



# GIANCE Project for innovation in Circular Recyclable Graphene based Crosspreg® reactive preregs to Super-Lightweight bodies production



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# Crossfire and GIANCE Project

- GIANCE Project offers innovative solutions to environmental challenges by developing the next generation of graphene and related GRM-based enhanced multifunctional, lightweight, recyclable materials, which present an exciting opportunity for the EU largest growing markets.
- Within GIANCE, Crossfire went developing the first generation of Circular Recyclable prepregs (Crosspreg®) graphene improved, to offer improved mechanical parameters at equal weight or equal at lower weight.
- The Graphene nanoparticles presence doesn't influence the EoL circular recycling of Crosspreg®, who went properly developed to prevent any H&S issue

- Applied R&D Laboratory dedicated to **Develop** and **Produce** innovative reactive prepregs, capable to give a solution to the latest requests of the “Net-Zero” economy.
  - **develop** and **license** the Crosspreg® dedicated transformation technologies and can make pre-series:
    - Mould shaped parts without size limits (Patent applied together with ENEA)
    - Sandwich panels (Patented)
    - Moving toward Circular Recyclable Resin Injection (in development)
  - **develop** and **apply** the 2-D nanomaterials into new Crosspreg® formulations (going to be Patented)
    - Super Lightweight moulded bodies
    - Moving toward Electronics

- **Solid at RT**
  - No solvents; no Emissions; no refrigerated storage/delivery
- **Very low viscosity at molten stage**
  - About 10 times lower viscosity than a thermoset liquid resin; lower than capillarity limit level
- **Isothermal curing**
  - 160-180°C, 3 to 10 minutes depending on thickness and fabric type
  - About 1,5Kg/cm<sup>2</sup> pressure
- **Thermoset up to T<sub>g</sub>, Thermoplastic behave over T<sub>g</sub>**
  - Thermoforms at about 200°C
  - Formula based T<sub>g</sub> from 65°C to 125°C

- No limits:
  - Basalt; Natural (cotton, linen, hemp,..); Aramide easy perfect impregnation
  - Pyrolysis Recycled carbon fabrics; no need of new sizing to performances like the virgin
  - Direct bonding to wood, metals, stones/ceramic, plastic films (PP, PET, PC, PBT, PE,...) in curing
  - Direct Tp over-molding in curing
  - Circular Recyclable at Secondary Raw Material high Value
    - Mechanical grinding + compounding in TP for injection/over-injection (ideal for GF)
    - Pyrolysis to full recovery of fabric and no sizing impregnation by Crosspreg® (ideal for CF)
    - Solvolysys to all Raw Materials recovery – back to monomers and solids
      - Graphene doesn't affect any of the above technologies, but Solvolysis only grants no nanoparticles release in the atmosphere

# Graphene related materials (GRM)



- GRMs are a broad category of carbon nanomaterials derived from **graphene**; a single layer of carbon atoms arranged in a **honeycomb lattice**.
- Graphene is the thinnest compound known at one atom thickness, **the lightest material** known (with 1 square meter weighing around 0.77 milligrams), **the strongest compound** discovered (between 100-300 times stronger than steel with a tensile strength of 130 GPa and a Young's modulus of 1 TPa - 150,000,000 psi), the **best conductor of heat** at room temperature (at  $(4.84 \pm 0.44) \times 10^3$  to  $(5.30 \pm 0.48) \times 10^3 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$ ) and also **the best conductor of electricity** known (studies have shown electron mobility at values of more than  $200,000 \text{ cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$ ).

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- Within GIANCE, Crossfire is responsible to develop 2 automotive Use Cases :
  - The aerodynamic bottom shield of Maserati Levante, today in SMC/Carbon
    - To get it cheaper and lighter at equal performances at lower LCA/LCC
  - The spare wheel well of Jeep Renegade, today in steel
    - To get it lighter and cheaper at lower LCA/LCC
- The Graphene grade selected is GO from Graphenea
- The Crosspreg® selected resin is grade H95
  - Reactive Hybrid Epoxy/Polyester
    - The polyester component comes from recycling
  - $T_g = 108^{\circ}\text{C}$



