AddJoining: Additive layered manufacturing technique for metal-polymer structures

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AddJoining

New use of additive manufacturing of polymers

- AddJoining is a new manufacturing technique for metal-polymer layered structures (German pat. applic. DE 10 2016 121 267.9, October 2016)

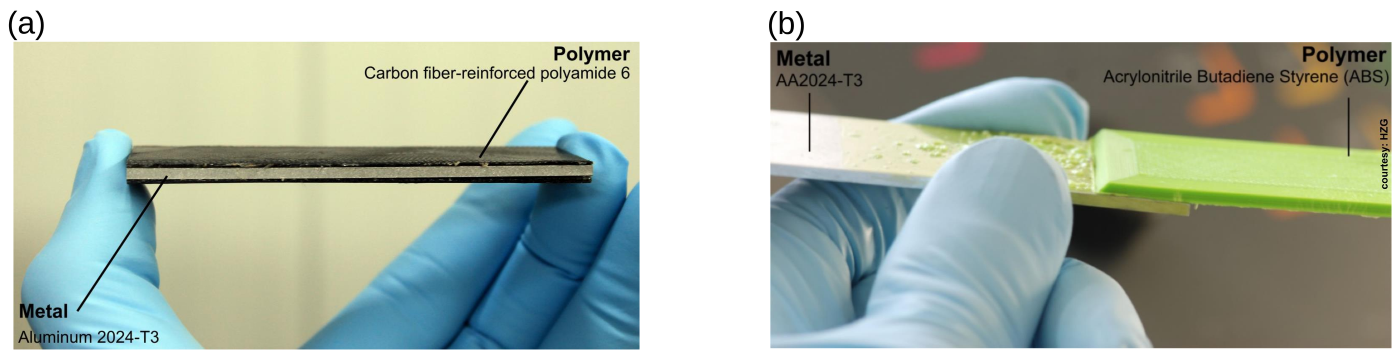

Figure 1: Samples produced using AddJoining: (a) CF-PA6/Aluminum 2024-T3/CF-PA6 laminate and (b) Aluminum 2024-T3/ ABS single-lap joint .

Potential applications

- Layered panel with multi-materials
- Local reinforcement
- Stiffeners

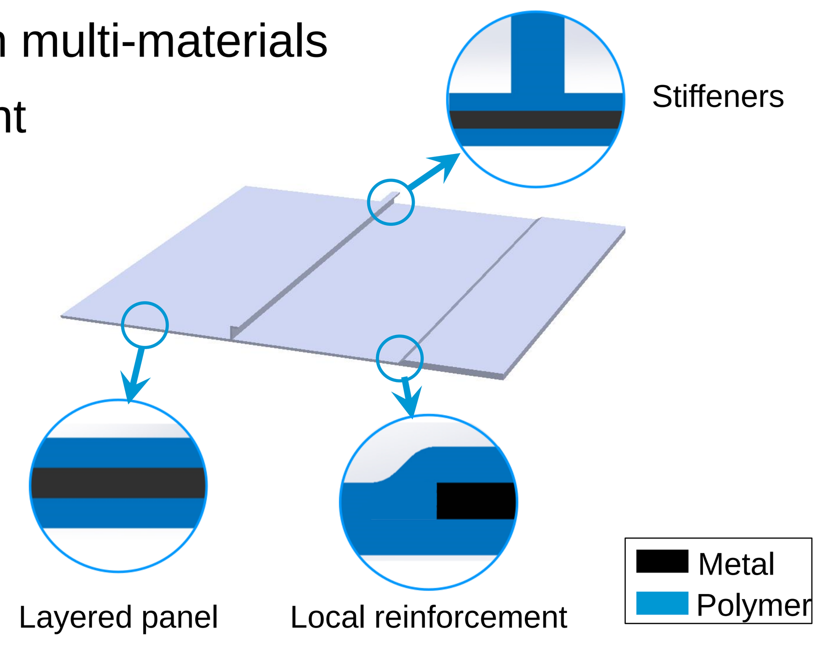

Figure 2: Potential application for AddJoining in the aerospace industry.

Principle of the process

Main phases

- Main steps of the AddJoining process (Fig. 3)
- The working principle of AddJoining is based on the thermoplastic extrusion (3D-Printing), deposition process and adhesion in the metal substrate
- No curing process is necessary

Advantages

- Automated manufacturing of metal-polymer layered structures
- Flexibility to build complex parts without mold production
- Wide range of material combinations is feasible

Current limitations

- Presence of internal voids intrinsic to the state-of-the-art Fused-deposition modelling (FDM) 3D-printing process
- Size of the parts limited to the working envelope of the 3D-printer

