

Reduced Graphene Oxide & CFRP's Maximized Properties: An Investigative Overview

Vicenza, Italy
22-26 September 2025

Spyros Tsiotos¹, Chrysanthi Paparouni¹, Despoina I. Batsouli¹, Antonios Vavouliotis¹,
Natalia Kantouni², Spyros N. Yannopoulos^{2,3}

¹Adamant Composites Ltd., Aghias Lavras and Stadiou St., GR-26504, Rio-Patras, Greece

² Foundation for Research and Technology – Hellas, Institute of Chemical Engineering Sciences (FORTH/ICE-HT), GR-26504, Rio-Patras, Greece

³ Department of Chemistry, University of Patras, GR-26504, Rio-Patras, Greece

BACKGROUND

Graphene production remains costly, intricate, and limited in scale, with most methods relying on chemically derived powders that are not water-soluble and lack environmental sustainability. In contrast, Carbon Fiber Reinforced Polymers (CFRPs) are already established in aerospace and space applications. Graphene oxide (GO) offers a more accessible precursor, deposited onto CFRP fabrics by wet-chemistry methods and reduced by laser processing, forming reduced graphene oxide (rGO) with a graphenic structure. In this study, we introduce an **environmentally friendly technique** for depositing **high-quality graphene** employing laser-assisted methods.

QUESTION

Future developments in graphene research raise questions regarding whether production could become more **economical**, **simple**, and **scalable**. Incorporating graphene into CFRPs could provide significant benefits, including **enhanced mechanical performance** as a nanodopant as well as improvements in **electrical properties** and production processes. Potential strategies for intermixing include roll-to-roll processing, in-house fabrication of prepregs with graphene oxide (GO), and **laser-based reduction of GO to rGO**, enabling the **formation of a graphenic structure**.

Graphene Production:

- Expensive
- Limited quantities
- Intricate

CFRP Usability:

- Aerospace
- Space

Could Graphene production be?

- Volume efficient
- Economic
- Simpler

Possible Intermixing?

