University of BRISTOL
Bristol Composites Institute

Multi-matrix continuously-reinforced composites for waste reduction and repair applications

Dominic R. Palubiski, Marco L. Longana, Janice M. Dulieu-Barton, Ian Hamerton, and Dmitry S. Ivanov

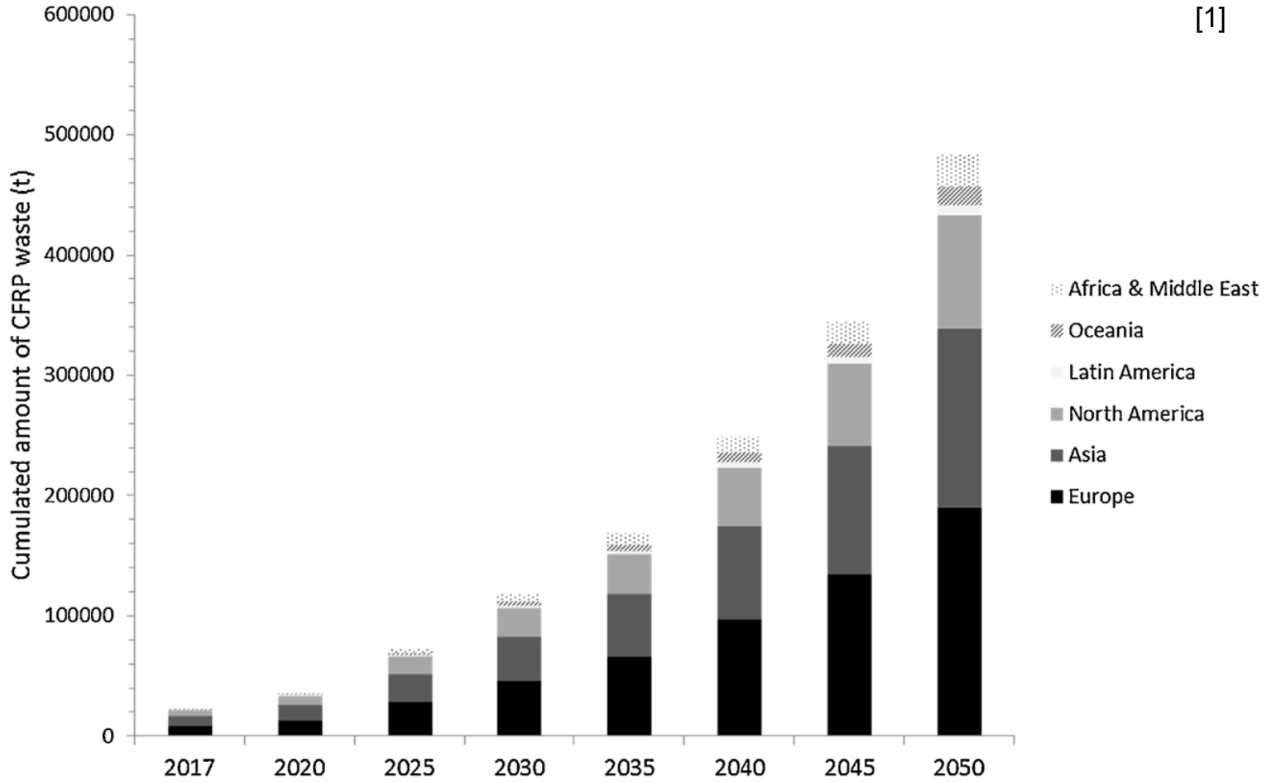
ICCM23 Belfast

4th August 2023

bristol.ac.uk/composites

CIMComp
EPSRC
Future Composites Manufacturing Research Hub

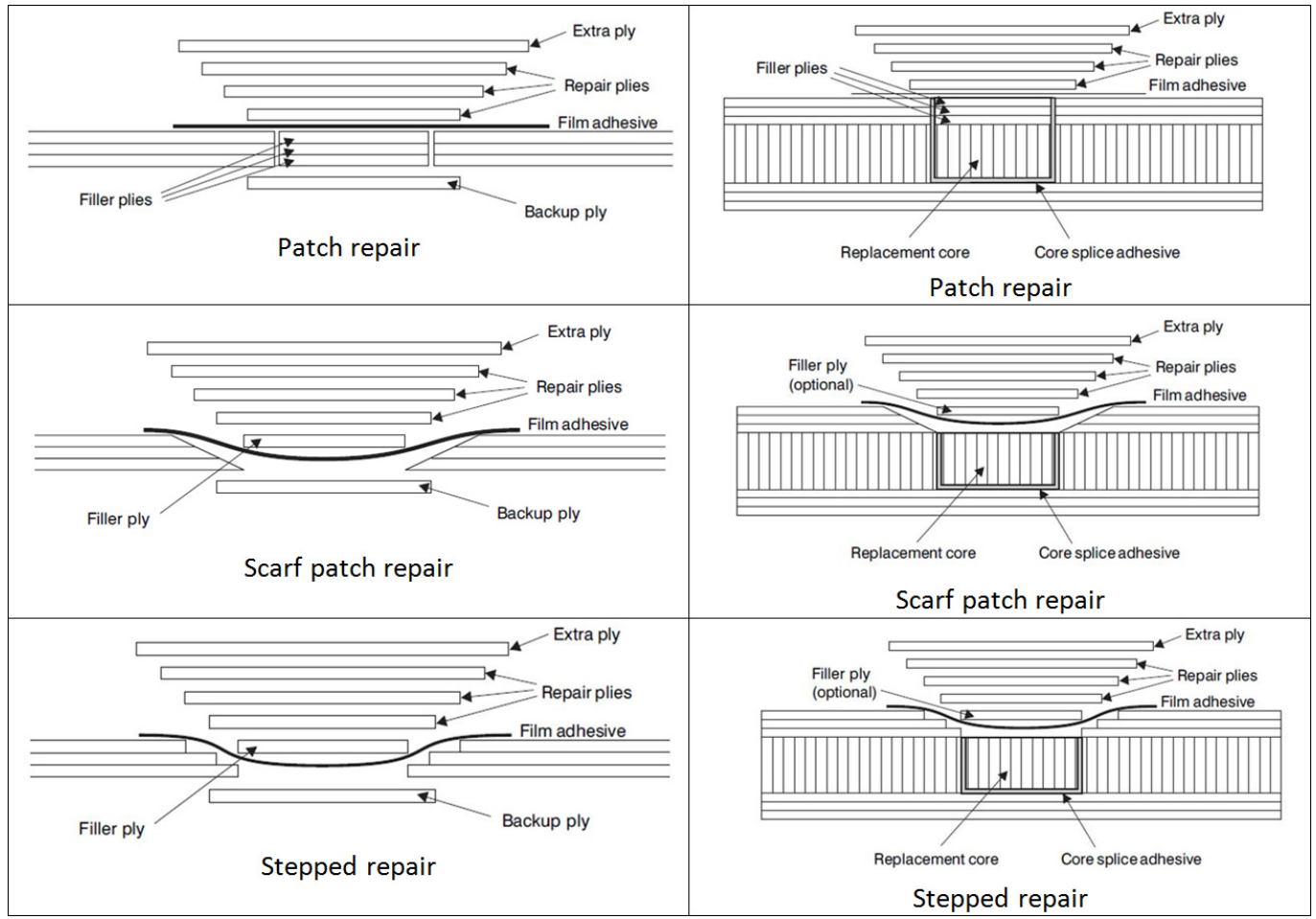
Growing Composite Waste



[1]

