

Matrix Microcracking in Cryogenic Environments

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Engineering and Manufacturing



Presentation Outline

- Motivation
- CFRP microcracking performance
- Matrix fracture properties
- Cryo-scanning electron microscopy (SEM) microscale damage
- Our approach to matrix modification

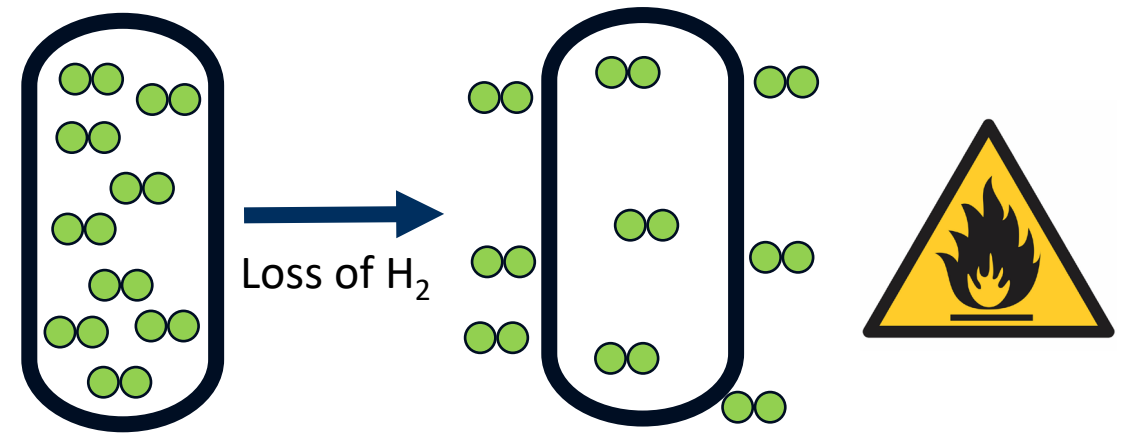
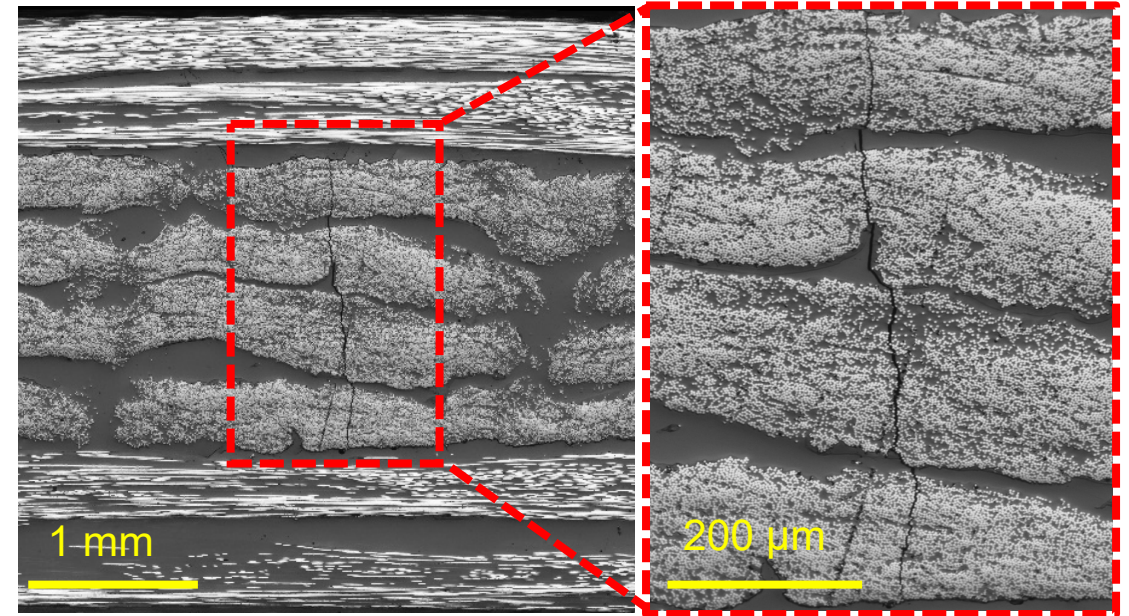


