Out-of-oven Manufacturing for Natural Fibre Composites with Integrated Deformation Sensing

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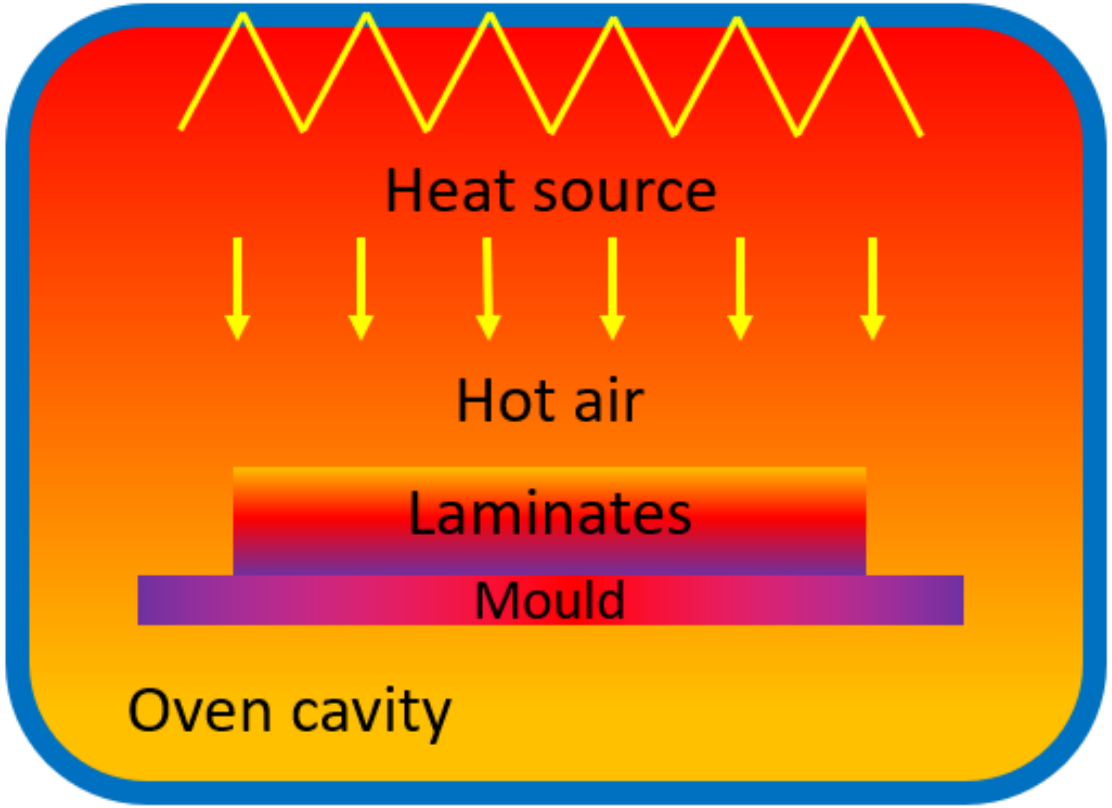
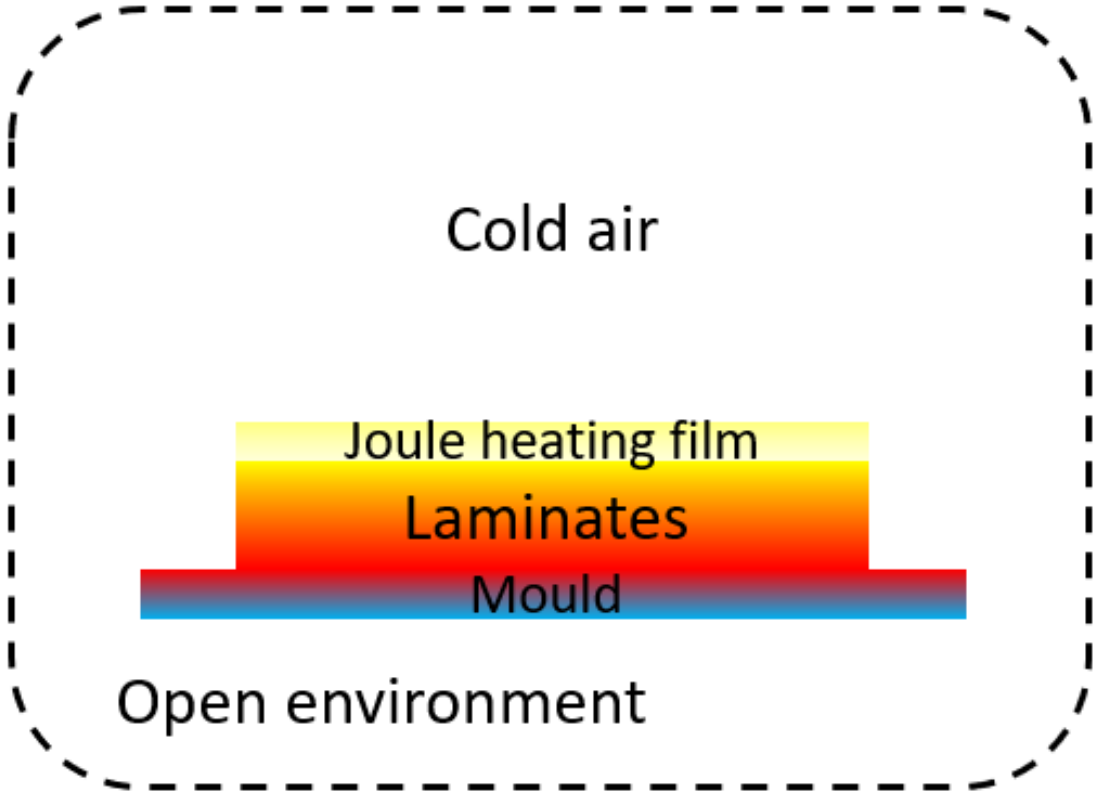
Energy Waste behind Sustainable Materials

Sustainable materials

Unsustainable manufacturing

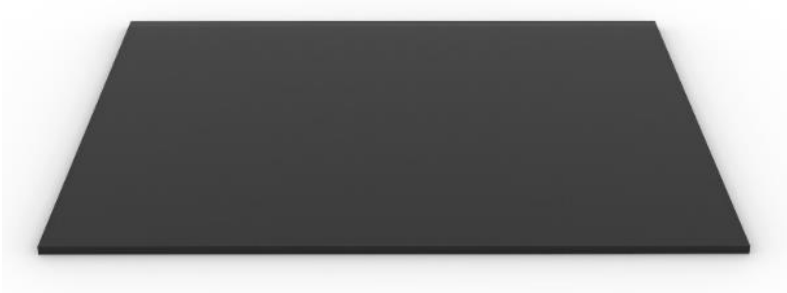
Traditional Oven Curing





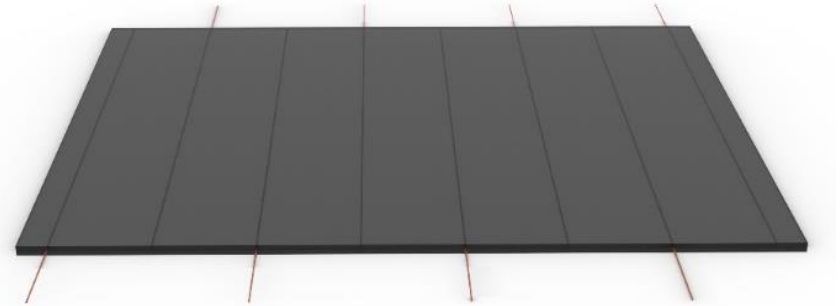
Energy inefficiency in convection heating

