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Piezo resistive behavior of GRMs coated glass fiber composite applied to structural health monitoring

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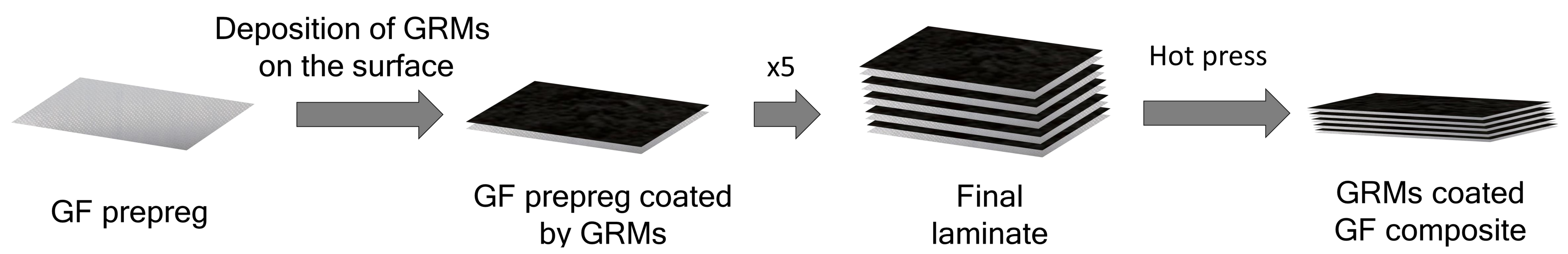
ABSTRACT

Thanks to its exceptional properties, glass fiber reinforced polymer composites are widely employed as advanced engineering material, notably in the automotive industry. Damage and failure of composites, unlike metals, are difficult to forecast under real-time stress due to their anisotropic structure. With that focus, we studied the use of Graphene Related Materials (GRMs) as electrical conductive fillers in insulating glass fiber reinforced composites (GFRC). The objective is to add new functionality to the resulting material such as piezo resistivity, a key property that might represent the breakthrough point for FRC components, allowing their structural health monitoring (SHM) which will increase their reliability. In particular, the piezo resistive effect is a change in the electrical resistivity of material when mechanical strain is applied and in our case is due to the rearrangement of the electrical conductive GRMs network inside the polymer matrix [1]. First, we demonstrated the piezo resistive behavior in the developed composite and second, we proved that it is possible to correlate its resistance variation with the structural health of the SHM prototype.