Motivation

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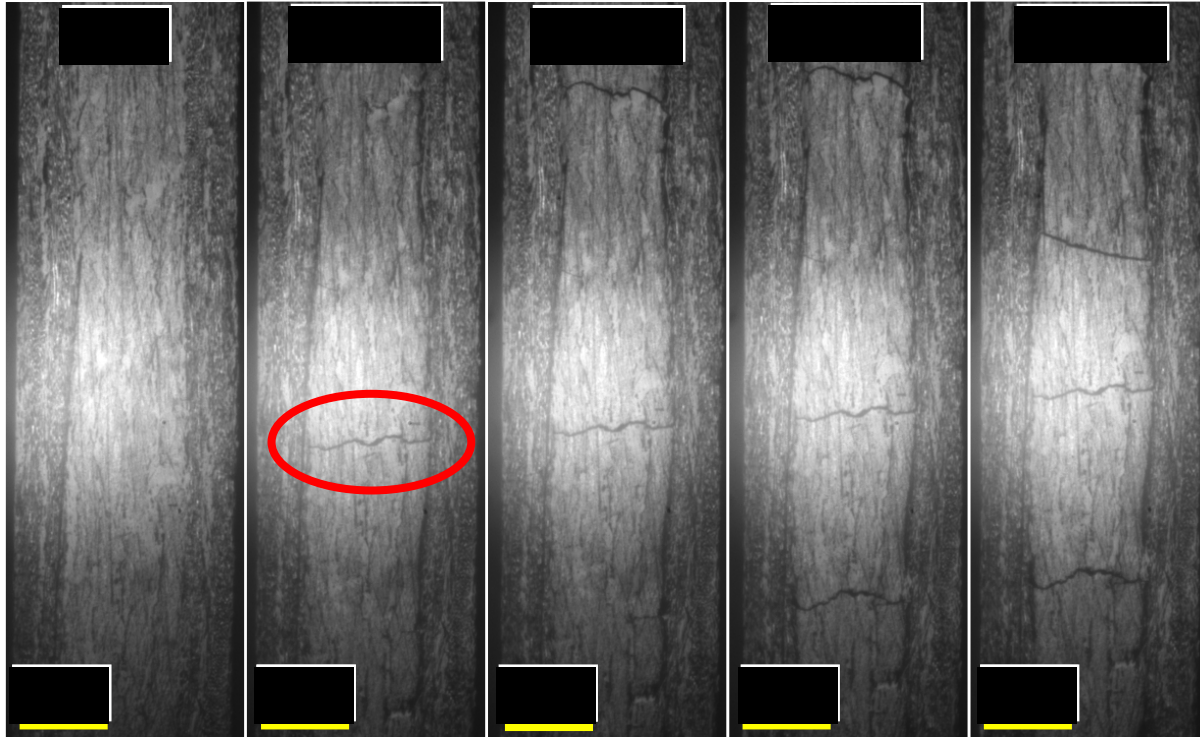
What does ~~good~~ look like?
What does **bad** look like?