Experiment Design



PCL/GNP nanocomposites

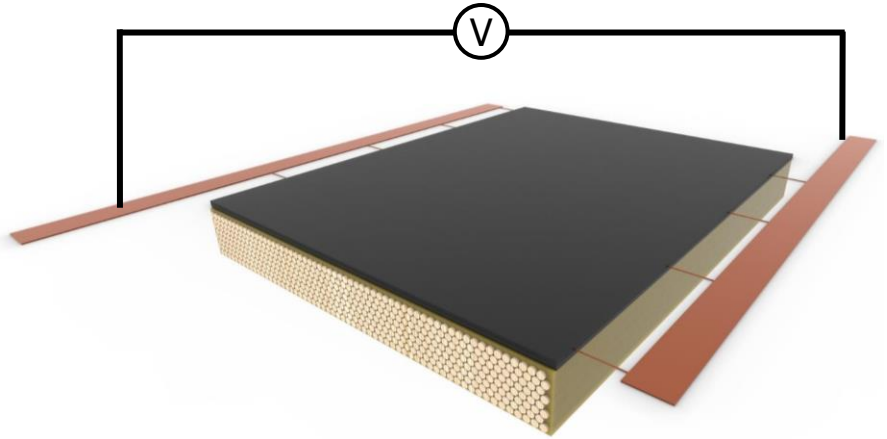
Hot press



Embedded copper wires

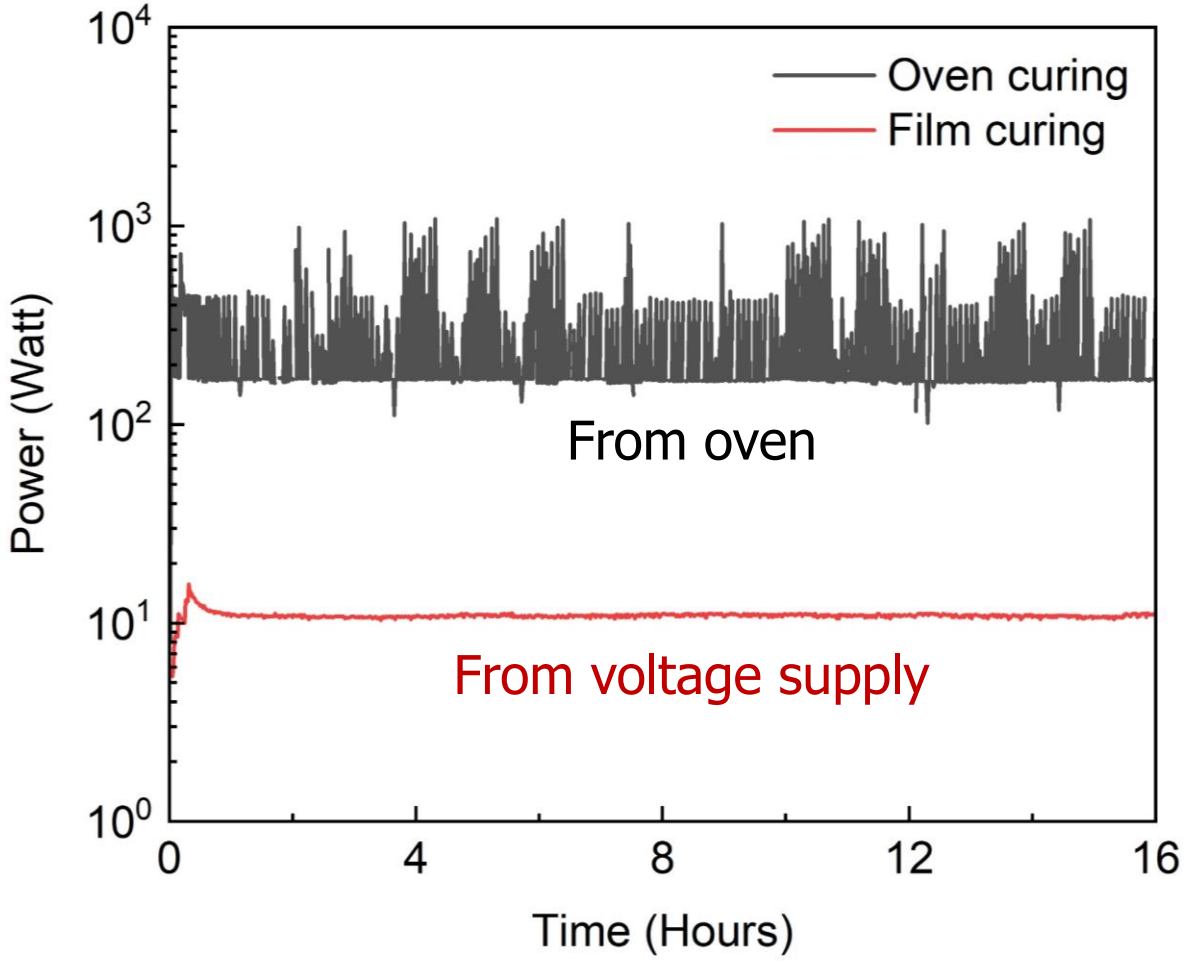
Apply voltage

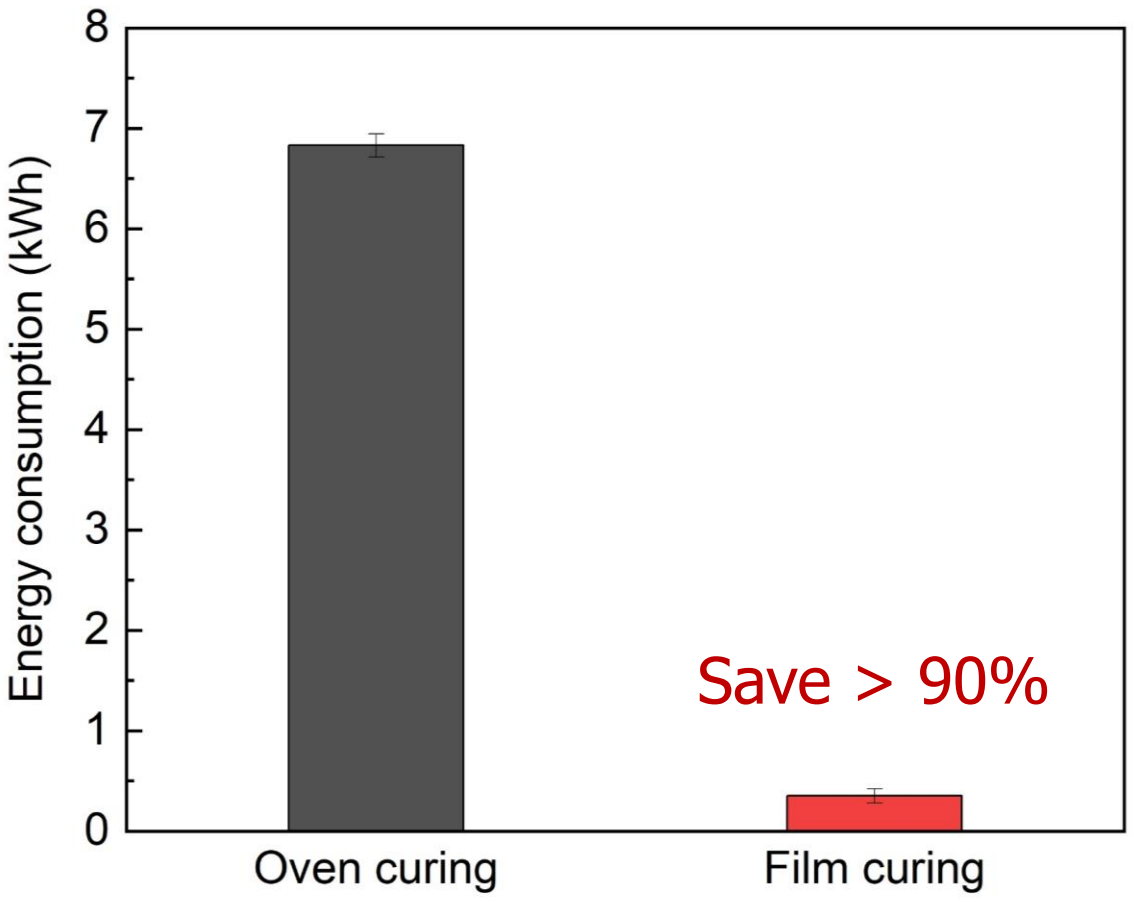
Energy efficient Out-of-Oven manufacturing