[1] Lefeuvre, A., *et al.* (2019). Anticipating in-use stocks of carbon fibre reinforced polymers and related waste generated by the wind power sector until 2050. Resources, Conservation and Recycling, 141, 30–39. https://doi.org/10.1016/j.resconrec.2018.10.008

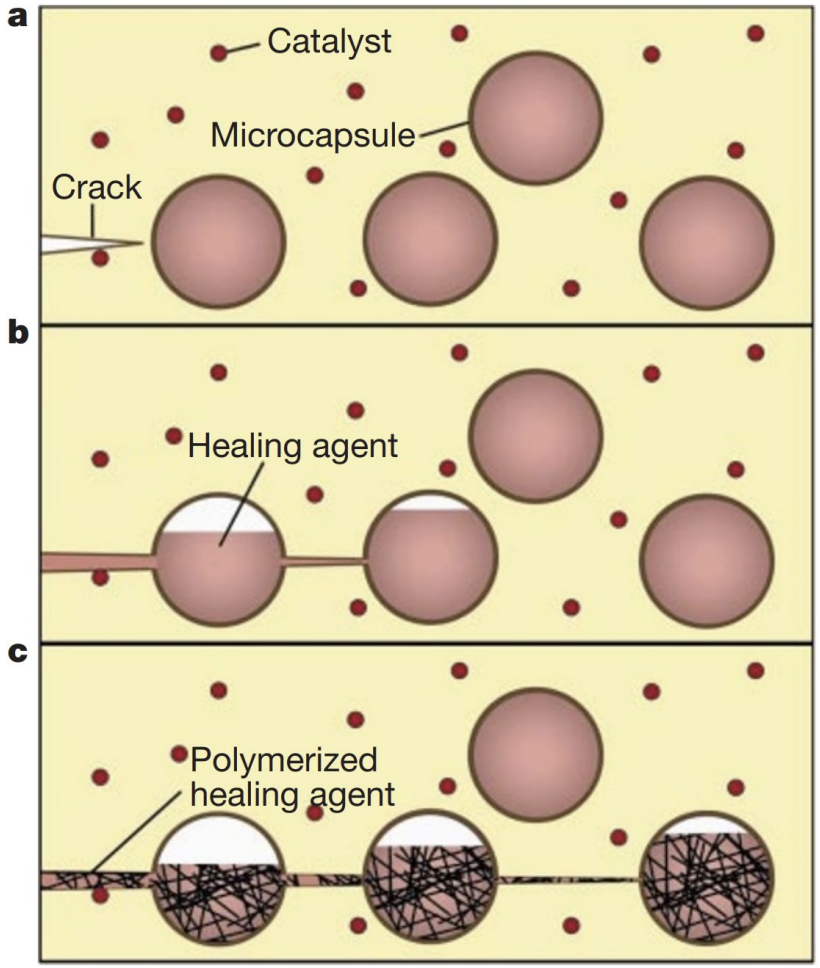
Current Composite Repair



[2]

[2] Lkovaios - https://upload.wikimedia.org/wikipedia/commons/4/46/Figure-4-typical-laminate-and-sandwich-repairs.jpg

Current Composite Repair



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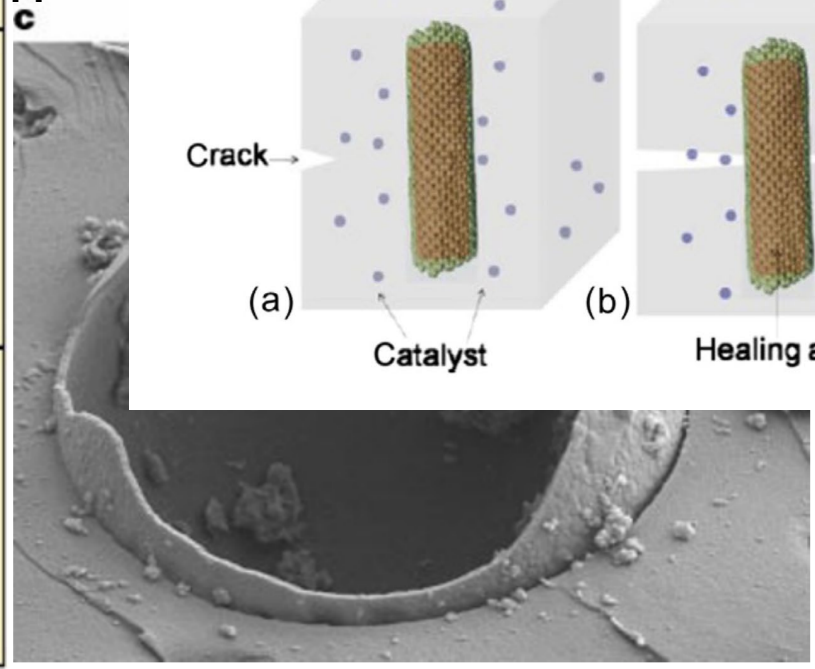