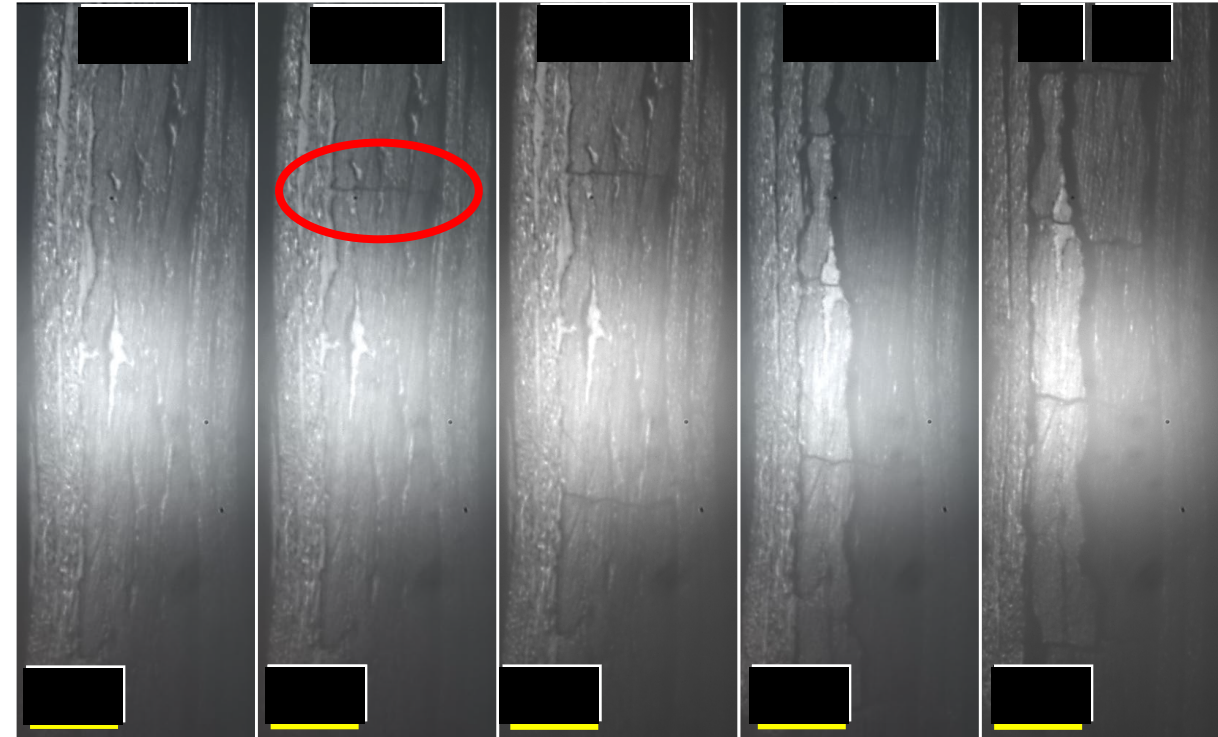
CFRP Microcracking

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- Material – low viscosity epoxy infusion resin.
- Layup $[0_2 90_2]_s$ – first damage is transverse matrix microcracking in blocked 90° plies.



