Experimental investigation of vitrimers in adhesive bonded and rebonded joints

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Introduction

Vitrimers are innovative polymers that combine the strength of thermosets with the reprocessability of thermoplastics, enabled by dynamic covalent bonds. Their ability to be re-bonded multiple times makes them promising for aerospace repair applications. However, understanding their mechanical and rebonding behavior is key to future use. This poster presents initial experimental results on vitrimer-bonded and re-bonded joints.

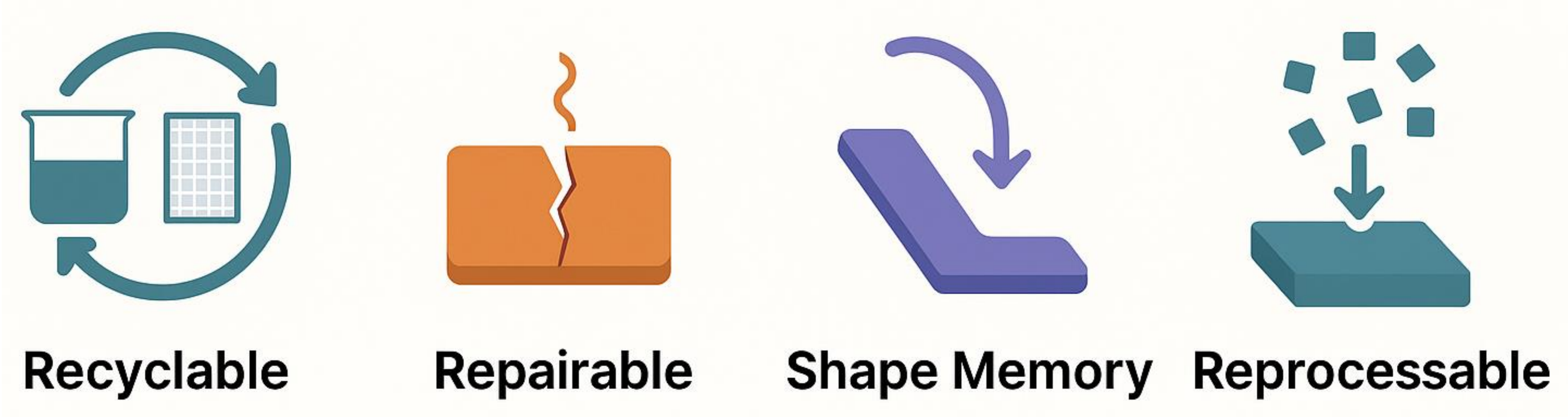

Figure 1 – Vitrimers applications.

Experimental details

1. Strength testing and analysis

Tensile and shear properties were measured using standard tests to evaluate vitrimer performance.

- **Tensile test (ASTM D638):** dog-bone specimens for strength and modulus
- **Shear test (ASTM D5656 – TAST):** to assess shear strength and stiffness

These tests provide baseline data for understanding adhesive behavior under load.

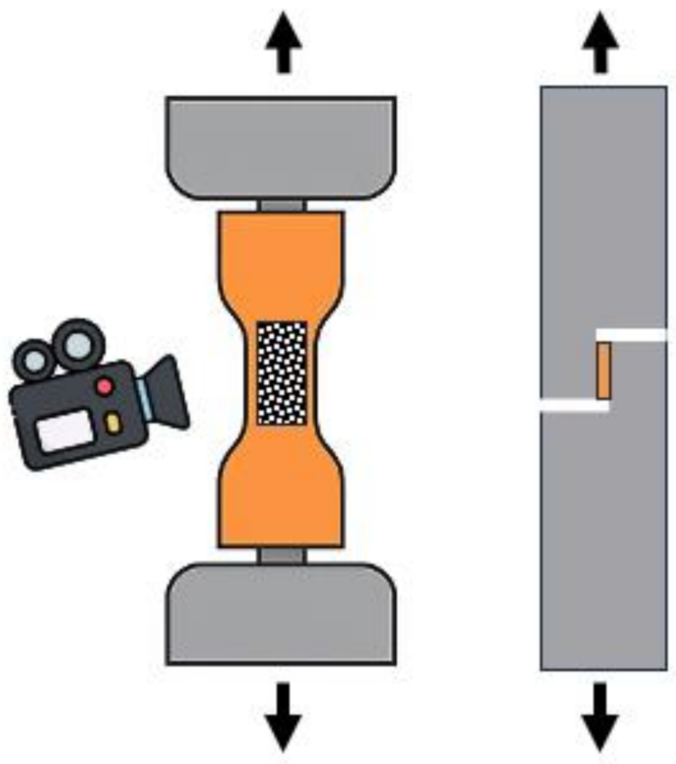

Figure 2 – Strength test.