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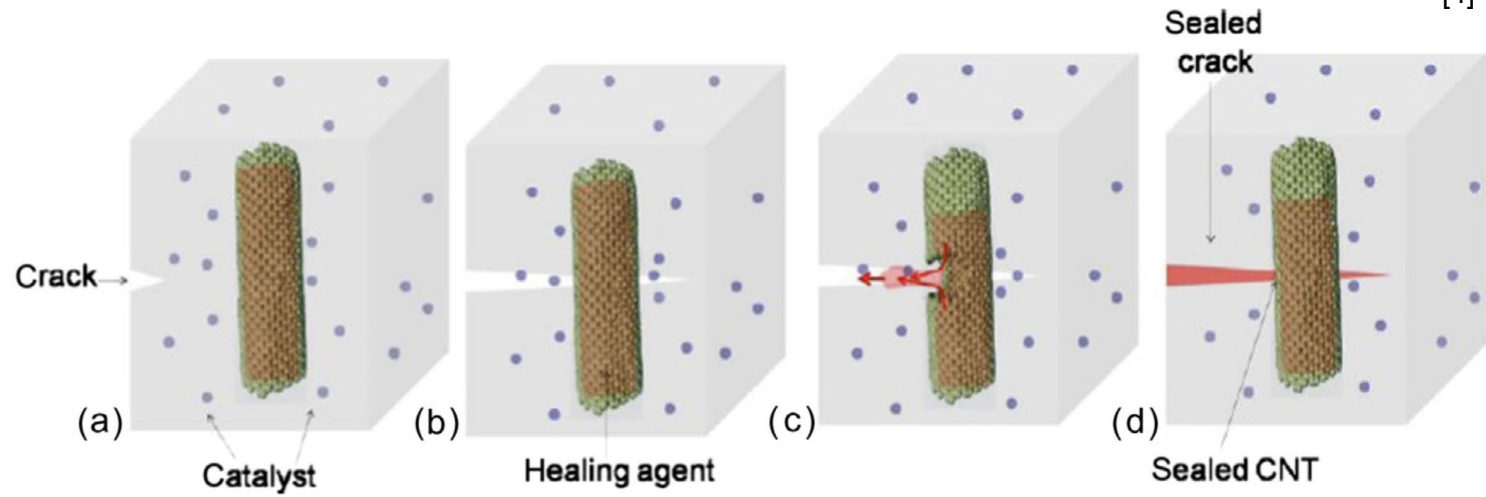
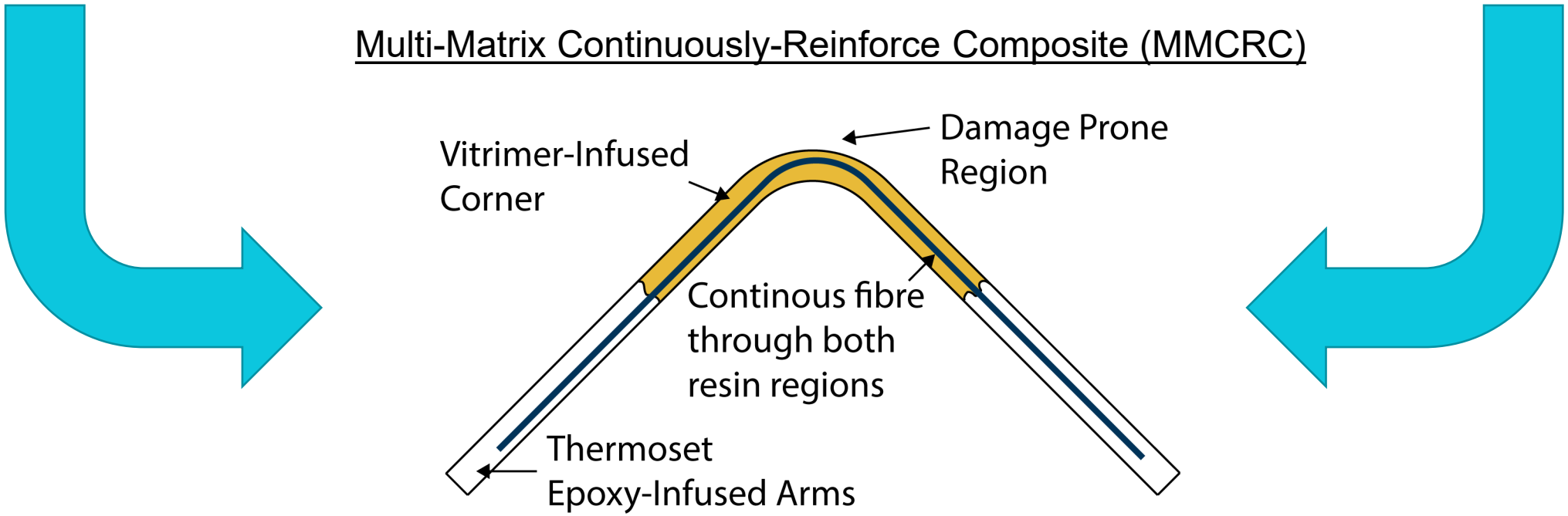


[3] White, S., *et al.* Autonomic healing of polymer composites. Nature 409, 794–797 (2001).
[4] Pulikkalparambil H, *et al.* Self-repairing hollow-fiber polymer composites. Self-Healing Composite Materials: From Design to Applications 2020:313–26.

Ideal Composite Repair

- Want continuously reinforced repairs
- Want full fiber volume fraction



Where could this be useful?

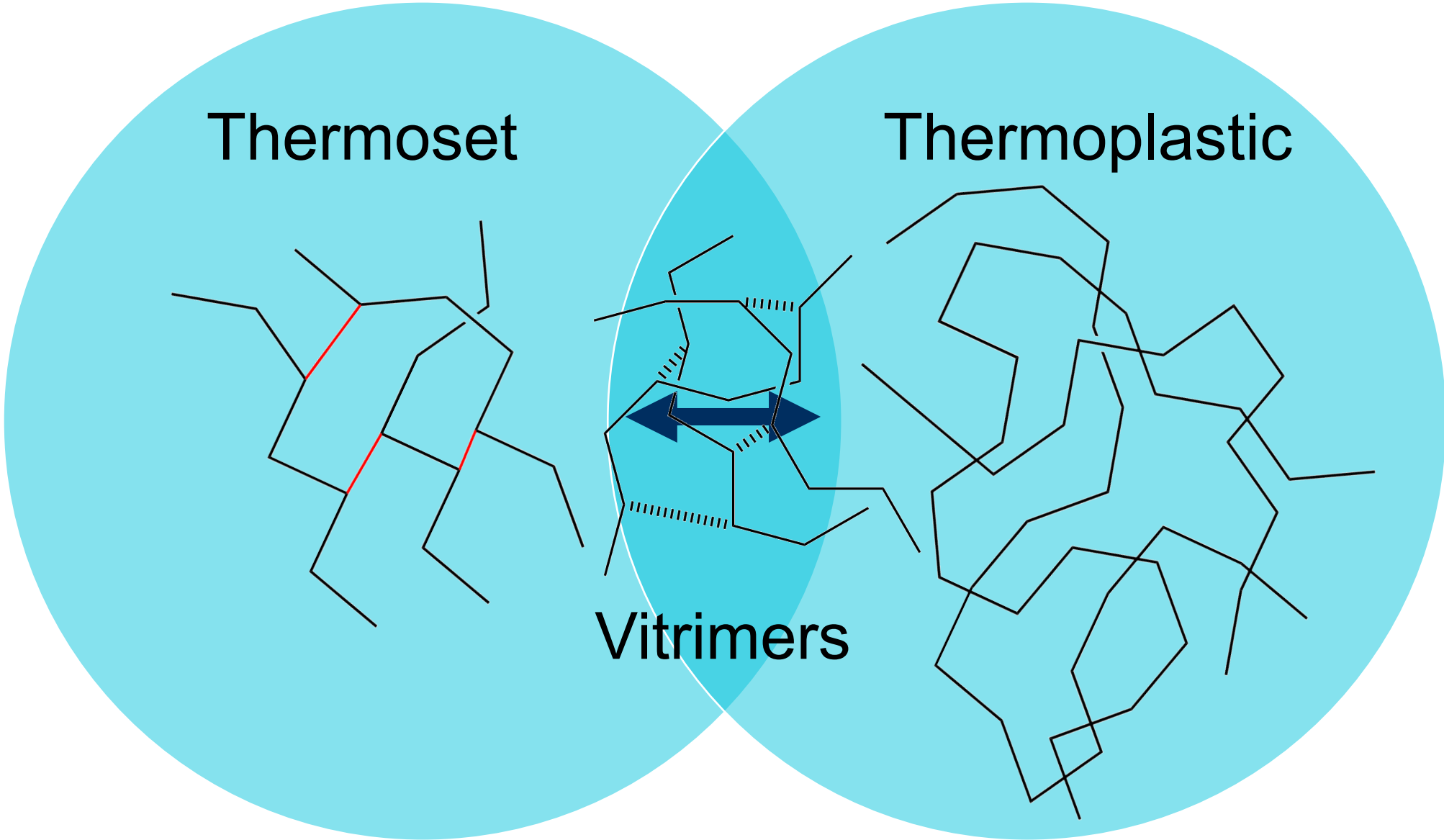
Locations where damage is expected:

- Leading edges of blades
- Contact/friction surfaces
- Damage susceptible corners of containers
- Likely impact locations
- Etc.

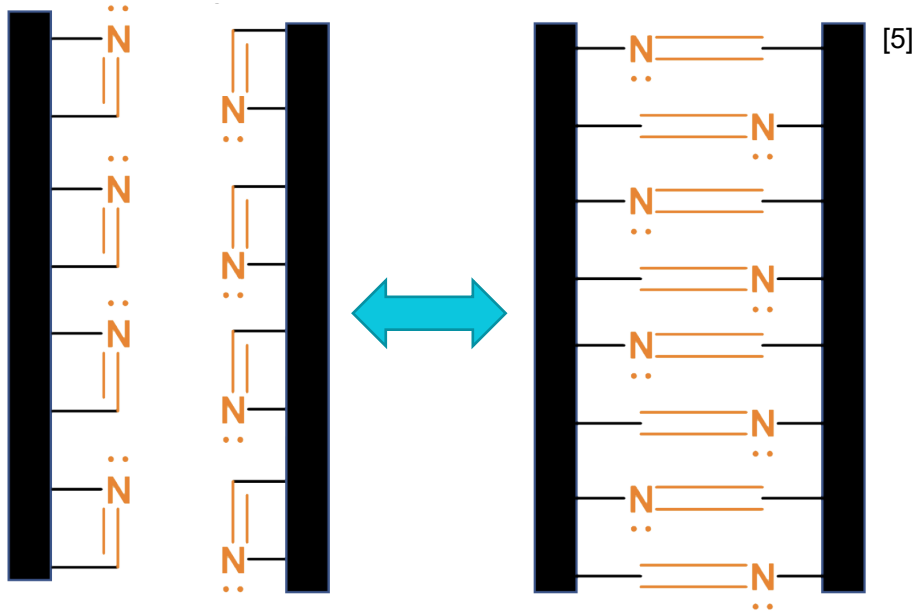
Leading Edge Erosion: Why We Keep Failing To Solve It (weatherguardwind.com)

When Your Luggage Arrives Damaged | BudgetAir.co.uk Blog

Carbon Fiber Brakes: An In-Depth Look With Strange Engineering - Dragzine


Thermoset
Thermoplastic
Vitrimers

Vitrimers

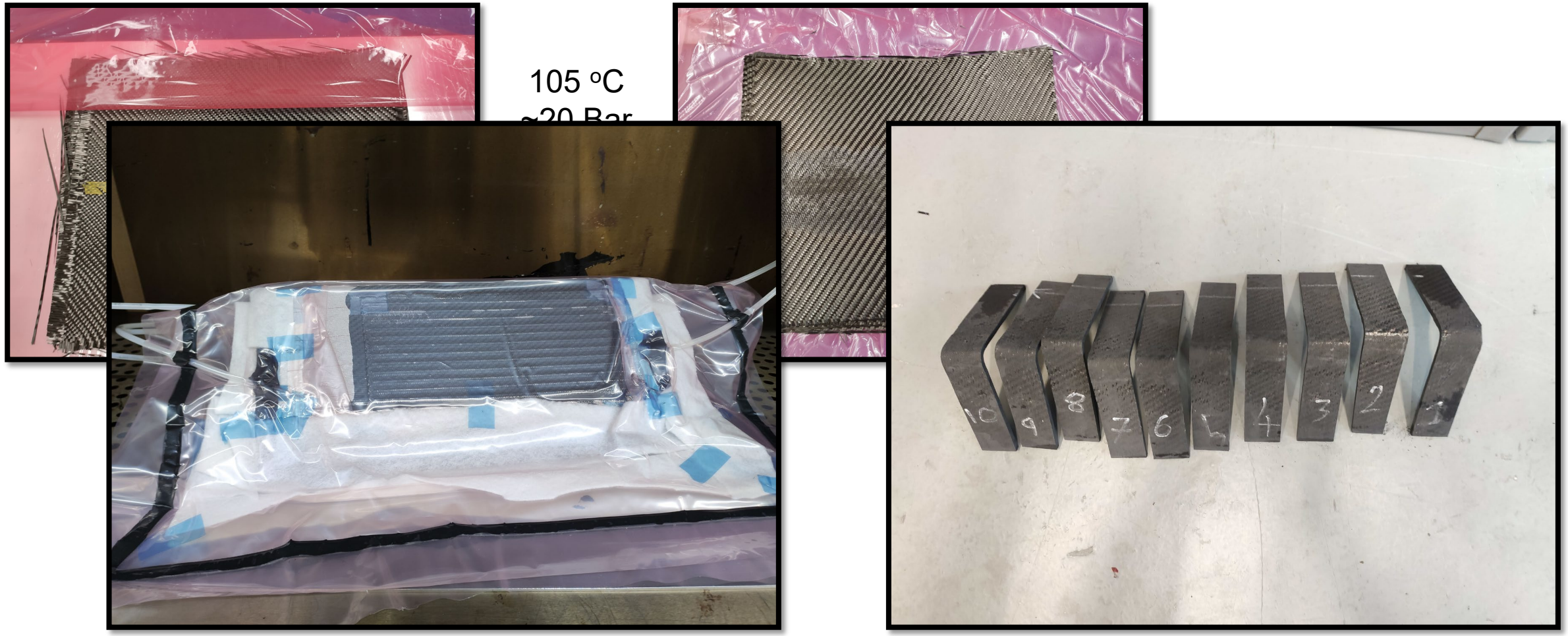

[5]

+ Strong mechanical ability
+ Gentle reforming conditions
+ Improved resilience in varied environments
+ Can be reformed and recycled

Can vitrimer-based resin composites sufficiently repair interlaminar failures?