- R2R Lines
- In-house Prepregs with GO
- Laser-based GO to rGO reduction

GO: Easily attainable

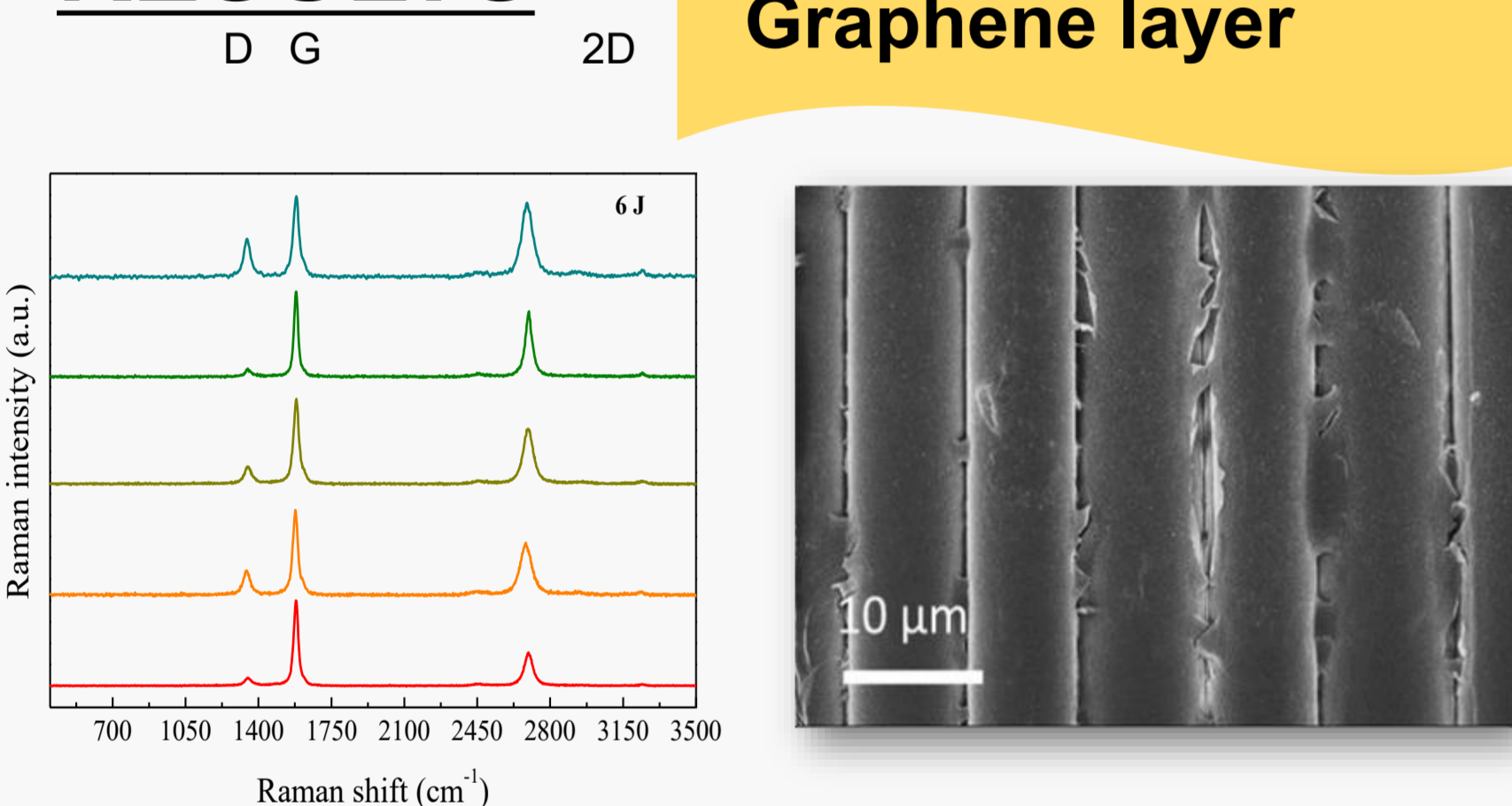
GO + LASER: rGO → Graphenic Structure

RAW MATERIALS

- UD and Plain-Weaved CF fabrics
- GO water dispersion (0.4 wt%) by Graphenea

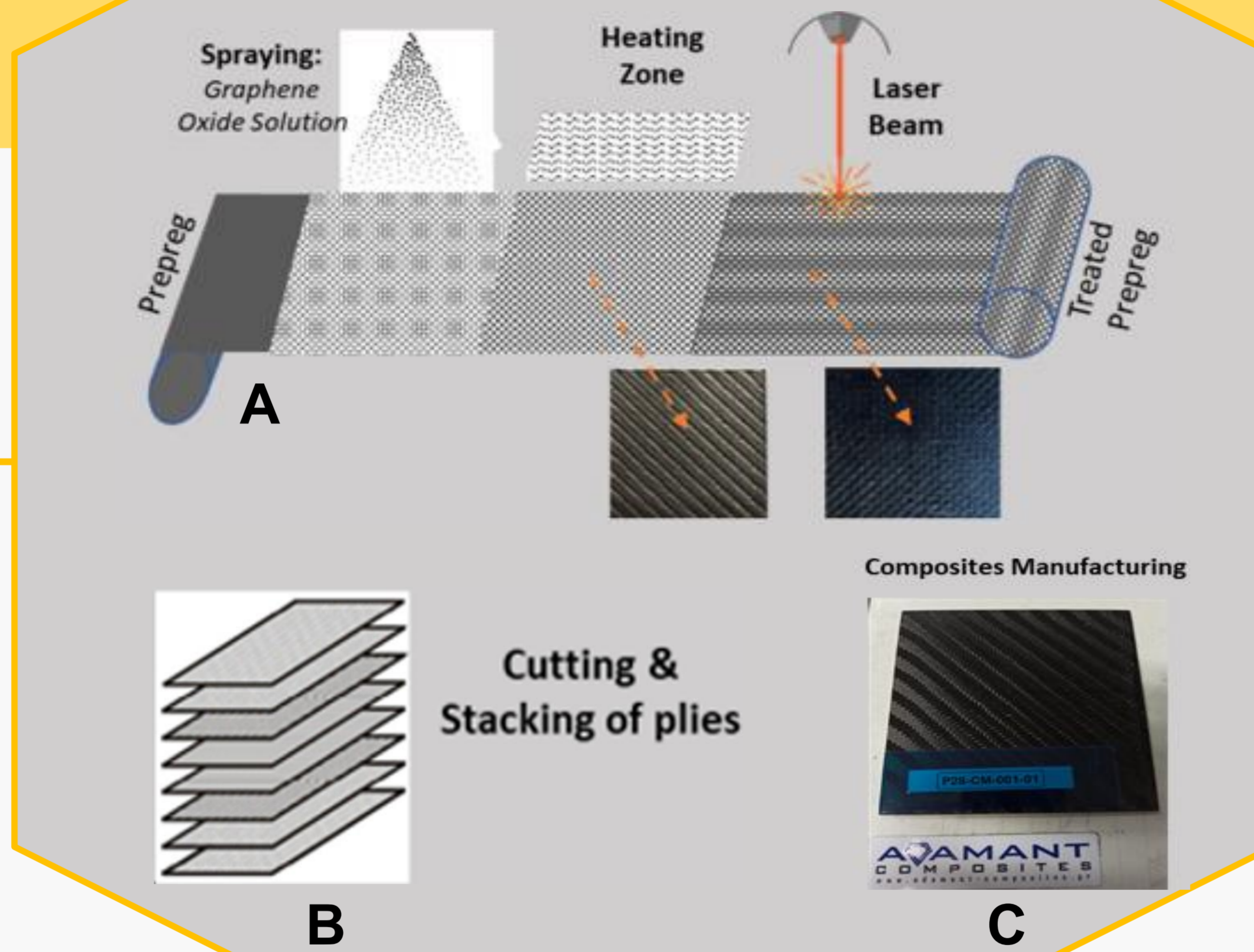
RESULTS

Graphene layer



Representative Raman spectra of rGO on CFRP prepregs by direct laser-assisted reduction & SEM imaging of rGO textile fibers

