

Investigation of the electrical resistance change of carbon fibre composites in the presence of damage

Dr. José David Acosta
AMADE (UdG)
Girona, 23/01/2026

Outline

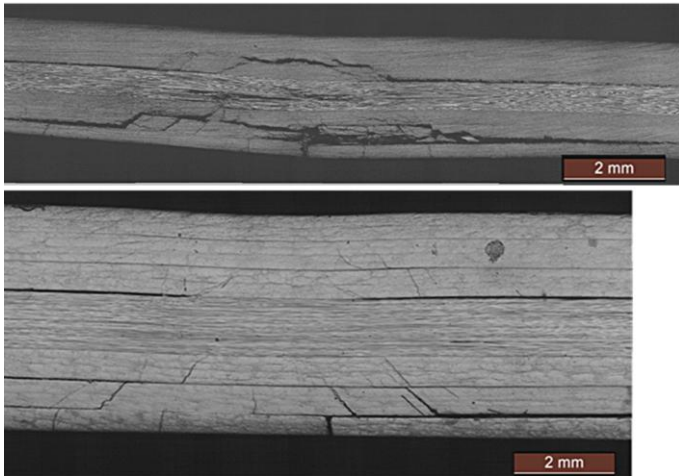
- **Introduction**
 - Context
 - Current State of the art
 - Background
- **Electrical resistance of CFRP**
 - Loading-unloading tensile response
 - Effect of carbon fibre type
 - Effect of carbon fibre layer thickness
 - Effect of cyclic loading
- **Applications**
 - Sensing layer
 - Out of plane sensor
 - Infrared thermography
- **Conclusions**

Context: Damage in composites

- **High Value**

CFRPs combine high strength with low weight, making them widely used in aeronautics, aerospace, sports, and wind energy.

- **The Challenge**



They are susceptible to internal damage that is often invisible from the surface.

Fail catastrophically with no warning.



Composites are more over-designed than metals

Current state-of-the-art

Damage detection techniques in composites

Global sensing

Quick monitoring of large areas to identify and locate damage.

Vibration based methods, guided waves, fibre optic sensing.

Pros: rapid large-area coverage, cost effective, continuous monitoring, etc.

Cons: Low sensitivity to minor damage, environmental sensitivity, etc.

A method that combine the best of global and local sensing is missing in the market!

Local sensing

High resolution. It quantifies damage

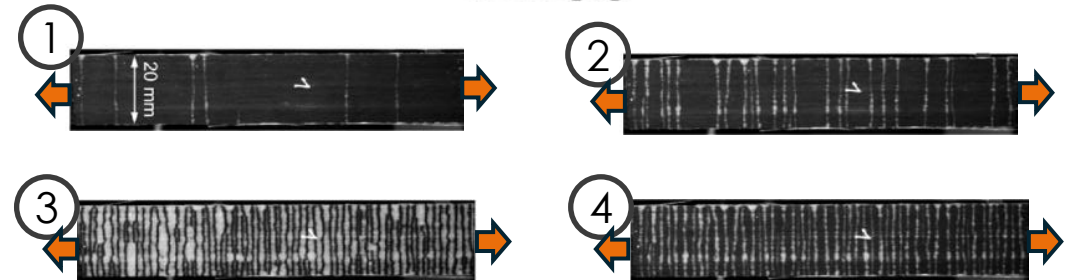
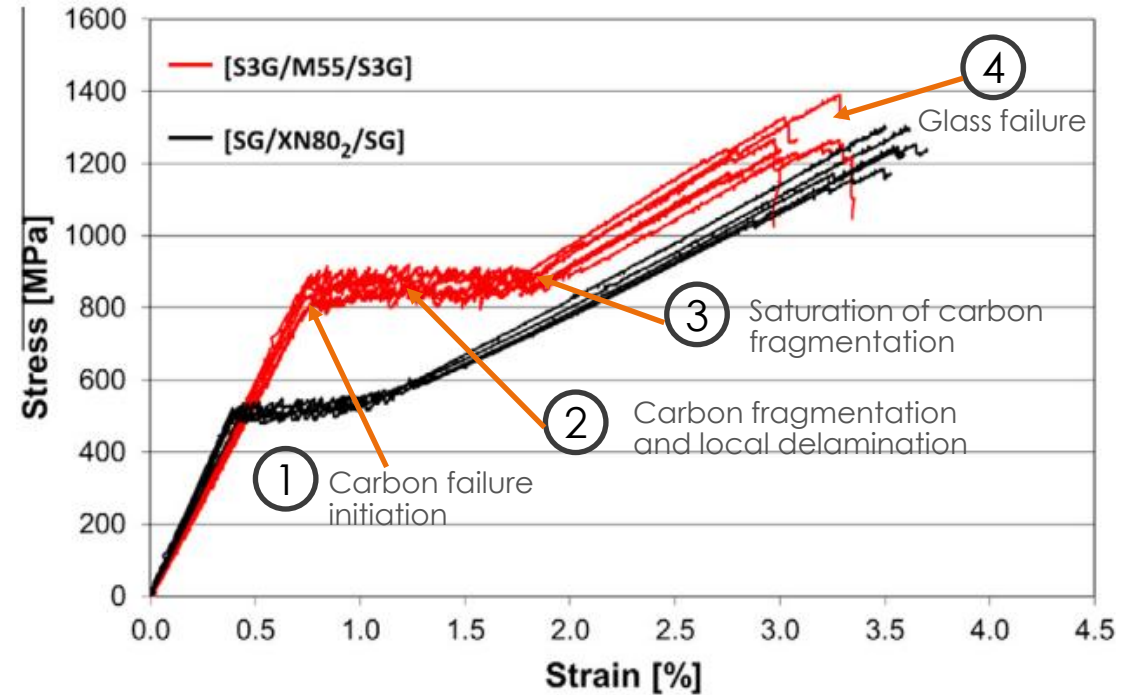
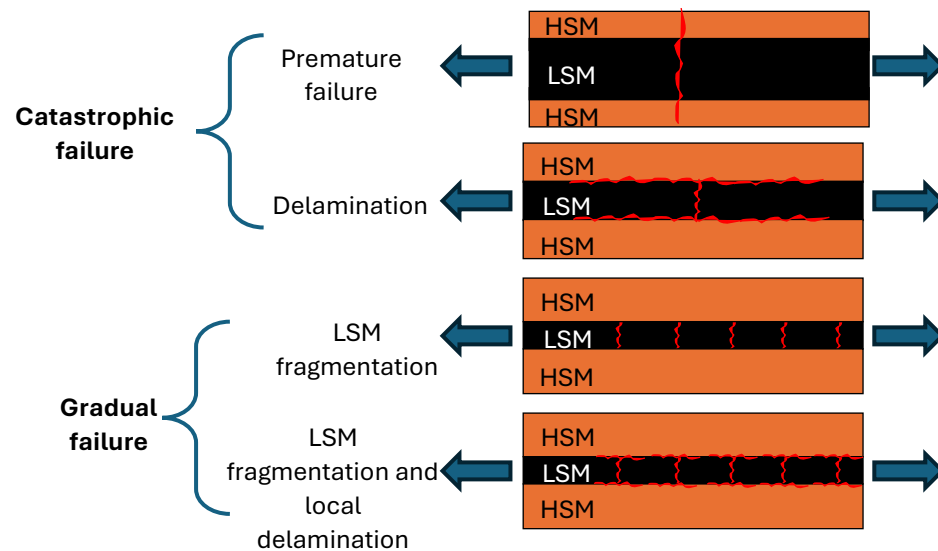
Infrared thermography, strain gauges, acoustic emission, X-ray CT-scan.

