Improved Thermal Conductivity of Carbon Fiber Reinforced Composites Based on Graphene Interpenetrating Networks

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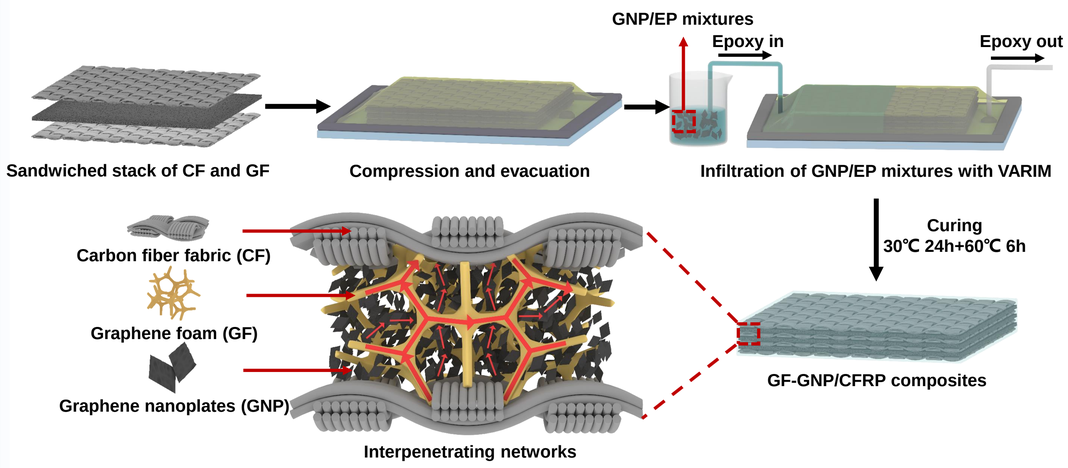
Introduction

- **Structure-function integrated carbon fiber reinforced plastics (CFRP) composites with high mechanical properties and high thermal conductivity (TC) exhibited an urgent demand due to the increased thermal load. However, there is still a main challenge that cannot obtain both high mechanical properties and high thermal conductivity.**
- **The key issues for achieving both enhanced through-plane thermal conductivity and high mechanical properties are to introduce high-efficiency heat transfer networks in the interlaminar region and form strong interlaminar bonding.**
- **Graphene foam (GF) and graphene nanoplates (GNP) were used to construct the interpenetrating networks between carbon fiber fabrics. The obtained composites have exhibited enhanced thermal conductivity and excellent mechanical properties.**

Experimental

Fabrication of GF-GNP/CFRP composites with interpenetrating networks



- **GF was synthesized on nickel foam by chemical vapor deposition technique followed by etching away nickel foam.**
- **GNP was obtained by breaking pristine graphene nanoplates produced by interlayer catalytic exfoliation technique.**

Fabrication of GF-GNP/CFRP composites

- **GF was sandwiched between CF fabrics, after compression and vacuum degassing, GNP/EP mixtures were injected into the mold through VARIM method.**