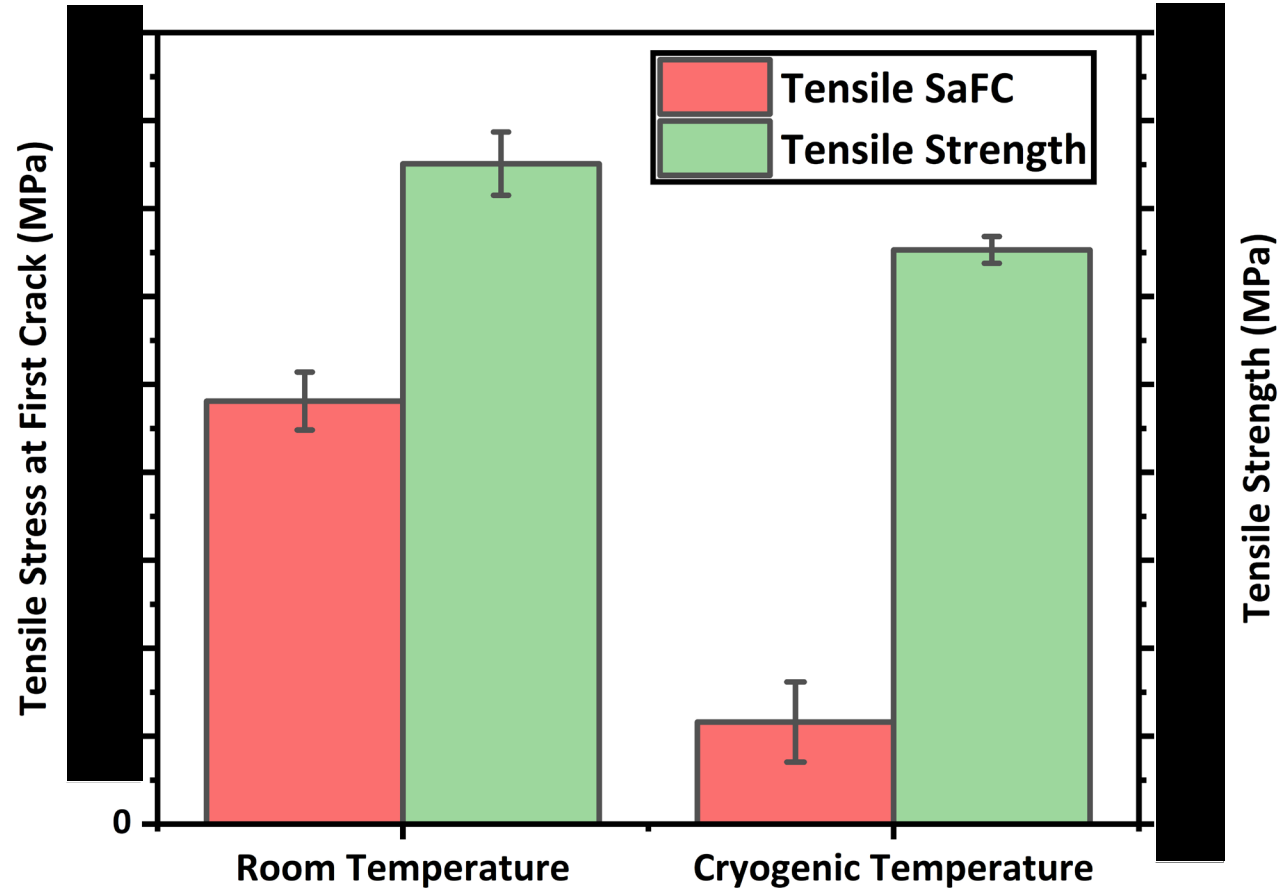
Room Temperature



Cryogenic Temperature (-155 °C)