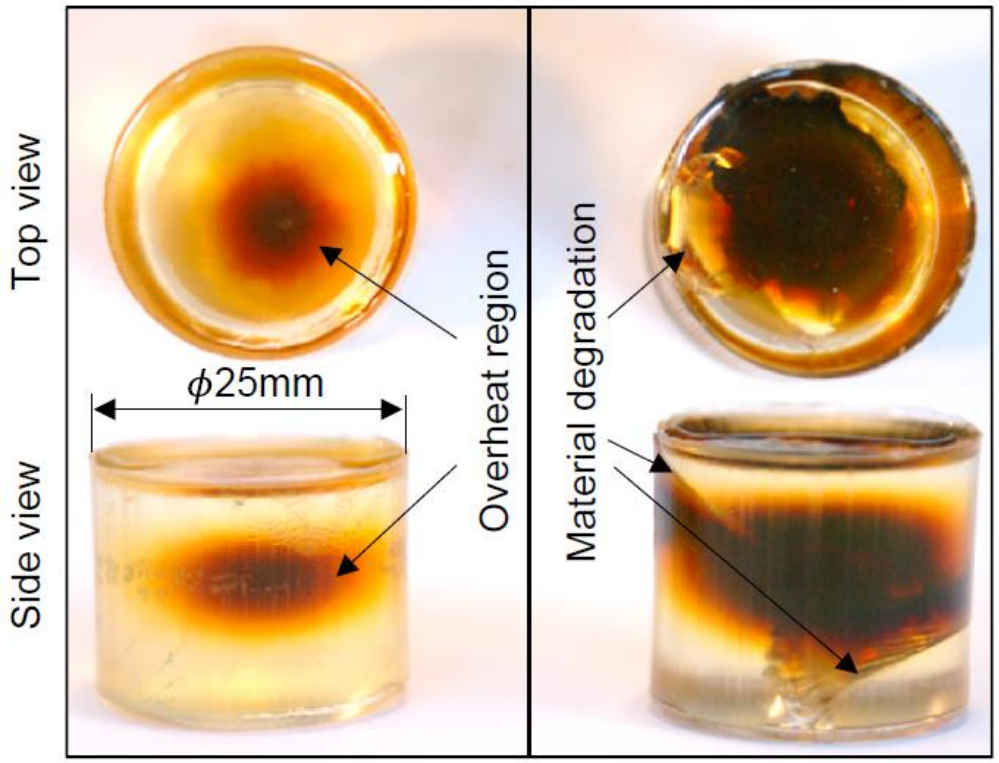
Curing via Joule heating

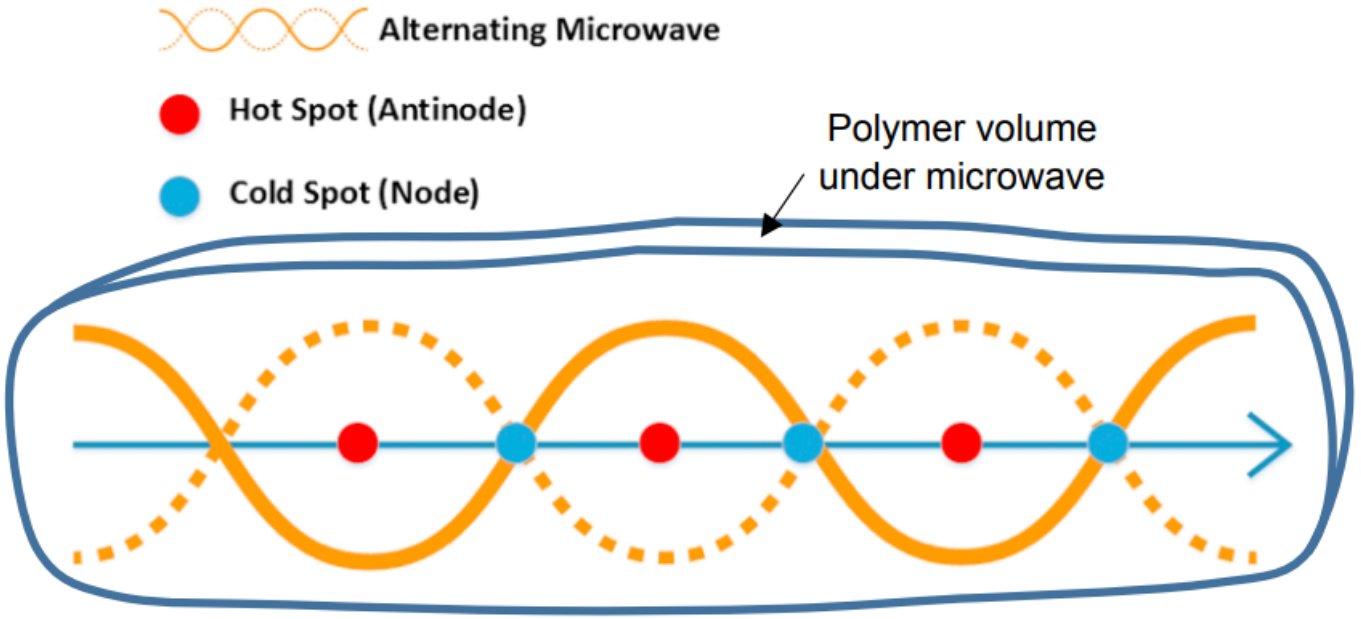
Comparison of Energy Consumption





Safety Concerns in Microwave Curing





Mgbemena C O, Li D, Lin M F, et al. Accelerated microwave curing of fibre-reinforced thermoset polymer composites for structural applications: A review of scientific challenges[J]. Composites Part A: Applied Science and Manufacturing, 2018, 115: 88-103.