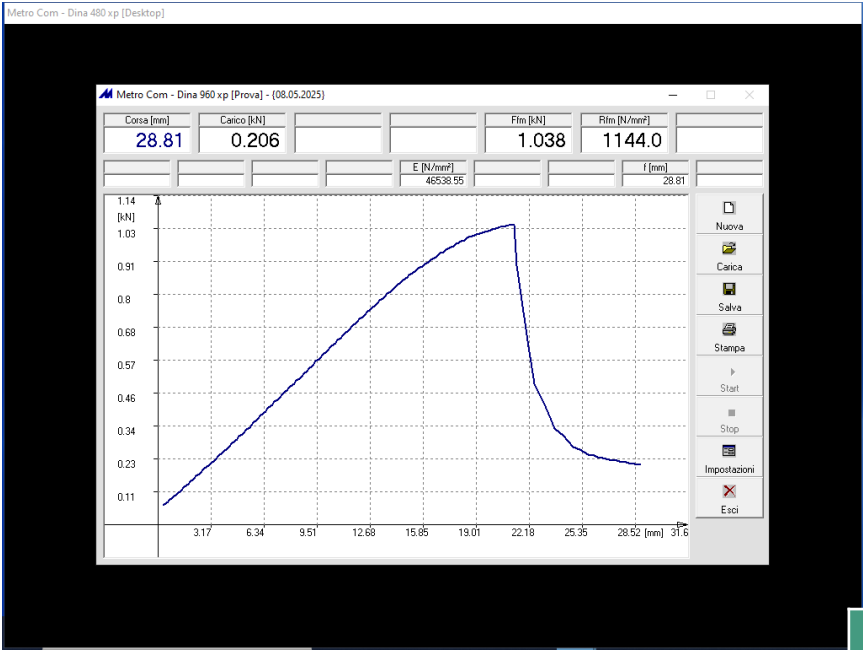
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- **Crosspreg®GOGUd600**
  - **Glass UD 600g/m<sup>2</sup> based – 5 plies**
  - **300gr/m<sup>2</sup> Resin H95 added with 0,2% GO from Graphenea**
- **Run test plates 400x400x2,3mm**
- **3-point bending test at RT**
  - **150x30x2,3 mm specimen**
  - **Span = 10mm**

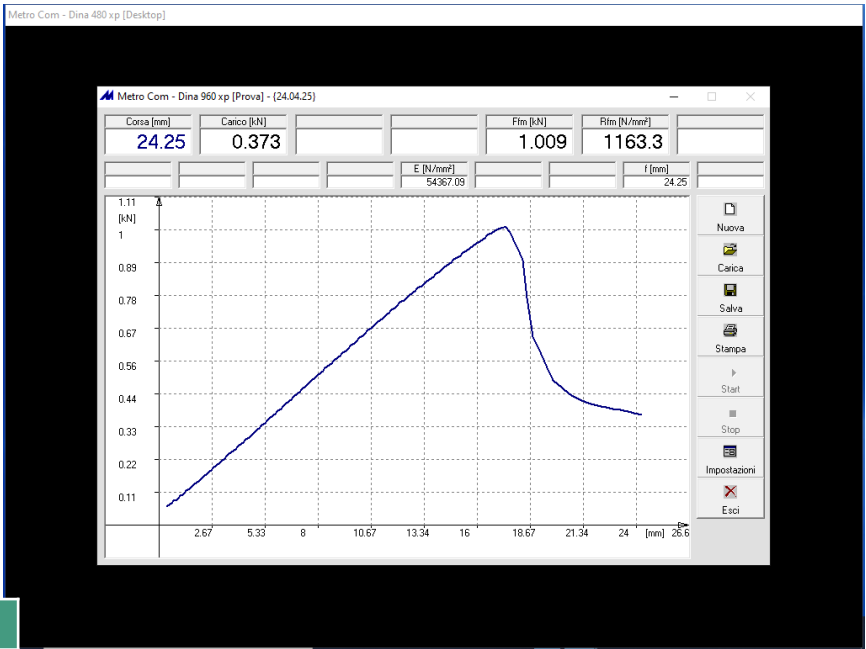


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5xCrosspreg®GUD600 reference

## Glass UD



5xCrosspregGOGUD600

	GO +2%	Reference
Deflection (mm)	22	17
Load (kN)	0,206	0,303
Ffm (kN)	1,038	1,009
Rfm (N/mm2)	1144	1163
E Modulus (N/mm2)	46639	54367