Pros: High precision, damage quantification, etc.

Cons: Restricted field of view, high data and equipment cost.

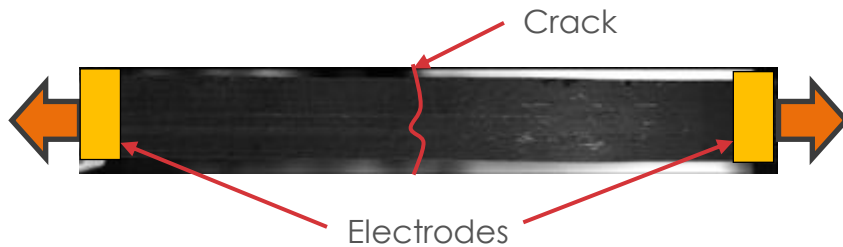
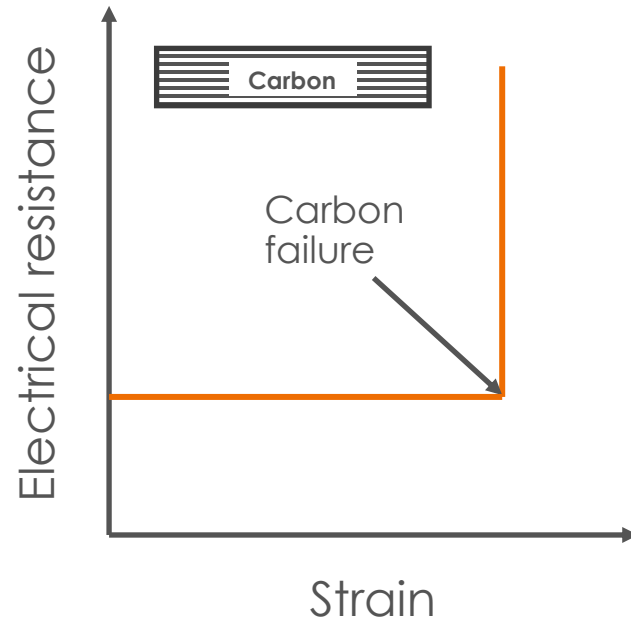
Background

Pseudo-ductile hybrid composites

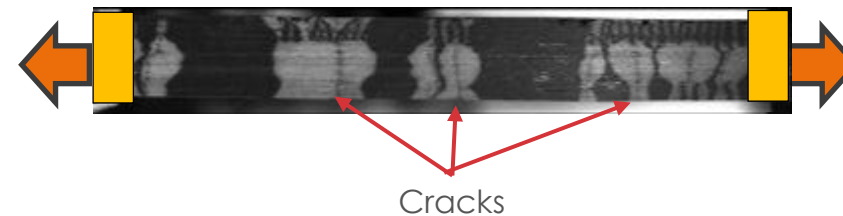
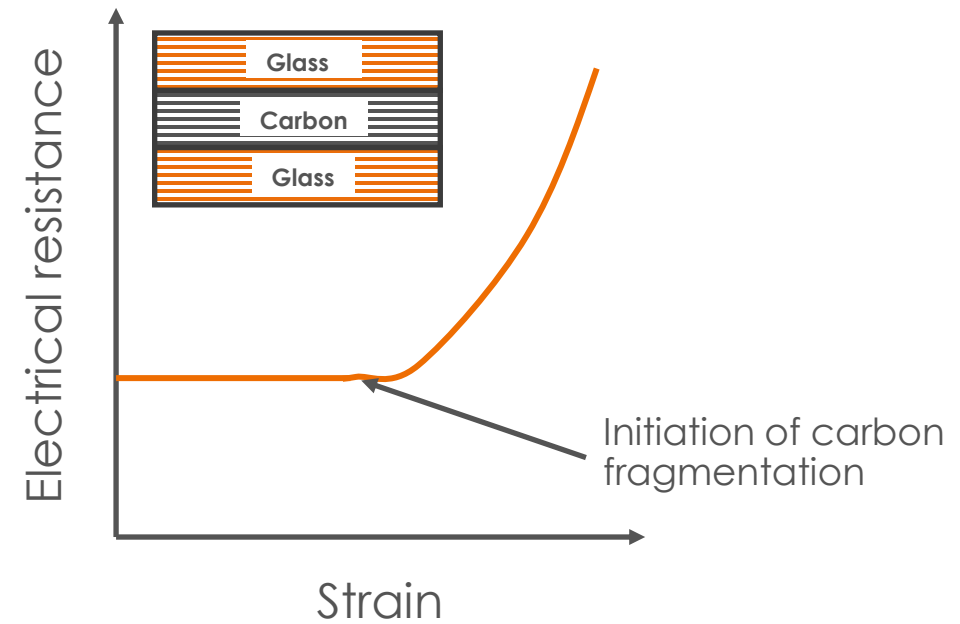


