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Overstrain sensors for Structural Health Monitoring

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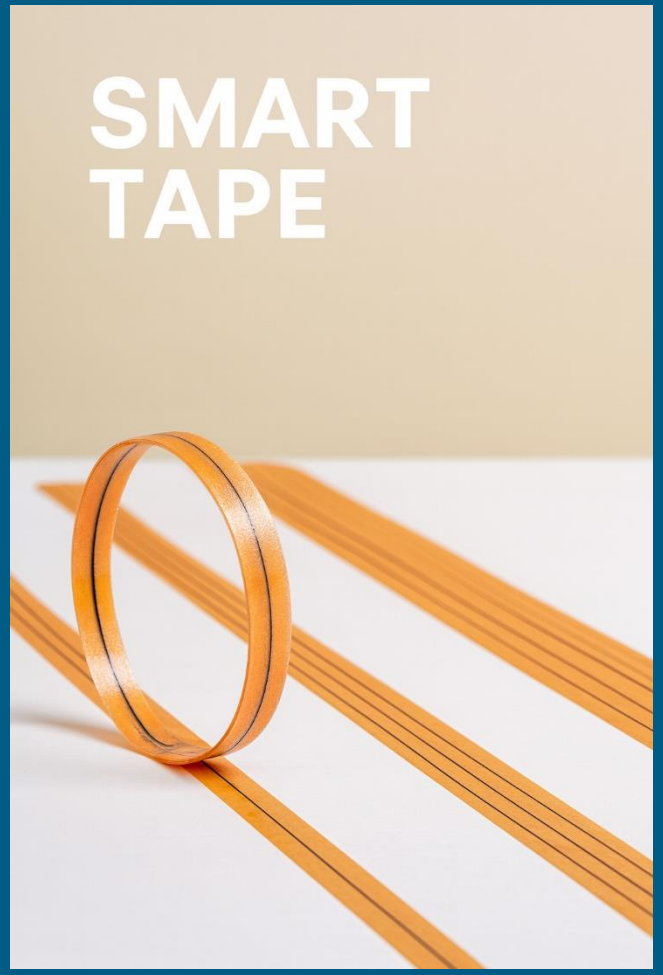
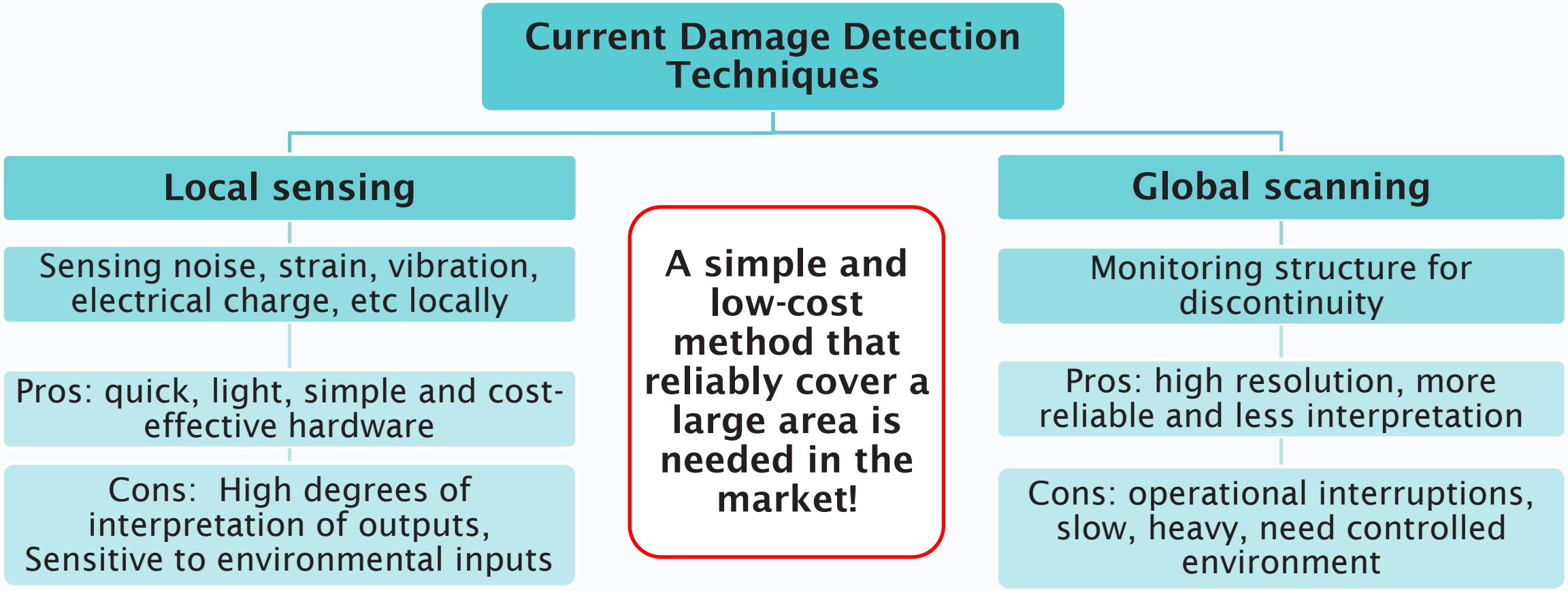
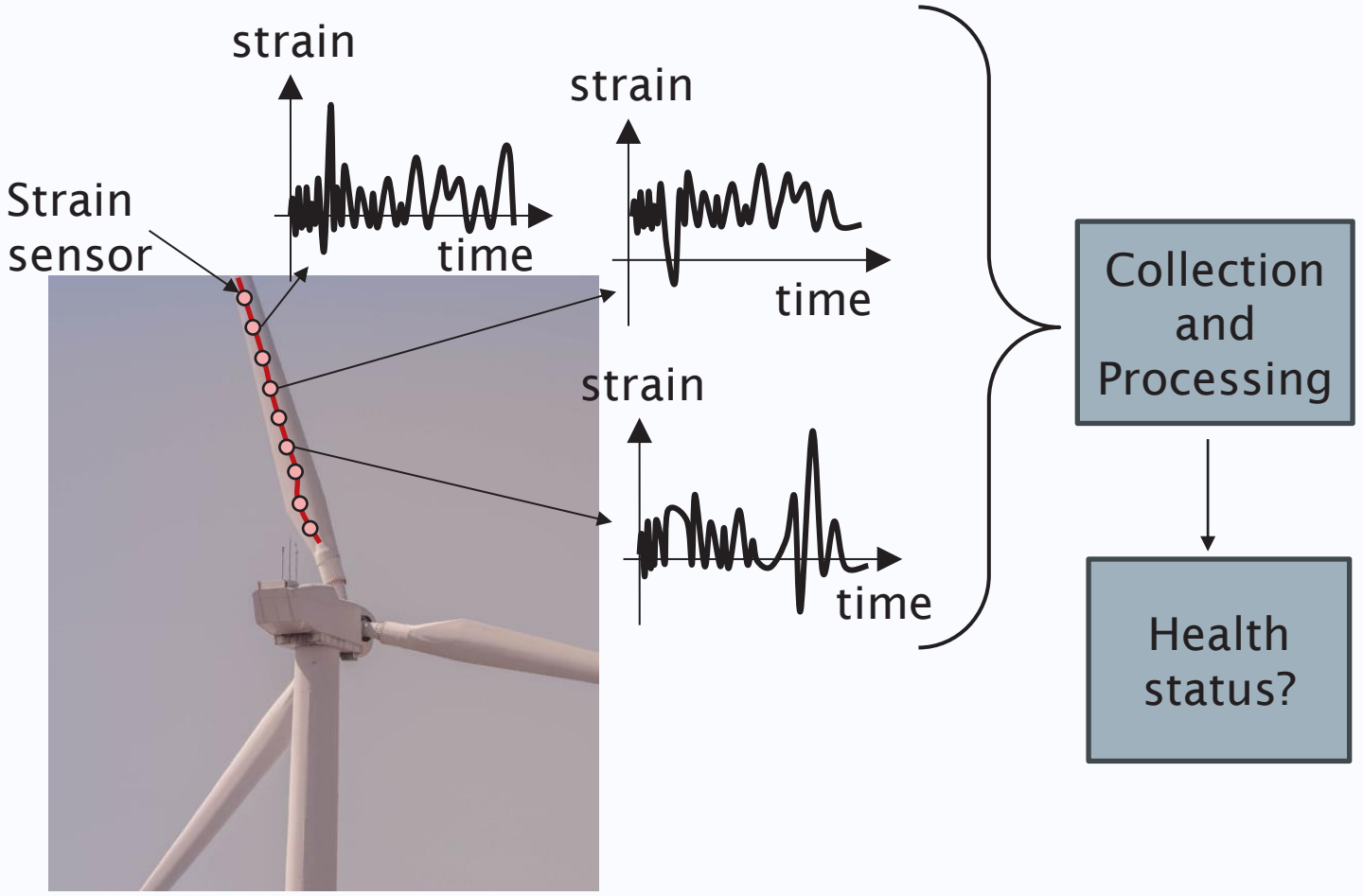


