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Towards implementing high-precision mapping of structural and functional properties in composite components

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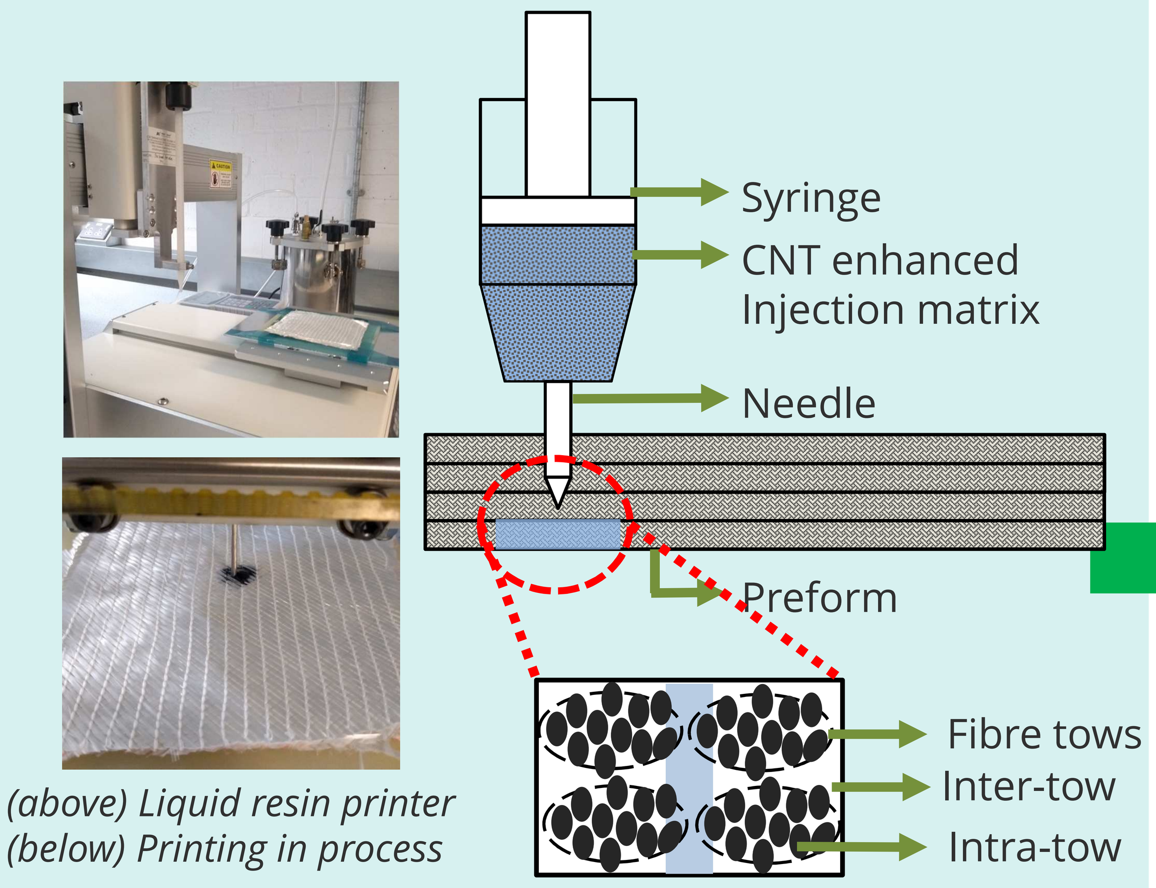
Summary:

This research demonstrates the feasibility of mapping composite properties to improve the structural performance and functionality of composites. The composite morphology is controlled by combination of high-precision liquid resin printing and consolidation programmes. This localised deposition enables higher additive loading and decreases the manufacturing costs compared to bulk modification of polymer composites. This novel technique maps local composites properties hence enabling a design space which exhibits greater stiffness contrast, which leads to improvement in the structural performance. Further, the functional properties can be tailored to local requirements by utilising a variety of additives like carbon nanotubes and core shell rubber particles.