Electrical resistance of carbon composites

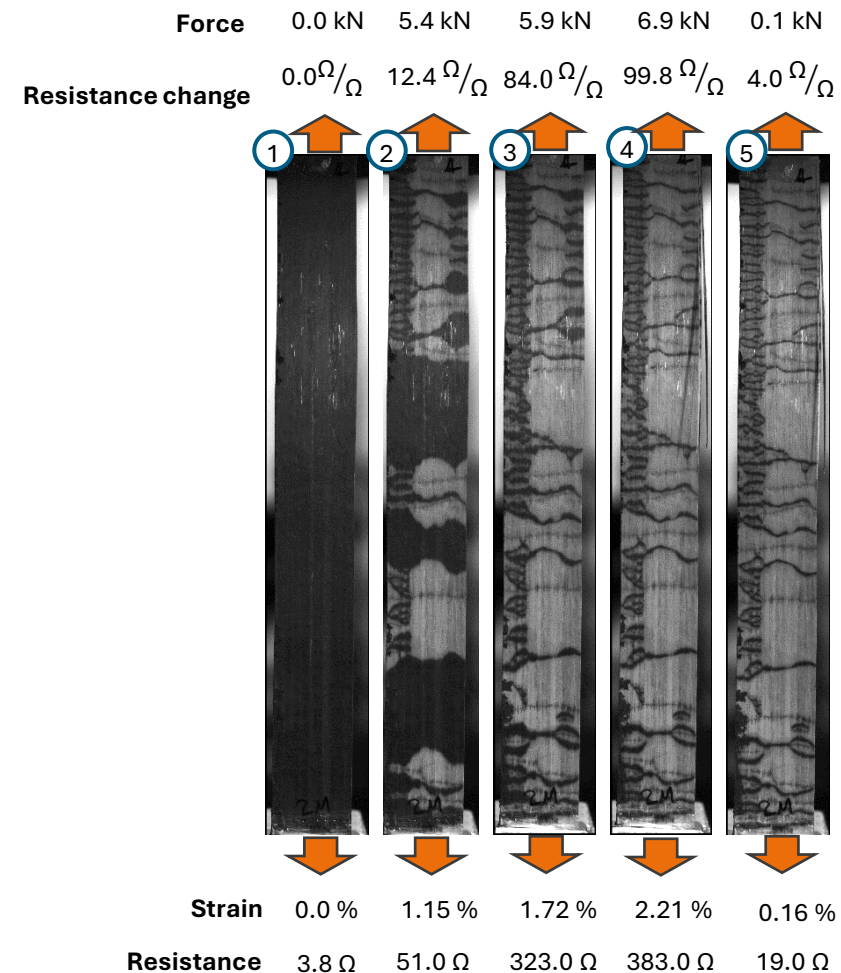
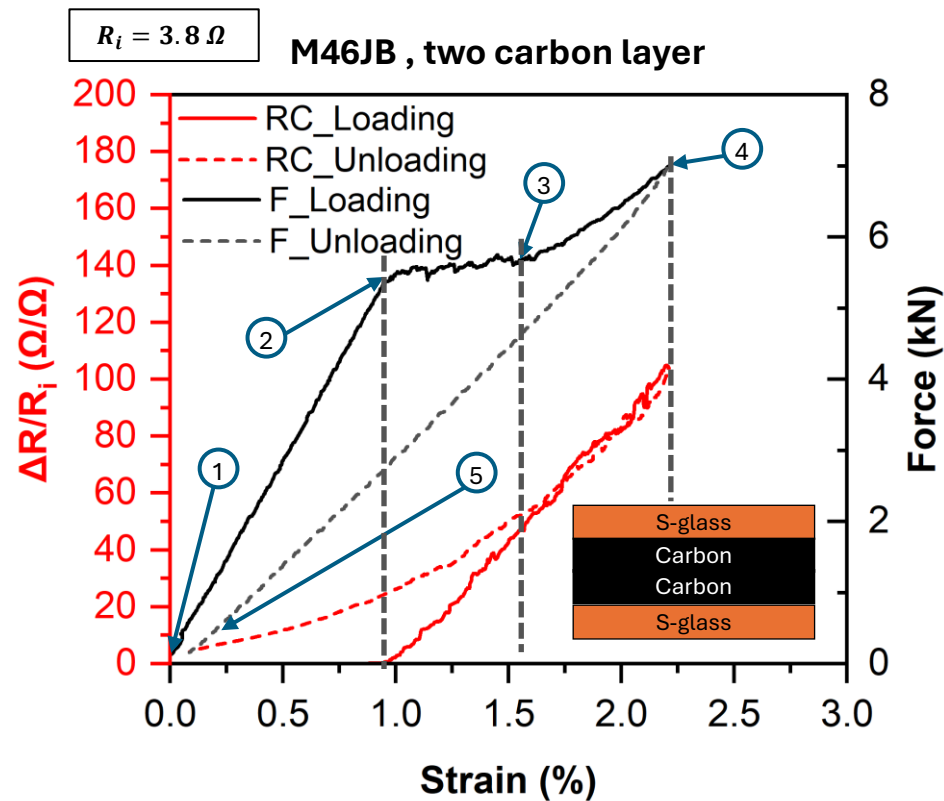
Standard carbon composite