High Safety Based on Thermal Expansion

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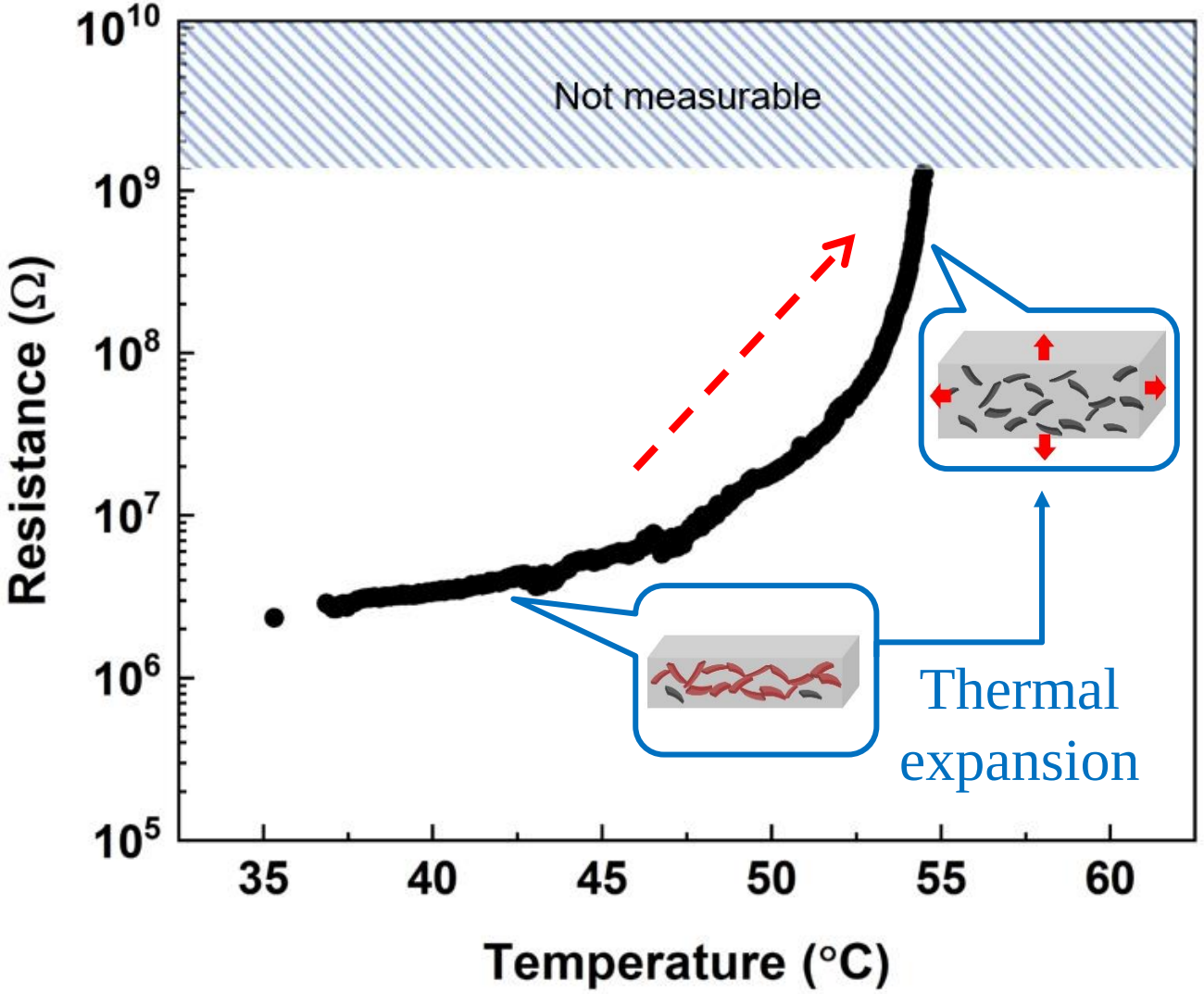
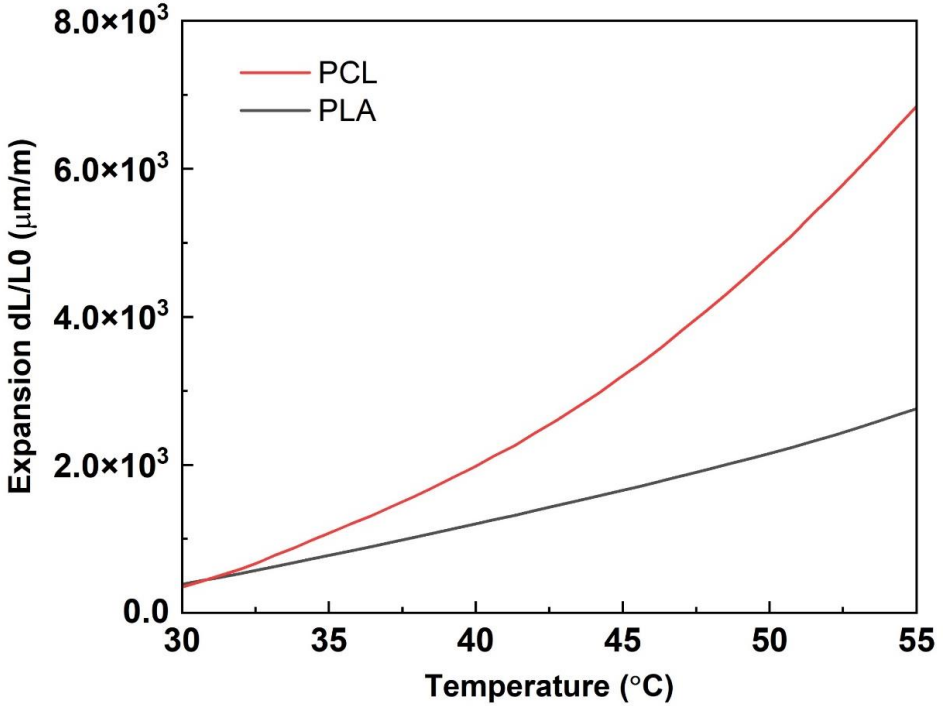
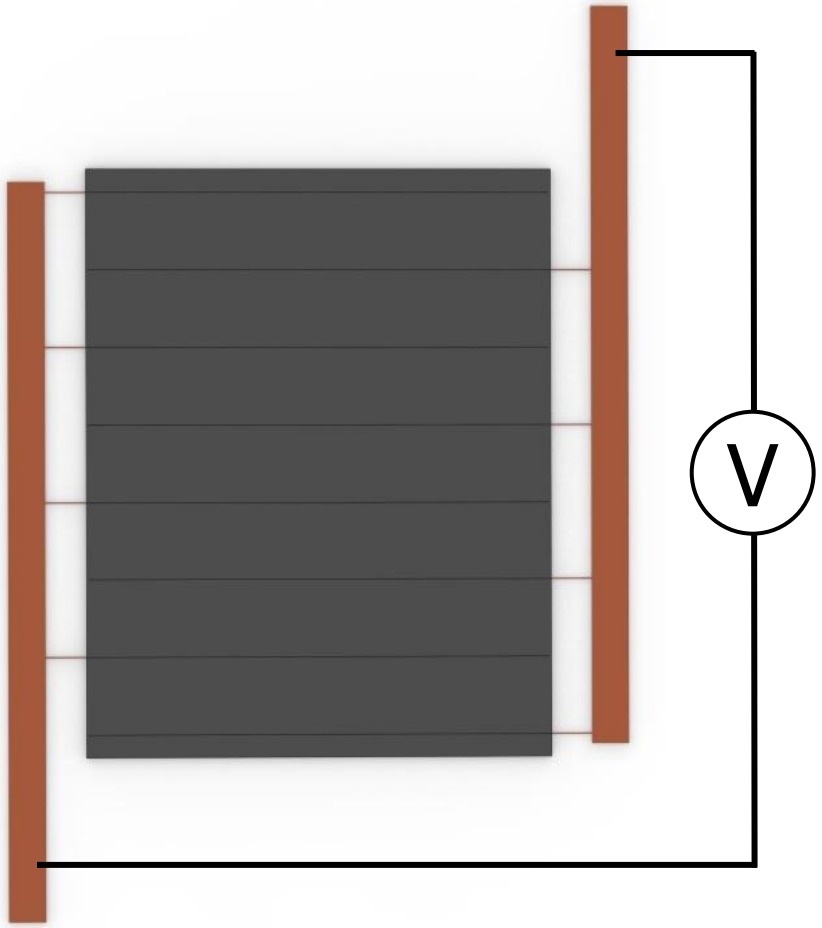
Resistance of PCL/GNP nanocomposites

