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Advanced Materials Strategy: fostering EU industrial leadership

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INTRODUCTION

This report[1] delves into the interconnectedness between policy objectives and research and innovation challenges, and its importance in outlining a framework approach fostering innovation, strengthening its industrial base and supporting the green and digital transitions, with a specific focus on advanced materials.

The European Union (EU) is a leader in advocating for sustainability as a core value. Ever since the Treaty of the European Union (TEU) entered into force in 1992, it was made clear that the then established EU internal market should "(…) work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment."[2]

Ever since then, the EU has been an international front-runner in seeking multilateral agreements towards a carbon-free and sustainable economic model. While prioritizing growth and job creation, it has managed to reduce its total greenhouse gas emissions by 24% during this period, as reported by the European Environment Agency.[3]

While being one of the main international players standing for the commitments made under the Paris Agreement[4], the EU created its own momentum to take the global lead on the green agenda. It was back in 2019 that the EU has embarked on a transformative journey encapsulated by a set of flagship initiatives, among which the European Green Deal (Green Deal) is considered to be the new 'conceptual hat' enabling EU's twin green and digital transition.

Why advanced materials?

Advanced materials are central to achieving the EU's green and digital goals as they underpin innovation in many critical sectors such as, among others, energy, healthcare, manufacturing and mobility. Besides enabling the development of greener technologies, these materials help reducing the EU's dependency on imports of raw materials, fostering industrial resilience and ensuring strategic autonomy in key supply chains. Due to its vital importance in the EU's pathway towards climate neutrality, advanced materials became an area where numerous political, legislative and strategic initiatives have been taken by the EU, making it difficult to the main target audiences to follow the process. Therefore, this document is specifically designed to provide to the whole research and innovation value chain engaged in European funding – from researchers to industry – a clear overview of key documents and initiatives, as well as its rationale, ambition and impact.

[1] This report was produced with the invaluable support of Sofiia Zhuchyk, EU Funding Team Trainee.

[2] Official Journal of the European Union. "Consolidated version of the Treaty of the European Union". 2012 (https://eur-lex.europa.eu/resource.html?uri=cellar:2bf140bf-a3f8-4ab2-b506-fd71826e6da6.0023.02/DOC_1&format=PDF).

[3] European Environment Agency. "Major drop in EU's greenhouse gas emissions in 2019, official data confirms". 2021 (https://www.eea.europa.eu/highlights/major-drop-in-eus-greenhouse).

[4] European Commission. "EU agrees to COP27 compromise to keep Paris Agreement alive and protect those most vulnerable to climate change." 2022 (https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7064). The Paris Agreement was the name given to an international treaty on climate change, adopted during the United Nations Climate Change Conference (COP21) held in Paris in 2015, which had as main objective to limit global warming to 1.5-2.0 °C compared to pre-industrial levels.

ROOTING WIDER POLICY OBJECTIVES

The EU has adopted in 2019 the European Green Deal (Green Deal) as its new growth strategy[5], tackling climate and environmental-related challenges. This climate-oriented agenda is designed to transform the EU into an efficient, sustainable and competitive economy. Its main objective is to develop and help Member States implementing changes that would help Europe become the world's first climate-neutral continent by 2050, a goal that should be achieved by stimulating the development of a circular economy, improving people's health and quality of life, and transforming climate and environmental challenges into opportunities across all EU sectors and policies, ensuring a fair and inclusive green transition. In order make it happen, the Green Deal established eight priority areas where targeted policy initiatives and meaningful action should take place: clean energy, climate action, construction and renovation, sustainable industry, sustainable mobility, pollution reduction, biodiversity and sustainable agricultural policy.

The Green Deal came to be later complemented by its 'industrial' counterpart: the Green Deal Industrial Plan (GDIP), which was officially launched in February 2023. The GDIP is an ambitious initiative of the EC to transform its industrial sector into a more sustainable and competitive force in the global market, and to enable EU's lead in the net-zero industrial age through an EU-wide approach deemed at increasing "technological development, manufacturing production and installation of net-zero products and energy supply" in the years to come. At this level, two particular initiatives worth being highlighted: the Net-Zero Industry Act (NZIA) and the Critical Raw Materials Act (CRMA), both presented by the EC on the 16th of March 2023.