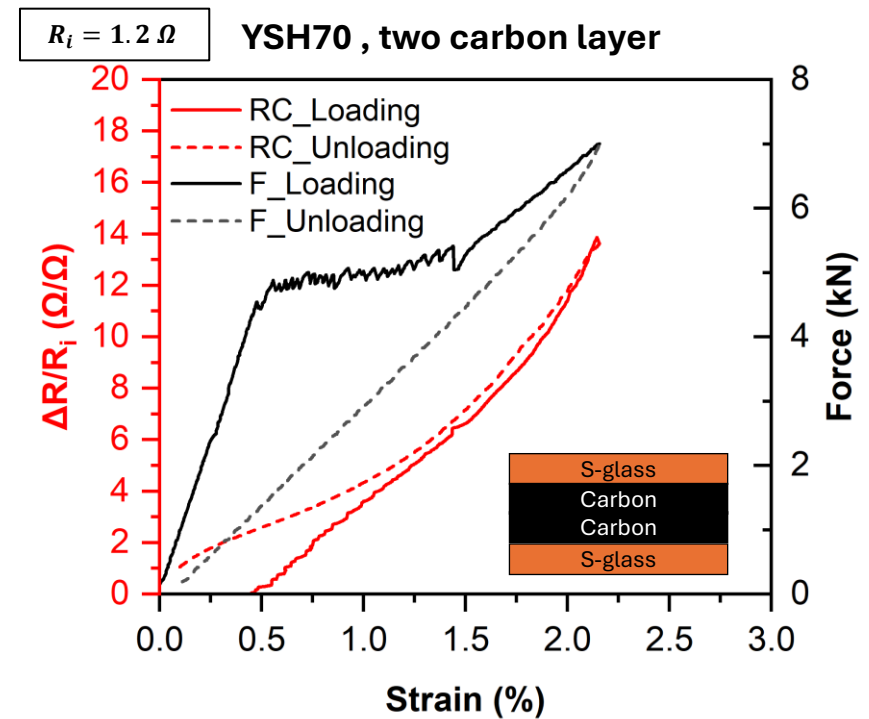
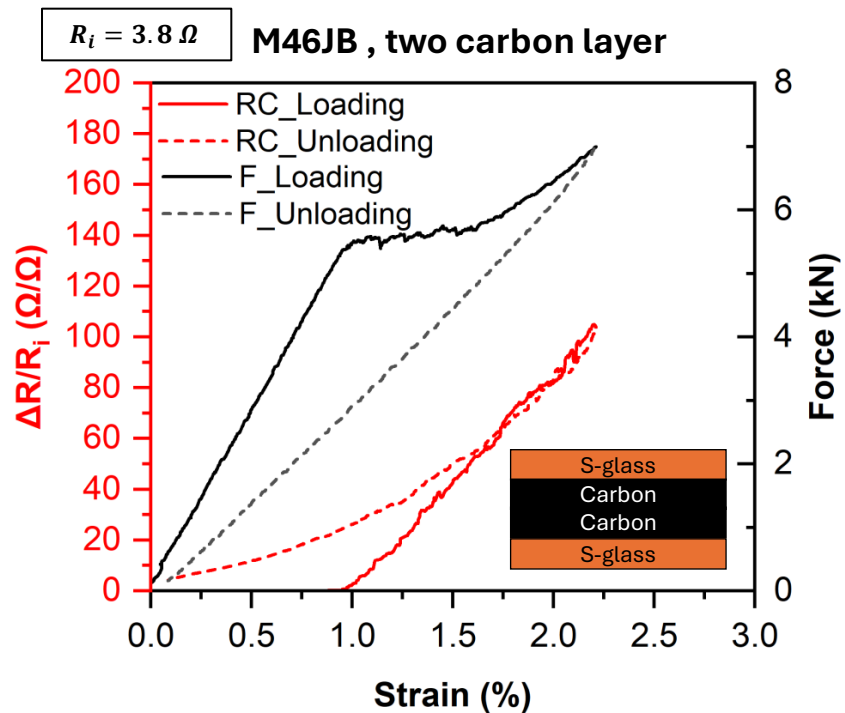
Hybrid composite



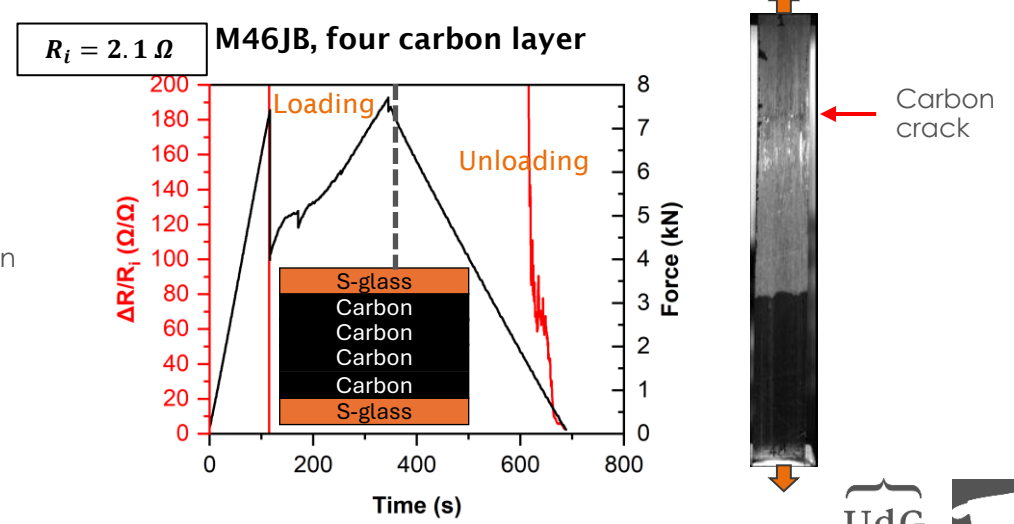
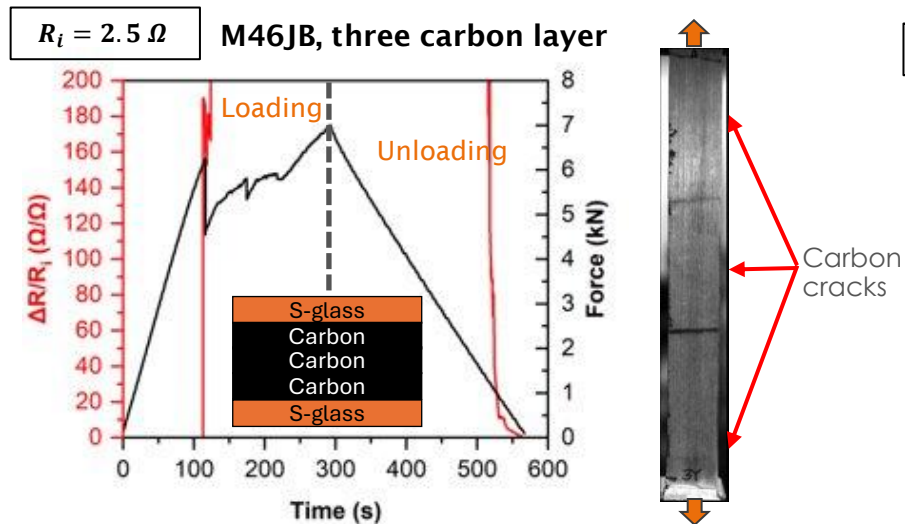
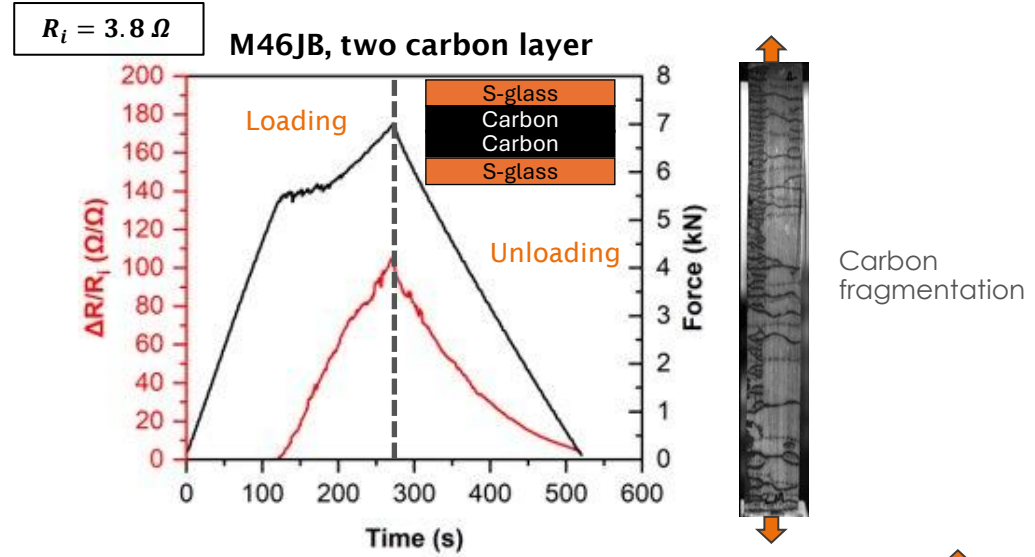
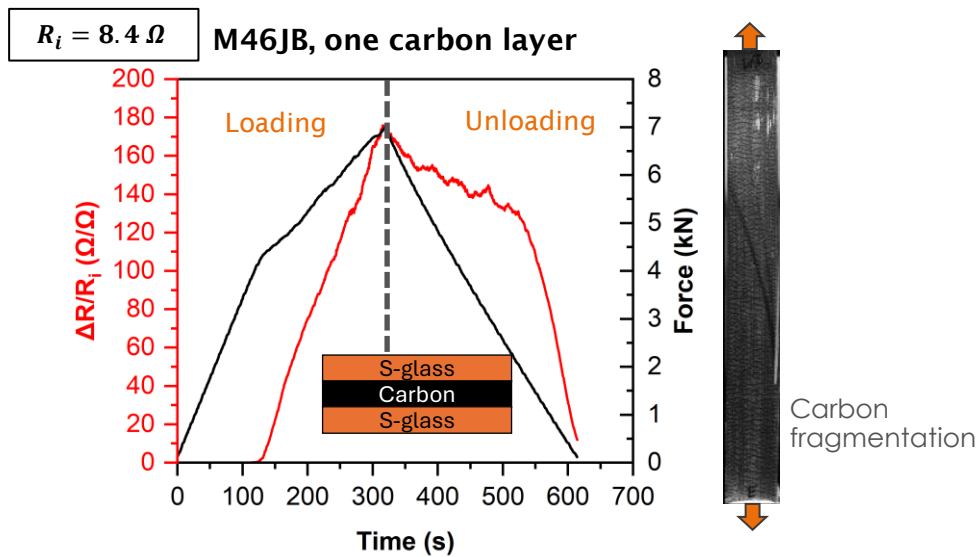
Loading-unloading tensile response