GRMs COATED GLASS FIBER (GF) COMPOSITE

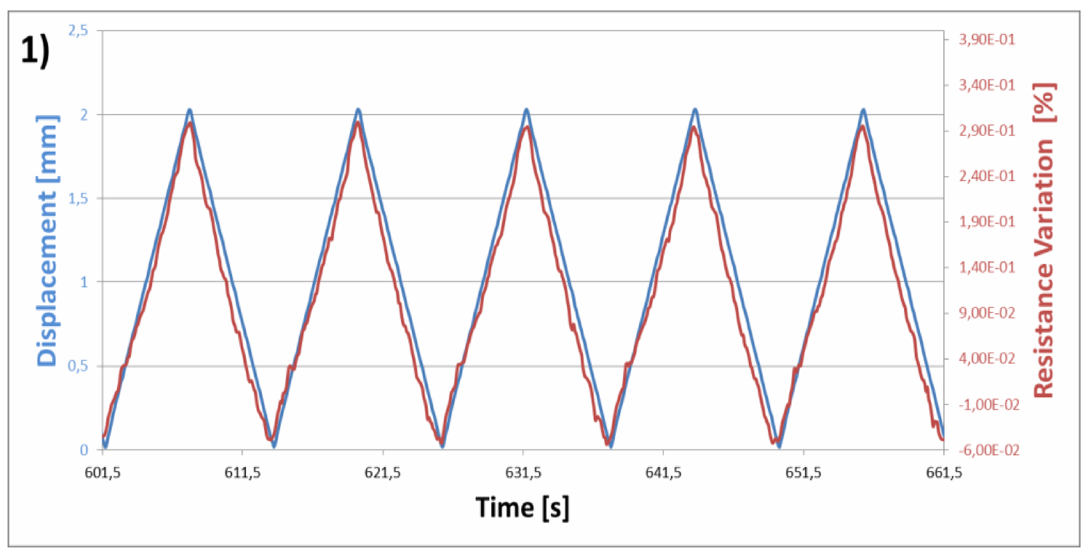
PRODUCTION SCHEME

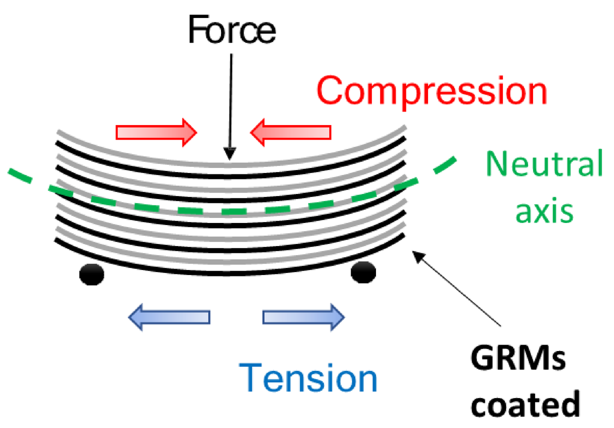


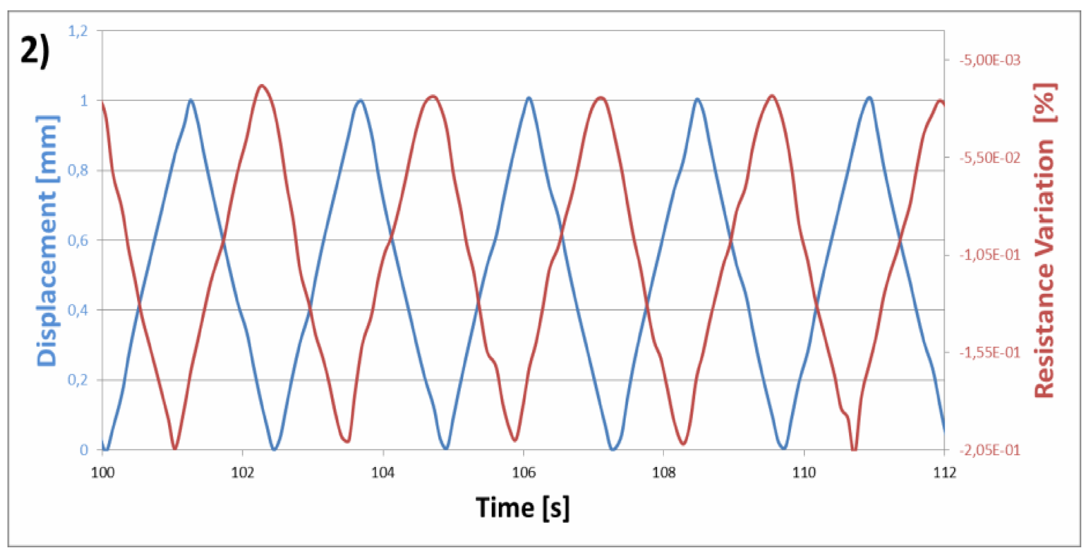
Conductivity: 7 ± 4 S/m

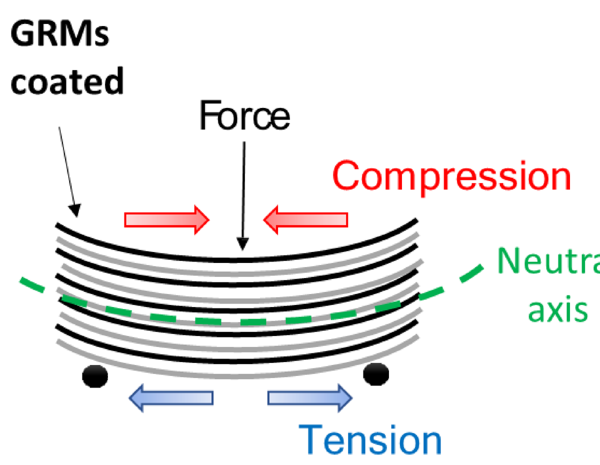
Resistance: 520 ± 30 Ω

EVALUATION OF PIEZO RESISTIVE BEHAVIOUR: BENDING TEST









RESULTS

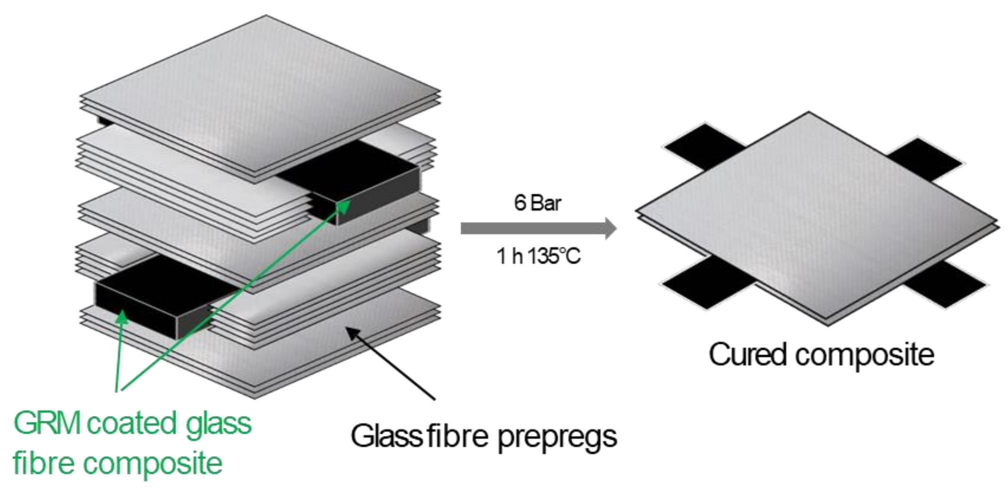
The samples show two different piezo resistive behavior depending on the samples side:

