translate the consolidated roadmap into a novel European strategic agenda for a sustainable society through the next generation of advanced materials (12 months).**

Signatories

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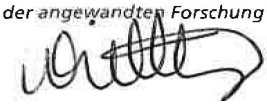

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