Effect of carbon fibre type

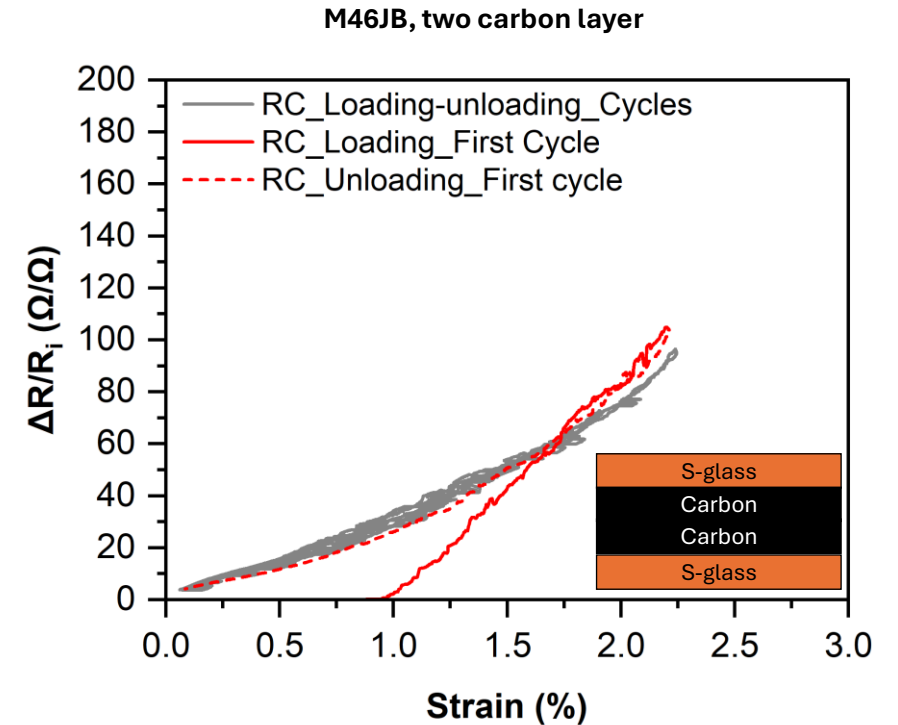
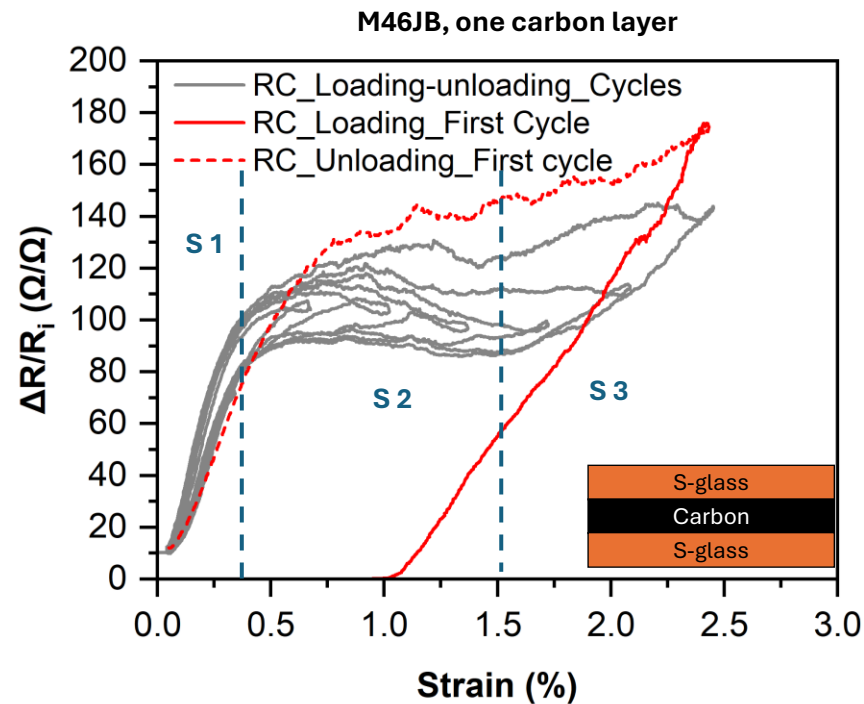