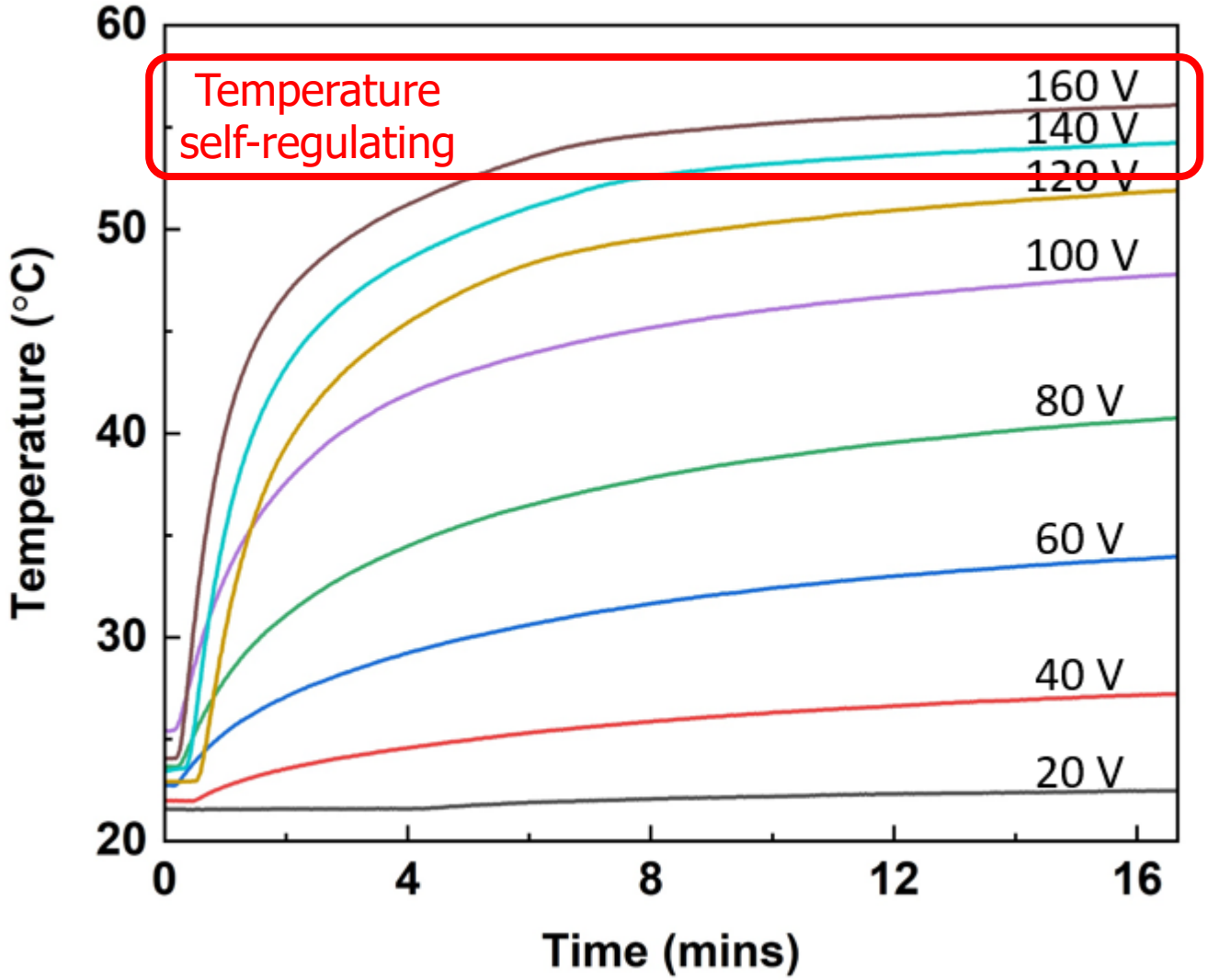




	Thermal expansion coefficient (10^{-6}/°C)
PLA	40-60
PBAT	70-80
PCL	130-160

Temperature Control of PCL/GNP Film





Comparison of Properties

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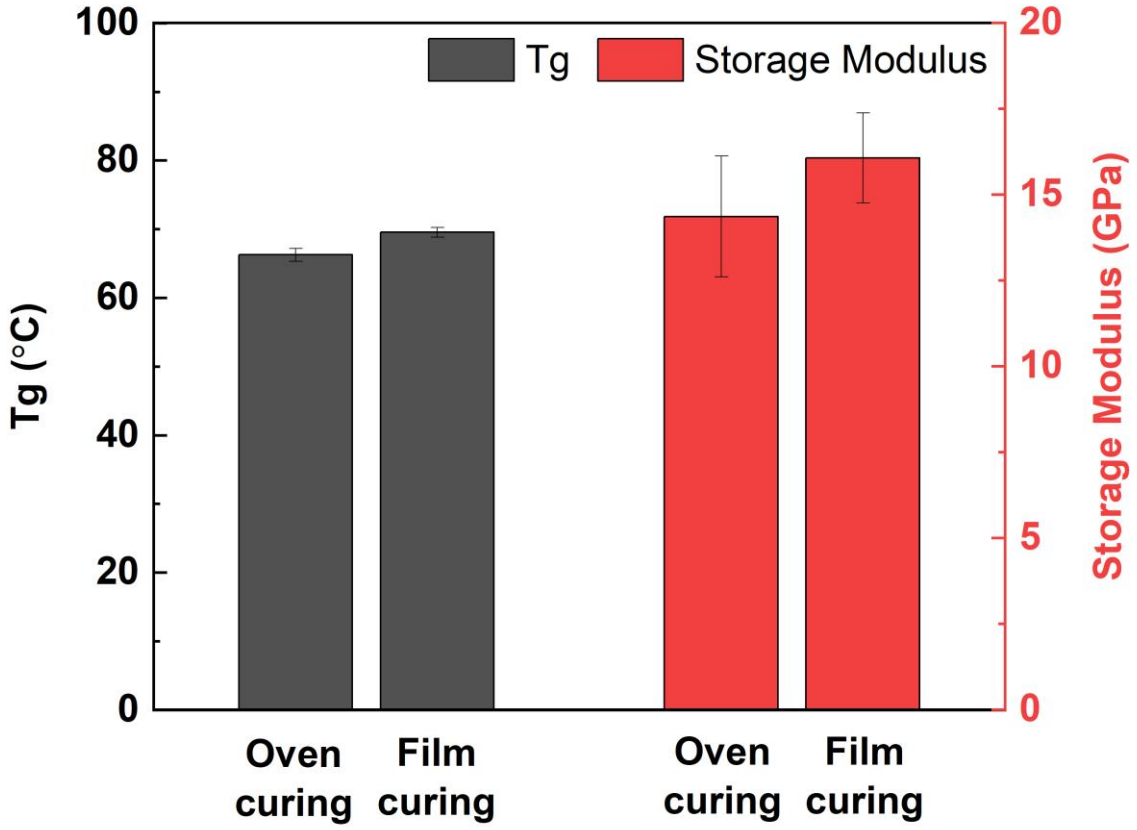
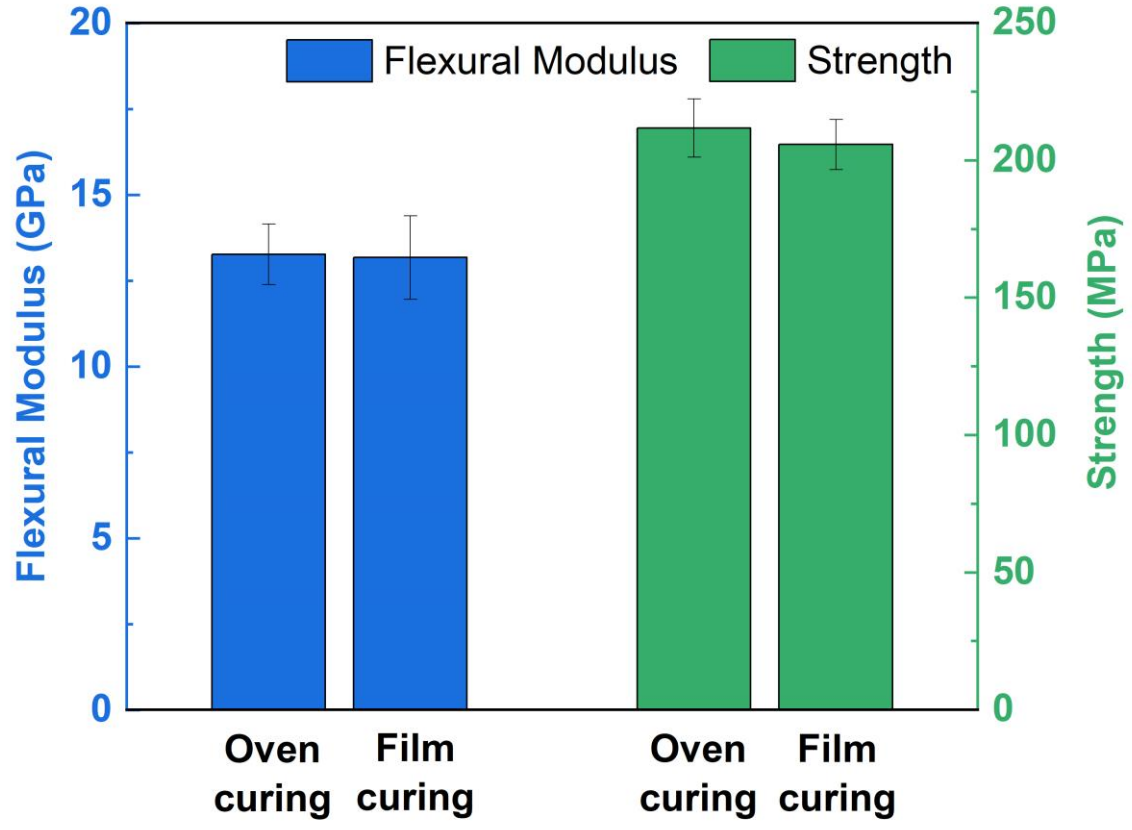
Dynamic mechanical analysis