The NZIA consists of a simplified regulatory framework aimed at scaling up the industrial manufacturing of technologies considered to be critical in meeting EU's climate neutrality goals (e.g. batteries, carbon capture, electrolysers, heat pumps, solar panels, windmills, among others), bringing the overall strategic net-zero technologies manufacturing capacity to at least 40% of the continent needs by 2030. The act also sets a specific target for carbon capture and storage with an annual capacity of at least 50 million tons of CO2 to be achieved by 2030. Furthermore, a relevant aspect is the establishment of the Net-Zero Europe Platform, working as a central focal point to facilitate the exchange of information and support investment initiatives across the EU.

Acting as a complementary piece of legislation, the CRMA points to the urgent need to reduce dependency and increase the resilience of important mineral raw materials supply chains in the EU, through diversifying sources and securing supply routes. The act defines a clear framework to decrease EU reliance on external suppliers and mitigate environmental impacts associated with raw material extraction and processing, by identifying key materials and establishing measures to promote recycling, resource efficiency and responsible sourcing. Additionally, the legislation establishes specific targets, both for domestic production capabilities across the strategic raw material supply chain, and for broadening the EU's sources of supply by 2030: at least 10% of the EU's annual consumption of strategic raw materials should be mined in the EU by 2030, while by the same date a minimum of 40% of the annual consumption should be enriched within the continent, and 15% of the EU annual consumption should be processed for reuse. It also determines that no more than 65% of the EU's annual consumption of enriched strategic raw materials would be sourced from a single third country.

The existence of a strong regulatory environment is just a key part of the conductive conditions needed to achieve climate neutrality. One of the other key aspects is to further enhance research and innovation efforts to reduce raw material usage and to develop credible alternative and substitute materials, where advanced materials emerge as a critical technology. This concern was first addressed in early 2022 with the Materials 2030 Manifesto, which brought about a new vision to develop a strong European materials ecosystem propelling the green and

[5] European Commission. "Communication and roadmap on the European Green Deal." 2019 (https://commission.europa.eu/document/download/954374b5-2f9a-48f3-882c-07d9afddbabd_en).

digital evolution of industry in the continent, setting ambitious goals centred around responsible sourcing, resource efficiency and innovation in materials technology. The realisation such vision was, however, hampered by a few Research & Development & Innovation (R&D&I) challenges of the European industry and advanced materials sector, to be discussed in the next section.

MINDING INDUSTRIAL RESEARCH AND INNOVATION CHALLENGES

The report "Industrial R&D&I investments and market analysis in advanced materials" was published in late 2023 by the Directorate-General for Research and Innovation of the EC with the objective of providing a comprehensive assessment of the industrial R&D&I investments in the field of advanced materials. The assessment was developed in line with the "Materials 2030 Roadmap", to understand the current trends, challenges, and opportunities in the development of advanced materials in Europe. This section will focus on the challenges highlighted in both documents.

1. Fragmentation of the R&I

Lack of a common and coordinated materials strategy among EU member states which in turn has the effect on reducing the competitiveness and innovation potential of the union

2. Private investment does not meet growing needs

EU capital markets do not sufficiently support the volume and diversity of financing needed by companies in strategic sectors, requiring special funding programs and enhanced networking opportunities to support young and innovative players in the EU market.

3. Lack of advancement in material efficiency and circularity

Transformation and development of new, cutting-edge materials takes decades (using conventional techniques) and demands large capital investments due to the rising speed and complexity of innovation. While EU's rate of circular material use is less than 12%, the digitalization of research and development might accelerate the process of finding new materials.

4. Gap between innovative research and practical application.

The excellent research produced in advanced materials collides with the low level of practical adoption in the EU industry, making it difficult to make real progress in this sector. Strengthening EU's leadership in innovation lies on reinforcing the capacity of industrial actors to internalise the results of cutting-edge science.

5. Lack of possibilities for experimenting and testing

For business to properly adopt these technologies, it is critical to provide them with appropriate infrastructure to test and refine their implementation before bringing them to market. Considering that it is not viable for the industry to acquire such facilities, it is of the utmost importance to grant them with easy access to these.