Effect of carbon fibre layer thickness



Effect of cyclic loading

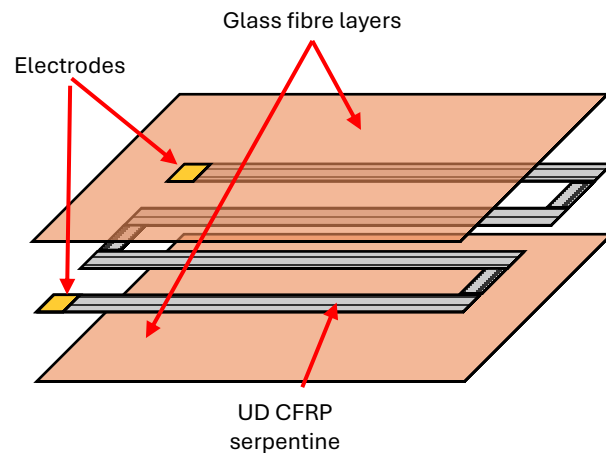
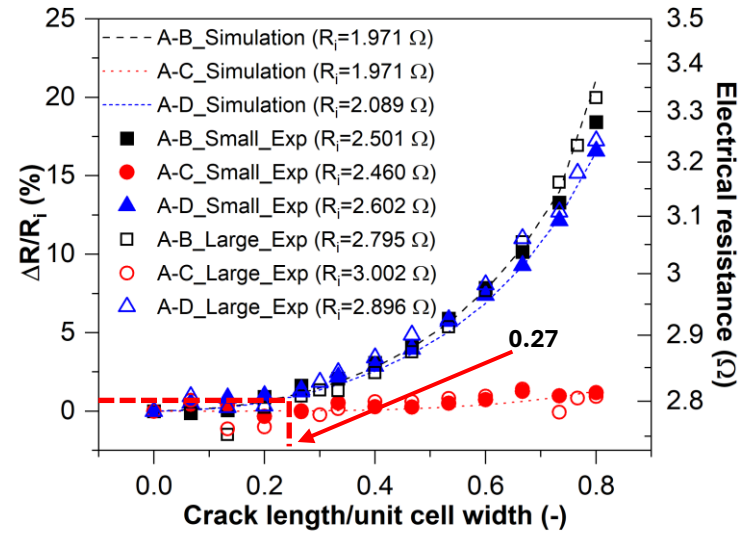
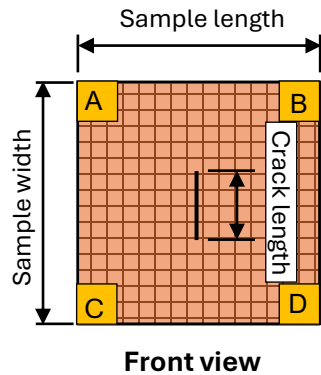
- Cyclic loading at increasing load levels opens existing cracks, leading to higher electrical resistance.
- For the single carbon-layer configuration, three distinct stages are observed in the resistance response.



The two-carbon-layer configuration exhibits a linear increase in resistance with applied load.

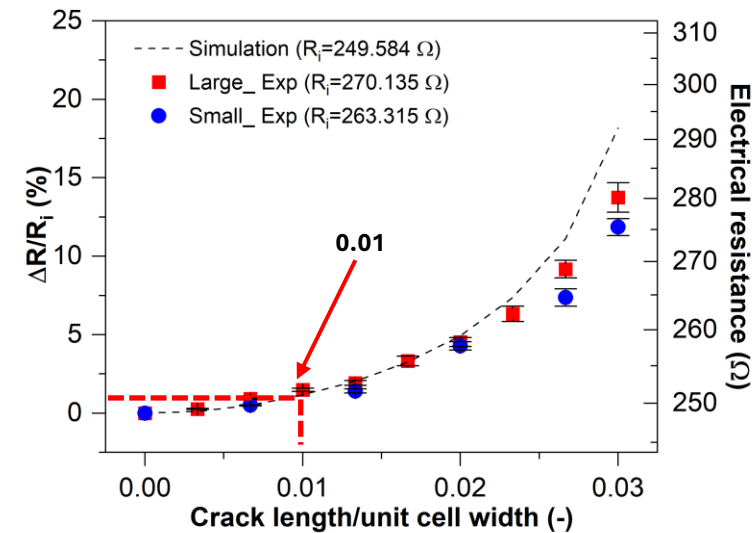
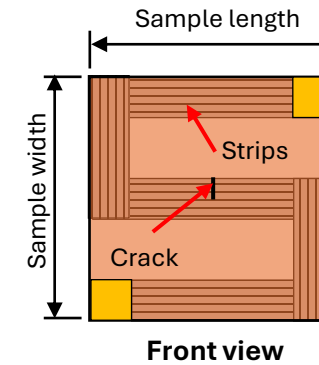
Application: sensing layer