Results & discussion

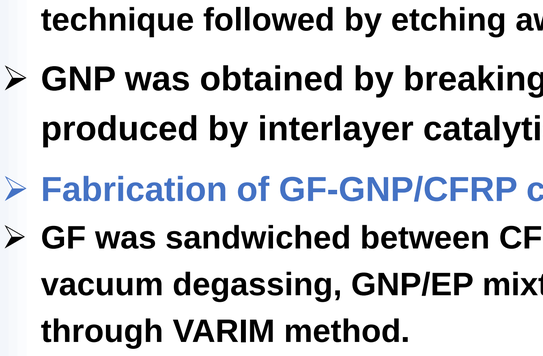
Microstructure of hybrid composites

CFRP

- **Interlaminar resin region**

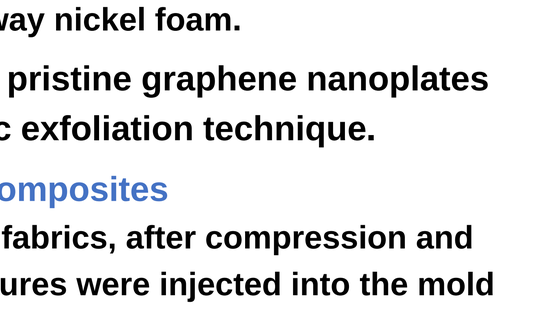
GNP/CFRP

- **Disconnected conductive fillers**



GF/CFRP

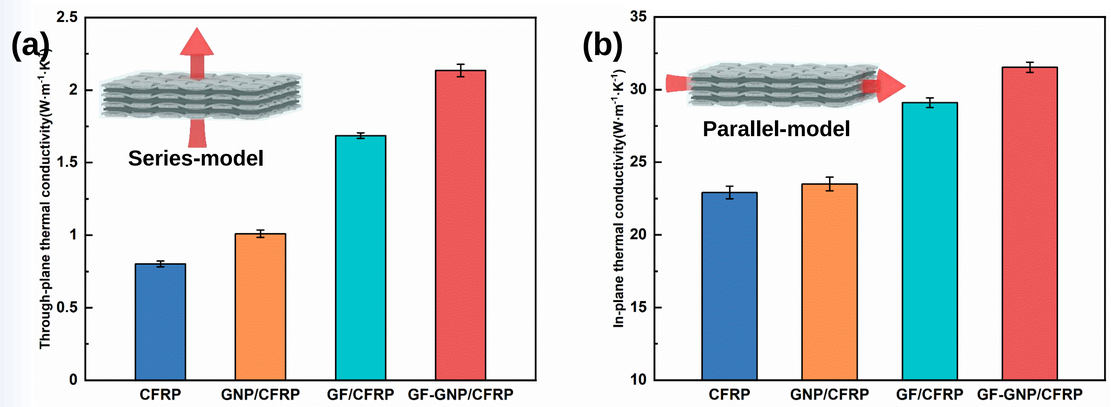
- **Continuous conductive pathways**
- **Limited pathways density**



GF-GNP/CFRP

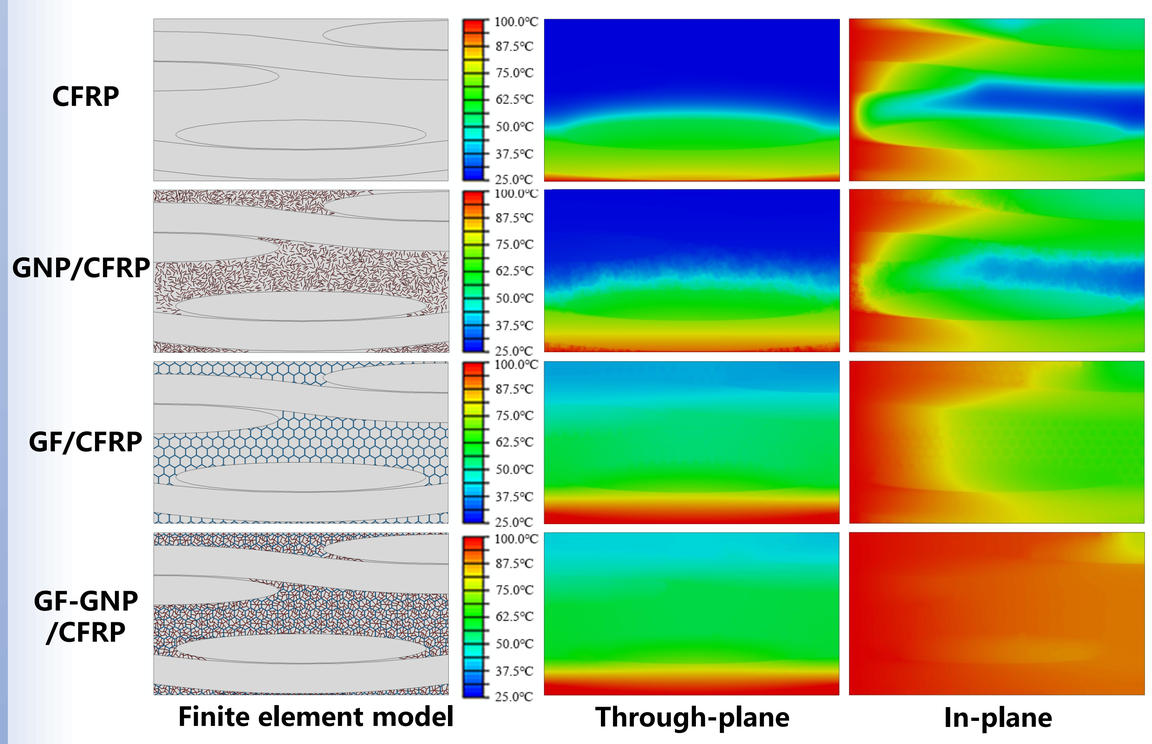
- **Continuous conductive pathways**
- **Rich heat transfer pathways**