6. Limited capabilities level

Europe faces a significant skills gap in the advanced materials sector, marked by a shortage of specialized talent in areas such as nanotechnology, biomaterials, engineering, mathematics and smart materials, which hinders innovation and competitiveness in this field. As this skills gap has doubled in recent years, significant effort is needed at this level to increase innovation capacity and produce innovative materials

7. Incoherent standardization among member states

The inexistence of harmonized among EU Member States in the advanced materials sector hampers cross-border collaboration, market integration and the development of a unified regulatory framework, thus impeding the sector's growth and innovation potential in a dynamic market.

8. Resource optimization and decarbonization of material processing

Europe's advanced materials sector faces challenges in resource optimization and decarbonization of material processing, necessitating more efficient use of resources and adoption of sustainable practices to reduce environmental impact, enhance industry sustainability and foster green transition in the EU.

9. Holistic approach in business models for the sustainable circular economy

It is necessary to establish industry-ready processes in relevant value chains in Europe, integrating lifecycle thinking, promoting resource efficiency and encouraging product reuse and recycling to minimize waste and environmental impact while maximizing economic and social benefits. Creating production processes that are resilient and flexible will be essential to duly manage the increasing variety of raw material sources with dynamic properties.

10. New methods and technology for processing materials

Europe's advanced materials sector still needs to make further progress on new methods and technologies for processing materials (e.g. additive manufacturing, nanotechnology or advanced recycling techniques) to enhance efficiency, reduce environmental impact, and enable the creation of innovative, high-performance materials. Innovative and unconventional materials, including lightweight or other modified structural materials require different techniques or an evolution of the existing ones.

11. Effective product customization

The integration of advanced materials with digital and manufacturing technologies (e.g. artificial intelligence, machine learning, robotics, etc.) is essential for constructing adaptable, decentralized and productive processes. This will allow the creation of tailored materials and components that meet specific customer requirements, enhance performance, and provide competitive advantages through personalized solutions.

THE STRATEGY: A FRAMEWORK APPROACH ENABLING EU'S TOP GAME ON ADVANCED MATERIALS

The landscape of advanced materials is marked by rapid innovation and complex challenges, as highlighted in both the "Industrial R&D&I Investments and Market Analysis in Advanced Materials" and the "Materials 2030 Roadmap". These reports underscore the significant hurdles that the research and innovation community in Europe faces in this dynamic field. This section focuses on explaining how the European Commission communication "Advanced Materials for Industrial Leadership" offers a strategic framework designed to overcome the challenges outlined in the text above . The strategic framework is organized in five pillars to overcome existing barriers and accelerate progress. These pillars aim to set common goals to encourage the usage of advanced materials, promote manufacturing, increase capital investment, and foster a collaborative approach. Each of them serves as a strategic lever to align sectoral objectives, stimulate innovation, and attract investment in advanced materials.

- Pillar 1: European research and innovation on advanced materials: a launchpad for the twin transition, EU resilience, and open strategic autonomy

It focuses on the importance of creating a solid base for autonomy by reducing the dependence on critical raw materials through innovative substitutes. The initiative is a part of its twin transition and supports global competitiveness. This pillar aims to address challenges 1, 7, 8 and 10, while strengthening Europe's strategic autonomy.

- Pillar 2: Fast track from lab to fab

It outlines the next steps aimed at creating a suitable digital environment for R&I simplifying the transition of innovations from lab testing to large-scale manufacturing. The Commission has proposed two key initiatives. The first one focused on the establishment of the European Digital Infrastructure Consortium that will be built on

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already existing frameworks and will help shorten the time of products coming to the market. The second one, the Single-Entry Catalogue for Technology Infrastructures, that will be launched to raise awareness about available services and financial tools. This pillar tackles challenges 4 and 5.

- Pillar 3: Increasing capital investment and access to finance

It aims to involve both the public and private sectors and facilitate the development of advanced materials industries by providing sufficient funding sources. It has become a target point for the following initiatives such as the co-programmed public-private partnership 'Innovative Materials for EU' under Horizon Europe, Innovation Fund, Strategic Technologies for Europe Platform, European Innovation Council (EIC) Work Programme, InvestEU, Capital Markets Union, and Global Gateway. All these programmes will open new opportunities for businesses to scale up the advanced materials sector, helping to overcome challenges 2 and 6.

