POSITION PAPER

Advanced Materials as a Strategic Domain for AI²

Why Portugal should select advanced materials as a national priority for research and innovation

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Recommendation

AI² should designate Advanced Materials as a strategic domain for the 2026-2030 cycle, with the proposed title: Advanced Materials for Societal Well-being, Sovereignty, Sustainability and Industrial Competitiveness.

This strategic domain is essential to develop materials that improve everyday life, strengthen resource independence, support environmental responsibility and reinforce Portugal's economic competitiveness. By prioritising Advanced Materials, AI² can turn research and innovation into functional, sustainable and socially valuable solutions for a more resilient and prosperous future.

Executive Summary

Portugal should not treat Advanced Materials as a narrow scientific speciality competing for space against energy, digital, health, sea, defence, construction, mobility, or manufacturing where it will serve circular economy. Instead, it must be recognized as the fundamental enabling platform beneath all these priorities, driving the transition toward a true circular economy across every sector. They are also inherently dual-use: the same capabilities in structural smart materials, coatings, membranes, sensors, batteries, semiconductors, composites, additive manufacturing and circular feedstocks strengthen both Portugal's defence and security resilience and its economic and societal competitiveness.

The strategic question for AI² is therefore not whether Advanced Materials deserve a separate priority because the research base is strong. It is whether Portugal can build the material capabilities needed to control the value chains that matter for future competitiveness.

The answer is yes, but only if the domain is selected now and organised as a mission-oriented, lab-to-fab (including scale-up, integration and qualification) and knowledge-valorisation programme that links fundamental science, technology infrastructures, companies, start-ups, pilot lines, industrial demonstrators, public procurement and European funding, with the explicit goal of turning research excellence into industrial deployment.

Vision

By 2031, Portugal should be recognised in Europe as a sovereign, sustainable and dual-use advanced-materials innovation hub: able to discover, design, scale up, qualify and deploy materials that strengthen national security, upgrade industry, accelerate the green and digital transitions, support civil preparedness, and improve societal resilience.

A Portuguese Advanced Materials strategic domain would serve five national objectives

- **Economic upgrading and transformation:** move Portuguese industry from component assembly and low-margin manufacturing toward design, formulation, processing, qualification, IP and high-value production in materials-intensive value chains, thereby increasing the competitiveness of the Portuguese secondary.
- **Industrial sovereignty and security of supply:** reduce external dependencies in batteries, microelectronics, polymers, composites, construction materials, smart materials for health critical raw-material substitution, recycling and strategic stockpiles (including gas and oil).
- **Green, digital and societal transition:** provide the materials basis for energy storage, renewables, electrification, electronics, wearables, flexible and conformable integrated systems, circularity, low-carbon construction, health technologies and resilient manufacturing.
- **Defence, security and civil resilience:** develop advanced materials for protection, sensing, communications, energy autonomy, drones and counter-drone systems, space assets, maritime security, emergency preparedness and resilient infrastructure, while ensuring civilian spillovers.
- **European leverage:** position Portugal early in the EU Advanced Materials Act, Horizon Europe partnerships, defence-readiness instruments, the Technology Council for Advanced Materials and future European industrial instruments, while aligning national priorities with the latest SAM/SAPEA advice on autonomy, safety, sustainability, prosperity, standards, data spaces, industrial uptake and advanced-materials scale-up.

The attached Portuguese contribution on advanced-material dependencies already shows that Portugal is not starting from zero: batteries, semiconductors, paper electronics, additive manufacturing, circular plastics, green public procurement, interface institutions and Iberian cooperation are already in motion. What is missing is an integrated national framework able to map dependencies, set priorities, finance scale-up and connect the scientific base to industrial deployment, thereby generating economic value, strategic resilience and societal well-being. AI² has a duty to create that framework.

1. Why this is urgent now: alignment with Europe and with AI²

The European policy window is unusually favourable. In February 2024, the European Commission launched the Communication on Advanced Materials for Industrial Leadership, defining advanced materials as intentionally designed and engineered materials with innovative properties and functionalities. The Communication identifies advanced materials as crucial for European competitiveness, resilience and open strategic autonomy, with demand expected to rise in the coming years. Its first target application areas are energy, mobility, construction and electronics, exactly the sectors where Portugal has scientific assets, industrial needs and strategic vulnerabilities. The scale of the challenge is stark: EU industrial R&D investment in advanced materials stood at €19.8 billion in 2020, less than half of the United States' €50.3 billion, and the EU ranks only fifth globally in industry-owned patents in this field, behind the US, Japan, South Korea and China.