Thermal conductivity of hybrid composites



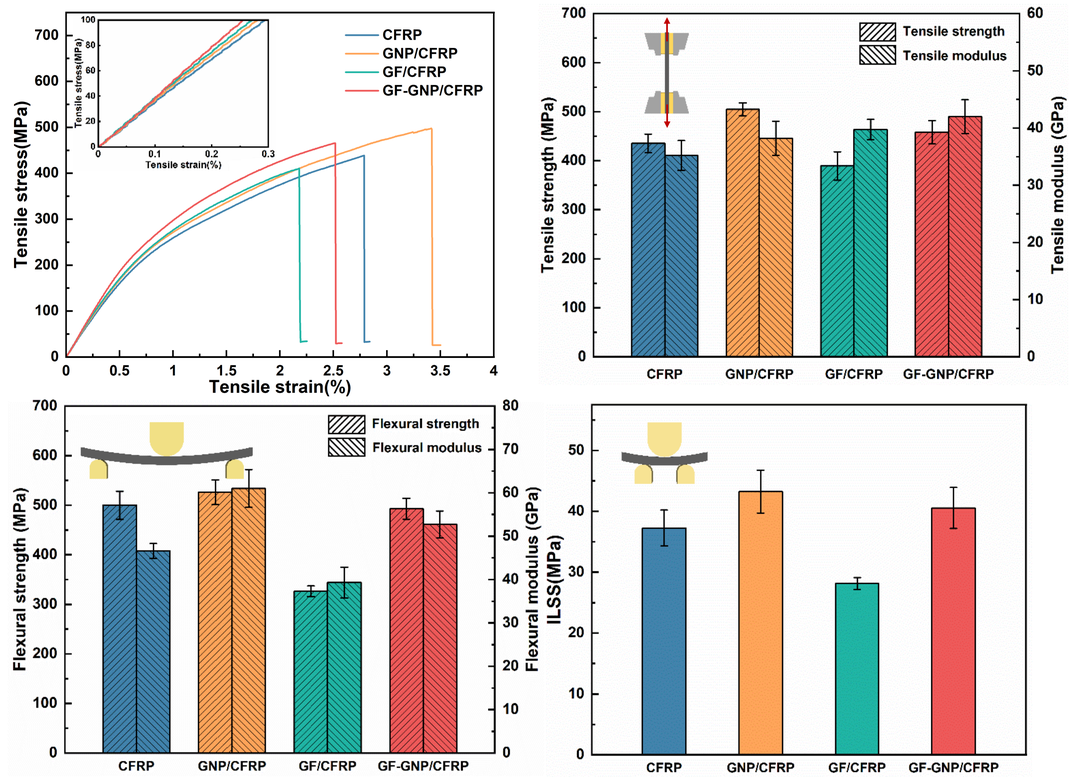
GF-GNP/CFRP composites exhibited efficient (a) through-plane and (b) in-plane TC enhancement, which is attributed to the high-quality and abundant heat transfer pathways provided by interpenetrating networks.

Heat transfer simulation of hybrid composites



The interpenetrating networks greatly reduced interlayer thermal resistance in the through-plane direction and provided heat transfer pathways other than fibers in the in-plane direction.

Mechanical properties of hybrid composites



The excellent mechanical properties of GF-GNP/CFRP composites are attributed to that porous GF facilitated resin infiltration and the filled GNP improved the interfacial adherence and stress transfer.

Conclusion

- **GF and GNP were used to construct the interlaminar interpenetrating networks between carbon fiber fabrics.**
- **The through-plane and in-plane TC of GF-GNP/CFRP composites increased to 2.16 W/m·K and 31.75 W/m·K, respectively, which is due to the efficient and abundant interlayer heat transfer pathways.**
- **The excellent mechanical properties are due to that GF facilitated resin infiltration and the filled GNP improved the interlayer stress transfer.**