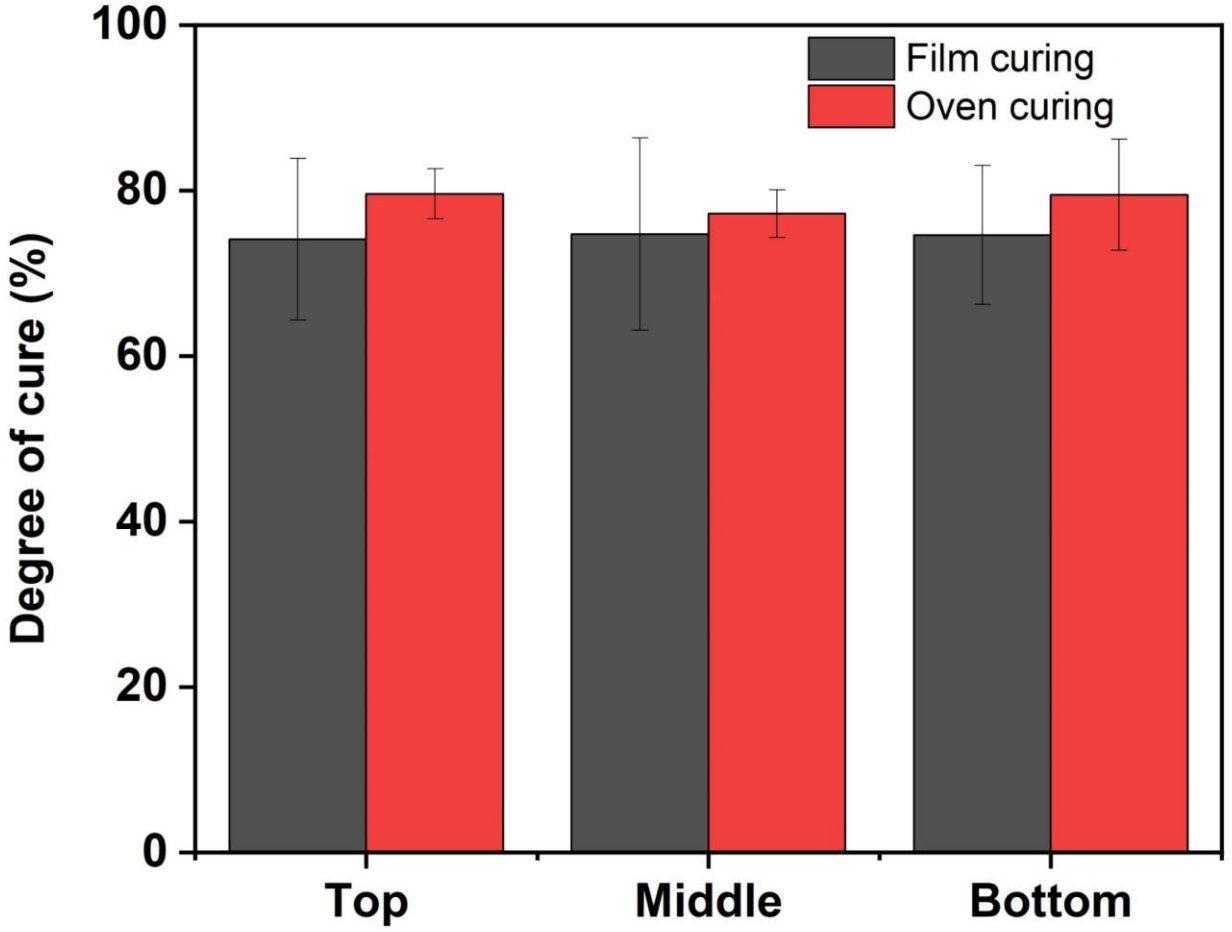
Three-point bending



Joule heating curing does not affect laminate properties.

Comparison of Properties

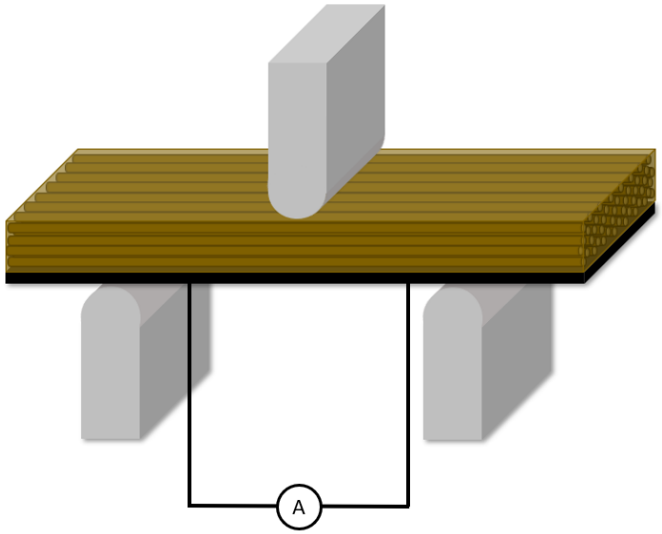
DSC analysis through the thickness



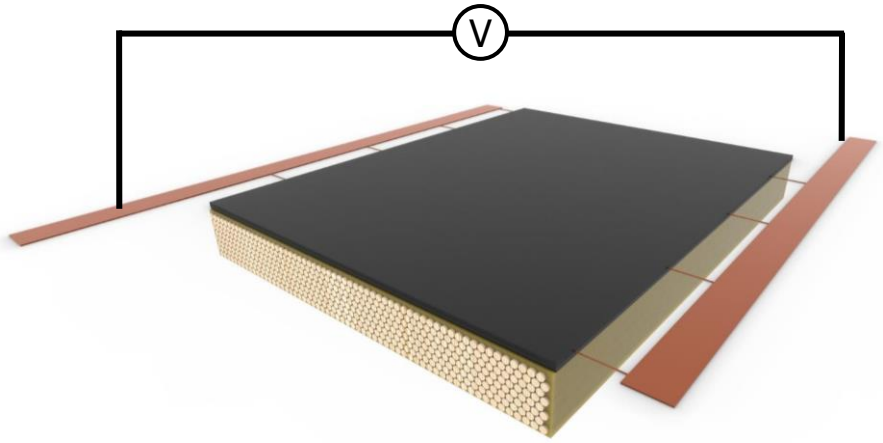
Joule heating curing does not affect laminate properties.