PROCESS OVERVIEW



Could CFRP's benefit from Graphene?

- Mechanical performance
- Electric Properties & Production

CHARACTERIZATION

- SEM
- Raman
- Thermal Conductivity
- DMA
- Mechanical Testing

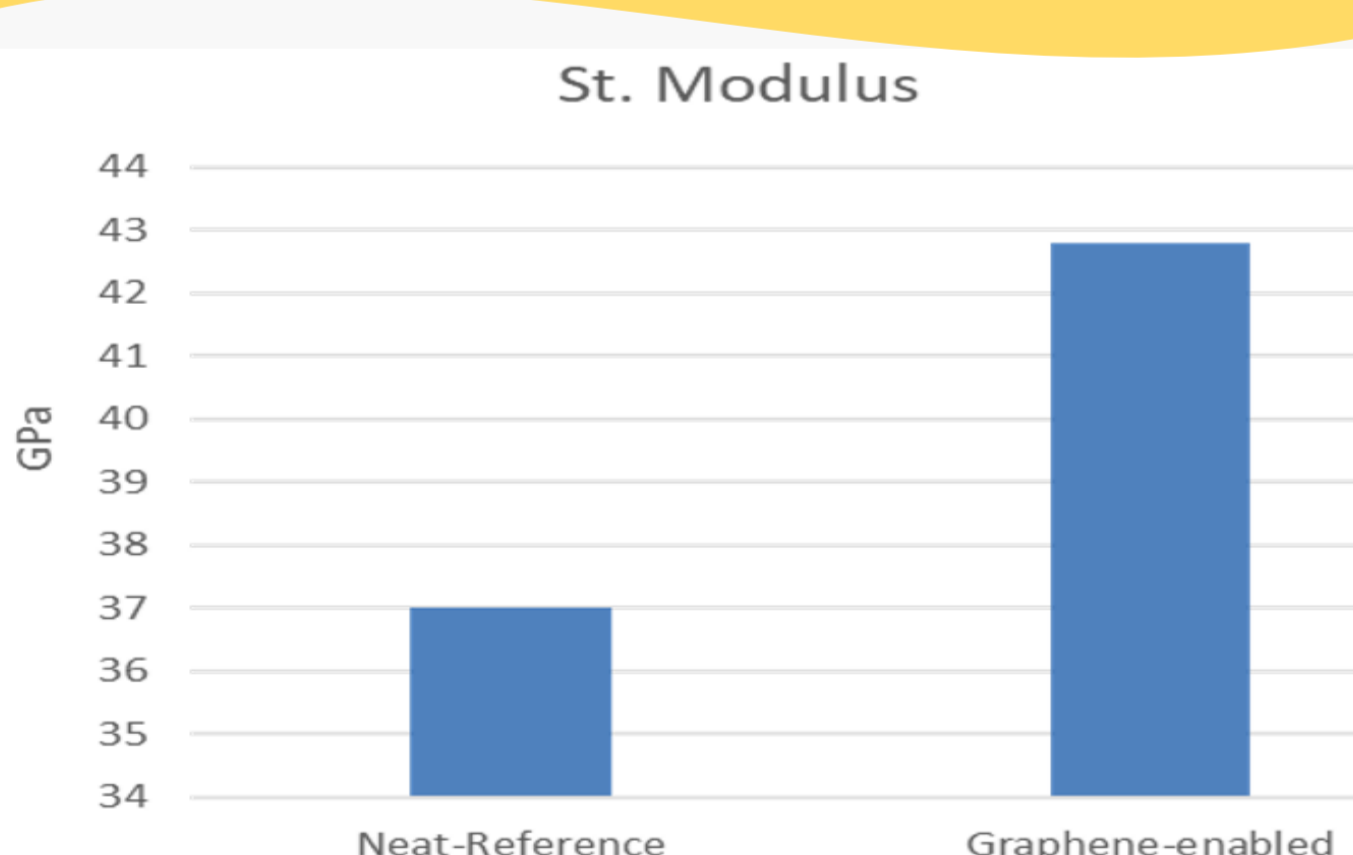
CONCLUSIONS

- A **single-step, eco-friendly technique** for depositing high-quality graphene utilizing laser-assisted methods was established.
- This technique resulted in the direct formation of **nano-doped CFRP laminates**.