2. Bonding & rebonding in single lap joint

Joints with 0.1 mm and 0.5 mm adhesive thicknesses were tested to study the effect of thickness on bonding and rebonding. Each underwent three rebonding cycles plus a reference test. Joint geometry is shown in Figure 3. To maintain adhesion, adhesive thickness was reduced in each cycle:

- **0.1 mm joints:** rebonded with ~0.0 mm
- **0.5 mm joints:** rebonded with 0.4, 0.3, and 0.2 mm

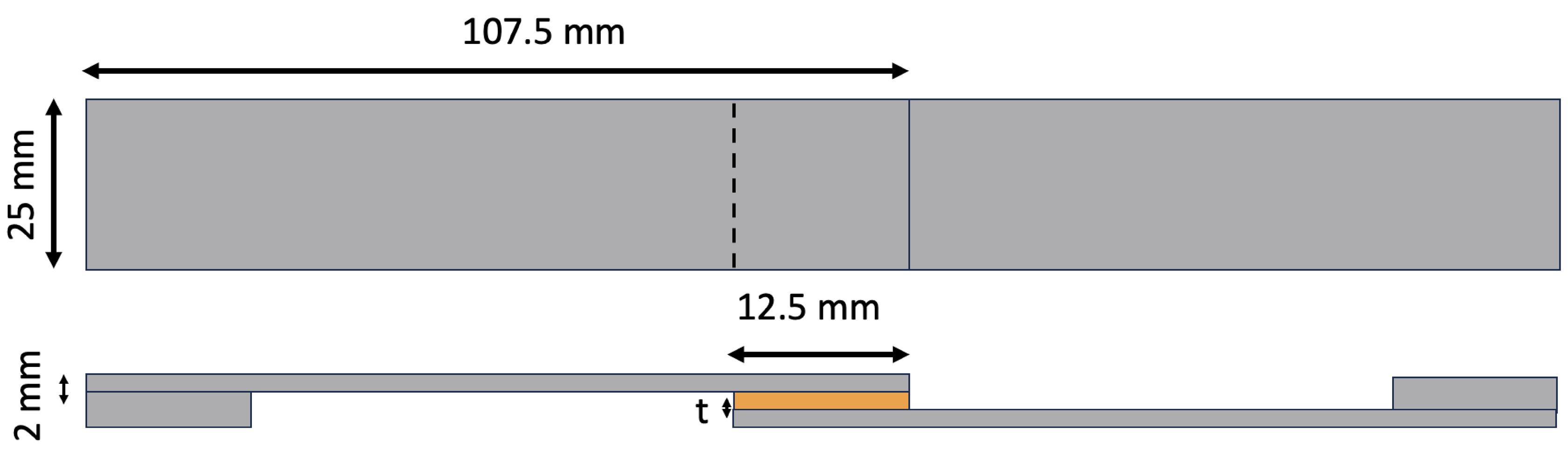

Figure 3 – Single lap joint geometry t is the thickness of adhesive 0.1/0.5 mm.

ACKNOWLEDGEMENTS

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Results and discussion

1. Tensile & shear test results

Tensile test (ASTM D638):
Dog-bone specimens showed elastic – plastic behavior with ductile failure.

- Tensile Strength: 48 ± 3 MPa
- Young's Modulus (E): 1218 ± 73 MPa
- Poisson's Ratio (v): 0.35

