AERoBOND – AdhEsive fRee BONDing of Complex Composite Structures

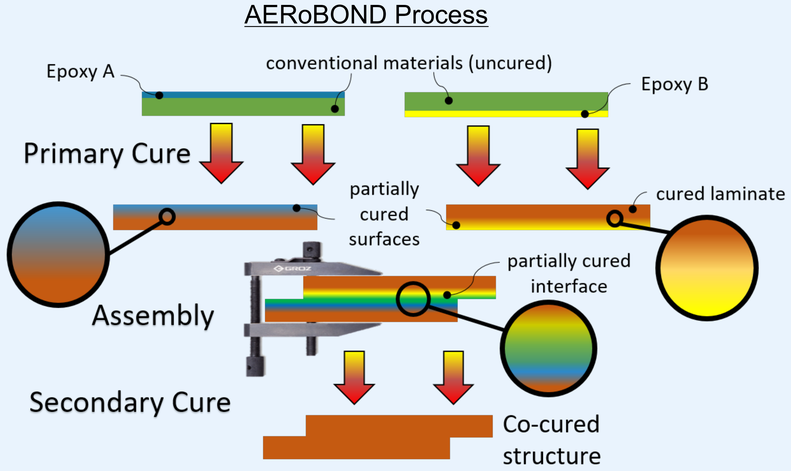
National Aeronautics and Space Administration

Novel structural joining concept for complex aircraft assemblies

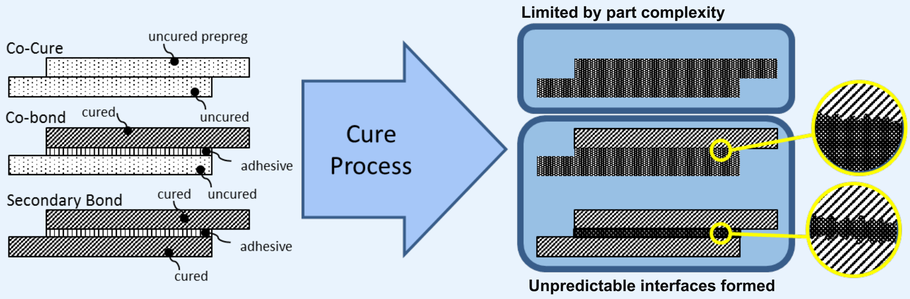
Overview/Description

- Airframes are assemblies of many parts
- Composites depend on adhesive, but due to uncertainty in bonds, OEMs often use redundant bolts, which impedes production
- To increase rate and reduce cost, a novel structural joining concept provides the predictability of co-cured joints with the manufacturability of a secondary bonding process

AERoBOND Process



Current Assembly Schemes

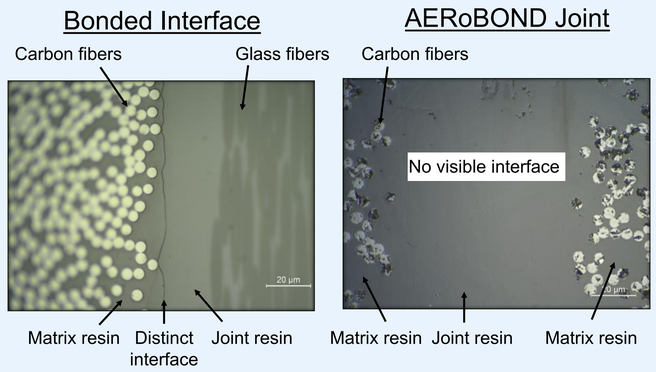


Feasibility Assessment

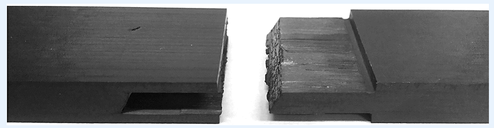
Benefit if Feasible

- Certification of composite assemblies with reduced redundant bolts
- Simplified composite fabrication methods
- Removal of thousands of machining/installation steps
- Reduced part count

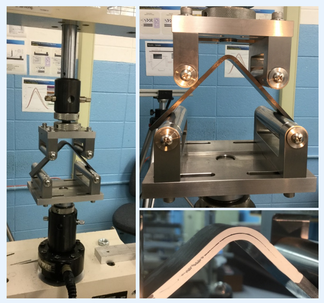
Benefits *increase production rate, decrease cost, and reduce weight*



Mechanical Testing



Double-lap Shear Test



Curved Beam

Partners

- NASA LaRC, Materials Formulation, Fabrication, Ultrasonic Inspection, Mechanical Testing, and Systems Analysis
- NASA GRC, Specialized Mechanical Testing
- NASA ARC, Process Modeling and Molecular Dynamics Simulation
- ASX Composites, Prepreg Fabrication (SAA Pending)

Recent Results / Status

- Completed baseline mechanical testing (~70 specimens, 12 properties) to quantify AERoBOND feasibility goals
- Systems analysis showed AERoBOND potentially eliminates 21,000 drilling and installation steps in wingbox of single aisle airframe (estimated time savings up to ~28 h per wing)
- Technology gap identified for analysis of bonded/bolted joint leading to new work in other ARMD projects
- Completed process model to predict mixing and degree of cure at AERoBOND joint during primary and secondary cure
- Mode II fracture toughness of AERoBOND joint achieved final feasibility requirement in several specimens

Next Steps

- Utilize process model to enable fast optimization of AERoBOND parameters (minutes/experiment vs. weeks/experiment)
- Complete mechanical testing on formulation that produced successful Mode II fracture toughness (~10 additional properties)
- Identify formulation, processing parameters, and architecture that achieves mechanical testing feasibility goal for all joint properties

Publications

- F.L. Palmieri, T.B. Hudson, R.J. Cano, E.R. Tastepe, D.S. Rufeisen, L.U. Ahmed, C.J. Wohl, and J.W. Connell, "Adhesive joining of composite laminates using epoxy resins with stoichiometric offset," *42nd Meeting of the Adhesion Society,* Hilton Head, SC, February 17-20, 2019.
- F.L. Palmieri, T.B. Hudson, R.J. Cano, E.R. Tastepe, D.S. Rufeisen, L.U. Ahmed, Y. Lin, C.J. Wohl, and J.W. Connell, "Reliable bonding of composite laminates using reflowable epoxy resins," *SAMPE 2019 Conference,* Charlotte, NC, May 20-23, 2019.
- F.L. Palmieri, T.B. Hudson, A.J. Smith, Y. Lin, J.H. Kang, I.J. Barnett, B. Clifford, and J.W. Connell, "Reduced dependence on redundant fasteners in secondary-bonded composite structures using modified epoxy matrix resins," *43rd Meeting of the Adhesion Society,* Charleston, SC, February 23-26, 2020.
- F.L. Palmieri, T.B. Hudson, A.J. Smith, Y. Lin, J.H. Kang, I.J. Barnett, B. Clifford, and J.W. Connell, "Modified epoxy matrix resins for reduced dependence on redundant fasteners in secondary-bonded composite structures," *2020 Spring Meeting of the American Chemical Society,* Philadelphia, PA, March 22-26, 2020.

CONVERGENT AERONAUTICS SOLUTIONS

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