SHM State-of-the-art: complex and/or costly

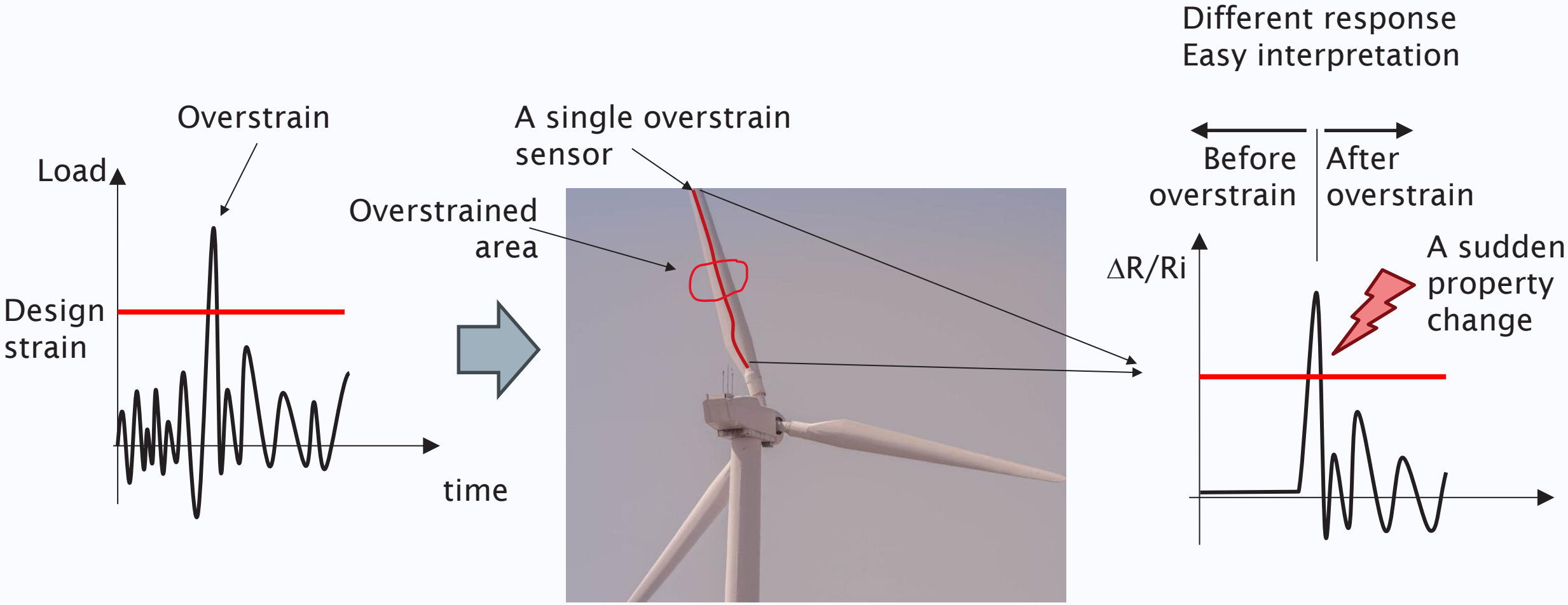


Interpretation of strain is challenging!

- Strain changes with time and location
- Needs continuous sensing
- Sensitive to environment e.g. temperature, moisture, etc,
- Generating a huge volume of data
- Often requires recalibration
- Interpretation of a structure's health from strain is challenging



Overstrain Sensing + localising the overstrained area



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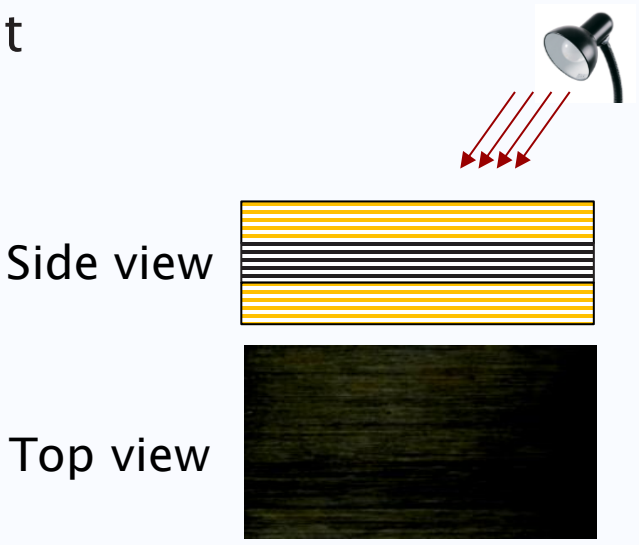
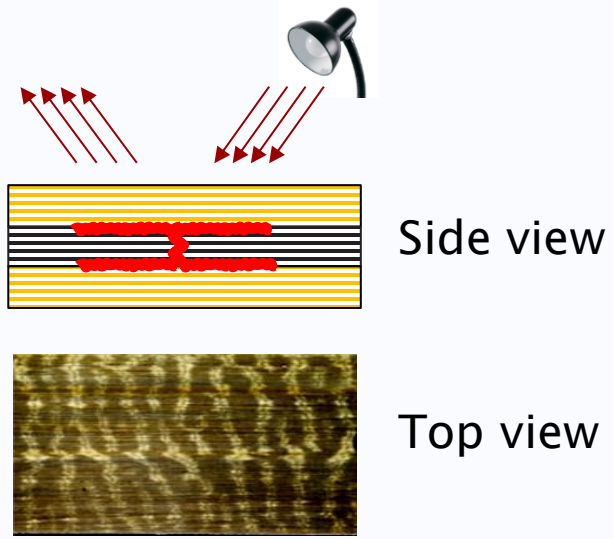
Visual Overstrain Sensor

Visual static overstrain sensor

- Carbon layer fracture and delamination produces light areas, changing the appearance of glass/carbon hybrids.
- UK Patent



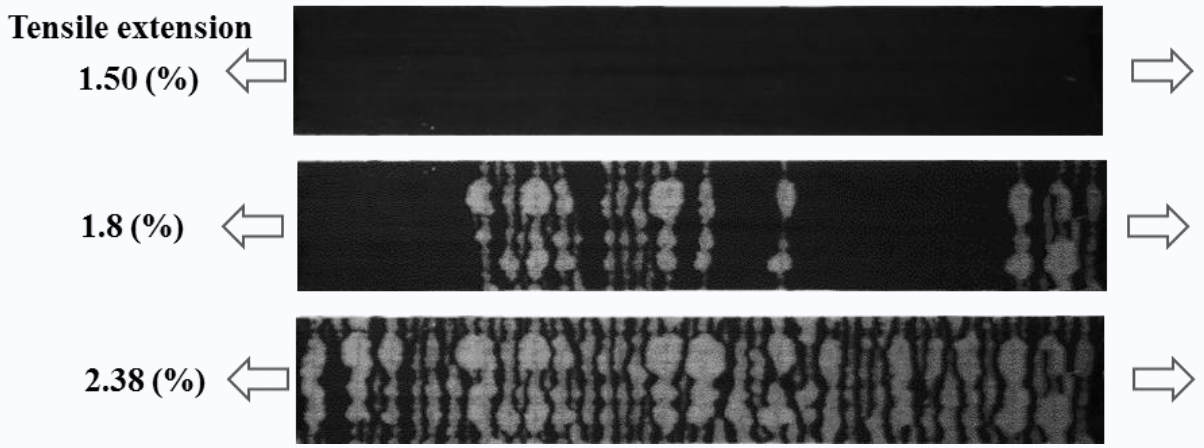
Light is completely absorbed by the carbon layer.



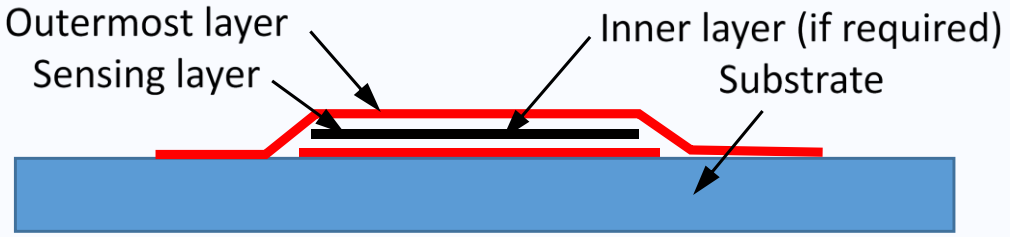
Delamination and gap at glass/carbon interface reflects light back.