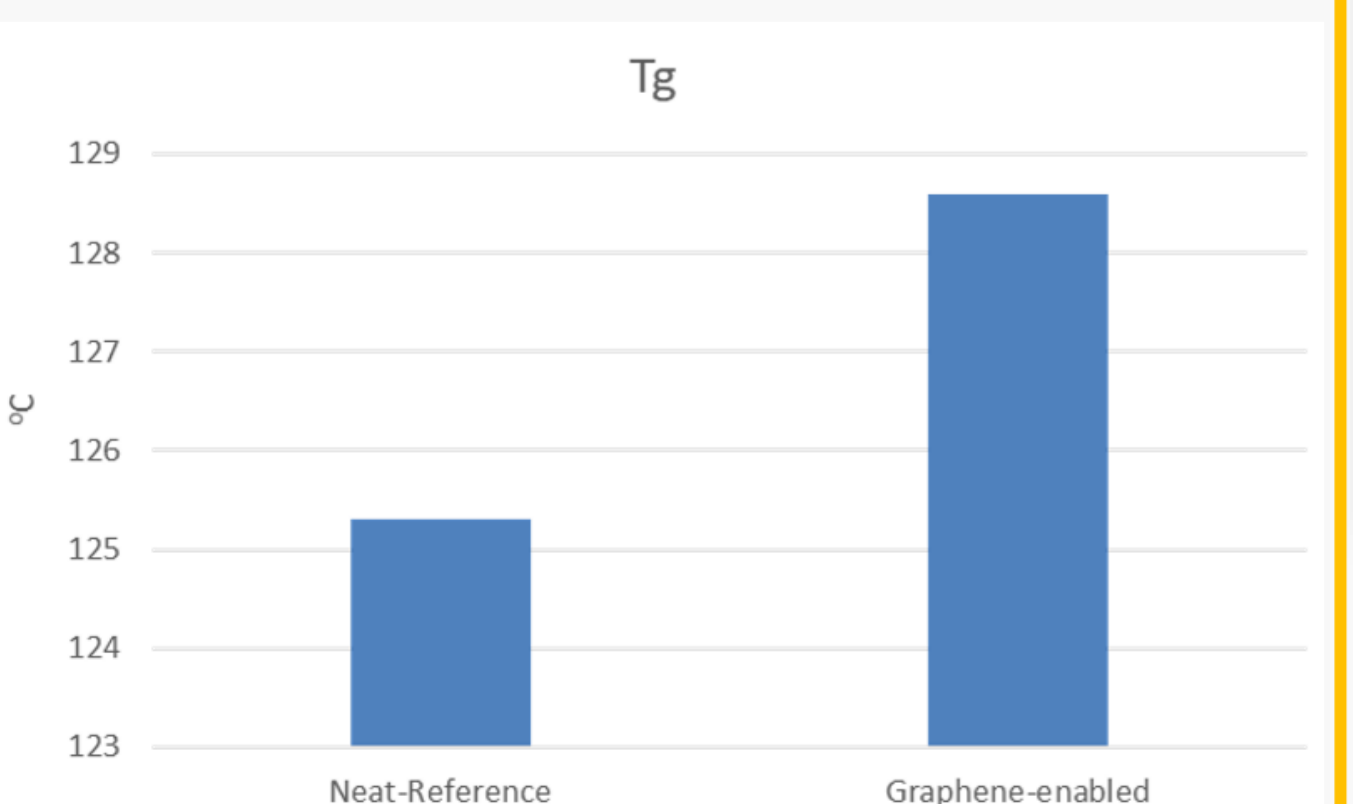


- The **developed TENG** demonstrated highly favorable energy harvesting properties suitable for **electromechanical energy conversion**, while also possessing both flexibility and durability.