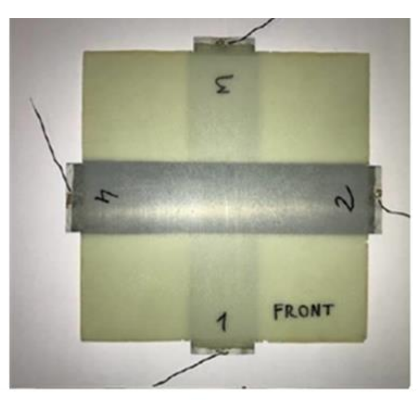
1) The electrical resistance rises when the GRMs coated side is subjected *to tension* (in phase with displacement);

2) The electrical resistance falls when the GRMs coated side is subjected *to compression* (out of phase with displacement).

PROTOTYPE FOR THE STRUCTURAL HEALTH MONITORING (SHM)

PRODUCTION SCHEME





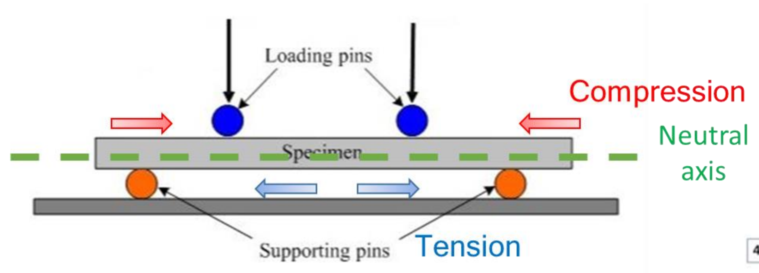
Optical image

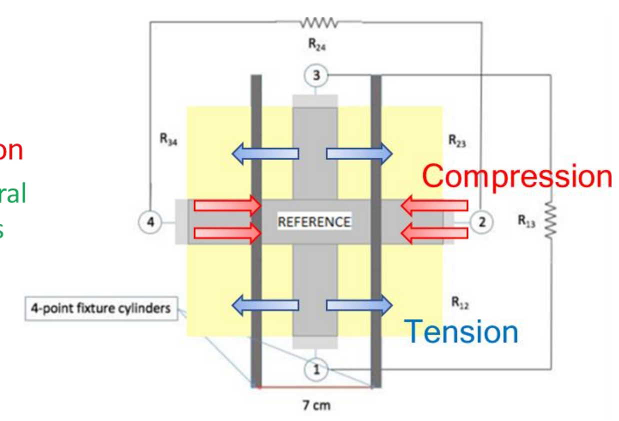
Conductivity: 10 S/m

$R_{13} \approx 730\ \Omega$

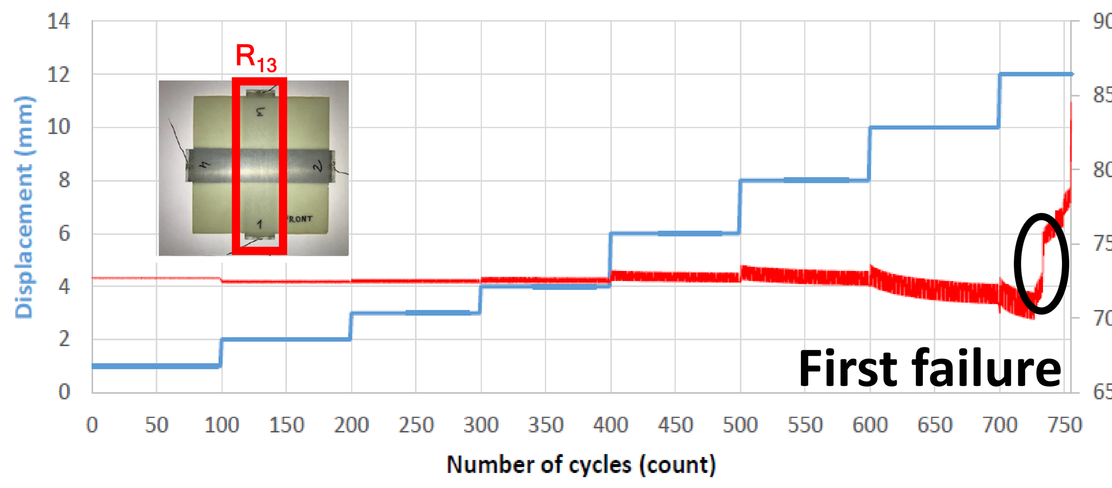
$R_{24} \approx 680\ \Omega$

ELECTROMECHANICAL CHARACTERIZATION: 4 POINT BENDING TEST



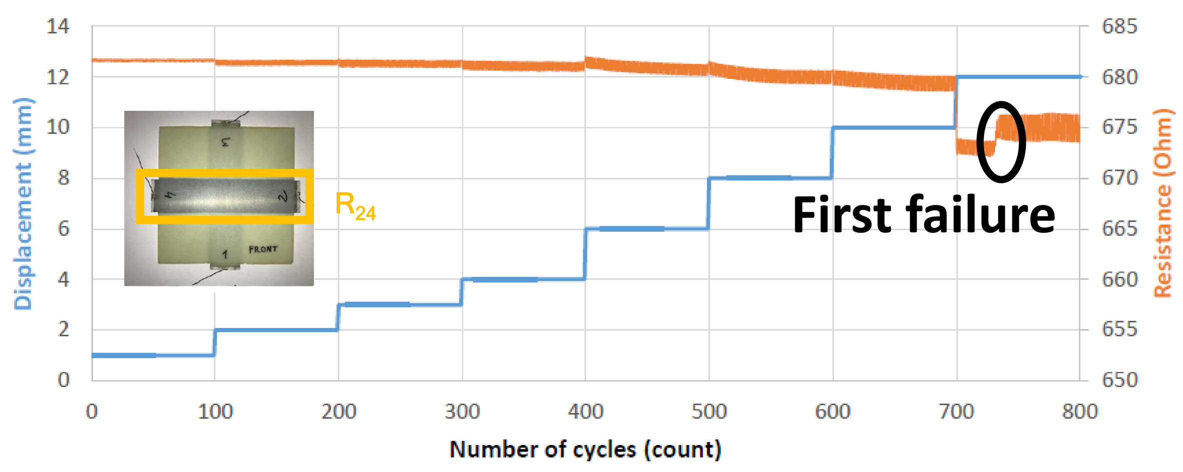


SHM RESULTS