Visually detectable damage

- Wireless and offline
- Low cost
- Robust
- Lightweight
- Requires no special training
- Whole surface layer or a patch
- Directional



Ordinary photos, NOT special NDT

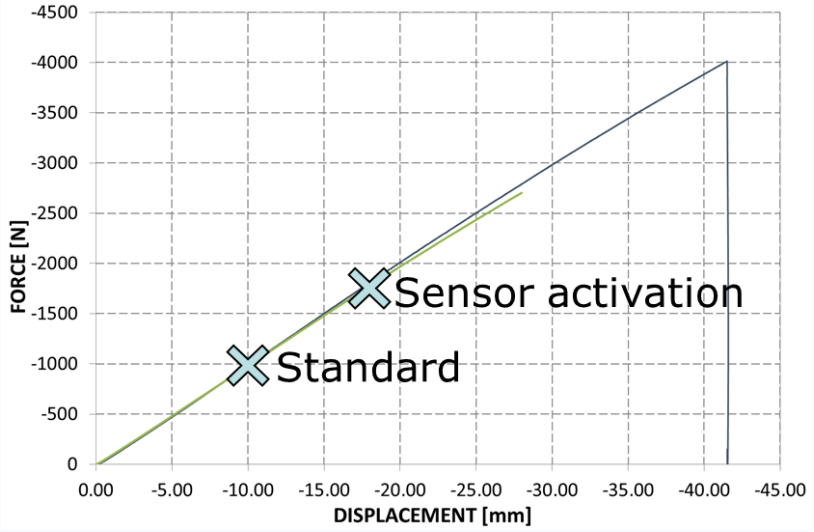


Handlebar instrumented by the overstrain sensor

EN14781 Standard load:
1000 N

Applied load: 2700 N

Damage visualised at:
1750 N



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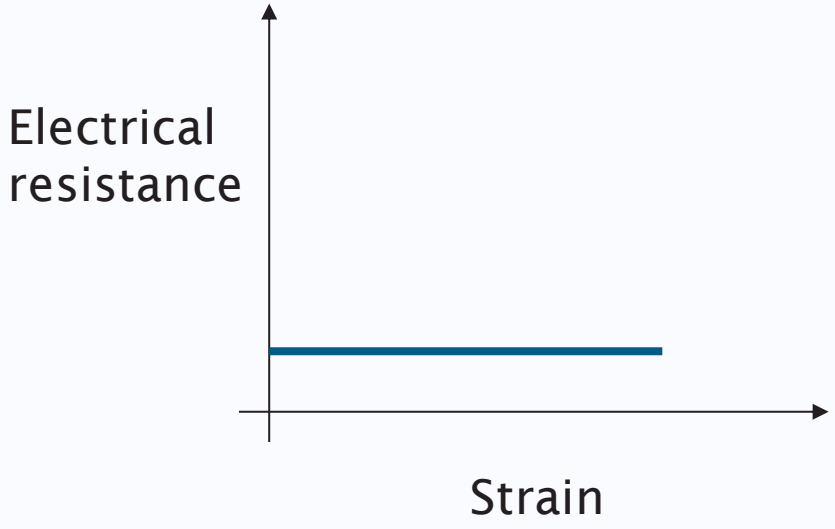
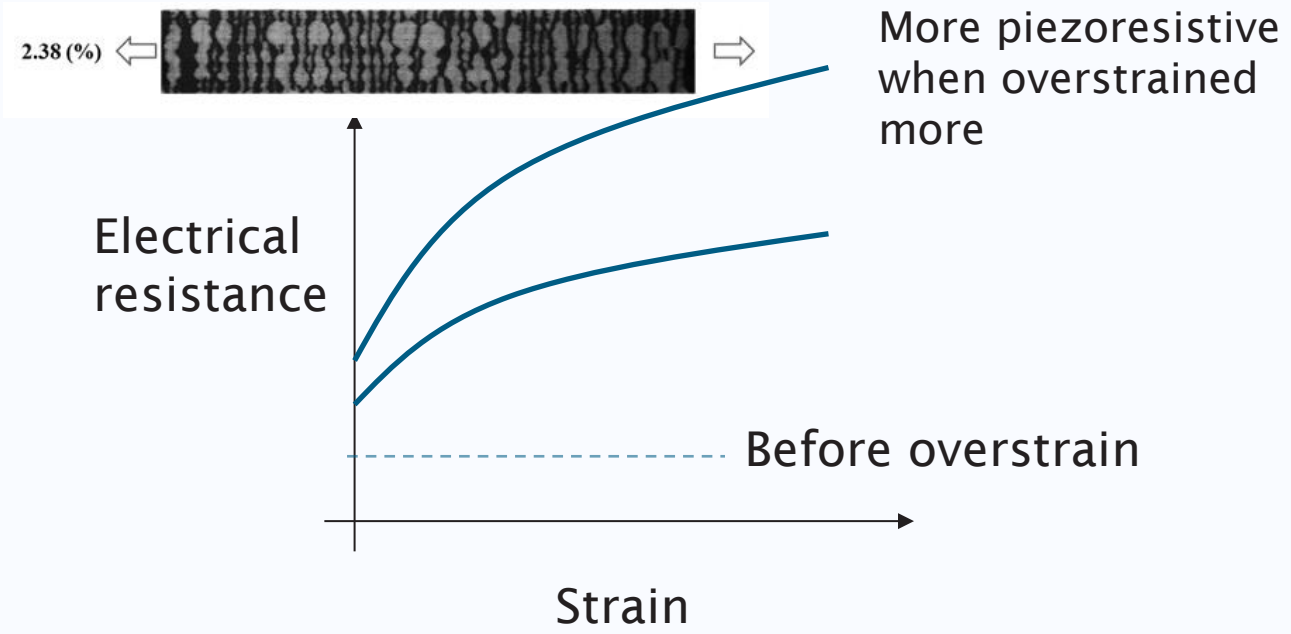
Remote Overstrain Sensor