- Pillar 4: Fostering the production and use of advanced materials

This pillar is aimed at encouraging the creation and use of cutting-edge materials in a variety of industries and building high-skilled profiles that will know how to uptake advanced materials in the member states. Within this pillar the EC launched several initiatives under this pillar, being the `Big Buyers Working Together` project - a project whose goal is to promote public procurement markets that are the key to the circular economy and increase collaboration between public buyers - the first of these. This pillar also brings about a strong focus on monitoring, as a critical success factor to assess the impact of Europe's twin transition. Moreover, under pillar 4 it was launched the Advanced Materials Academy, which targets the enhancement of skills and knowledge in advanced materials through targeted education and training initiatives. The initiatives foreseen under this pillar face the gaps outlined in the challenges 3, 7, 9, and 11.

- Pillar 5: Overall governance framework

Finally, Pillar 5 focuses on enhancing collaboration and coordination among stakeholders to accelerate the innovation and deployment of advanced materials. This includes fostering public-private partnerships, promoting international cooperation, and integrating efforts across various sectors to ensure a cohesive approach towards research, development, and commercialization. Under this pillar, the EC proposed to establish a Technology Council for Advanced Materials, composed of the Member States ministries responsible for research and innovation in the country. This coalition will set up a coordinated roadmap on how to secure a common set of actions within the European advanced materials ecosystem. The initiatives under this last pillar will tackle the challenges 1, 3 and 7.

Europe's strategic pillars for advanced materials not only tackle present difficulties but also lay the road for future innovation and sustainable growth. Optimization of resources, digitalization, investment, skills – all this is a key to strengthening the EU position on a global scale.

CONCLUDING REMARKS

This report argues that the Advanced Materials for Industrial Leadership strategy sets up a comprehensive framework to tackling the research and innovation challenges outlined in both the "Industrial R&D&I Investments and Market Analysis in Advanced Materials" report and in the Materials 2030 Roadmap. By addressing critical gaps in funding, infrastructure, and collaboration, the strategy ensures that the necessary resources and support are available for groundbreaking advancements in the field. The emphasis on fostering strong public-private partnerships and enhancing international cooperation exemplifies a concerted effort to streamline innovation processes and reduce fragmentation within the industry.

Furthermore, the focus on integrating efforts across various sectors ensures a multidisciplinary approach to research and development, which is essential for addressing the complex and interconnected challenges of advanced materials. By promoting a cohesive framework for collaboration, the strategy not only accelerates the

pace of innovation but also enhances the capacity to bring new materials to market more efficiently. This holistic approach is crucial for maintaining industrial competitiveness and driving sustainable economic growth.

Regarding the main takeaways for its target groups, this report aims to help industry and the research and innovation community align their work with the current policy priorities and funding opportunities, while allowing the anticipation of future trends and new associated lines of research/innovation, and the identification of collaboration opportunities. Additionally, it enables the community to redefine their research and innovation focus to those areas benefiting from political and financial support.

As an EU member state, Luxembourg stands to significantly benefit from the new Advanced Materials for Industrial Leadership strategy. This framework initiative will continue to foster international cooperation, enhance industrial competitiveness and provide greater opportunities for European funding within the country. These developments are expected to boost companies' market performance, leading to more cost-effective and sustainable manufacturing techniques. To date, the country's organizations have already been awarded 38 grant projects in 42 participations under Horizon 2020 / Horizon on materials technology topics[6]. This success has resulted in a net EU contribution of 11.8 million EUR, structured as follows: 47% for public research organizations, 35% for private for-profit organizations, 10% for higher education institutions and 9% for other public organizations.

In a nutshell, the Advanced Materials Strategy paves the way for significant progress, ultimately contributing to a stronger, more innovative industrial landscape in Europe through the promotion of strategic investments, coordinated efforts and a commitment to fostering collaboration.

[6] Under the material technology topics, we have considered grants awarded on the following areas: "Advanced Materials", "New materials and their production and transformation (including steel)", "Industrial Materials Technologies", "Nanosciences, Nanotechnologies, Materials and New Production Technologies", "Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices" and "Climate action, environment, resource efficiency and raw materials".

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