The overall objective of the MASTRO project is to develop intelligent bulk materials for the transport sector incorporating self-responsive properties

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Newsletter

Issue 4 December 2020

In this issue:

From nanomaterials and manufacturing know-how to building self-responsive materials for the aerospace, automotive, and transport sectors

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no **760940**.The material presented and views expressed here are the responsibility of the author(s) only. The EUCommission takes no responsibility for any use made of the information set out.

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1. Overview

WP1. PROJECT MANAGEMENT

WP9. Innovation, exploitation, training & dissemination

WP2
Industrial needs
Demo specifications

WP3
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compatibility

WP4
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application
for modelling

WP5
Intelligent bulk
materials design

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ICT Platform

WP7
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in transport sector

WP8
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standardization
& training

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2. END-USERS´ DEMOS

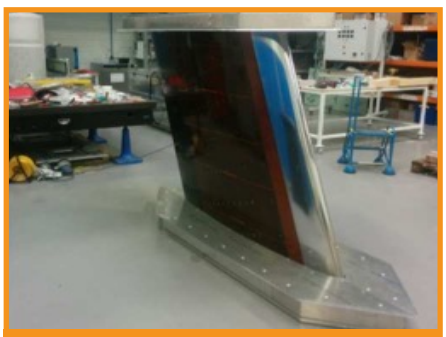
The overall objective of the MASTRO Project is to develop intelligent bulk materials for smart applications in the transport sector incorporating several self-responsiveness properties such as self-sensing, self-de-icing, self-curing, self- healing and self- protection aiming at increasing consumer safety, component lifespan and performance while reducing maintenance and manufacturing costs. The technologies will be demonstrated at prototype level in a relevant environment (TRL6), for the aeronautic, automotive and transport infrastructure sector.

AERONAUTIC SECTOR:

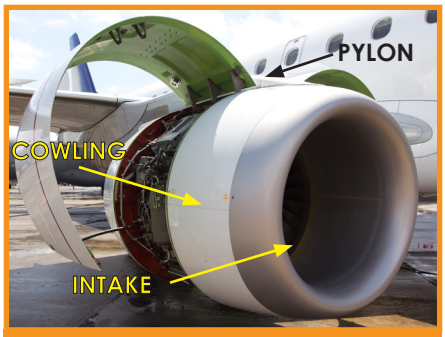
The aviation industry is the one of the most affected sectors by the COVID-19 pandemic due to the travel restrictions applied and the general decline in demand among personal as well as professional trips. Passenger traffic, workforce, and incoming revenues are consistently decreasing having a direct impact on the net profits and endangering the future of many actors in the industry. In this uncertain market conditions, the technologies developed within MASTRO which are focusing on the reduction of maintenance costs, have the potential to act as a compensation for the aeronautic industry. The reduction of costs in combination with the increase of safety and comfortability for passengers, are two strong assets that the aviation sector could count on until the stabilization of the market landscape in the future. In this framework, 3 different aeronautic demonstrators are being manufactured within MASTRO.

Aeronautic sector demonstrators

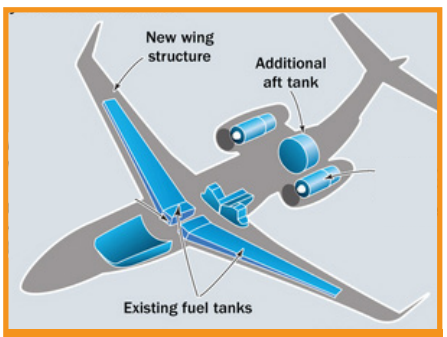
Code	Element	Matrix	Self	Purpose
AE1	Wing leading edge	CFRP	Sensing	To monitor critical components such as wing leading edge, including barely visible impact damage (BVID). Structural health monitoring even during flight, not only on ground.
			De-icing	To provide ice protection to wing leading edges. Important in the case of extreme cold and humidity conditions during flight.
			Curing	Complete cure equivalent to conventional methods achieved with lower energy and time, without the need of big ovens.
			Healing	To self-heal the composite by means of microcapsules containing a reactive monomer, which are added into the composite in its fabrication. On ground and during flight.
AE2	Engine intake	CFRP	De-icing	To provide ice protection to engine intakes. Important during flight.
AE3	Fuel system	Thermoplastic	Protection	To electrically grounding all areas of the airframe; then the potential for discharge sparks in critical areas such as fuel systems is reduced.