[5] Mallinda - https://mallinda.com/wp-content/uploads/2021/10/what-are-vitrimers-presentation-2021.pdf

Manufacturing



Testing

D6415/D6415M – 06a (2013)

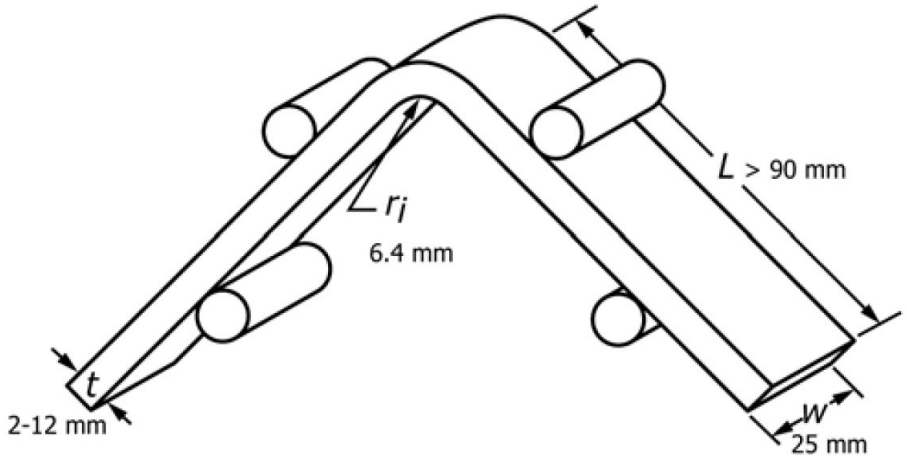
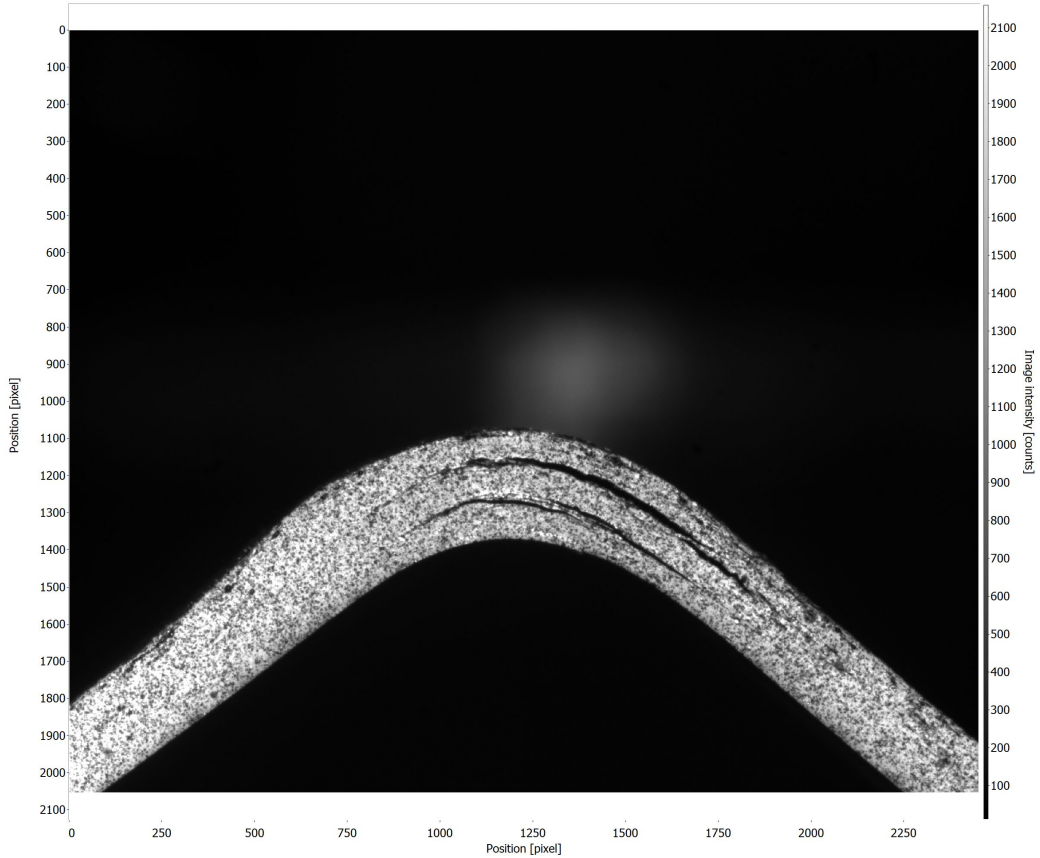
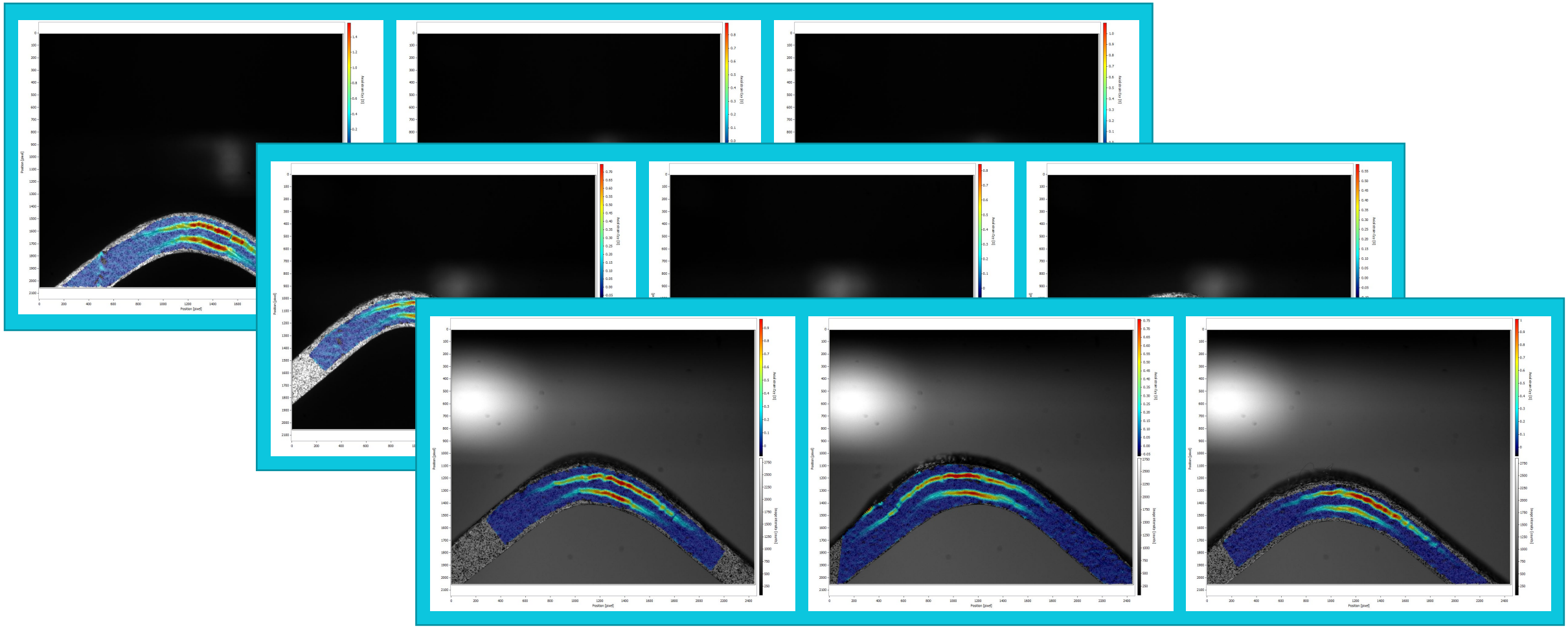