Mechanical & Material properties



rGO nano-doping →
16% increase of 5.9 GPa

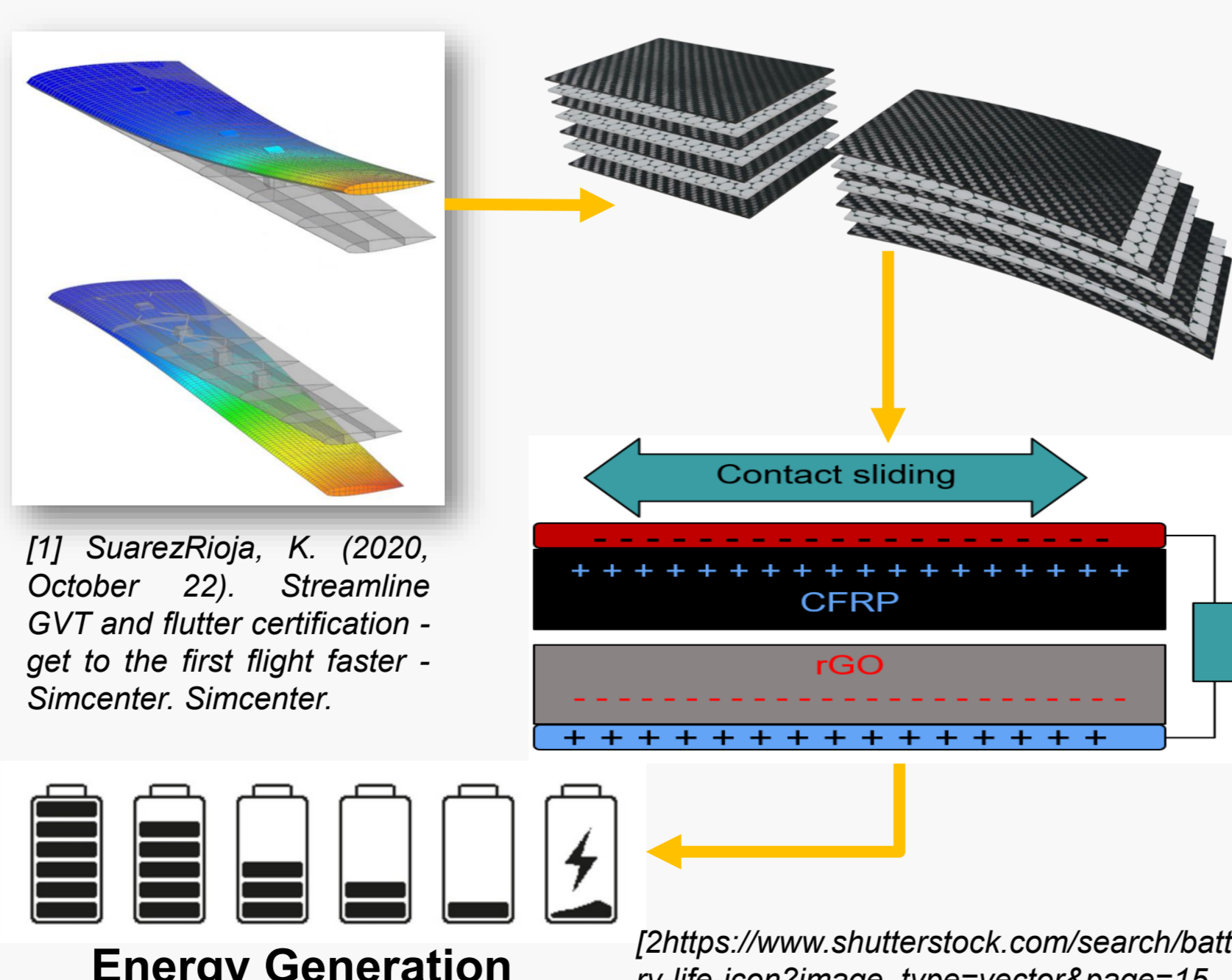


Addition of rGO to the CFRP laminates →
2.8% increase of 4.5 °C

TENG

CFRP:
Tribo-Positive material
Graphene:
Tribo-Negative material

Both function as electrodes →
Touch & Separation →
Charge difference → **Power**



FUTURE PROSPECTS

- Implementation of **rGO-CFRP TENGs** in real life scenarios could provide:
 - Self sufficient power generation
 - Self sufficient fault detection
 - Implementation of **rGO-doped CFRPs** in in field scenarios could provide:
 - Refinement of mechanical properties
 - Increase of durability and reliability in assorted structures
- Minimal increase of cost in the process provides maximal increase in properties and promise



Acknowledgements: This work is funded by the European Union under Horizon Europe Programme. Project: GRAPHERGIA (Grant Agreement n. 101120832).
Website: <https://graphergia.eu/>