The strategic relevance of Advanced Materials is also recognised by the European Research Council, which has established a dedicated evaluation panel for Materials Engineering as a key area for breakthrough developments. This gives greater visibility to frontier materials research and signals Europe's view that materials breakthroughs are foundational for innovation in energy, electronics, healthcare, mobility, defence and sustainability.

The Commission is now preparing an Advanced Materials Act, scheduled for 2026. According to the Commission, the Act is intended to create a legal framework for the design, development and deployment of advanced materials, address barriers in research and innovation ecosystems, streamline regulatory processes, enhance production capacity, promote circularity and reduce dependencies on critical raw materials. This is not a marginal research topic it is becoming part of the EU competitiveness and sovereignty architecture. "Europe's challenge is no longer only to invent advanced materials, but to scale, finance, regulate and deploy them efficiently" (FAME Workshop 2026). This is precisely the gap that a Portuguese Advanced Materials strategic domain should help close.

A second European policy window reinforces this argument. The EU's Defence Readiness 2030 agenda calls for closing capability gaps, strengthening industrial production, reducing dependencies, building strategic reserves and supporting dual-use infrastructure. Advanced Materials sit at the intersection of these agendas: they are needed for defence readiness, but also for batteries, chips, clean industry, healthcare, mobility, the ocean economy and construction.

Portugal also has a timely national policy window. AI² was created as the new Agency for Research and Innovation through the integration of the competences of FCT and ANI. Its mission and institutional design are precisely suited to domains that require continuity from fundamental research to industrial innovation. The Government has stated that AI² will support strategic and articulated financing across the complete development cycle, from university and research-centre knowledge to application in industry, and that its future contract-programme will define strategic investment domains with stability and clear targets over a five-year horizon.

Advanced Materials are an ideal first test of this new model because the field cannot be managed effectively by separated science and innovation instruments. It requires groundbreaking science, characterisation, modelling, standards, process engineering, pilot-scale production, qualification with industrial users, regulatory confidence and market creation. Public funding must de-risk the early stages, while scale-up will also require private co-investment, corporate R&D, venture capital and industrial finance capable of supporting demonstrators, pilot lines, start-ups and first-of-a-kind production. This is exactly where the historical gap between research excellence and industrial uptake has been most costly.

The cost of delay is strategic. Other Member States will use the Advanced Materials Act to organise national platforms, shape European calls, attract pilots and influence standards. If Portugal does not define its priority before these instruments mature, it will be a participant in other countries' agendas rather than a co-designer of the European value chains in which it has genuine assets.

A Portuguese Advanced Materials strategic domain would allow AI² to enter the European strategy with a credible offer: a country with critical mineral relevance, strong potential in forest and ocean resources, abundant renewable energy, excellence in materials science and nanotechnology, competitive manufacturing sectors, ports and energy infrastructure, and a growing capacity to connect research to industry through interface institutions. Portugal's Atlantic position further extends European advanced-materials value chains towards Brazil, South America and Africa, linking complementary resource bases, industrial capabilities and innovation ecosystems. That combination is rare and should be presented as a national advantage.

Policy thesis
AI² should make Advanced Materials a strategic domain because it is the point where Portuguese science, industrial policy, European sovereignty and the green/digital transitions converge.

2. The Portuguese case: existing assets and dependency-reduction measures

Portugal has a broad and diversified materials sector, spanning traditional industries and emerging strategic technologies. Materials-intensive manufacturing activities represent a substantial part of Portugal's industrial base. Based on an aggregation of PORDATA/INE gross value added data for textiles and leather, wood and paper, chemicals, rubber and plastics, non-metallic minerals, and basic and fabricated metals, these activities can be estimated to account for 6–7% of national GDP, before considering wider downstream impacts in construction, mobility, energy, electronics, packaging and health. The sector is deeply embedded in Portugal's industrial base and supports export-oriented clusters in automotive components, packaging, construction materials, aeronautics, electronics, energy systems, health technologies, tooling and consumer goods. This industrial base provides real absorption capacity for advanced materials, but that capacity must be activated through challenge-led programmes, demonstrators, pilot-line access, company engagement and market validation.