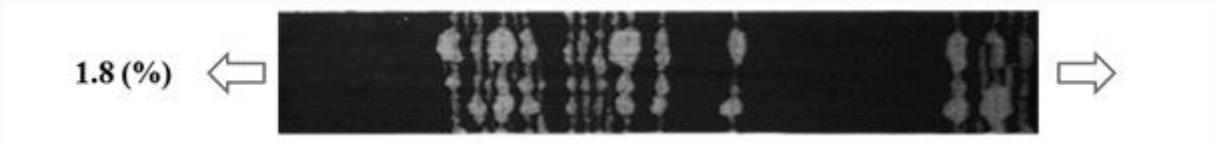
Sensing mechanism

Non-piezoresistive when not overstrained

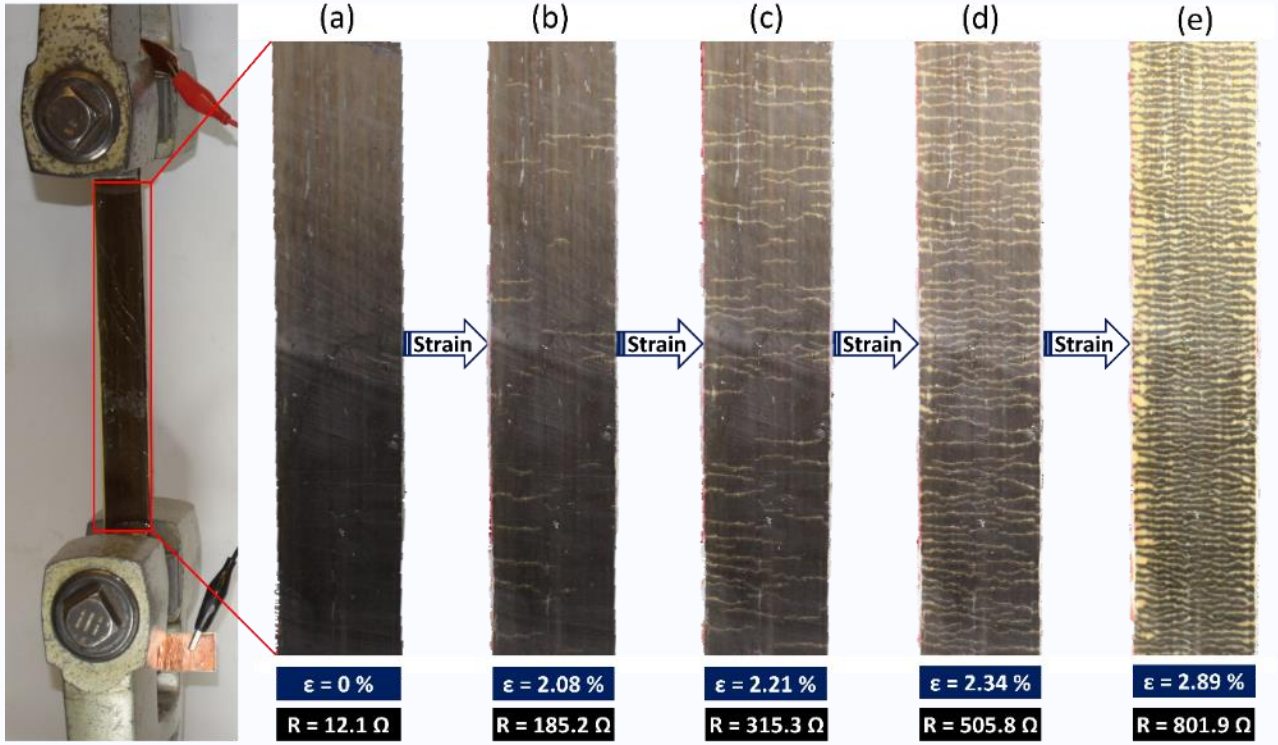


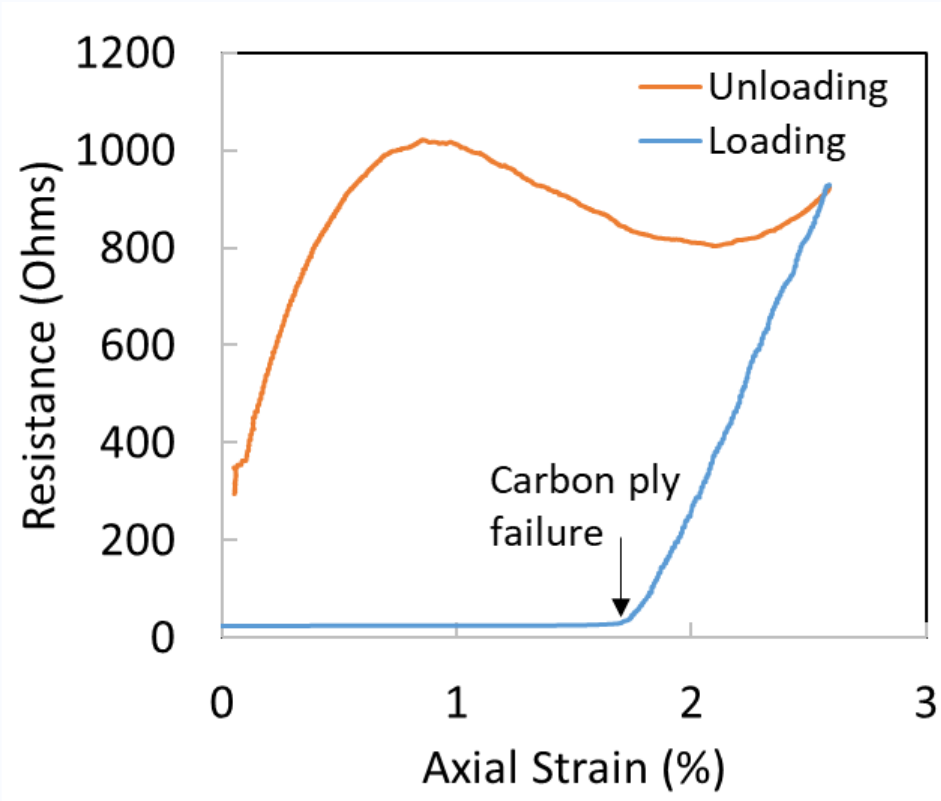
Piezoresistive when overstrained





Tensile Loading-unloading



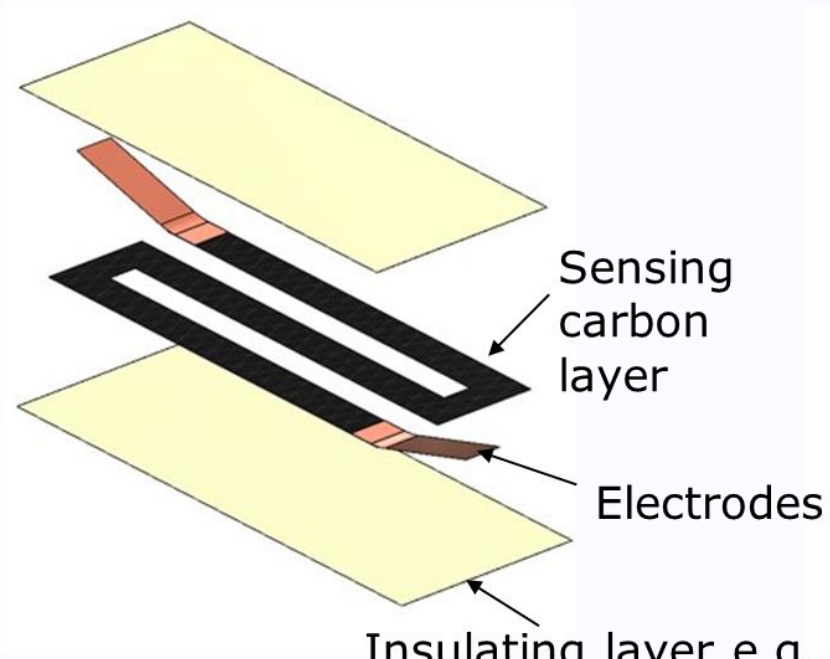


Malik, S. A., & Jalalvand, M. Strain-Dependent Electrical Resistance Response to Fibre Fragmentation in Thin-Ply Carbon/Glass Hybrids for Structural Health Monitoring (preprint). SSRN

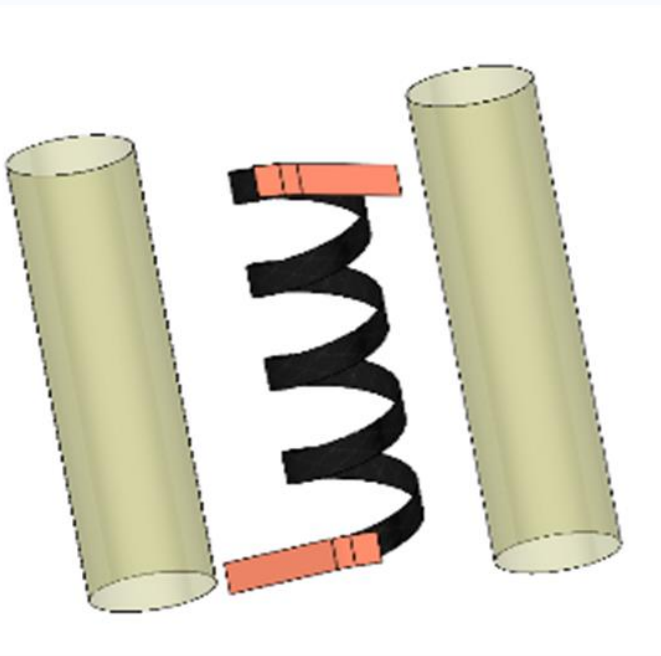
Application

- New sensor designs for identifying overstrains e.g. flat panels or cylindrical shapes