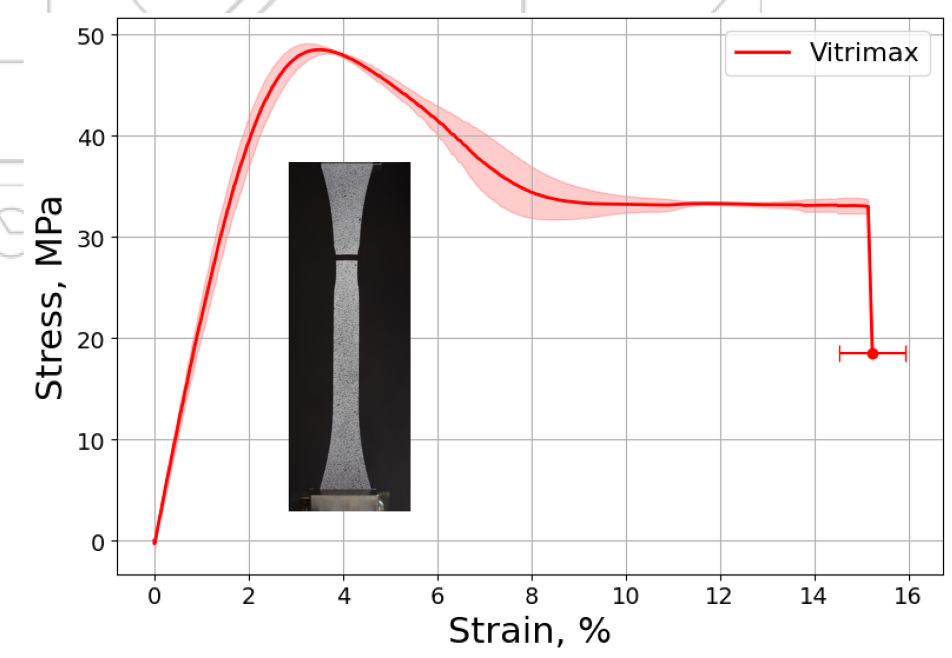

Figure 4 – Tensile test.

TAST – Shear test (ASTM D5656):
Shear specimens revealed a rapid elastic response followed by strain softening.

•Shear Strength ($\mathcal{T}$): 27 ± 7 MPa
•Shear Modulus (G): 564 ± 32 MPa

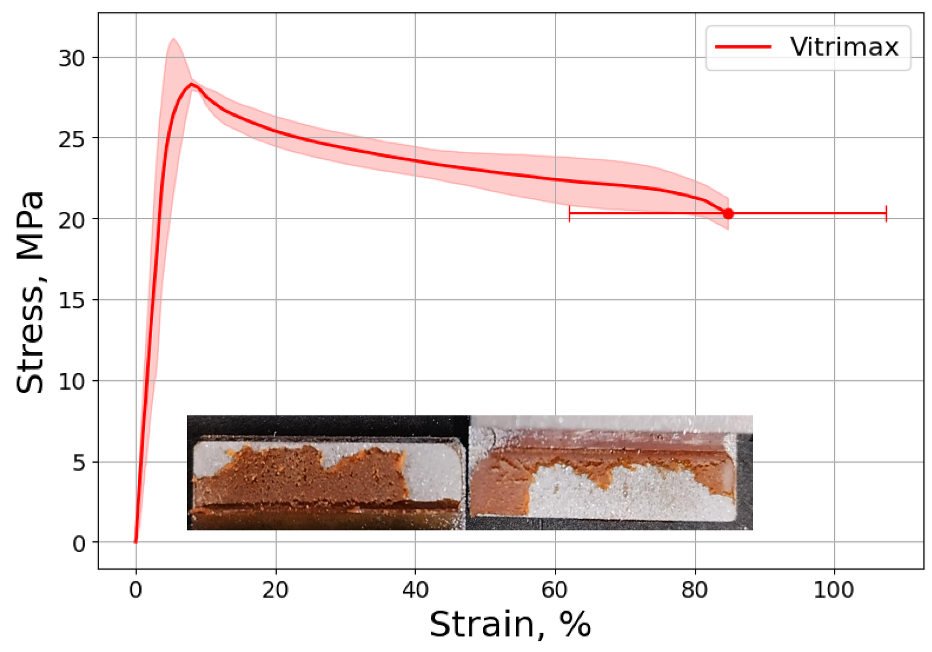

Figure 5 – Shear test.

2. Bonding & Rebonding Performance

Rebonding performance varied significantly with adhesive thickness. After three cycles:

- **0.5 mm joints retained 75%** of their original strength
- **0.1 mm joints retained only 57%**

Load–displacement curves show that thicker joints consistently reached higher peak loads and exhibited slightly better ductility across all cycles.

These results highlight the importance of adhesive thickness in maintaining mechanical integrity during repeated bonding. Thicker adhesive layers improve durability and performance in repairable joint applications.