FIG. 1 Test Specimen Geometry (SI units)



Manufacturing Issues, Part 1



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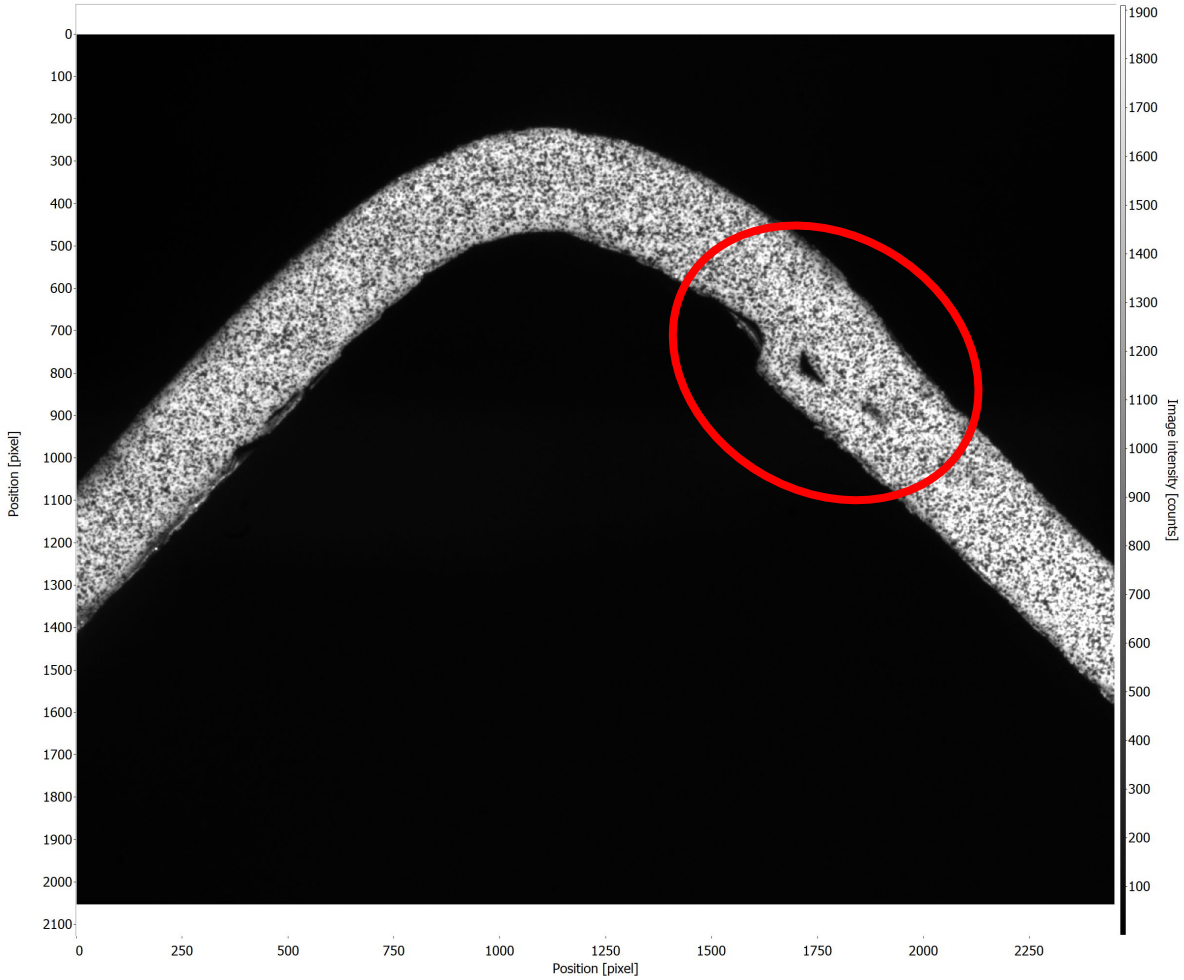
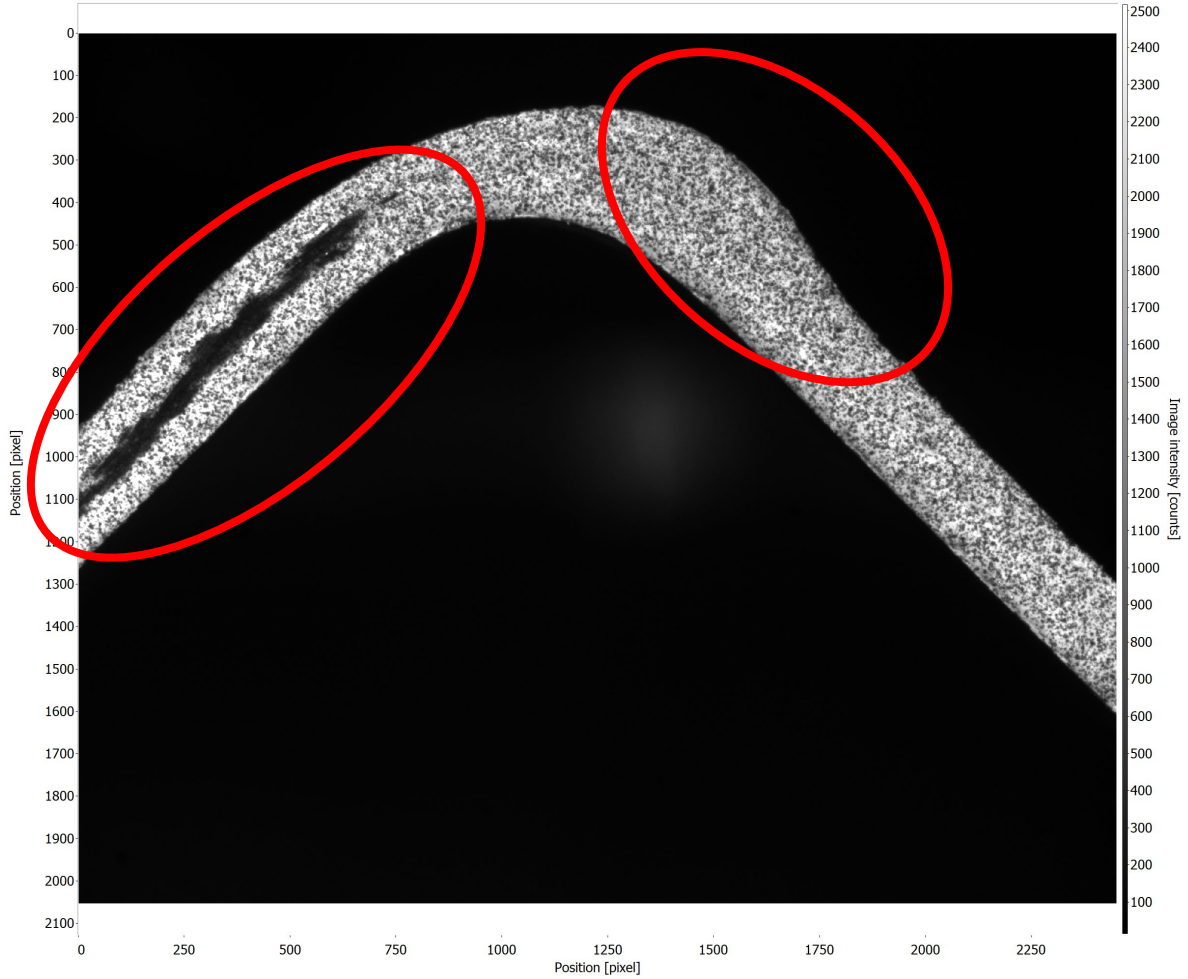
Manufacturing Issues, Part 2