Localised processing of polymer composites:

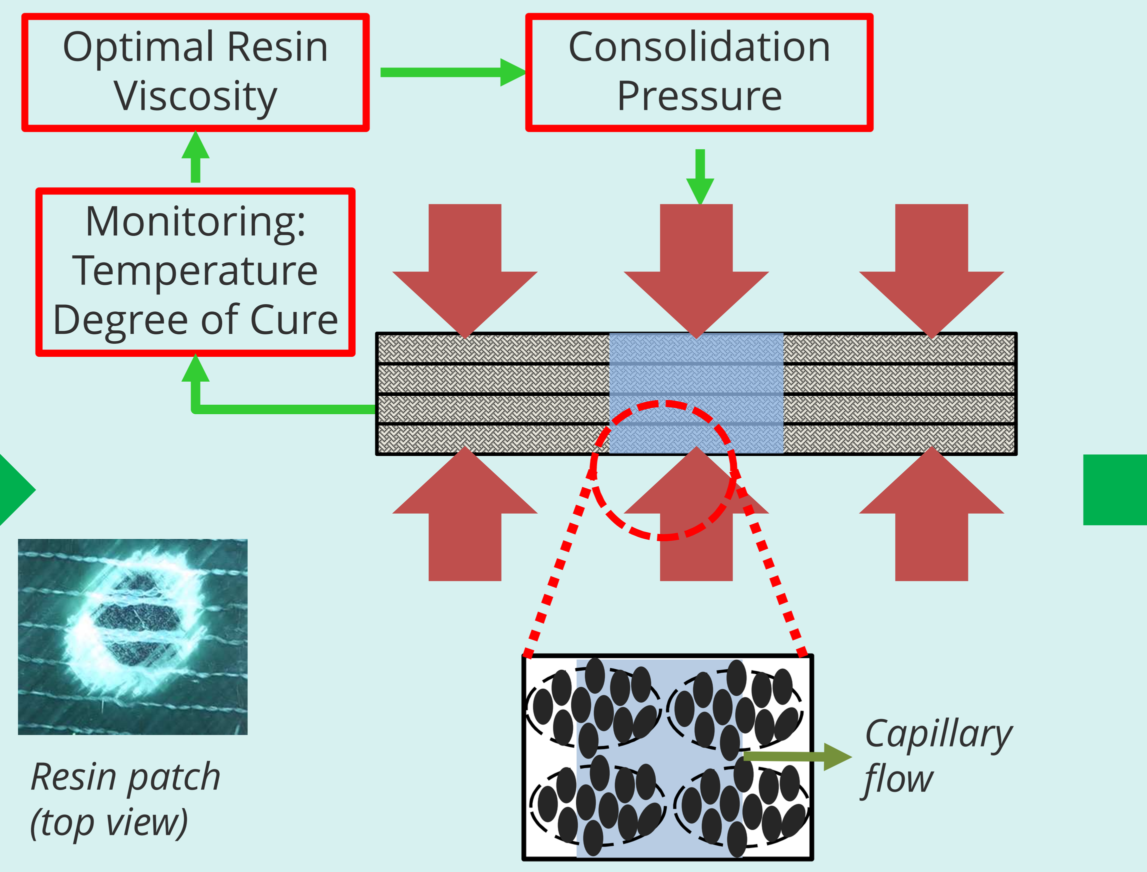
Step 1: Liquid resin printing (LRP)



(above) Liquid resin printer (below) Printing in process

- Precise injection with various loadings can be used to vary the properties of the resultant composite.