CFRP Microcracking



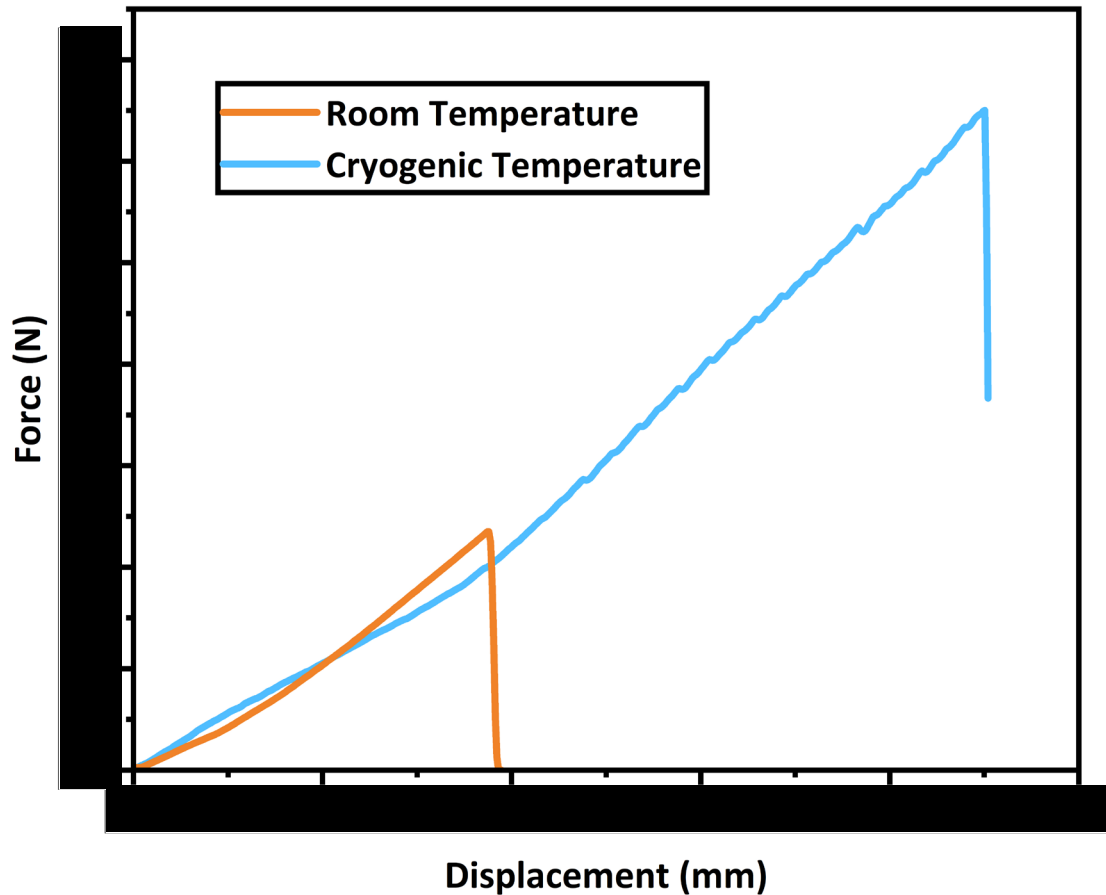
76% reduction in stress at first matrix crack