AE1. Wing leading edge.
USFD-AMRC



AE2. Engine intake.
Embraer 190 engine



AE3. Fuel systems.
Embraer Legacy 650

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2. END-USERS´ DEMOS

AUTOMOTIVE SECTOR:

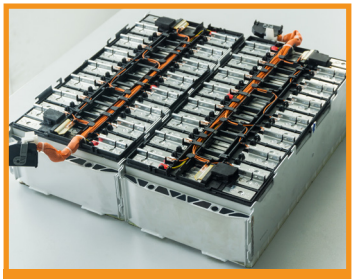
The automotive industry is crucial for Europe's prosperity considering that the sector provides jobs for 13.8 million people and accounts for 7% of the EU's GDP establishing Europe as the world´s biggest producer of motor vehicles. In fact, Europe represents one of the largest investors regarding research and development in order to maintain this strong and competitive position in the automotive industry. Five different automotive demonstrators will be manufactured in MASTRO to support and push forward this strong position, and will cover five different smart features:

Automotive prototypes:

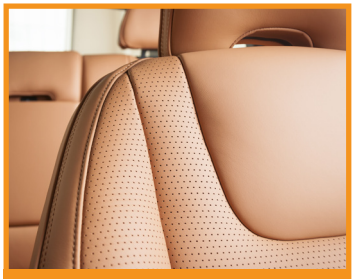
Code	Element	Matrix	Self	Purpose
AU1	Bumper	GFRP	Sensing	To monitor external aerodynamic parts with 3 different aims: 1) to optimize which is their proper orientation during the development phase of a new car model; 2) to monitor in real time their deformation (motor sports and luxury cars) to automatically change their orientation; and 3) to detect damage in critical parts like bumpers.
		GFRP	Curing	Complete cure equivalent to conventional methods achieved with lower energy and time, without the need of big ovens.
			Healing	To self-heal the composite by means of microcapsules containing a reactive monomer
AU2	Door gaskets	Rubber EPDMP	De-icing	To develop de-icing gaskets and tape in car doors perimeter (to avoid sticking in winter).
AU3	Wind screen wiper area	Thermoplastic PPS	De-icing	To prevent snow and enhance visibility and safety.
AU4	Battery filling system	Thermoplastic Transparent PVC	De-icing	To self-heat a battery filling system prototype. This filling system is needed, but currently is installed only on 95% of electric vehicles, because it could not be installed in the Northern countries due to frost problems. The absence of this system makes last longer the maintenance activity.
			Protection	To protect some components of explosion proof electrical vehicle models, which must not be electrostatically charged for safety reasons (generate sparks with dangerous consequences).
AU5	Seats (textile)	Thermoplastic PES, PA, PP	De-icing	Textile matrices based in polymeric multicomponent fibers to use as heating elements with tunable resistance for heating comfort performance in seats.

AU1, AU2, AU3
DIAD LAB CAR

AU2, AU3, AU4
ALKE ATX



AU4. BATTERY FILING SYSTEM. ALKEATX



AU5. ADVANCED TEXTILES. SEATS. CITEVE

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2. END-USERS´ DEMOS

TRANSPORT INFRASTRUCTURE SECTOR:

Transport infrastructure, and in particular road transport, is part of the lifeblood and a strategic sector of the EU economy. About 44% of goods transported in the EU go by road. People also travel mainly by road, with private cars accounting for 73% of passenger traffic. The MASTRO project enhances this sector by developing novel solutions for quality and safety improvement, addressing the targets set out in the European Road Safety Programme which aims at a reduction of casualties. Three different demonstrators will be carried out throughout MASTRO project in the Transport Infrastructure sector: Concrete-road, FRP adhesive joints used in truss structures and Asphalt-road.

Automotive sector demonstrators

Code	Element	Matrix	Self	Purpose
TI1	Road	Concrete	Sensing	To monitor concrete pavement and beam prototypes to be implemented in roads and bridges. Structural Health Monitoring for safety reasons.
			De-icing	To prevent ice/snow on the road and enhance safety. To be implemented later on in accident black spots, airports, truck loading docks, parking garages, bridge decks.
TI2	FRP joints	Epoxy based adhesive	Sensing	To monitor critical joints in GFRP truss structure
			Curing	To perform self-curing process in components too big to be cured in a chamber (beams, pedestrian bridges) and adhesive junctions.
TI3	Road	Asphalt	Sensing	To monitor asphalt pavement prototypes to be implemented in roads and bridges. Structural Health Monitoring for safety reasons.
			De-icing	To prevent ice/snow on the road and enhance safety. To be implemented later on in accident black spots, airports, truck loading docks, parking garages, bridge decks.
			Healing	To repair by softening the pavement.