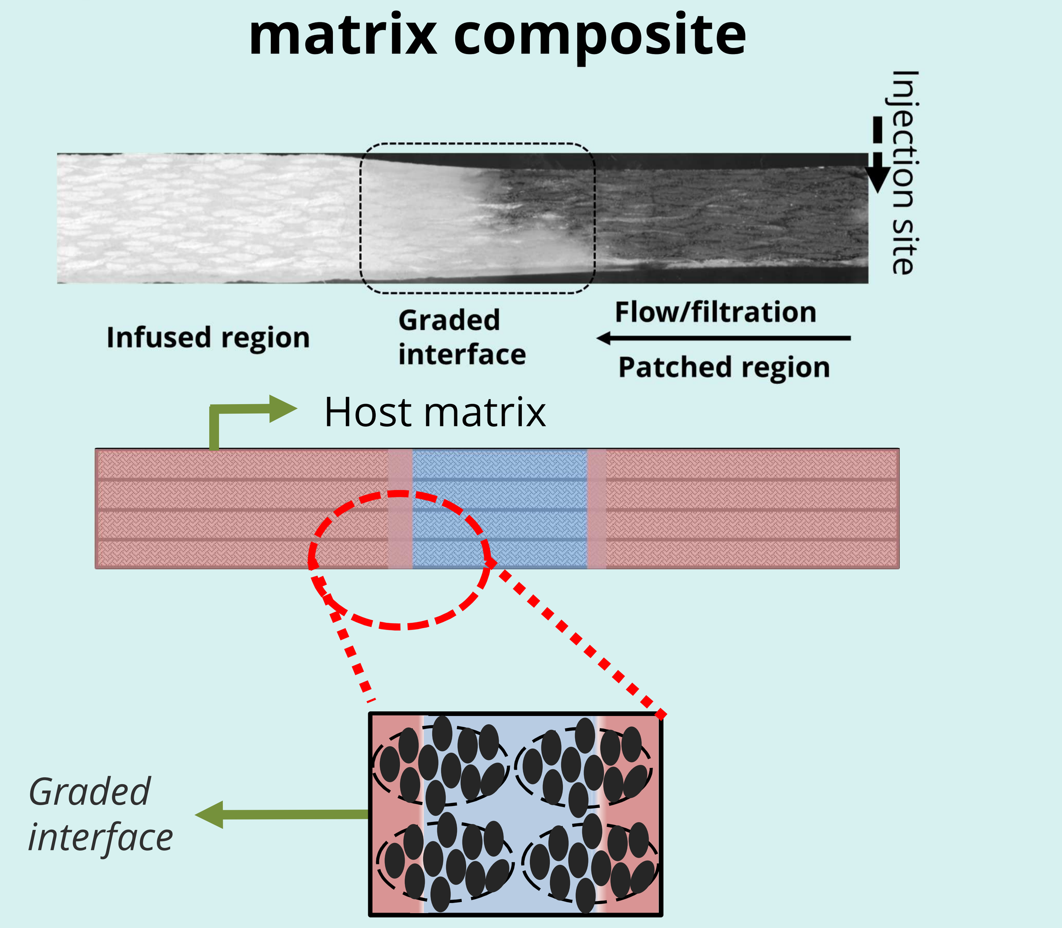
Step 2: Cure and consolidation of patch



Resin patch (top view)

- Consolidation pressure is applied at optimal resin viscosity to suppress the porosity in the patch.

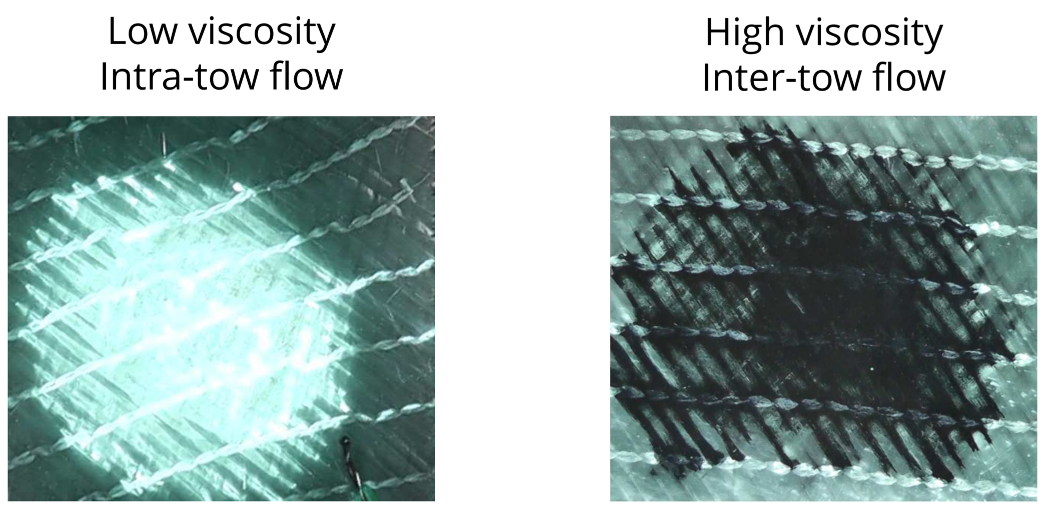
Step 3: Resin infusion to form multi-matrix composite



- The remaining preform infused with host matrix *via* vacuum assisted resin infusion.
- A graded multi-matrix interface is formed.