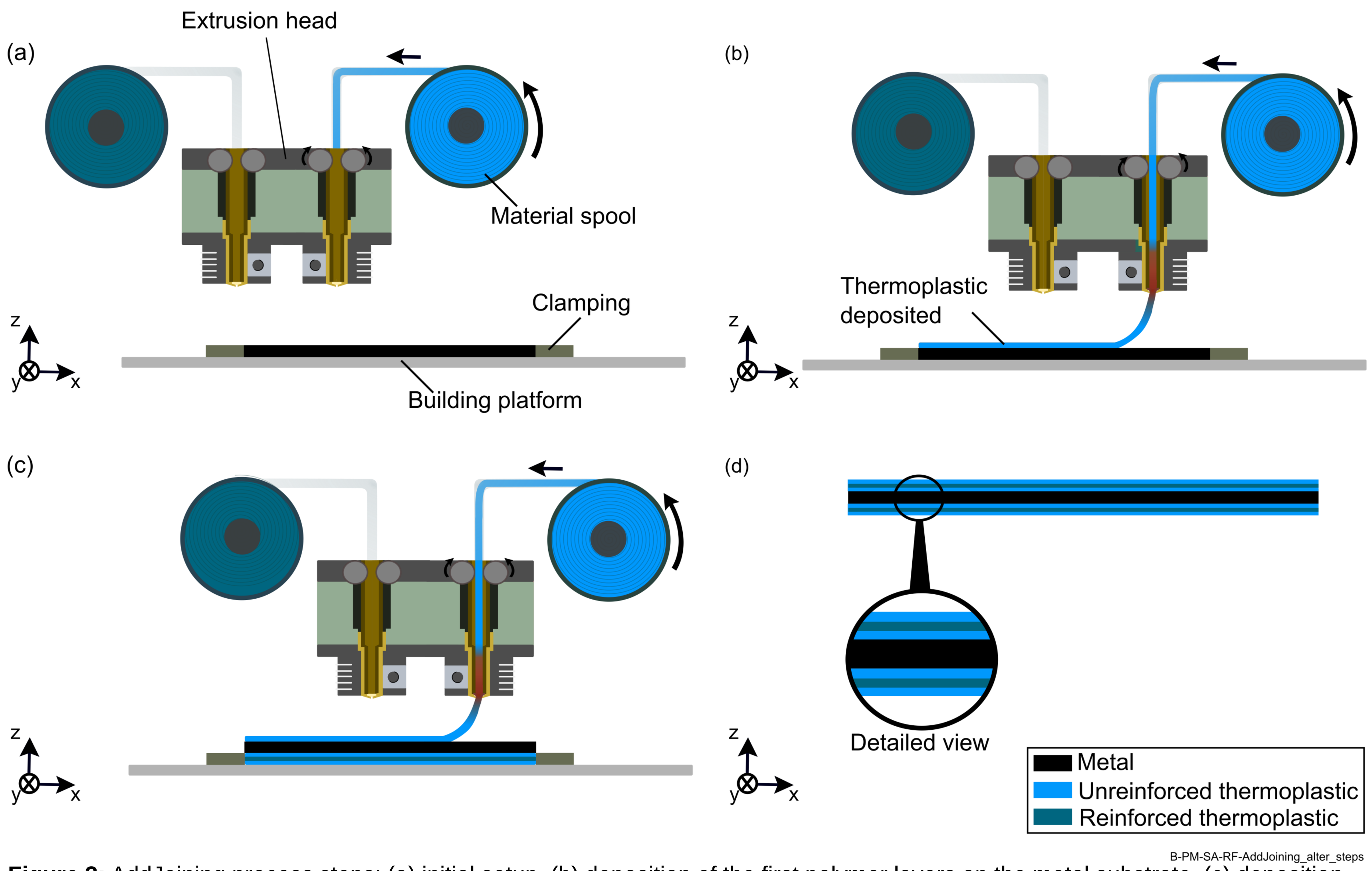

Figure 3: AddJoining process steps: (a) initial setup, (b) deposition of the first polymer layers on the metal substrate, (c) deposition of the polymer layers on the opposite side of the metal substrate, (d) final metal-polymer layered.

Results

Current results

- Ultimate lap shear force (ULSF) has shown no difference between ABS / Aluminum 2024-T3 (single-lap joint) and maximum strength for FDM ABS base material (BM) (Fig. 4)
- Good mechanical interlocking between the coated metal and printed ABS (Fig. 5)

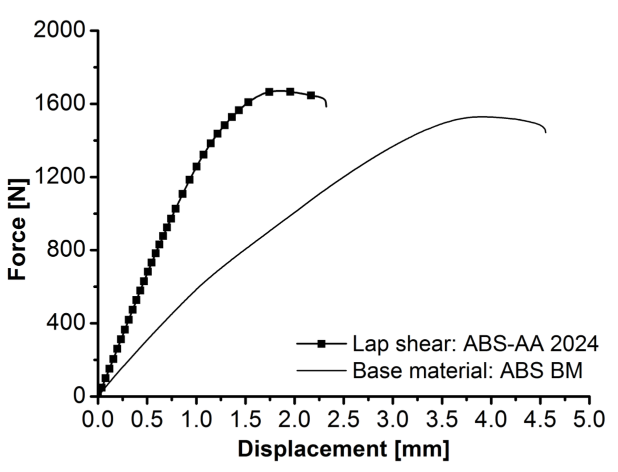

Figure 4: Force-displacement curves for single-lap joint and FDM ABS base material (BM).