Portugal also has distinctive scientific, technological and industrial assets in materials. National strengths in cork, ceramics, natural fibres, polymers, advanced textiles, composites, sustainable construction materials and functional materials coexist with internationally recognised research centres, universities, collaborative laboratories and interface institutions. These capabilities give Portugal the basis to move beyond commodity production and subcontracting towards higher-value activities such as materials design, advanced processing, functionalisation, recycling, testing, certification, demonstrators and scale-up.

At the same time, the sector faces strategic vulnerabilities. Portugal remains dependent on imported raw materials, specialised chemicals, advanced components, semiconductor materials and certain high-performance materials and, critically, the oil and gas inputs that still support energy supply, industrial heat, transport and many petrochemical feedstocks. These dependencies create exposure to supply disruptions, price volatility and geopolitical risk across energy storage, electronics, emerging materials and devices beyond silicon, defence and security, construction, health, mobility and the circular economy. Advanced Materials should therefore be understood not only as an industrial opportunity, but as a national capability for resilience, sovereignty and competitiveness.

Portugal already has a portfolio of advanced-material initiatives that respond directly to these dependency risks and can be mobilised for both defence/security and civilian competitiveness. The problem is that they remain dispersed. AI² can transform this portfolio into an integrated national capability, with dual-use spillovers deliberately designed from the start. The examples below are illustrative rather than exhaustive; they show how existing Portuguese initiatives across several value chains already provide a strong basis for a coherent national Advanced Materials domain within AI².

The Sustainable Battery Value Chain is Portugal's most explicit response to strategic dependency. The New Generation Storage agenda covers the battery life cycle from component manufacturing to end-of-life recycling. Industrial investment is concentrated in Sines, Estarreja Boticas, and Braga, with projects linked to battery manufacturing, lithium refining, battery second life, battery recycling, and cathode active materials. The strategic opportunity is to move from importing finished battery components to hosting higher-value stages of the value chain: materials processing, electrodes, electrolytes, separators, recycling, testing and certification.

Microelectronics creates a materials challenge as much as a digital one. The National Semiconductor Strategy and the Microelectronics Agenda aim to position Portugal in chip design, advanced packaging, back-end processes, talent development and semiconductor recycling. This ambition should also exploit emerging materials and process strategies where Portuguese research institutions are already internationally competitive, including modular and ready-to-use technology platforms such as R2U Technologies. This cannot succeed without materials capabilities in substrates, thin films, dielectrics, thermal management, encapsulation and packaging, interconnects, sensors, power electronics and reliability testing.

Additive manufacturing strengthens supply-chain resilience by enabling local production of complex parts, new alloys, polymers, composites and functionally graded materials. The INOV.AM project is therefore relevant not only to industrial productivity, but also to strategic repair, rapid prototyping and emergency production in security-sensitive contexts.

Circularity and recycling are central to material sovereignty. The Sustainable Plastics agenda and the Recicla+ project show how domestic secondary-material streams can reduce exposure to imported virgin inputs and price volatility. This logic should be extended to composites, critical metals, batteries, electronic waste, construction materials, textiles and bio-based polymers, combining circular economy with advanced characterisation and processing.

Demand-side instruments already exist. The ECO360 strategy and green public procurement can stimulate early markets for bio-based, recycled-content and low-carbon materials. This is especially important because many

advanced materials fail not in science but in market uptake: firms cannot scale without reference customers, standards and predictable demand.

Portugal has interface institutions capable of bridging science and industry. CeNTI (nanotechnology, smart materials, biobased materials, batteries), CITEVE (textile-based technical materials), VG CoLAB (energy storage), PIEP (polymers), AlmaScience (smart cellulose-based materials), and other relevant CTI and CoLAB, together with research institutes such as CICECO, INL and i3N, should be connected with key enabling companies, sectoral clusters, and pilot, demonstration and qualification infrastructures in a National Advanced Materials Translation Network. This network would reduce technology-transfer risk from low-TRL research to industrial deployment by supporting demonstrators, pilot lines, qualification protocols, industrial training, start-ups and market-ready solutions.

Finally, Portugal is already moving toward ecosystem coordination and Iberian cooperation. The Battery Cluster Portugal and the 2024 Joint Declaration with Spain on value-chain assessment in semiconductors, electric vehicles and sustainable lithium processing show that dependency reduction must be addressed through cross-border platforms. An AI² strategic domain would give Portugal the governance capacity to act coherently in these partnerships and to position itself within European value chains linked to the future Advanced Materials Act.