Cross ply sensing layer



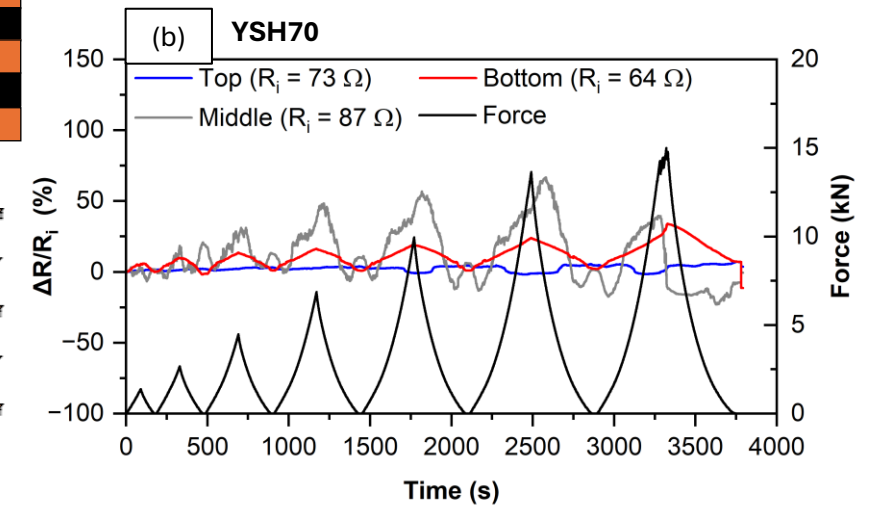
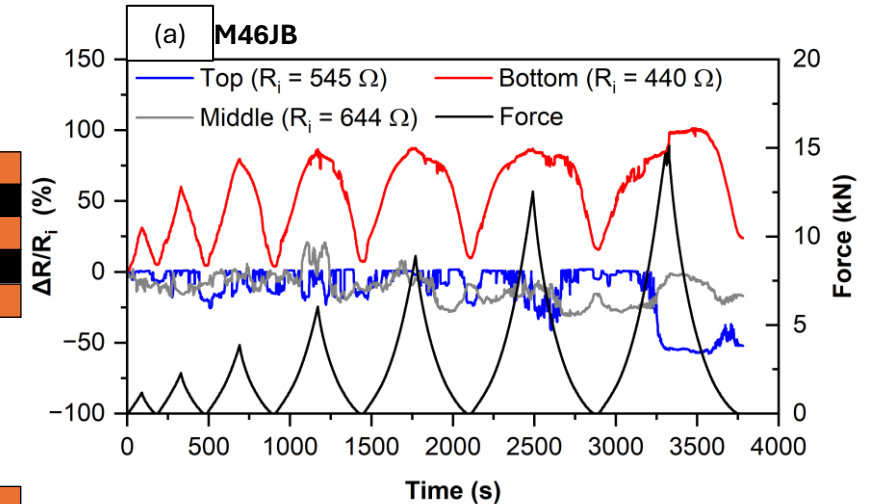
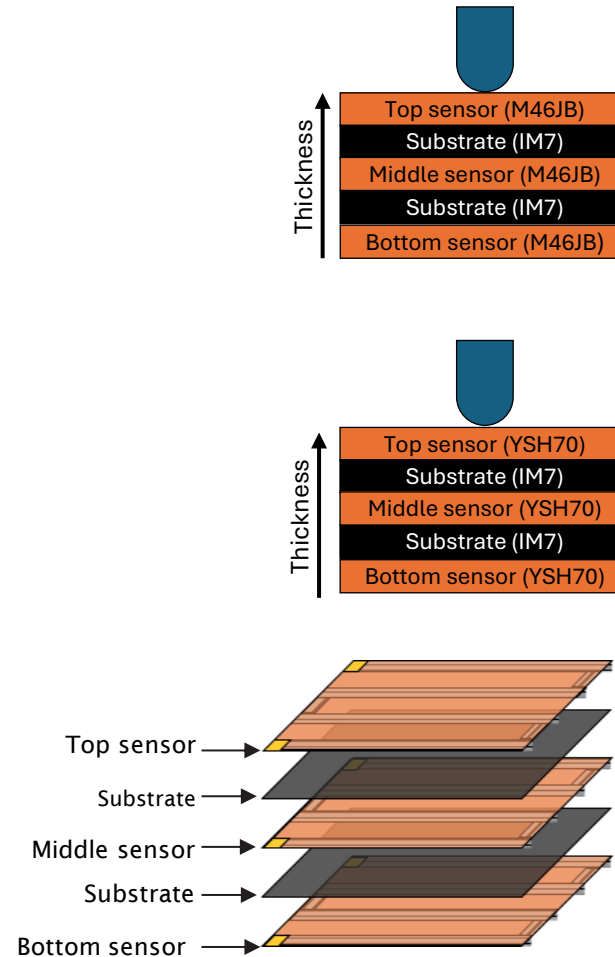
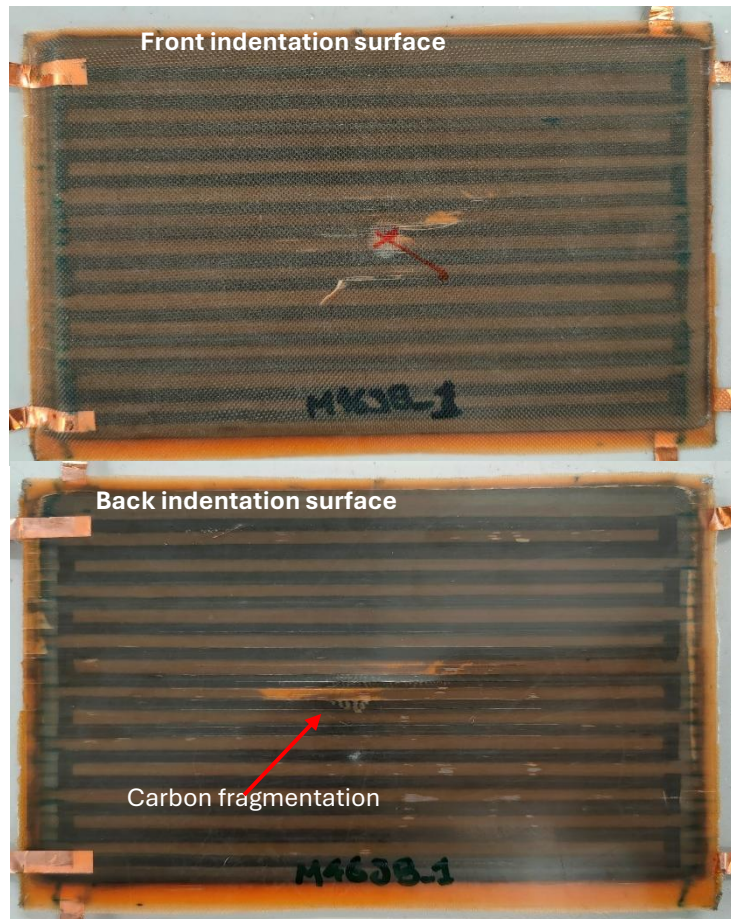
Sensor layout