Reduced matrix fracture properties?

Thermally induced structural damage?

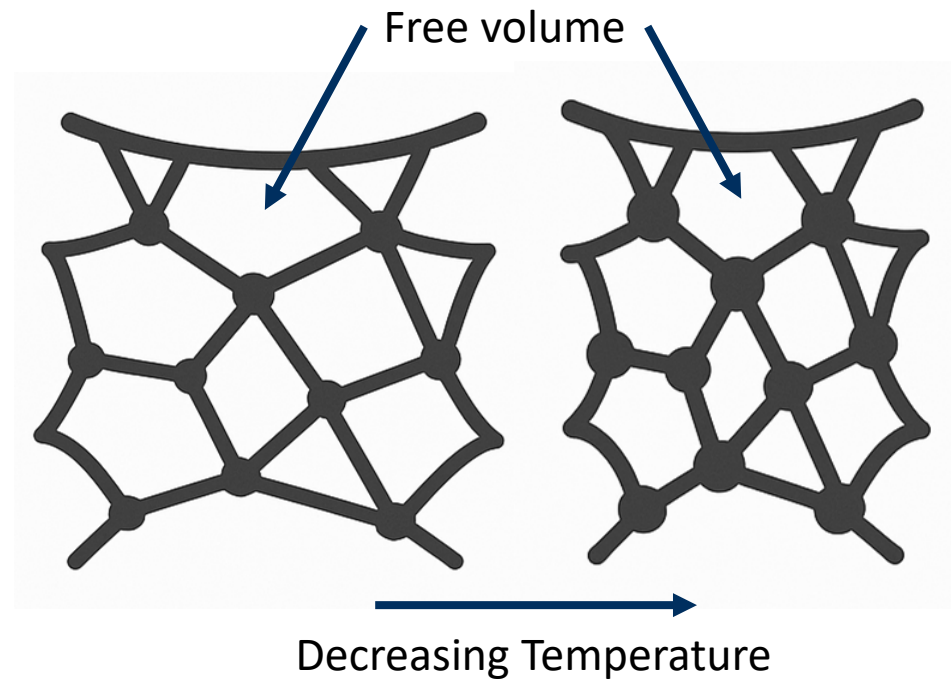


Matrix Fracture Properties