New Functionalities

Damage sensing based on piezoresistive methods



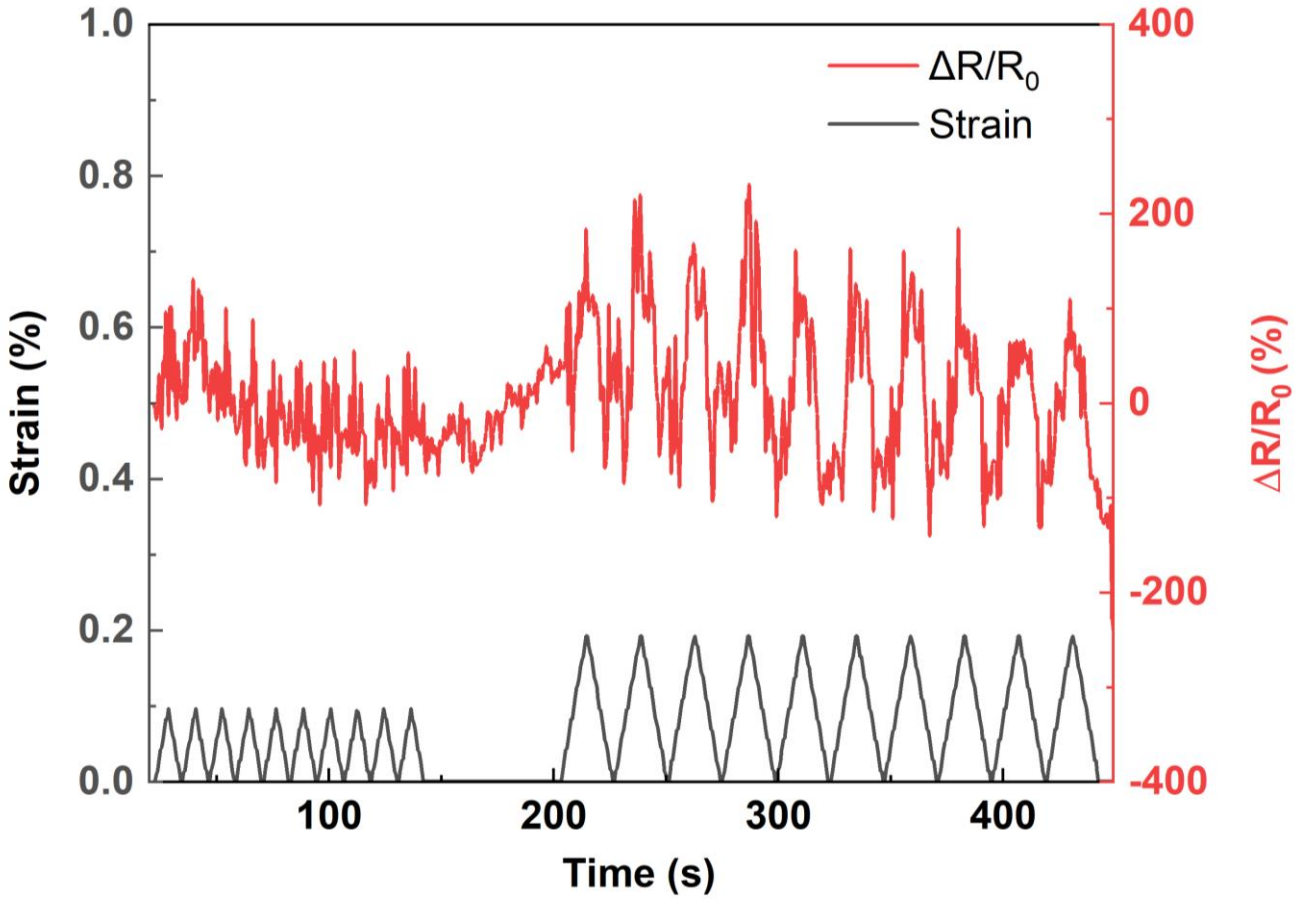
New functions

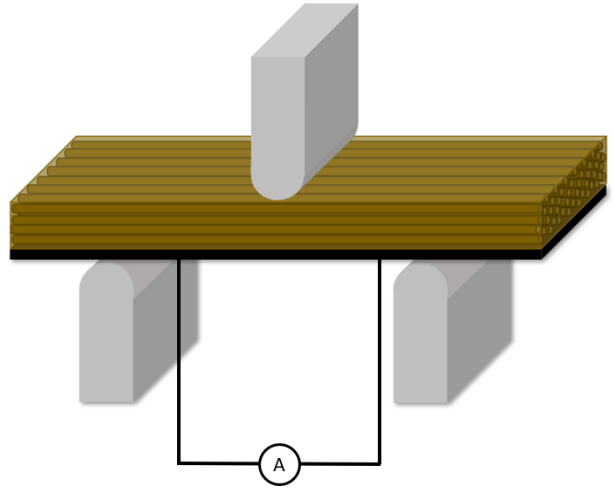


Deformation and damage sensing

Self-regulated heating for energy efficient manufacturing

Deformation Sensing

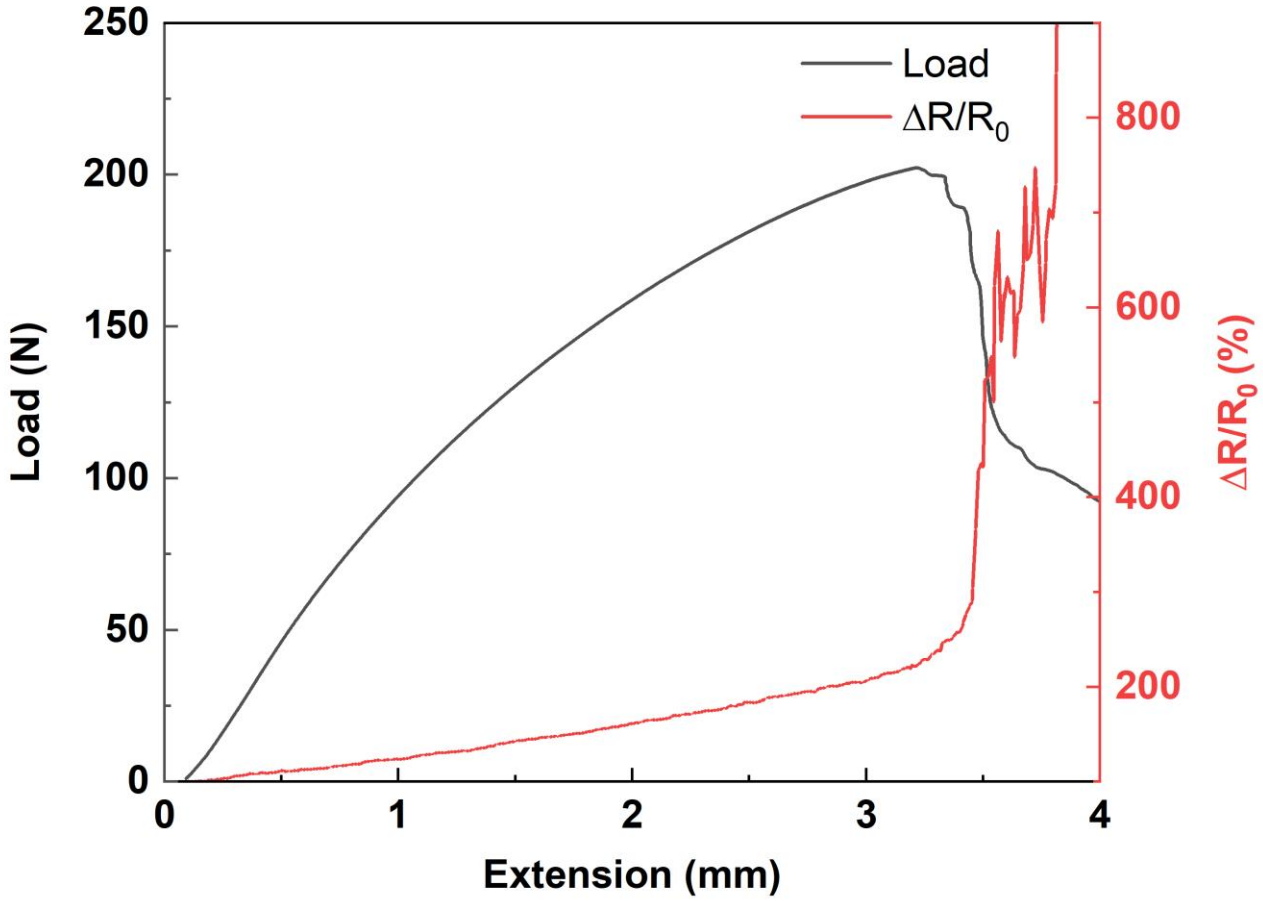


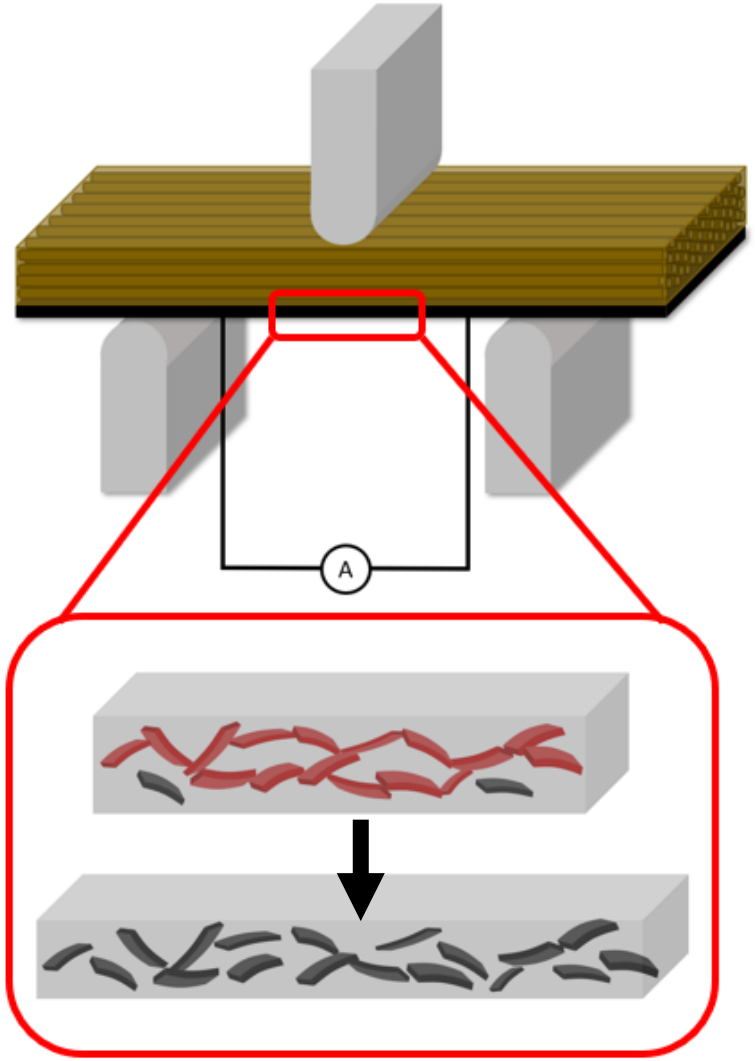


- Resistance signal corresponding to the strain.
- Monitor sample deformation.

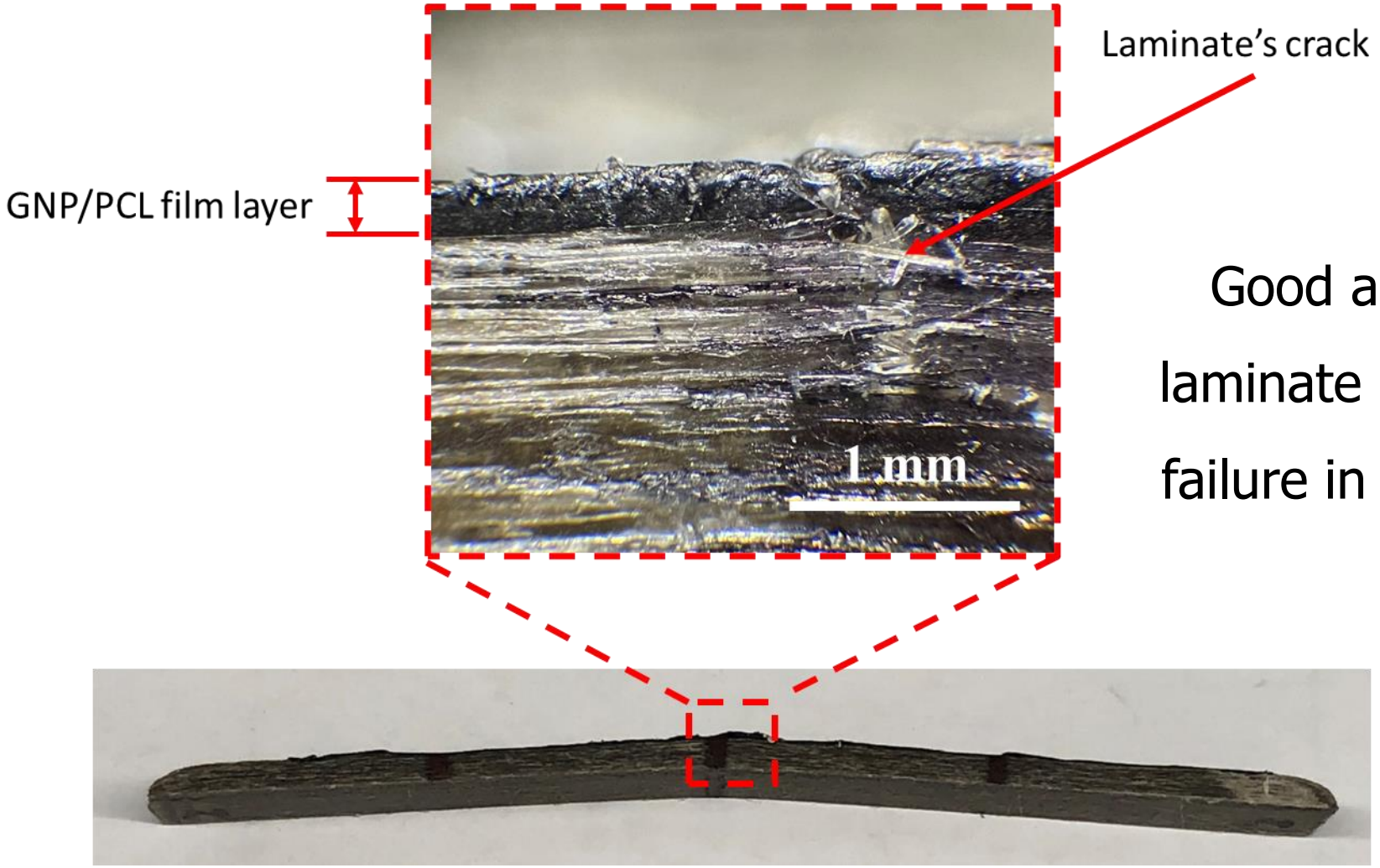
Damage Sensing