Gap to close

Portugal has initiatives, assets and clear industrial needs. It now requires a single Advanced Materials framework that maps strategic dependencies, links each vulnerability to targeted research, scale-up and deployment instruments, and explicitly addresses the two transitions where investment and industrial capacity most often fail: from laboratory to pilot scale, and from pilot scale to first industrial production, including access to shared pilot infrastructures and qualification-grade testing environments.

3. Proposed scope for an AI² Advanced Materials strategic domain

The domain should be broad enough to serve multiple sectors but focused enough to produce measurable industrial outcomes. The following seven missions are proposed.

- **Materials for energy storage and conversion.** Electrodes, electrolytes, separators, membranes, catalysts, hydrogen materials, battery recycling, post-lithium and solid-state concepts, thermal storage and materials for grid flexibility, as well as for decentralized power harvesting. This mission would support batteries, renewables, green fuels and industrial decarbonisation.
- **Materials for electronics, sensors and advanced packaging.** Substrates, thin films, dielectrics, conductive and semiconducting materials, thermal-management materials, 2D materials, photonics, printed electronics, flexible and hybrid electronics, smart packaging, neuromorphic devices, spintronics, quantum-enabling materials and reliability testing. This mission would connect the semiconductor strategy to Portugal's materials base.
- **Circular, bio-based and low-carbon materials.** Recycled polymers, composites, cellulose and bio-based materials, ceramics, cement and construction materials, textiles, packaging, critical-material substitution and circular feedstocks, guided by Safe and Sustainable by Design, Circular by Design, eco-design and life-cycle assessment principles. This mission should support repair, reuse, recycling, low-carbon processes and alignment with future European Advanced Materials instruments.
- **Materials for resilient manufacturing.** Additive manufacturing feedstocks, high-performance polymers, lightweight alloys, coatings, surface engineering, moulds, tooling and digital process control. This mission would support Portugal's manufacturing exporters and reduce dependence on fragile supply chains.
- **Materials for defence, security and civil resilience**. Protective and lightweight materials, coatings, signature-management materials, thermal-management materials, sensors, secure communications materials, maritime and space materials, repair materials and materials for critical infrastructure resilience, with strict alignment to European and Portuguese ethical, legal and export-control frameworks.
- **Materials intelligence and digital infrastructure.** AI-driven materials innovation, including AI-assisted discovery and design optimisation, autonomous experimentation, high-throughput synthesis and characterisation, process optimisation and control, manufacturing digital twins, predictive maintenance, accelerated qualification and certification, computational materials science, a national materials data space, FAIR data, metrology and interoperability with European materials platforms.
- **Scale-up, standards, metrology and demonstrators.** Pilot lines, shared testbeds, certification, industrial demonstrators, public procurement pilots, regulatory support and support for intellectual property, spin-offs and venture finance. This mission should prevent the common failure mode in which excellent papers do not become qualified, standardised and trusted products.

The central implementation challenge is scale-up. Advanced materials often fail after research succeeds, at two critical transitions: from laboratory to pilot and demonstration, and from demonstration to first industrial production

and market uptake. These stages require pilot lines, application-development facilities, validation with industrial users and patient capital, long-term capital suited to capital-intensive deep-tech scale-up. AI² should therefore design the domain not only around research missions, but also around the financial and infrastructural instruments needed to cross these two "valleys of death". The Commission itself acknowledges that developing advanced materials with conventional methods can take between 10 and 30 years, highlighting the need for dedicated instruments to accelerate translation from research to deployment.

These missions should be supported by four horizontal instruments

- **A National Advanced Materials Doctoral and Skills Programme:** integrating materials science, chemistry, physics, engineering, data science, manufacturing, regulation, entrepreneurship and industrial placements.
- **A Lab-to-Fab Voucher and Pilot-Line Fund:** providing access to characterisation, prototyping, scale-up, safety testing and qualification facilities, supported by a systematic national mapping of available infrastructure and clear, SME-oriented access rules.
- **A Materials Dependency and Security Observatory**: mapping imported materials, criticalities in the supply chains, reusing and recycling potential, substitution options, technology readiness, stockpiling needs, export-control risks and industrial demand.
- **A Green, Strategic and Dual-Use Procurement Sandbox**: allowing public entities, public-sector companies and qualified security/civil-protection users to act as early adopters of advanced materials, including recycled-content, low-carbon and resilience-enhancing materials.