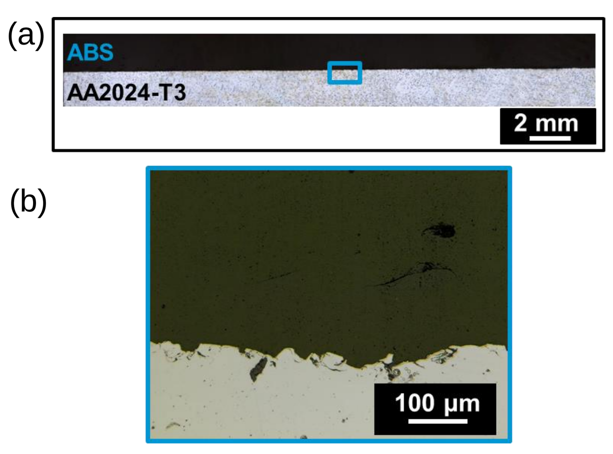

Figure 5: Single-lap joint ABS/Aluminum 2024-T3: (a) cross sectional view of overlap area and (b) high-magnification view.

Ongoing investigation

- Single-lap CF-PA6 and Aluminum 2024-T3 joints with an average ULSF of 6992 ± 243 N (Fig. 6)
- Good mechanical interlocking (Fig. 7(b.1)). However, presence of a few gaps between the printed fiber layer and PA6 coating layer (Fig. 7(b.2))

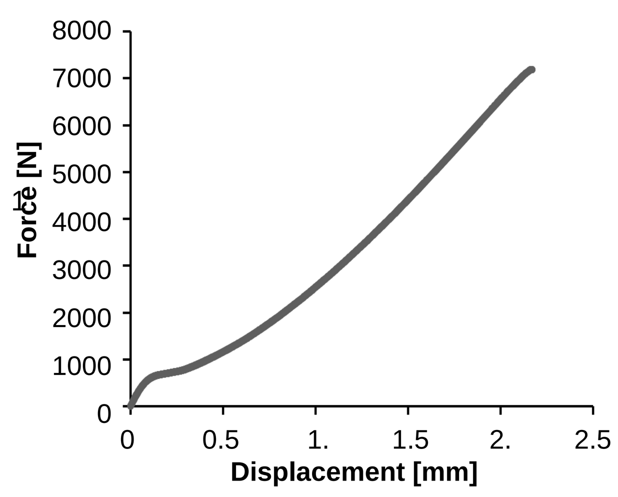

Figure 6: Force-displacement curves for CF-PA6 / Aluminum 2024-T3 single-lap joint.

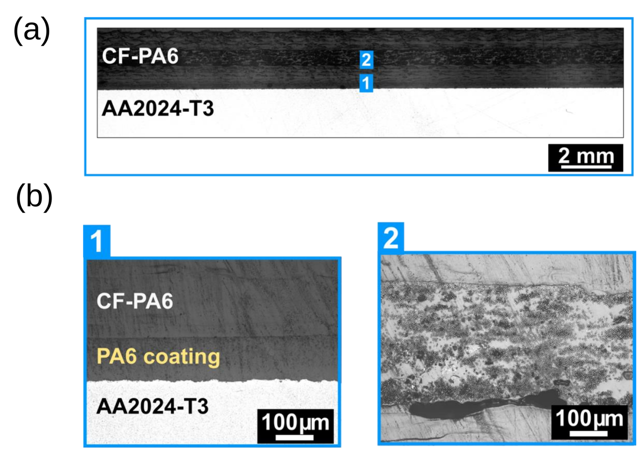

Figure 7: Single-lap CF-PA6/Aluminum 2024-T3 joint: (a) cross-sectional view of the overlap area; (b.1) mechanical interlocking between PA6 coating and CF-PA6, and (b.2) presence of a few 3D-printing –related gaps between fiber layer and PA6 coating.

Summary

- For the first time, an approach that uses 3D printing to manufacture metal-polymer structures has been introduced
- Bonding mechanisms in AddJoining were studied on the single-lap joint configuration.
- The process feasibility was demonstrated for single-lap ABS and Aluminum 2024-T3 joints
- Initial tests on the aircraft material combination CF-PA6 / Aluminum 2024-T3 is very promising (good ULSF)

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