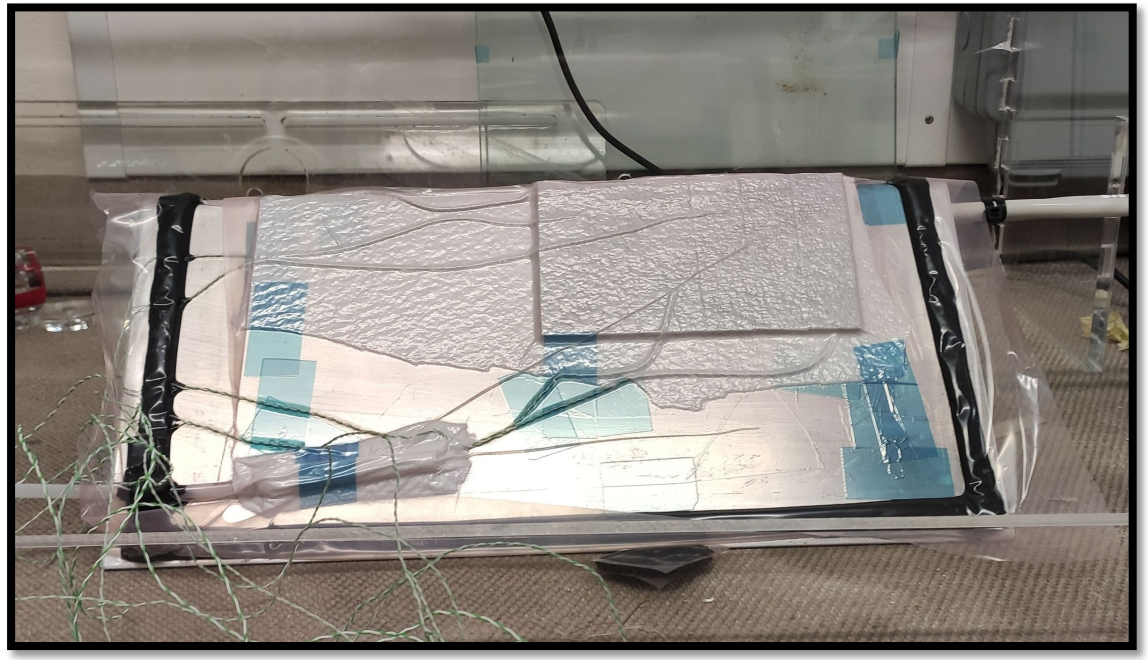




Repair

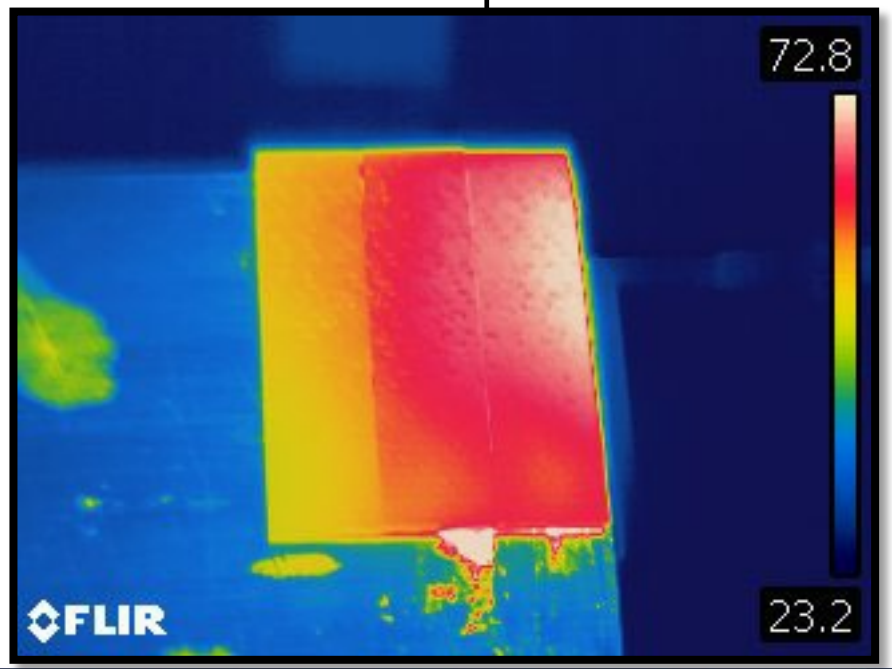
Oven Heal

- 1 or 2 hours, depending on samples at 110 °C.
- Under vacuum pressure.