Clear correlation established between damage and sensing signals





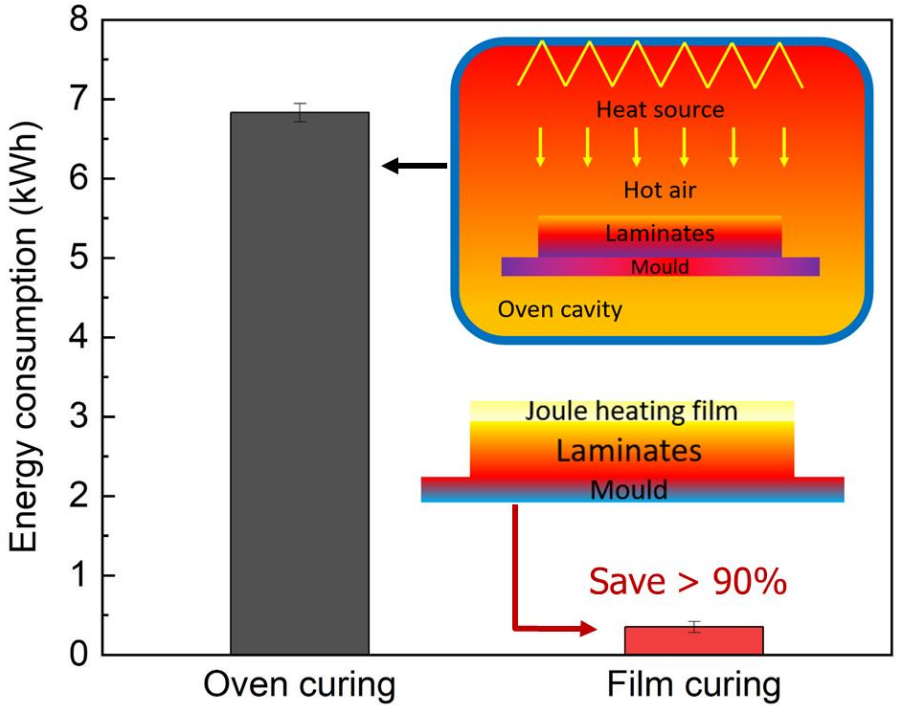
Adhesion between the Film and Laminates



Good adhesion to the laminate surface after the failure in damage sensing

A Brief Summary

- 90 % energy savings.
- Self-regulating heating for safety.
- No effects on laminate properties.
- New functions introduced (e.g. sensing).
- Good adhesion to the laminates.



Acknowledgements

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Polymers and Composites Group at QMUL