Shaping the Future with Advanced Lightweight Materials in the Automotive Sector

AMULET

AS PART OF THE AMULET TECHNOLOGY ROADMAP

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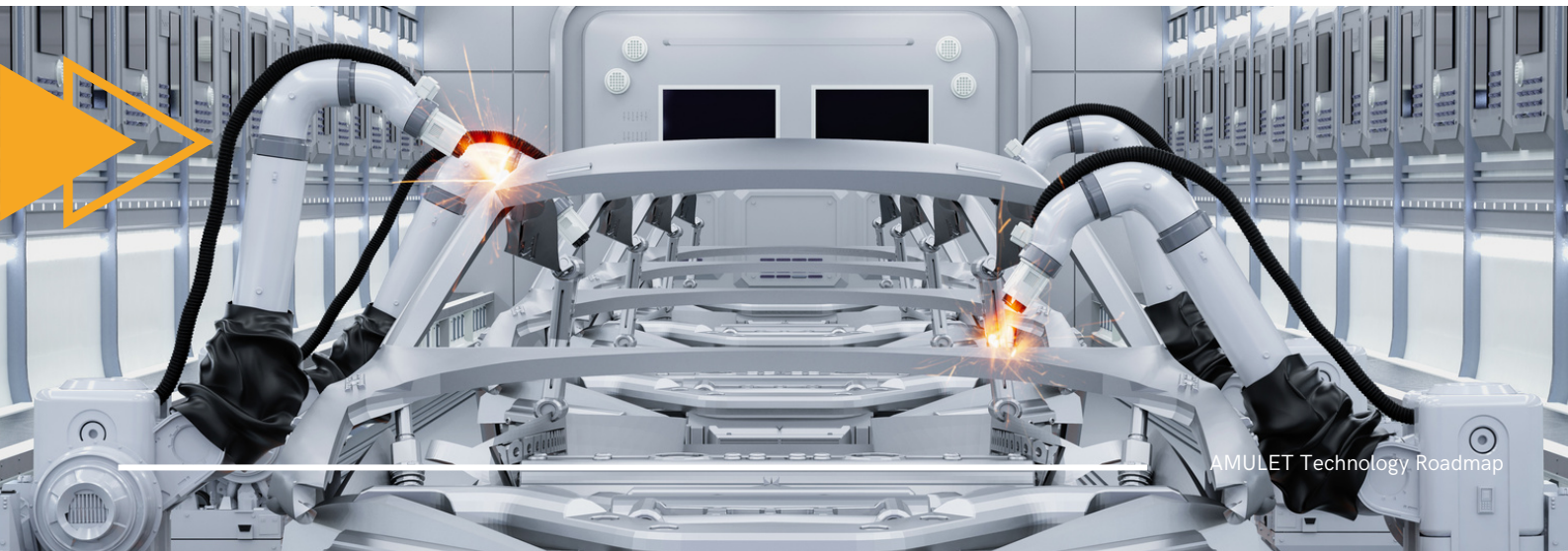
Introduction

The tremendous increase in anthropogenic CO2 emissions arose after the Industrial Revolution until our days are bringing undesired climate changes at a rate steeper than predicted. Although still unpredictable, the effects of these changes will impose important stresses on Earth's ecosystems and measures to mitigate these effects are being put in place.

European Climate Law includes a set of measures targeting net greenhouse gas emissions reductions of at least 55% by 2030, compared to 1990 levels, aiming to make Europe climate neutral by 2050. These changes will involve the radical transformation of multiple value chains, from material development to the product's End-of-Life. In this context, advanced lightweight materials will play a critical role in providing solutions for many applications to drive the green and digital transition. In fact, lightweight materials have been identified as relevant enablers for nine selected Materials Innovation Markets representing the 'market pull' to address the societal needs and citizen challenges sustainably in the long term.

AMULET's technology roadmap aims to inform decision-makers about the drivers, challenges and innovations related to lightweight materials in four different industrial sectors: Automotive, Aerospace, Energy and Building. This information will provide relevant technological insights about the developments being made in these sectors, allowing the elaboration of better policies as well as providing recommendations on which developments are more suitable to be financed.

The information used for the elaboration of this technology roadmap comes from a series of four sectoral workshops (one per sector) which have involved relevant stakeholders with expertise in the different stages along the value chain. The information has been completed with a detailed bibliographic search.



The Automotive sector

The new EU legislation, such as the EU Climate Law, Fit for 55, and the EU Green Deal, reflects the global trend towards reducing CO2 emissions and enhancing resource efficiency. These regulations have increased the importance of lightweighting in the automotive sector in recent years, with the goal of meeting the target of 60 gCO2/km by 2030. Achieving this stringent target cannot be achieved without the implementation of electrified powertrains which will likely result in an increase in vehicle weight and cost. Advanced lightweight materials hold great potential for mitigating the impact of additional system costs, as well as for-optimising CO2 emissions in internal combustion engines (ICEs).

The impact is clear: a 10% weight reduction results in a decrease in fuel consumption of approximately 6–8% at comparable functionality[1] levels1. However, the average mass of European vehicles has increased over the past 15 years due to added safety and comfort equipment as well as growing customer demand for SUV-type vehicles. Nevertheless, automotive companies are continuously searching for solutions that enable weight reduction aiming to comply with new environmental regulations.

The transition towards a more environmentally friendly automotive sector is fostering car manufacturers to adopt sustainable as well as circular strategies to meet current legislation. Here, lightweight materials and related technologies play a pivotal role in achieving the objectives set forth. Moreover, there is a sound market pull to develop and further implement resource and energy-efficient manufacturing methodologies aiming to mitigate carbon footprint and reduce manufacturing costs.

Two other factors that strongly influence the evolution of the automotive industry driven by the use of lightweight materials, are autonomy and safety. Weight reduction benefits autonomy by extending the distance a vehicle can travel without recharging the battery or refilling the tank. At the same time, it enhances the vehicle's structural integrity, handling, manoeuvrability, and energy efficiency, thereby improving safety.

In this transition scenario, the automotive industry faces important challenges to adapt to the new era. In this regard, the application of eco-design strategies is becoming a standard when conceiving a new product or process with the aim of maximising the circularity and sustainability of each component along the value chain. Moreover, the use of renewable, bio-based, and/or recycled materials requires adjustments in manufacturing technologies and processes. This adaptation which is being accomplished in parallel with the implementation of digitalisation and automation solutions into materials (e.g., structural health monitoring, functional integration) and processes (e.g., digital twins) to improve energy and resource efficiency. Additionally, vehicle electrification brings additional issues, such as EMI shielding.

Our study demonstrates that to address these challenges, a significant number of innovations are being researched and tested at different scales. For example, the utilisation of thermoplastic materials will enable an increase in the recycling rate of products at their end of life. Besides this, the integration of embedded sensors in the material will allow predictive maintenance enhancing the extension of the product's lifetime. Other strategies like design-for-disassembly, modular design, and self-healing polymers will benefit the sustainability of the goods. In terms of circularity, the use of recyclable and recycled polymers as well as the establishment of the Materials Passport ID, will add significant value to the increased use of secondary materials. In addition, bio-based materials (e.g., natural fibres, bioplastics) are becoming available, enabling circular-by-design strategies to be easily implemented.

Overall, advanced lightweight materials play a crucial role in realising the transition towards a more sustainable and environmentally friendly automotive sector, all while maintaining competitiveness.

AMULET's technology roadmap will provide insightful information on challenges and innovations related to the sectoral drivers. The full technology roadmap will be available in 2024.

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