Process characterisation and performance:

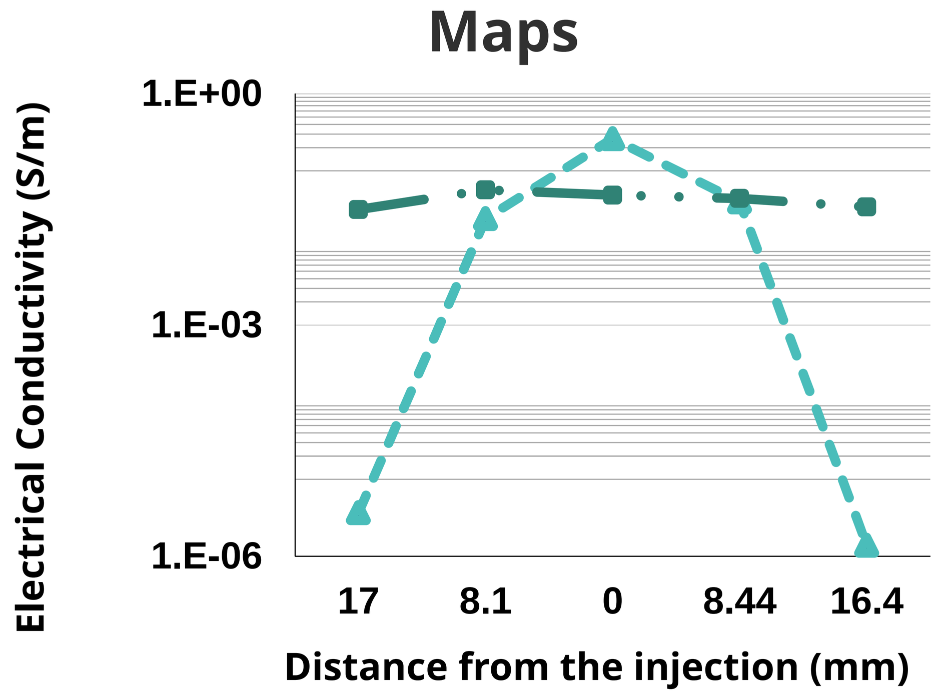
Resin flow visualisation



Resin flow through glass non-crimped fabric

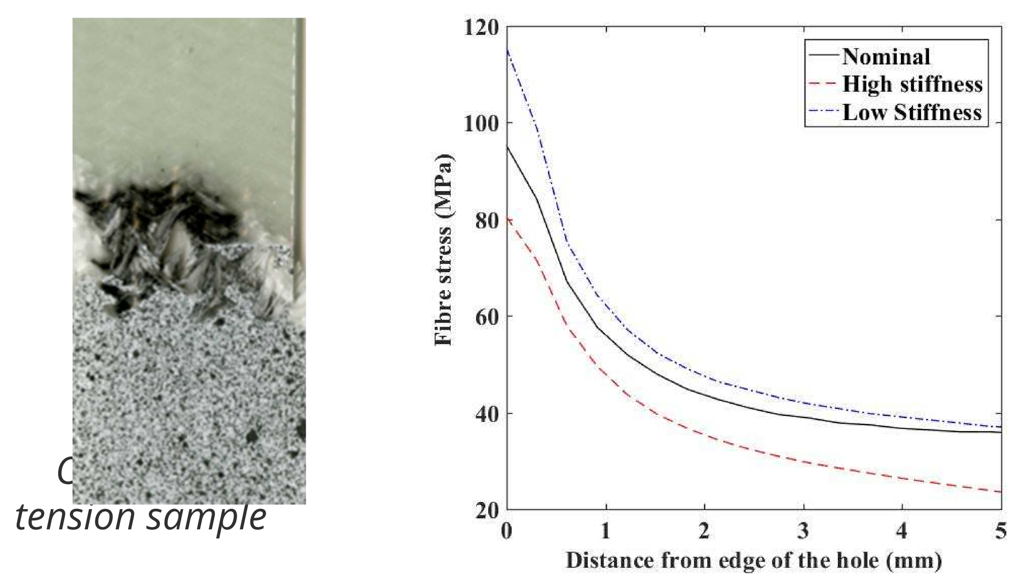
- Viscosity at point of consolidation in step 2 is critical to suppressing porosity.
- Closed loop processing is required to control the patch morphology.

Electrical conductivity - Maps



- A conductive network is formed by CNTs in a GFRP composite.
- Conductivity plots across the patch is used to map CNT distribution.

Mechanical performance – Design Tool



- CNT patch introduces novel damage mechanisms in GFRP composites.
- **Peak fibre stresses reduce with introduction of stiffer CNT patches.**

Future work and capabilities:

Printed multi-matrix carbon fibre composites

- Various conductive nanofillers can be utilised to formulate the mapping of properties.
- **Predictive tool to be developed in order formulate the design space for closed loop out-of-autoclave processing for multi-matrix multifunctional polymer composites.**

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