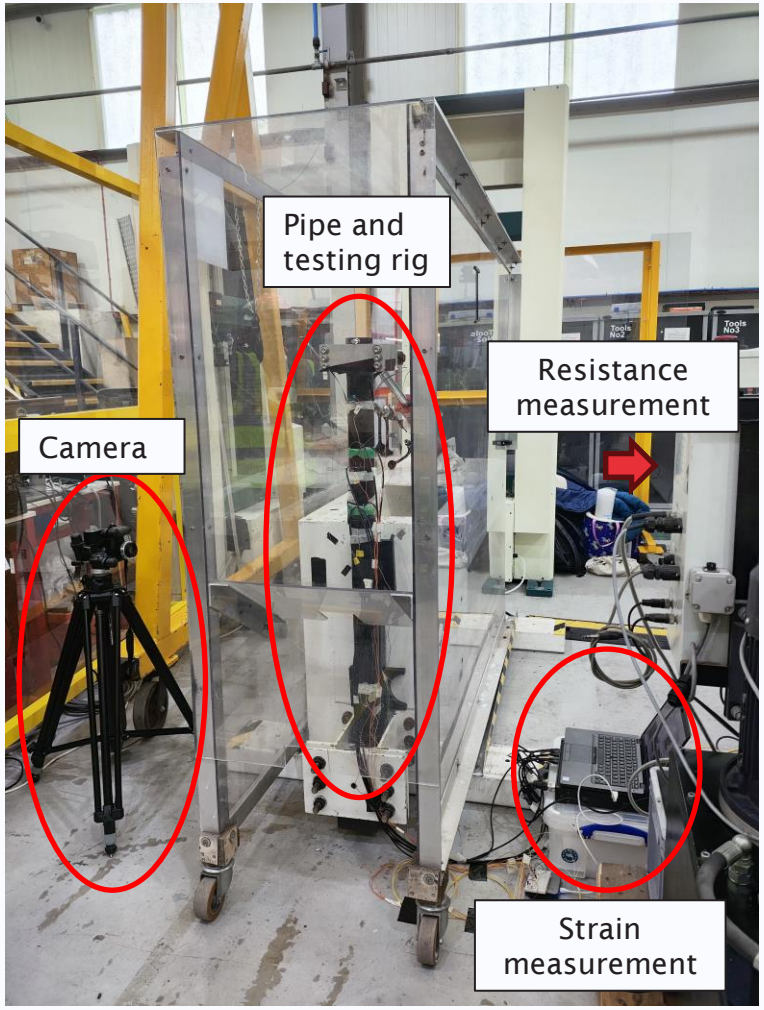
Serpentine configuration

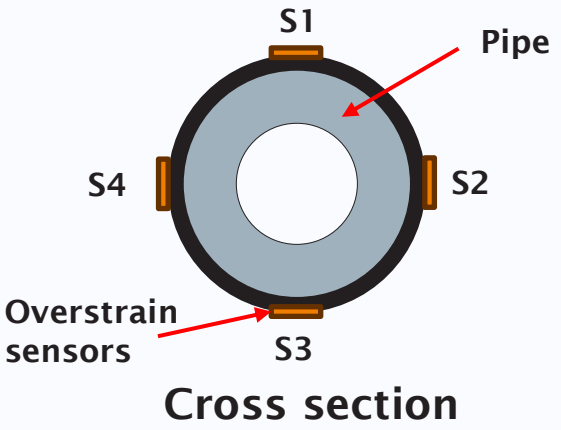


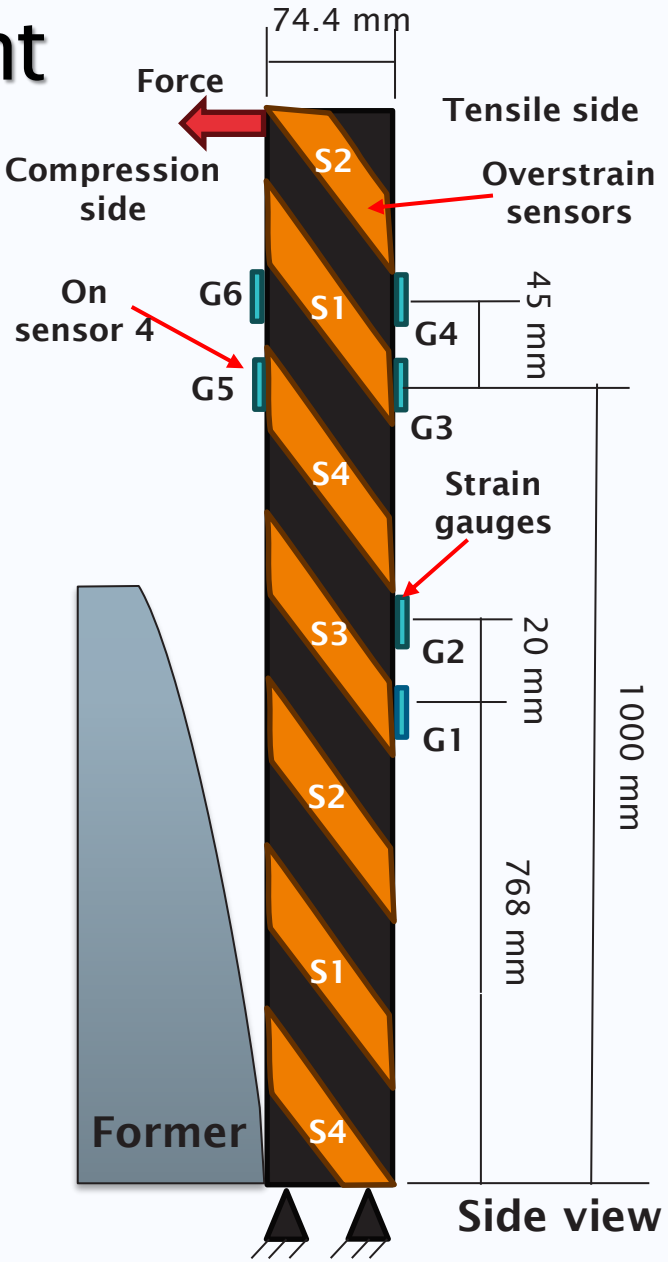
Helical configuration



Testing composite pipes for being overbent







Successfully detecting overbent in a pipe

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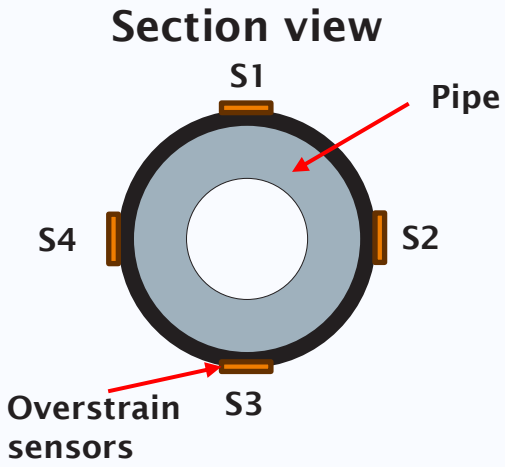
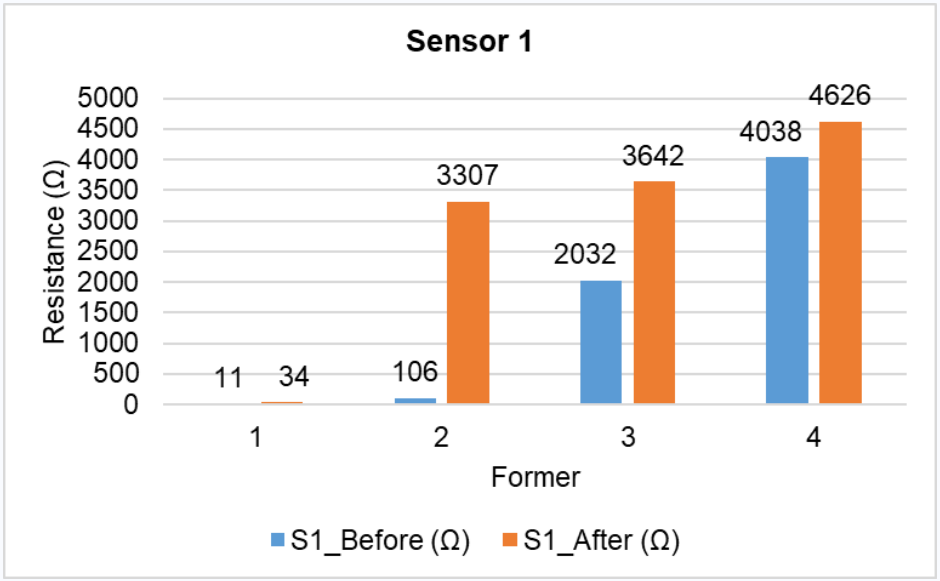
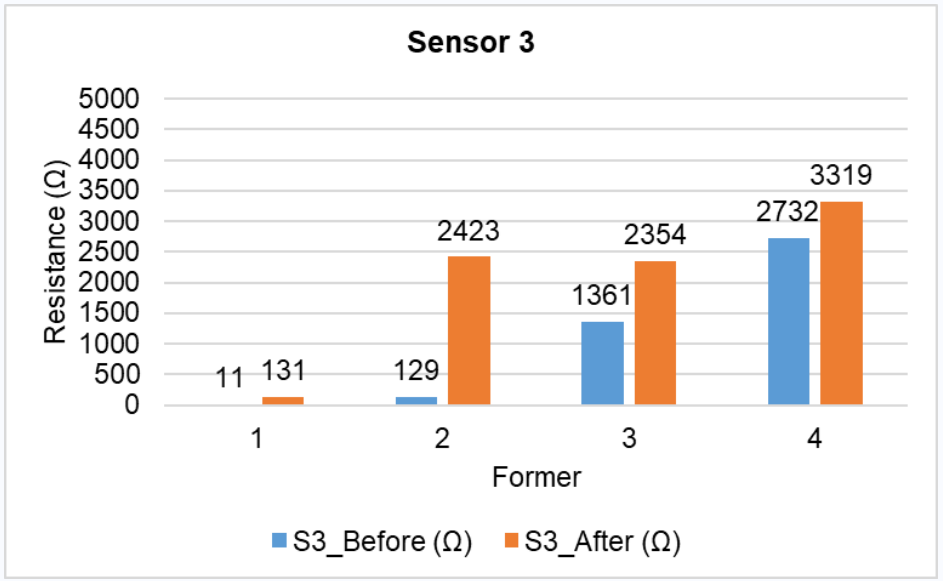
- Used the same material as was used in the pipe's manufacture
- Successful in detecting former that causes overstrain