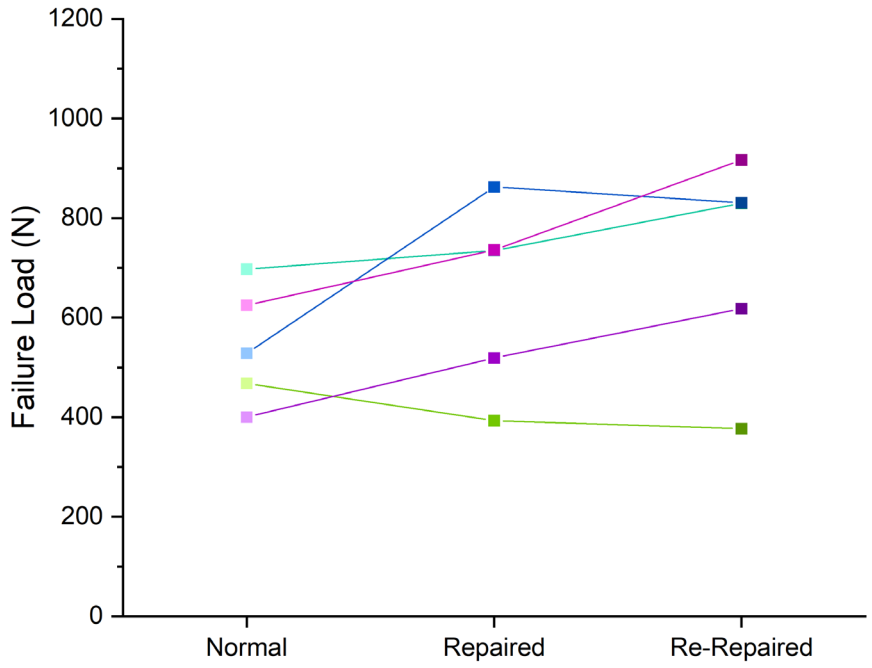
Induction Healing

- 2 hours heated and under vacuum.
- Temperature maintained between 100 and 135 °C on all thermocouples.

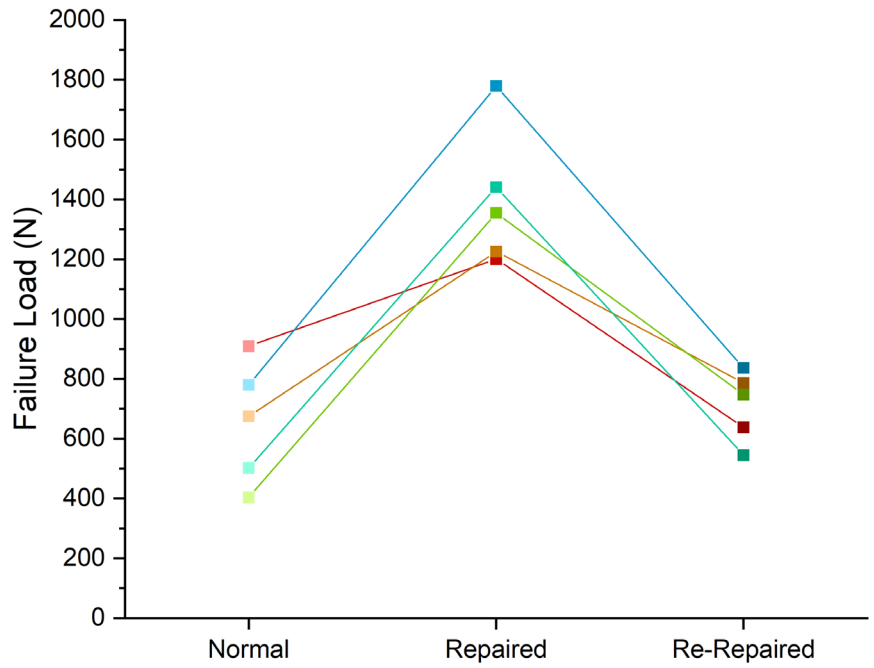


Oven Repair Performance

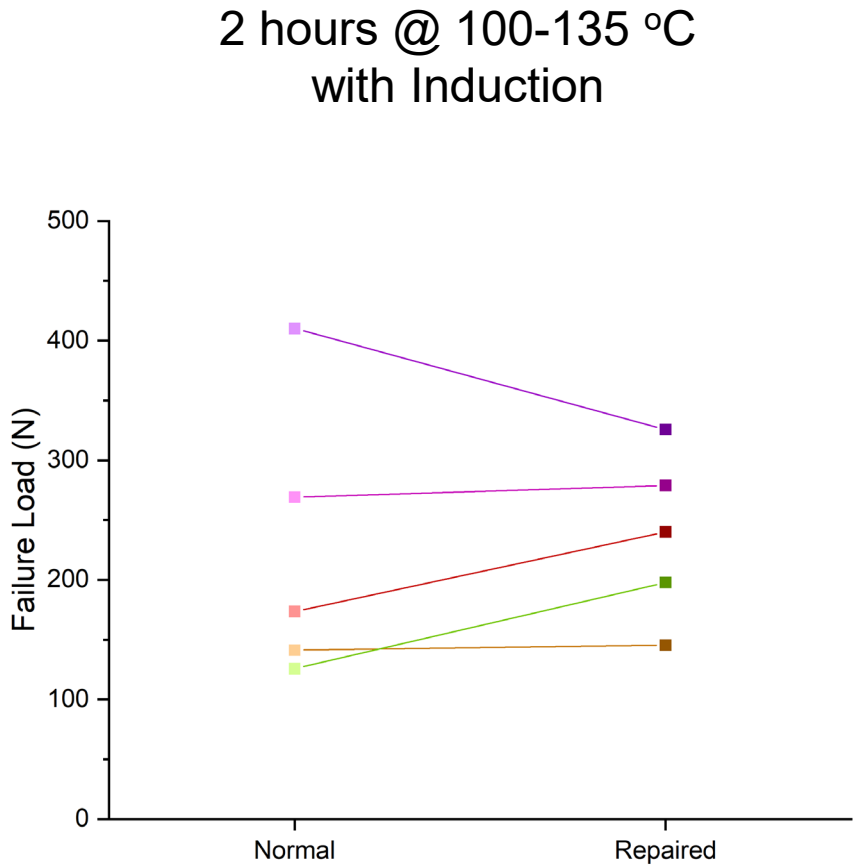
1 Hours @ 110 °C in Oven



2 hours @ 110 °C In Oven



Induction Repair Performance



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Thank you

dominic.palubiski@bristol.ac.uk

We would like to thank Mallinda for the supply of their vitrimer

MALLINDA