TI1. CONCRETE PAVEMENT.
TING-KAU BRIDGE. ACC

TI2. FRP JOINTS
GFRC LIGHTHOUSE. ACC

TI3. SNOW FREE ASPHALT PAVEMENT.
SGD

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3. Market landscape of MASTRO Nanotechnologies

Introduction:

Smart materials find a wide range of applications due to their varied response to external stimuli. The different fields of application include the day-to-day life of citizens but also big industries such as the automotive or the aerospace industry as well as civil engineering have directed their interest in smart material applications. The scope of application of smart material is to provide solutions to engineering problems with unfeasible efficiency and to provide an opportunity for the creation of new products that could generate revenues.

Market size

The global smart material market size is anticipated to reach USD 98.2 billion by 2025, expanding at a CAGR of 13.5% owing the increasing demand mainly to the needs of the aerospace, consumer electronics, and automotive sectors. Extensive research & innovation activities have also widened the industrial applications of smart materials while the augmented use of smart actuators & motors, sensors, and structural materials is anticipated to further boost the demand over the next few years.

Market segmentation:

The global smart materials market is segmented by product type, application, and end-user.

As depicted in the following figure, there are numerous of sub-segments depending on the initial market segmentation. In detail, based on product type, the market is segmented as piezoelectric materials, electro-rheostatic, magneto-rheostatic, shape-memory materials, smart fluids, smart hydrogels, electrochromic materials, and others. On the basis of the application, the market is segmented as actuators & motors, sensors, transducers, structural materials, and others. The market based on the end-user is classified as industrial, defence, aerospace, automotive, consumer electronics, healthcare and transportation infrastructure. Within MASTRO the focus has been directed mainly on the end-user segmentation having as a central point the sectors of the automotive, aerospace and transportation infrastructure industry.

Figure 1 Smart Material Market Segments

BY PRODUCT TYPE

- Piezoelectric materials
- Electro-rheostatic
- Magneto-rheostatic
- Shape memory materials
- Smart fluids
- Smart hydrogels
- Electrochromic materials
- Others

BY APPLICATION

- Actuators & motors
- Sensors
- Transducers
- Structural materials
- Others

BY END-USER

- Industrial
- Defense
- Aerospace
- Automotive
- Transportation infrastructure
- Consumer electronic
- Healthcare

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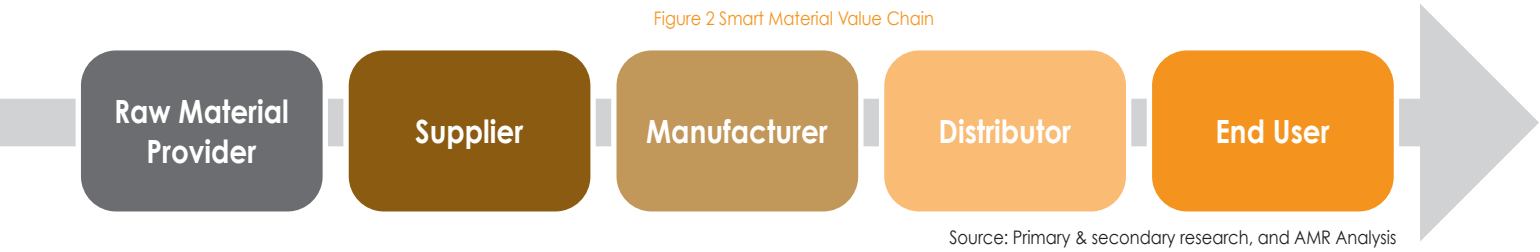
3. Market landscape of MASTRO Nanotechnologies

Value Chain:

The value chain of smart materials includes a large number of actors starting from the raw material providers and ending at the final end users. Within this chain, each stakeholder creates and shares at their point of operation a certain amount of value, contributing simultaneously to the creation of competitive high added value products. R&D activities, innovations, and marketing strategies further enhance the value associated with end-deliverables by each player.