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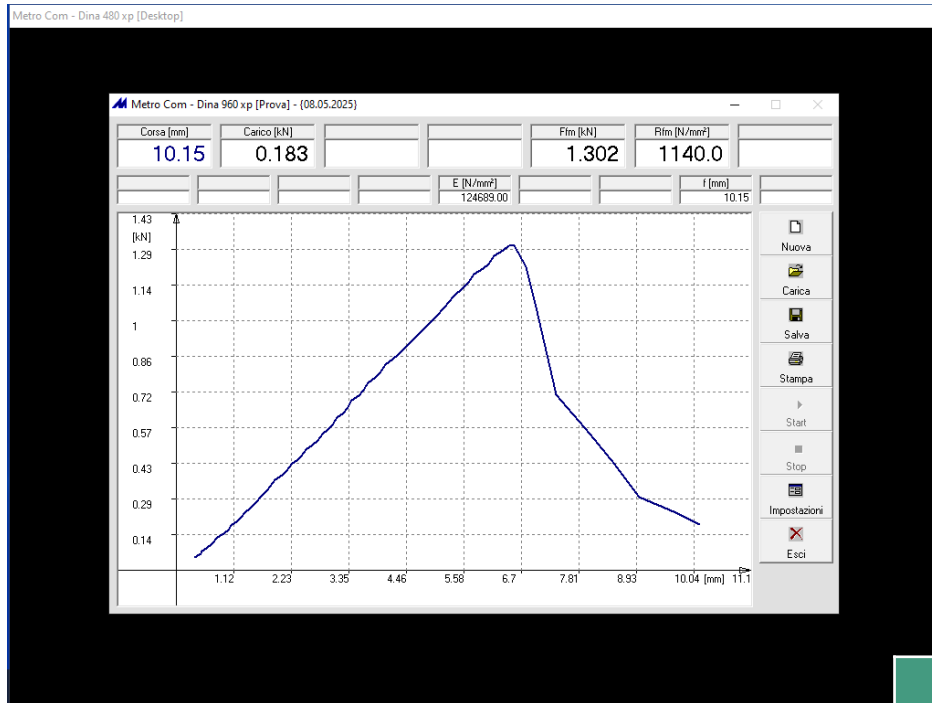


- Wrap up data – GLASS UD with Graphene
  - Definitively higher Load/Deflection ratio
    - Higher load ..... about 50% higher
    - Lower deflection .....about 30% lower
  - Higher E-modulus (shear)
    - + 16%

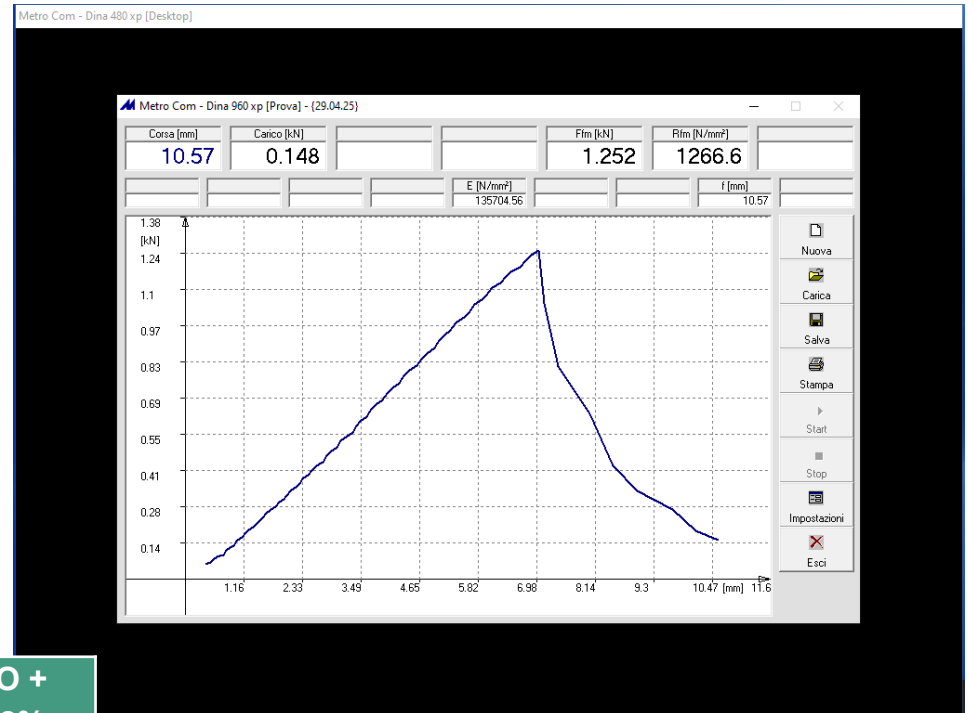
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## Carbon UD



4xCrosspreg®CUd600 reference



4xCrosspreg®GOCUD600

	Reference	GO + 0,2%
Deflection ( mm)	6	6,9
Load (kN)	0,183	0,148
F <sub>fm</sub> (kN)	1,302	1,252
R <sub>fm</sub> (N/mm2)	1140	1266
E Modulus (N/mm2)	124689,9	135704,56

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- Wrap up data – Carbon UD with Graphene
  - No meaningful change in Load/Deflection
  - Slightly Increased E-modulus (shear)
    - + 10%

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- Conclusions :
  - The development is at its beginning and some more variables can influence the results; Graphene works by chemical bonds either with resin and fibers
  - The next variables to keep care of:
    - The sizing on fibres
    - The amount % of Graphene
    - The Graphene chemical functionality
  - Developments are in progress with Natural and Aramide fabrics



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