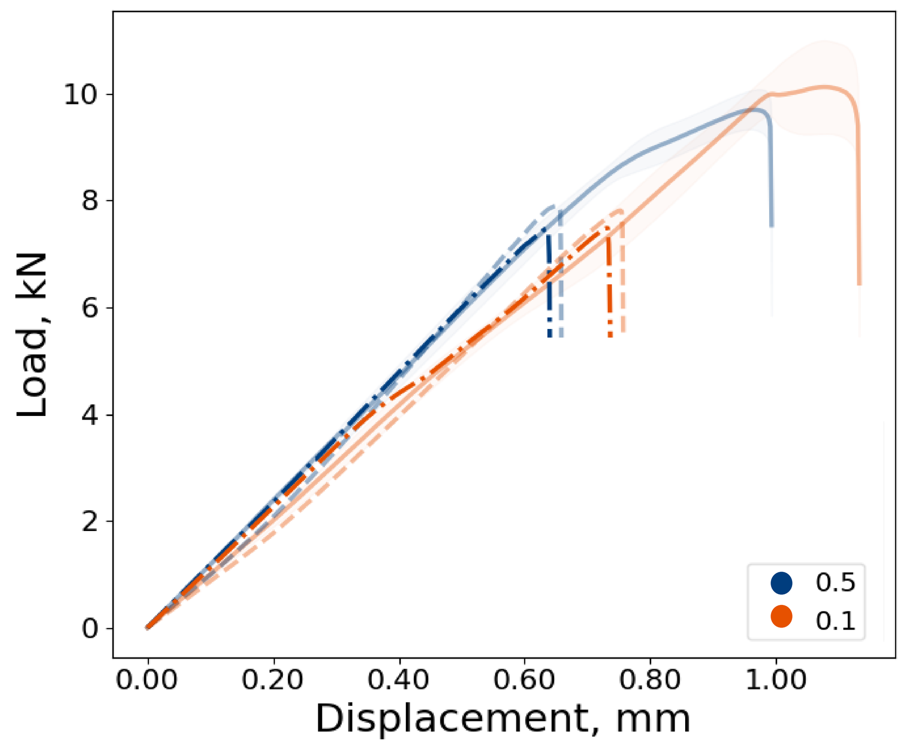

Figure 6 – load-displacement behaviour.

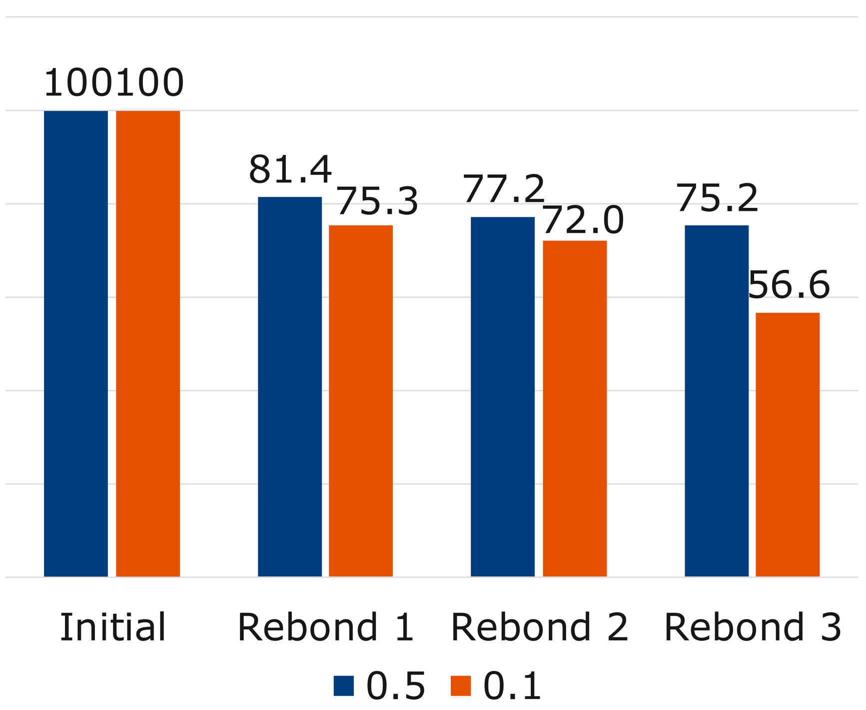

Figure 7 – Percentage of strength loss of SLJs.

CONCLUSION

- Mechanical tests confirmed solid tensile and shear performance.
- Rebonding tests showed strength retention over multiple cycles.
- Thicker adhesive layers improved durability and mechanical reliability.
- Results support the use of vitrimers in repairable bonding applications, especially in demanding structural fields.

REFERENCES

[1] Vaught, Louis O., et al. "Shape Memory and Fatigue Reversal in a Covalent Adaptive Network Polymer below Glass Transition Temperature." Macromolecules 58.8 (2025): 3916-3923.