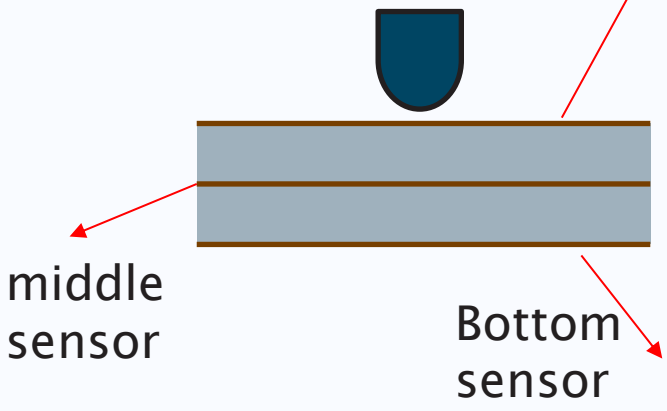


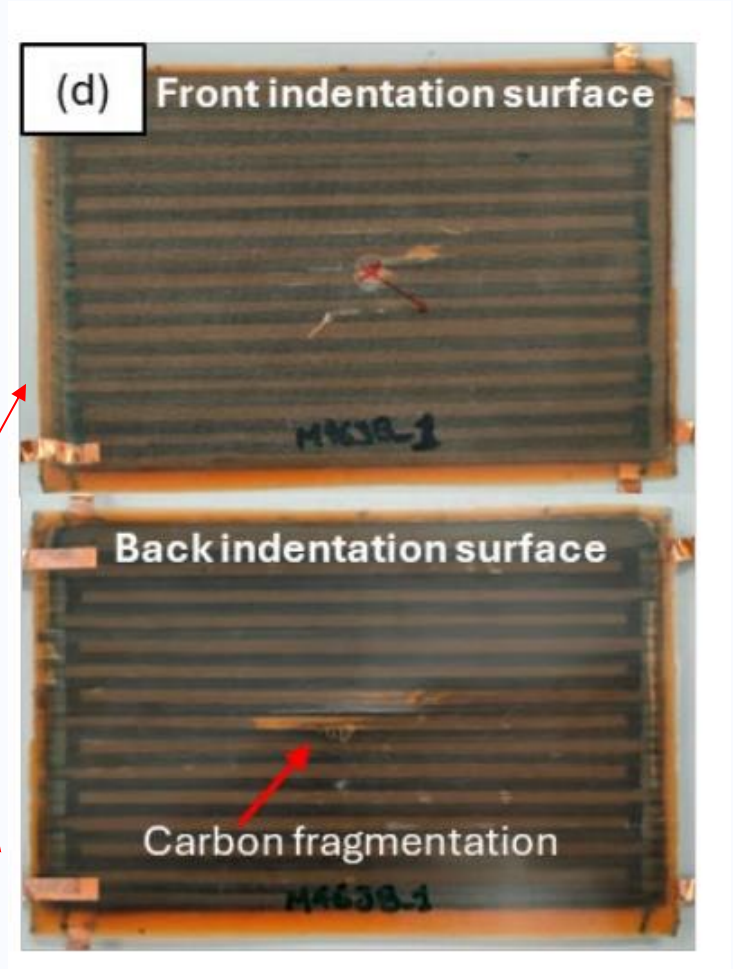


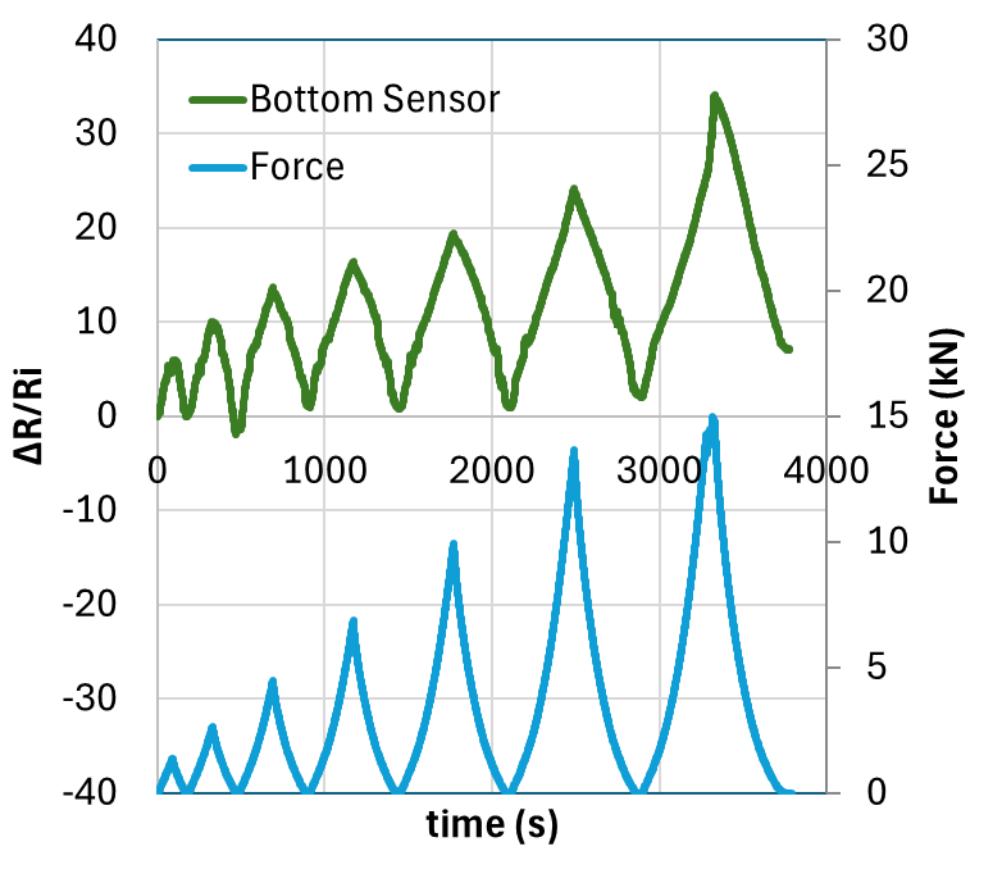


Detection of indentation overload

- Three sensors placed on the top, bottom and at the midplane of composite substrates

