

Application of Graphene-based 2D materials in composites for aerospace applications

Muhammad Zahid^{1,*}, Nicola Gallo², Ignazio Scavo² and Stefano G. Corvaglia²

¹Leonardo Labs, Aerostructure division-Leonardo SpA, str. prin. Grottaglie-Monteiasi, 83/84, Monteiasi (TA), Italy

²Product Engineering and IP Management, Aerostructure division-Leonardo SpA, str. prin. Grottaglie-Monteiasi, 83/84, Monteiasi (TA), Italy

*muhammad.zahid.ext@leonardocompany.com

Abstract

Carbon fibre reinforced composites (CFRPs) show excellent features like high strength to weight ratio, zero corrosion, ease of manufacturing and high resistance to fatigue [1]. These features translate into enhanced fuel efficiency, low maintenance costs, improved life span as well as reduced carbon foot prints of transportation sectors such as aviation and automotive [2]. Therefore, the CFRPs are being employed increasingly to replace current metallic structures in those sectors. However, the CFRPs lack several functionalities that would be a pre-requisite for the future zero-emission mobility. For instance, the CFRPs do not exhibit high electrical conductivity, thermal management, gas barrier and moisture barrier properties. The epoxy resin that constitutes 40% by volume of an aerospace composite is vulnerable to impacts, resulting in crack formation and their subsequent propagation. To overcome these shortcomings, external devices or coatings are employed that not only increase fabrication and maintenance costs as well as add significant weight to the structures. For instance, hydrogen (H₂), as a green fuel, has tremendous potential to solve future energy and pollution crisis. Automotive and aerospace vehicles will be major beneficiaries of this technology and are developing CFRP-based storage cylinders. To stop the vapour escape, a metallic barrier layer is used in those composite-based cylinders. Similarly, lightning strike protection and anti-icing/de-icing require additional devices to keep the aircraft operational in extreme weather conditions. Carbon-based nanomaterials, specifically graphene, have exceptional electrical, mechanical, and thermal properties in addition to its lightweight [3]. Graphene with broad set of properties is fully capable to modify surface properties of the conventional CFRPs. The graphene-based films or coatings exhibit the enhanced electrical, thermal and gas barrier properties that can be exploited to protect the aerospace structures against high atmospheric temperatures, icing, static charges, lightning strikes, corrosion, humidity and gases. Whereas, their incorporation to the epoxy matrix can modify resin properties significantly. For example, the graphene enhanced epoxy resin display improved tensile and compression strength, better fracture toughness and fatigue resistance, as compared to the baseline CFRPs (without graphene). The epoxy polymers filled with graphene-based 2D materials can also be co-cured in a single cycle with CFRPs to reduce process time, cost and complexity. Therefore, the graphene-based 2D materials have huge potential to enhance capabilities of the current CFRPs rendering them multifunctional smart composites.

References

- [1] Roeseler W. G. et al., 16th International Conference on Composite Materials, (2007). Authors, Journal, Issue (Year) page (Century Gothic 11) Indicate references with sequential numbers within [square brackets].
- [2] Traveller, viewed 13 May 2022, <https://www.traveller.com.au/airline-weight-reduction-to-save-fuel-the-crazy-ways-airlines-save-weight-on-planes-h14v1h>
- [3] K. S. Novoselov, et al., Nature, 490 (2021) 192- 200.