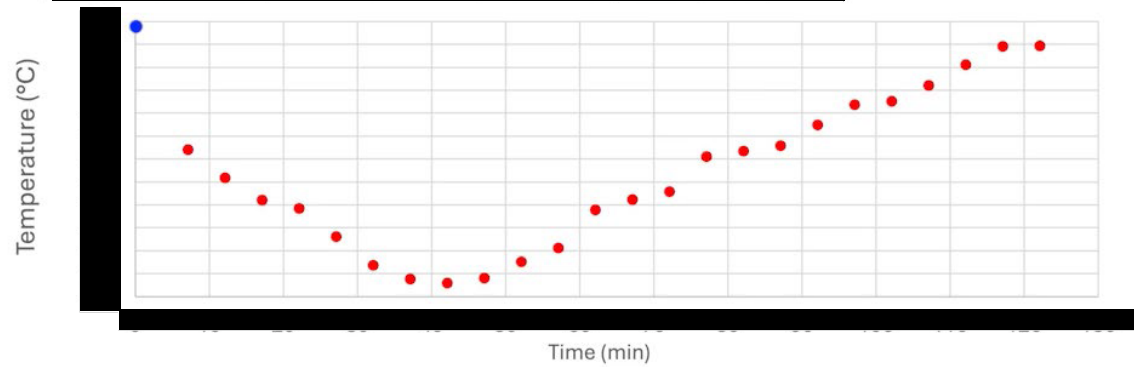
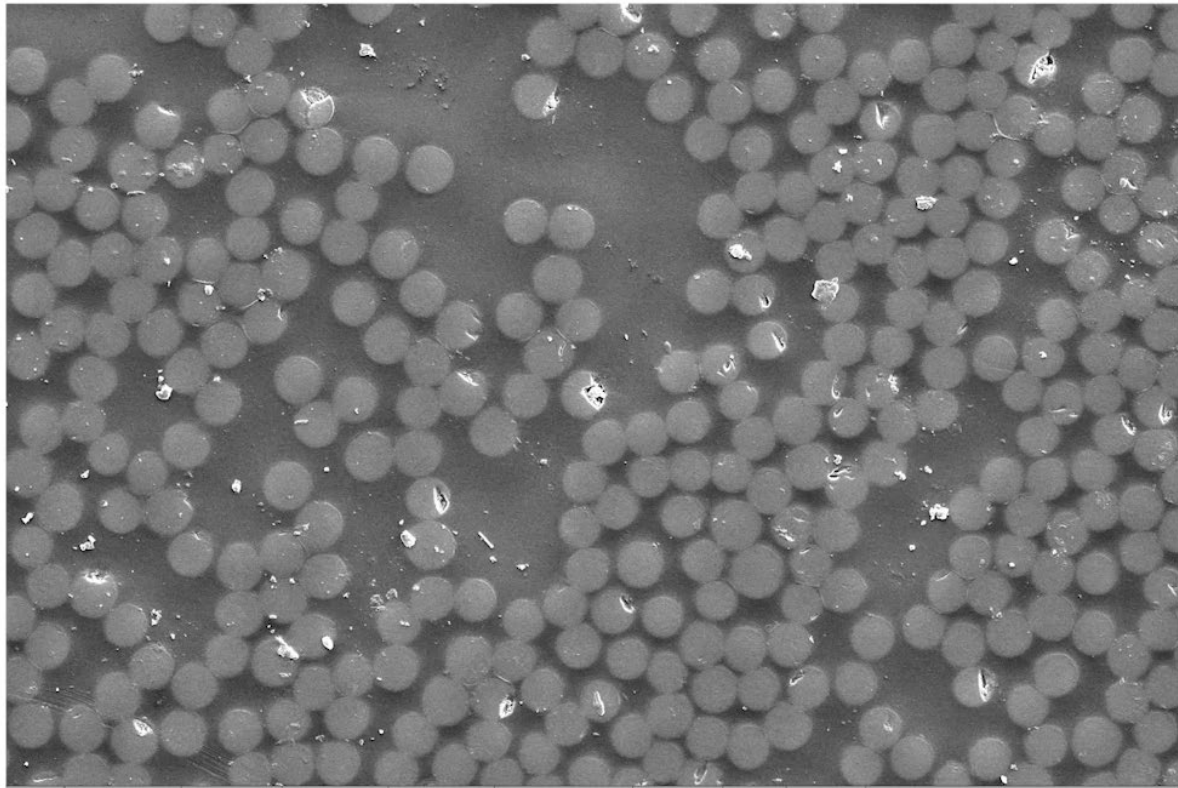
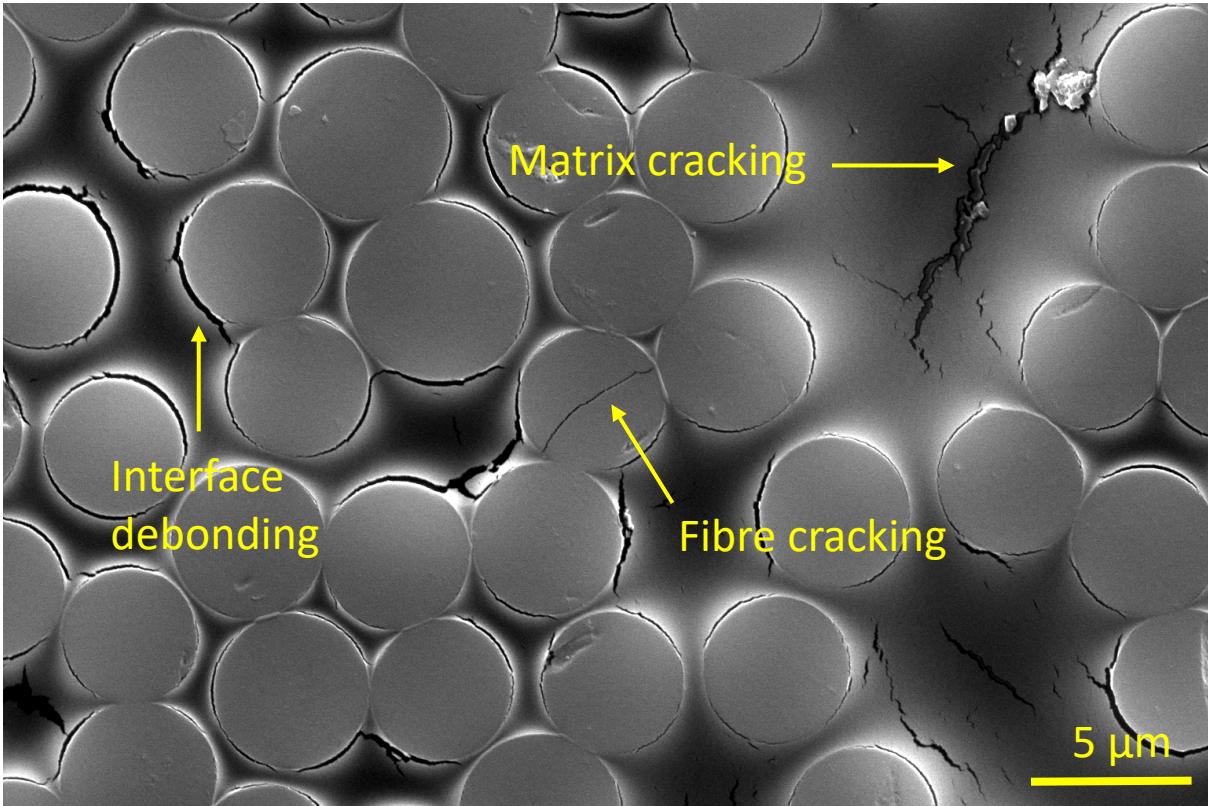
Fracture Toughness (K_{IC}) ↑ 144%