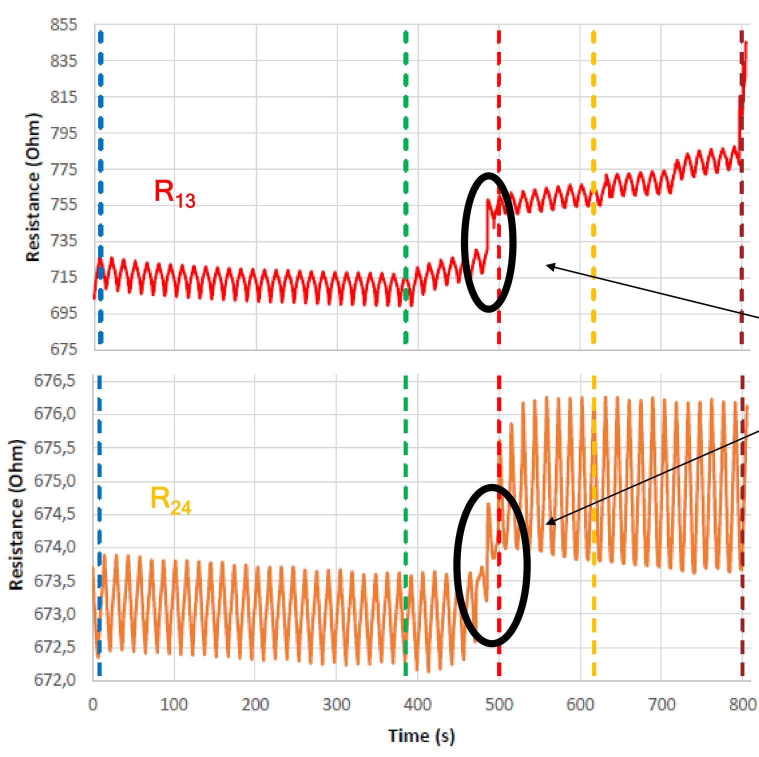
R_{13} is in phase with displacement (subjected to tension)

Rise of electrical resistance



R_{24} is out of phase with displacement (subjected to compression)

Fall of electrical resistance



Failure detected though resistance variation

CONCLUSIONS

- GRMs-enhanced composites showed good piezoresisitivity behavior with high reproducibility;
- It is possible to correlate the resistance variation with the structural health of the GRMs-composites.

CONTACT PERSON

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REFERENCES

1. Valorosi et al, Composites Science and Technology 185, 2020, 107848

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