Figure 2 Smart Material Value Chain



Source: Primary & secondary research, and AMR Analysis

Key drivers / Growth Factors

Top factors impacting World Smart Materials Market:

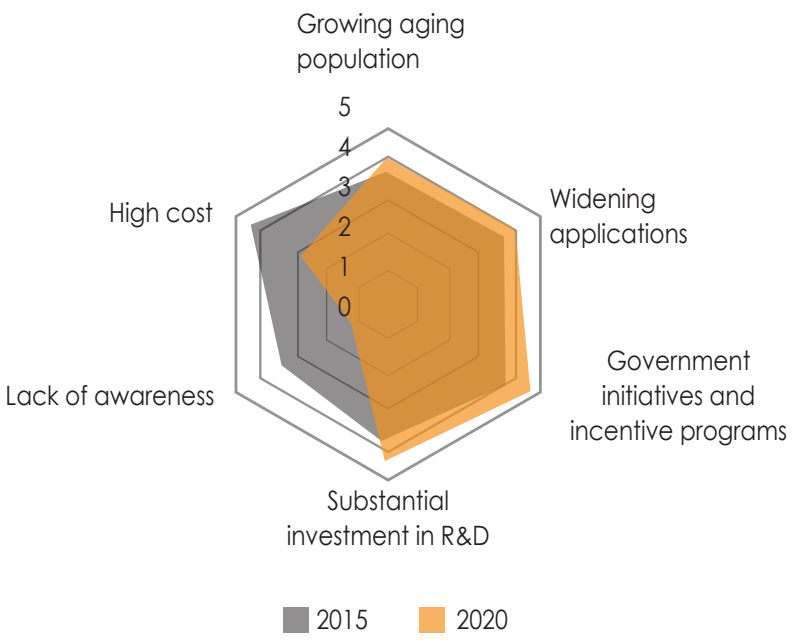


FIGURE 3: Smart Material Market Drivers

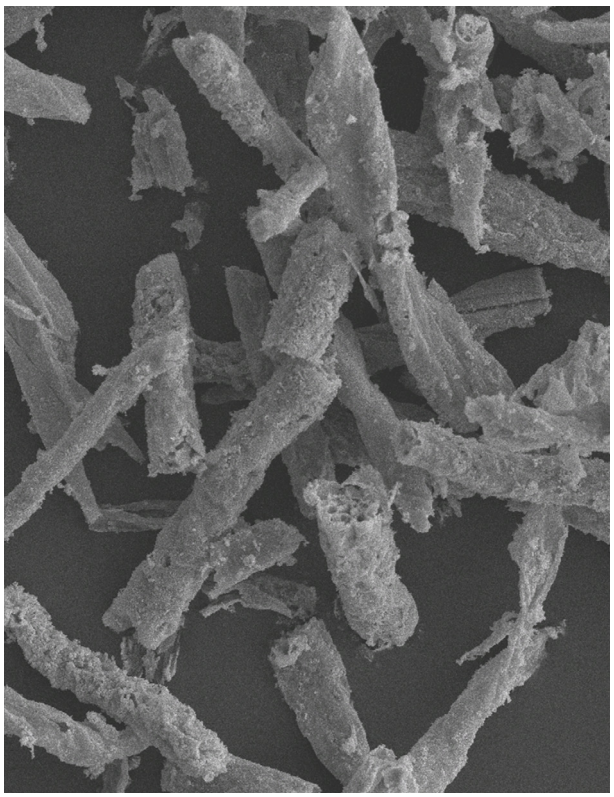


PHOTO: Nanoparticles under microscope

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3. Market landscape of MASTRO Nanotechnologies

1. Growing Aging Population

Smart materials show an increase in gaining traction in older population-centric products. In addition, these products help reduce daily routine complexities and make life easier for old people. In near future, the population share of this age group is projected to increase at a significant rate which in turn is anticipated to increase demand for smart materials products.

2. Widening Applications

Continuous development in manufacturing processes and the adoption of enhanced materials have increased the applications of smart materials across various end-user industries. In the coming years, smart materials are projected to further expand their applications and are anticipated to play a pivotal role.

3. Government Initiatives & Incentive Programs

Currently, some specific groups of industries, such as small and medium enterprises (SMEs) lack in terms of adoption of smart materials due to high cost. The introduction of several initiatives and programs to encourage industries to invest in and utilize smart materials is projected to achieve a broad impact.

4. Substantial Investment in R&D

The rise in R&D efforts to develop innovative materials has been instrumental in driving the growth of the market. Increases in demand for enhanced smart materials and products from various industries, such as construction, manufacturing, and automotive are anticipated to encourage key players operating in the smart materials market to invest considerable amounts in research and development to introduce efficient products and stay ahead in the competition.

Smart materials have an enormous potential as a key technology to transform future transportation systems. Understanding and controlling the composition and microstructure of any new materials are the ultimate objectives of research in this field and are crucial to the production of good smart materials.