AI² should also support Portuguese participation in international standardisation and metrology platforms, including OECD, ISO, and EURAMET processes, so that Portugal has an active voice in shaping the rules for advanced materials rather than merely adopting them.

Intellectual property should also be managed as a scale-up condition rather than an administrative afterthought. AI²-funded pilot-line and demonstrator projects should include early freedom-to-operate analysis, access to IP and regulatory expertise, and trusted IP-sharing environments that allow universities, SMEs, start-ups and large companies to collaborate without exposing core proprietary assets.

The domain should not be designed as a conventional call for academic projects. It should operate as a coherent national program and a portfolio in which companies, start-ups, interface centres, investors, public procurers and regulators help co-design challenges, demonstrators and adoption pathways. AI² should require consortia to show the pathway from material capability to product function, user need, proof of concept, pilot-line access, qualification, IP or start-up route, and industrial or public-procurement adoption. The domain should, therefore, be a public-private co-investment platform, where public instruments de-risk discovery and scale-up while companies and investors provide matching resources, infrastructure, market validation and routes to scale.

Success should be measured across four stages: scientific capacity, including publications, doctoral training and international leadership; valorisation capacity, including patents, licences, start-ups, spin-offs and industry-sponsored R&D; industrial deployment, including pilot-line use, demonstrators, certification, procurement pilots and private co-investment; and strategic impact, including European funding attracted, qualified materials entering supply chains, reduced dependency risks and new industrial capabilities.

Proposed title
Advanced Materials for Societal Well-being, Sovereignty, Sustainability and Industrial Competitiveness.

4. Governance model and decision requested

This proposal is not simply a request to recognise a disciplinary priority. It is a proposal to establish a national operating system for strategic technologies. Advanced Materials should become the domain through which Portugal coordinates materials science, technology infrastructures, industrial policy, circularity, public procurement and European positioning.

AI² should create a Portuguese Advanced Materials Council with permanent core representation from research institutions and interface centres, alongside companies, the Portuguese Materials Society, clusters, public procurers, regulators, regions and relevant ministries, including economy, science, environment, energy, defence and internal administration. The Council should also be designed as Portugal's interface with the EU Technology Council for Advanced Materials, ensuring alignment between national priorities and European-level strategic coordination. The Council should not become another advisory body; it should have an operational coordination function, maintaining the dependency map, setting annual mission priorities, monitoring KPIs, validating demonstrators, involving companies and public procurers, and aligning national and European funding opportunities.

The first year should produce three deliverables:

- **A national dependency and capability map,** building on existing European methodologies such as the Raw Materials Information System (RMIS) and the Critical Raw Materials Act framework, covering batteries, semiconductors, polymers, composites, construction materials, critical metals, bio-based materials and recycling streams.
- **A portfolio of mission calls and demonstrator calls,** with separate instruments for discovery research, collaborative R&D, pilot-line access, industrial scale-up and public-procurement pilots.
- **A European positioning plan,** identifying where Portugal will lead, co-lead or strategically participate in the Advanced Materials Act, Horizon Europe partnerships, Regional Innovation Valleys, IPCEI-type instruments, EIC challenges and Iberian value-chain initiatives.

The governance principle should be simple: every identified dependency must be matched with at least one policy response. For example, battery dependency should lead to calls on electrodes, electrolytes, recycling and qualification; semiconductor dependency should lead to materials for advanced packaging and thermal management; polymer dependency should lead to recycled and bio-based materials; construction dependency should lead to low-carbon cementitious, ceramic and insulation materials; and critical-material dependency should lead to substitution, circularity and strategic partnerships.

Decision requested

AI² is asked to include Advanced Materials among the national strategic domains and to launch it as a five-year mission-oriented programme. The programme should have sufficient scale to coordinate existing measures, attract private and European co-investment, and create a permanent bridge between Portugal's scientific capacity and the industrial value chains of the next decade.

Closing message

Advanced Materials are not just another priority. They are the material basis of the priorities Portugal already claims to have: energy independence, digital capacity, resilient industry, circular economy, health preparedness, maritime security and credible defence readiness. In the present geopolitical situation, the same national capability that protects society also upgrades the economy. Portugal's Atlantic position gives it a geostrategic reach towards Brazil, South America and Africa, allowing it to connect European advanced-materials value chains with complementary resource bases, industrial capabilities and innovation ecosystems. AI² should, therefore, make Advanced Materials one of Portugal's strategic domains from the outset, explicitly designed to bridge the valley of death between research excellence and industrial deployment.

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