Fracture Energy (G_{IC}) ↑ 395%



Cryo-SEM

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Conclusions

- 76% drop in stress at first crack for the CFRP at -155°C under thermo-mechanical loading.
- 144% increase in fracture toughness for neat epoxy at -196°C.
- Cryo-SEM revealed matrix cracking and fibre-matrix debonding as early as -20°C.
- Microscopic damage from CTE mismatch during thermal loading was key in reducing the CFRP's microcrack resistance.



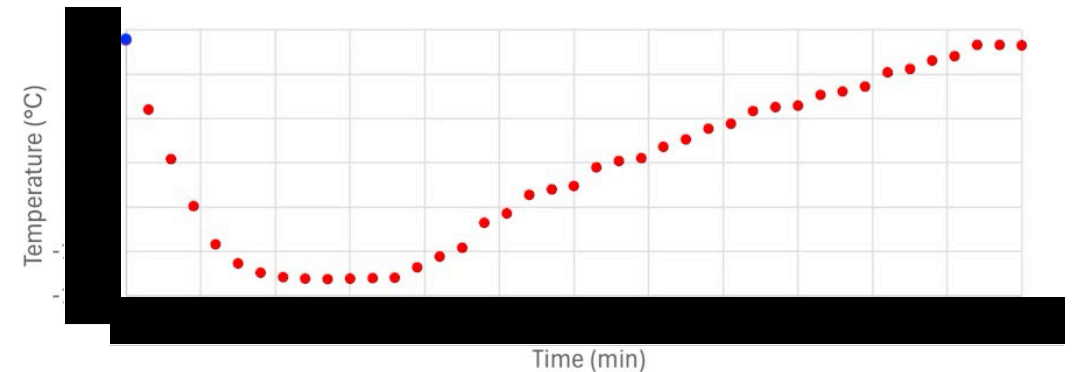
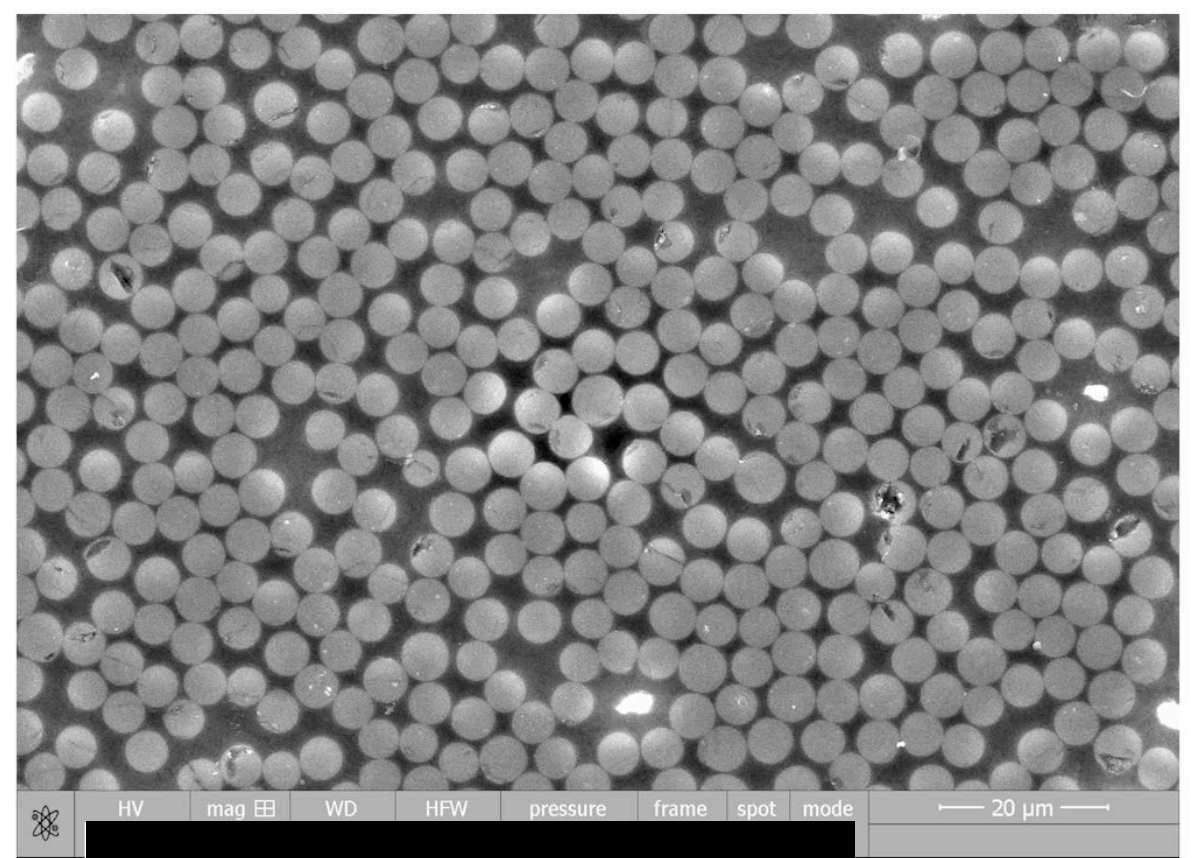
Our Approach

Tripartite polymer (patent application filed)

- Toughening component
- CTE modifier
- Healing agent

Next steps

- EPSRC impact accelerator award
- NCC technology pull through programme



Thank you for listening!
Any questions?

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