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4. Publications

1. B. Del Moral, I. Martín Gullón, R. Navarro, O. Galao, F.J. Baeza 1, E. Zornoza, B. Calderón, I. Rodríguez, N. Arnaiz, M.D. Romero Sánchez, P. Garcés. "The Effect of Different Oxygen Surface Functionalization of Carbon Nanotubes on the Electrical Resistivity and Strain Sensing Function of Cement Pastes". 2020 Nanomaterials 2020, 10(4), 807; (https://doi.org/10.3390/nano10040807)

2. Greta Donati, Antonio De Nicola, Gianmarco Munaò, Maksym Byshkin, Luigi Vertuccio, Liberata Guadagno, Ronan Le Gofff, Giuseppe Milanoa. "Simulation of self-heating process on the nanoscale: a multiscale approach for molecular models of nanocomposite materials". 2020 Nanoscale Advances, 2; (https://doi.org/10.1039/D0NA00238K)

3. Giovanni Spinelli, Patrizia Lamberti, Vincenzo Tucci, Liberata Guadagno and Luigi Vertuccio. "Damage Monitoring of Structural Resins Loaded with Carbon Fillers: Experimental and Theoretical Study". Nanomaterials 2020 10(3), 434; (https://doi.org/10.3390/nano10030434)

4. Maria Rossella Nobile, Marialuigia Raimondo, Carlo Naddeo and Liberata Guadagno. "Rheological and Morphological Properties of Non-Covalently Functionalized Graphene-Based Structural Epoxy Resins with Intrinsic Electrical Conductivity and Thermal Stability". Nanomaterials 2020, 10(7), 1310; (https://doi.org/10.3390/nano10071310)

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5. Upcoming Events

The MASTRO consortium is made up of partners from all around Europe, all of them coping with the current COVID-19 pandemic in the best way possible, considering the health and safety of their people as their number one priority. A lot of events were affected by this situation; however, the consortium already identified a list of events in 2021 which will allow the active involvement and dissemination of MASTRO through various channels and initiatives.

1. Electric & Hybrid Vehicle Technology Expo

18 - 20 May, 2021 Stuttgart, Germany

2. 30TH Anniversary INTERNATIONAL CONFERENCE ON METALLURGY AND MATERIALS

19 - 21 May, 2021 Brno, Czech Republic

3. Paints and Coatings 2021

1 - 2 June, 2021 Barcelona, Spain

4. ICCM2021

ACI/RILEM INTERNATIONAL CONFERENCE ON CEMENTITIOUS MATERIALS AND ALTERNATIVE BINDERS FOR SUSTAINABLE CONCRETE

7 – 9 June, 2021 Toulouse, France

5. Imaginenano 2020

25 – 27 May, 2021 Bilbao, Spain

6. TOP CONFERENCE 2021

13 – 17 June 2021 Ischia, Italy

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6. Deliverables & Milestones

Deliverables Submitted:

WP5	1. D5.1 Report on the development of the final self-responsive thermoplastic fabrics and composites M27 2. D5.2 Report on the development of the final self-responsive thermoplastic fabrics and composites M27 3. D5.3 Report on the development of the final self-responsive bitumen composites M27 4. D5.4 Report on the development of the final self-responsive concrete composites M27
WP6	5. D6.1 ICT Platform reference architecture M27 6. D6.2 Aerospace ICT Platform Module M27 7. D6.3 Automotive ICT Platform Module M27 8. D6.4 Transport infrastructure ICT platform module M27
WP7	9. D7.1 Detailed prototypes design M27
WP4	10. D4.5 Final version of User-oriented Application M30
WP9	11. D9.2 Data Management Plan M30

Milestones

MS5 — Self-sensing properties proven in different matrices at component level according to defined KPIs (M27)

MS6 — Self-deicing properties proven in different matrices at component level according to defined KPIs (M27)

MS7 — Self-curing properties proven in different matrices at component level according to defined KPIs (M27)

MS8 — Self-healing properties proven in different matrices at component level according to defined KPIs (M27)

MS9 — Self-protection properties proven in different matrices at component level according to defined KPIs (M27)

MS11 — Final version of MASTRO ICT platform and reference architecture (M27)

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7. Who we are…

MASTRO consortium is a multidisciplinary mix of engineers, materials experts, and high tech companies, from 6 European countries

For more details visit: www.mastro-h2020.eu/partners

17 PARTNERS **6** COUNTRIES **7** RTDs

5 RTDs **5** LEs **6M.** FUNDING

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no **760940**.
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