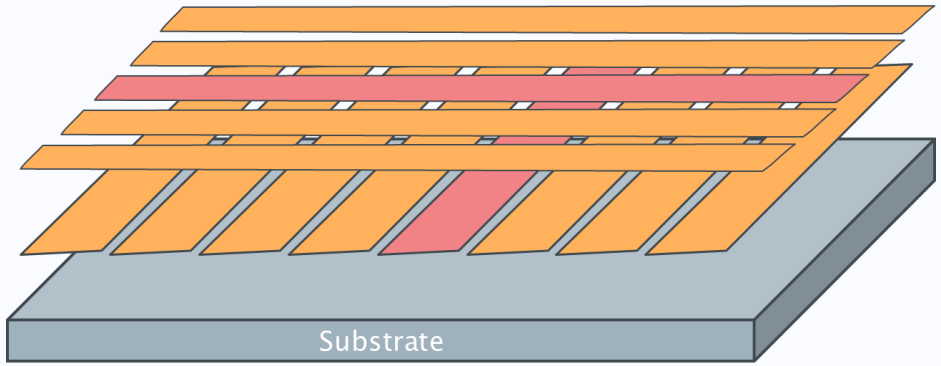


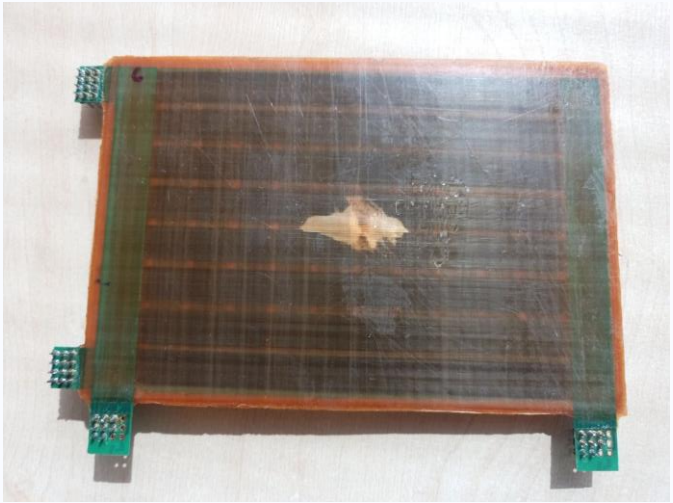


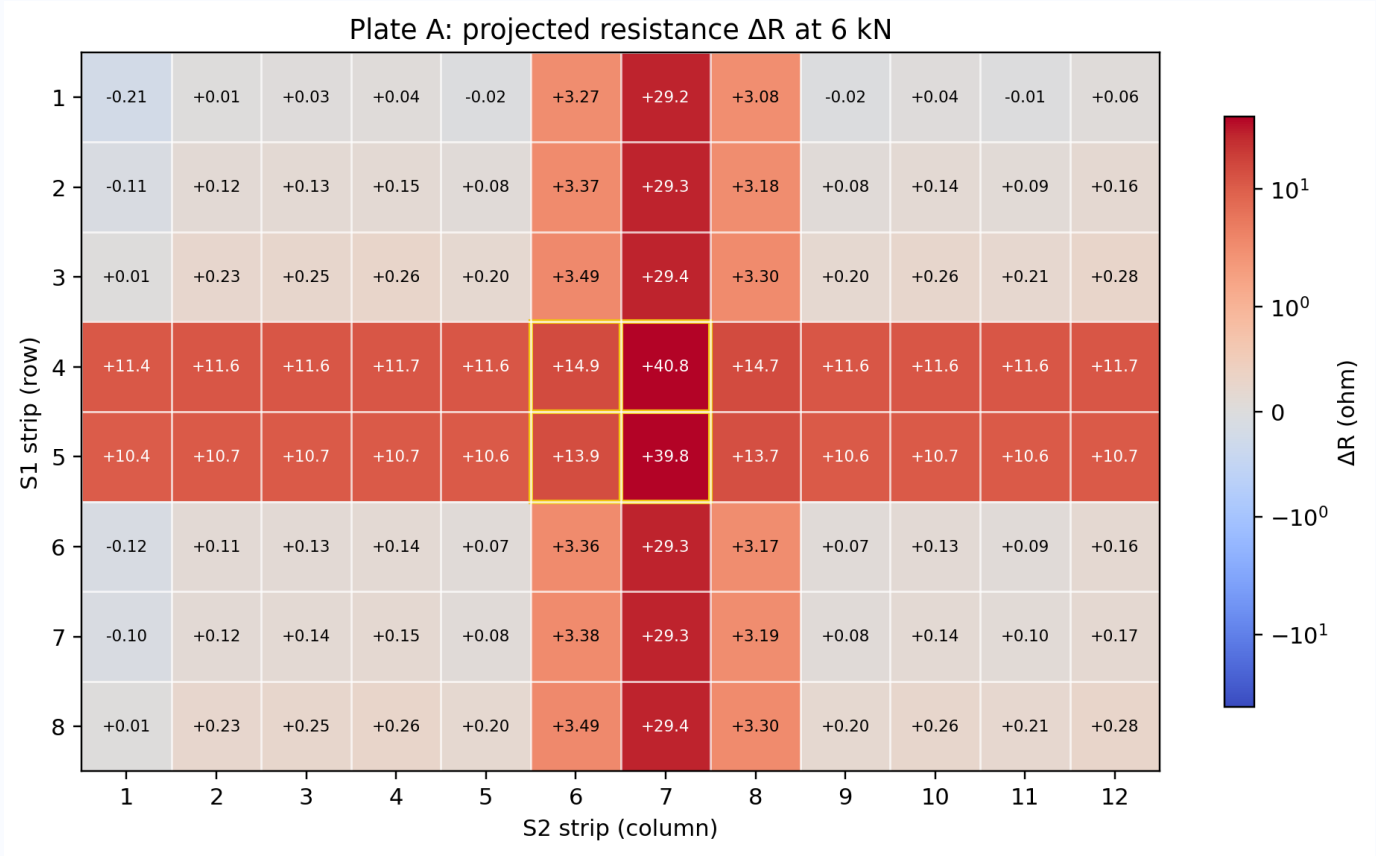


Full area coverage and localising the overstrain area

- Crossing Smart Tapes

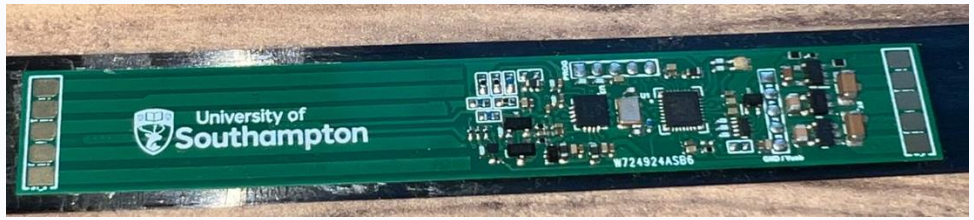






Lightweight and low-cost electronics

- A prototype circuit has been developed and tested electronically
- Commercially available components at low cost
- Variety of sensors included: temperature, strain gauge
- More advanced solutions feasible



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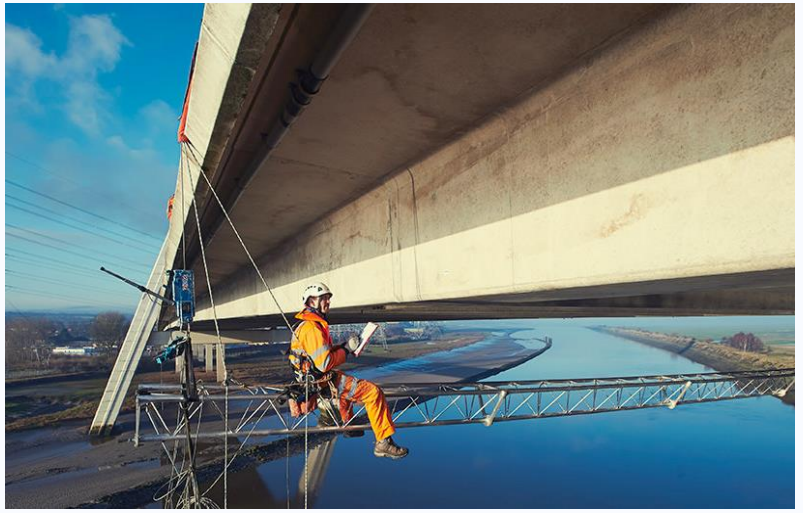
Smart Tape as a product

Reducing human inspection cost and downtime

- Embedding when a structure is manufactured
- Monitoring transportation, long time storage, operation



Local sensing on a patch

- Smart repair patches

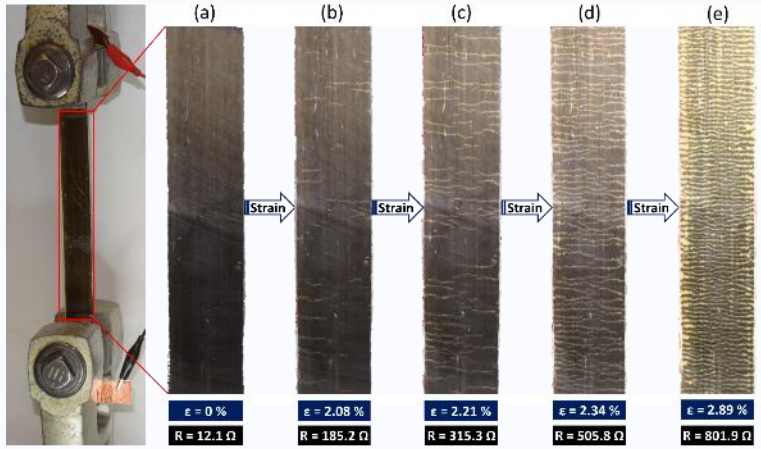
Compared to Fiber Bragg Gratings (FBG) optical fibres