Serpentine sensing layer



Application: Out of plane overload detection

Indentation tests

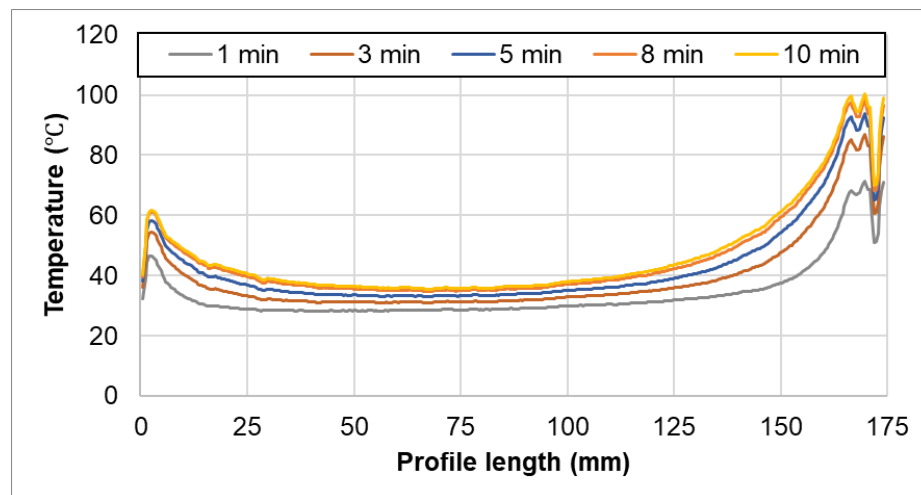


Infrared thermography

Healthy sample



Temperature profile



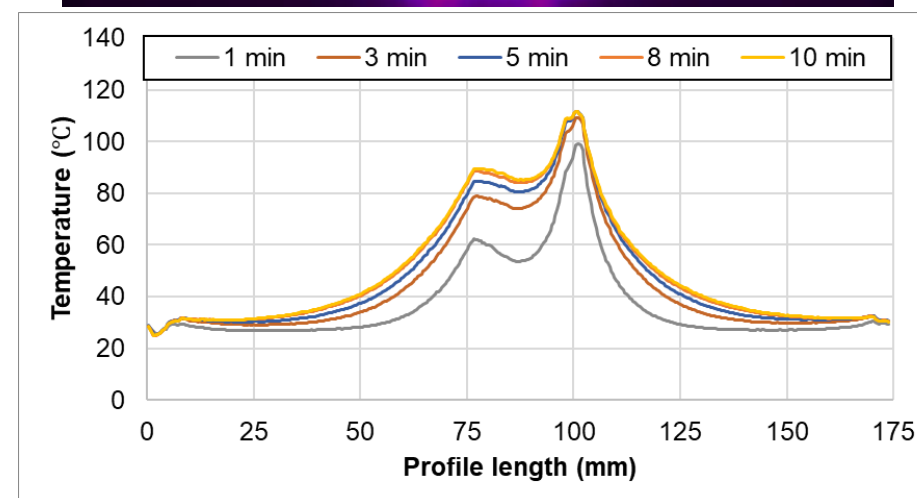
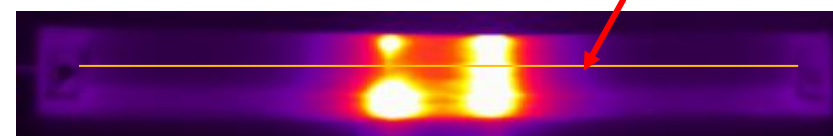
Damaged sample

(after a three-point bending test)



Cracks

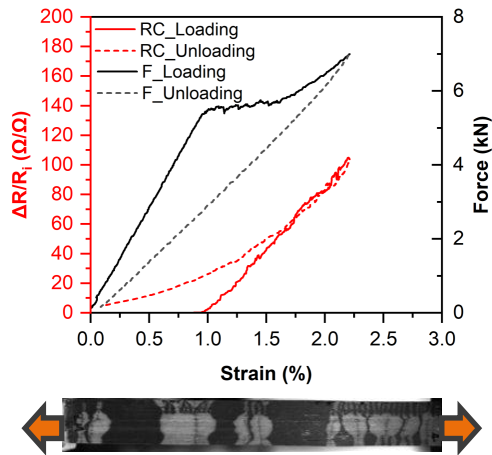
Temperature profile



CONCLUSIONS

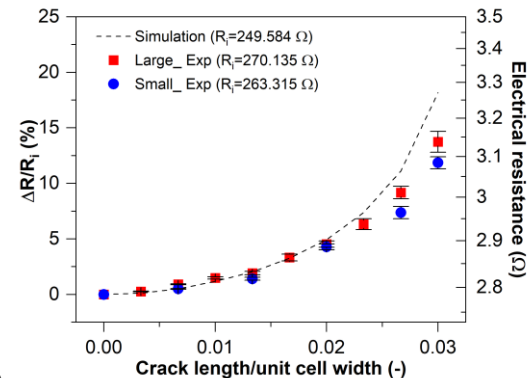
Conclusion :

Hybrid overload **sensors** show resistive **sensing** properties and can be **used** as a sensor to **indicate overloads**.



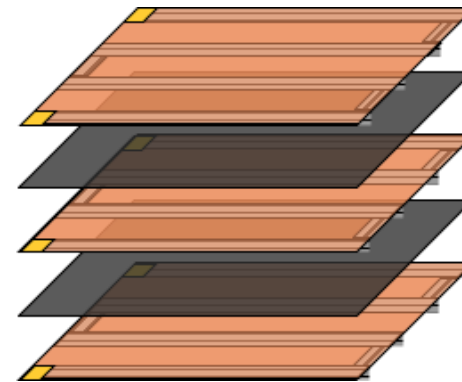
Conclusion :

This investigation provides a validated methodology for designing **low-cost**, **scalable**, and **highly sensitive monitoring systems** for **composites** by using an embedded serpentine sensor architecture.



Conclusion :

This approach **shifts** **damage sensing** from **intrinsic electrical properties** of the structure to a **standardized**, independent **sensing layer**.



Future work :

Evaluate the proposed approach under **various conditions**, including **fatigue loading**, **environmental factors** such as **temperature** and **moisture**, **drop-weight impact**, **electrode degradation** and **application to structural components**, among others.





Thank for your attention!

Jose David Acosta Correa

Josedavid.acosta@udg.edu



AMADE

ANALYSIS AND ADVANCED MATERIALS
FOR STRUCTURAL DESIGN



University of
Southampton