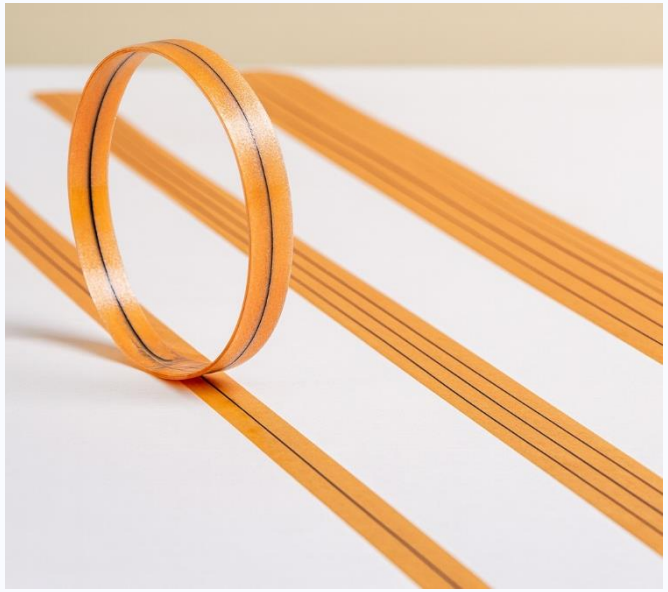
	Smart Tape Overstrain sensor	FBG optical fibres
Measured parameter	overstrain	strain
Coverage	area	point
Sensor cost	Pennies / m	Pounds / strain gauge
Electronics cost	£10s	~£20k
Weight of electronics	gr	kg
Manufacturing	Compatible with filament winding	Challenging
Memory?	Yes	No
Structurally taking load	Yes	No

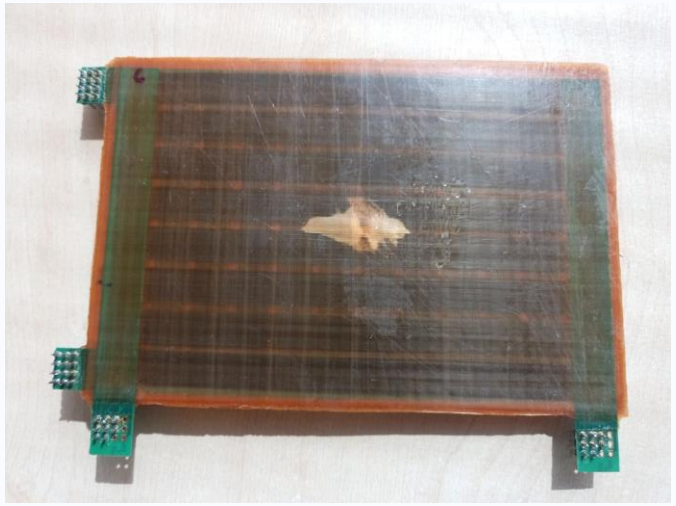
Confidential

Overview

- Hybrid overstrain sensors provide a simple visual indication plus quantitative piezoresistive signal when structures experience overstrain events.
- Their performance has been validated on multiple configurations and loading scenarios.







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YOUR QUESTIONS

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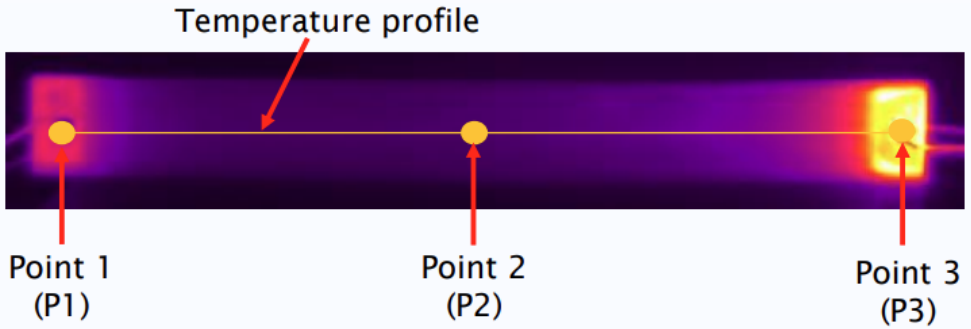
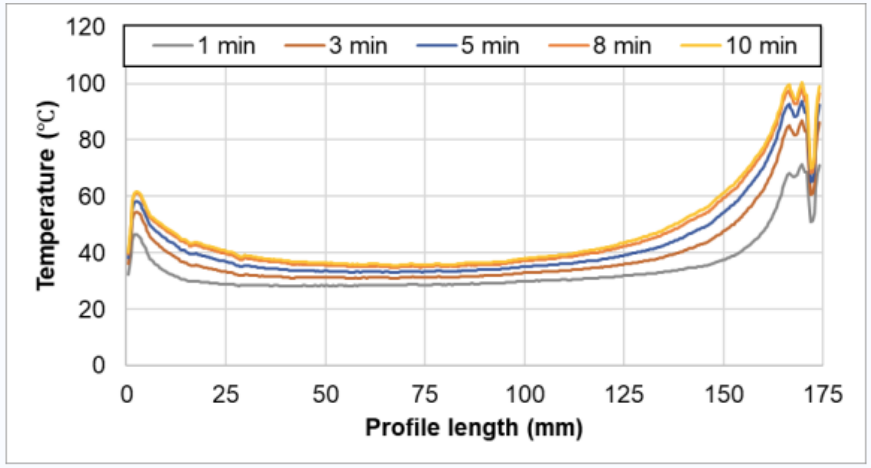
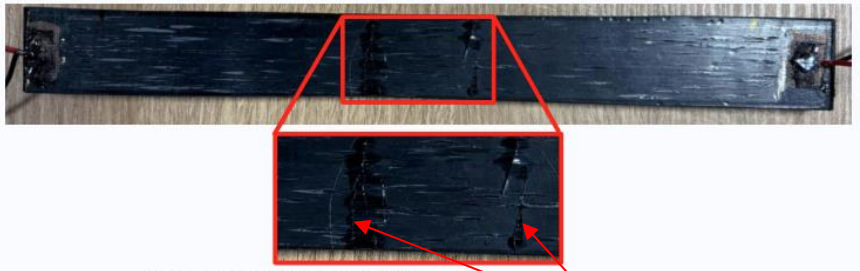
Thermography

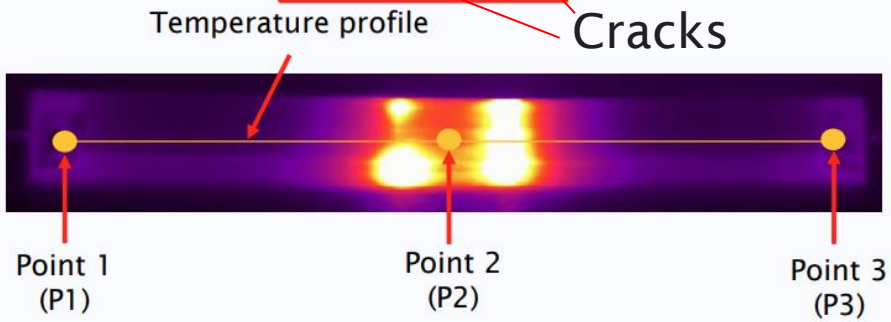
Healthy Sample

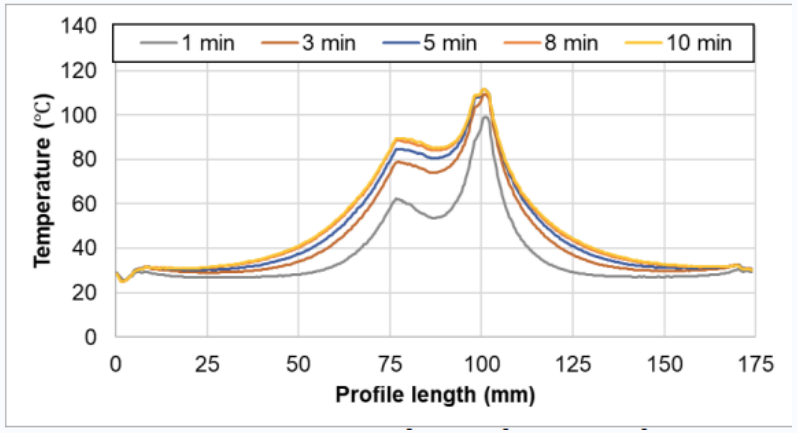




Damaged Sample







D Acosta, A Hamilton M Jalalvand, Resistive heating carbon fibre-reinforced thermoplastic composites for non-destructive evaluation, CompTest2025, Latvia, May 2025