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Repair of composite and aluminum structures with intelligent vitrimer bonding

Lightweight, aerodynamic and invisible repairs: Vitrimere, a new class of plastics, can reduce the processing time and storage costs of repair processes, as well as reduce the handling of hazardous materials and make handling safer.

New repair strategies required

The aim of any repair is to restore the original strength and stiffness of the structure and to meet the prescribed mass balance and aerodynamic requirements. Generally, composite repairs are either screwed or glued. In the case of thin laminates or sandwich composites, bolted repairs are not permitted, so bonded repairs are carried out, preferably in the form of a flush formwork repair. Rail vehicles are exposed to a high operational and traffic loads, and damage requires repair processes that can have economic consequences due to temporary and unplanned downtimes. The aim is therefore to make repair processes simpler, faster, and safer. When repairing composite materials, wet lamination and vacuum processes are time-consuming and multi-stage processes. In order to increase the reliability of the repair processes, it is important to reduce the process requirements. Therefore, materials with dynamic covalent bonds are of great interest. Various approaches for the use of vitrimers are known, but a repair patch for repairs in the transportation sector with high utilization via vitrimers and their potential has not yet been considered as part of the use case.

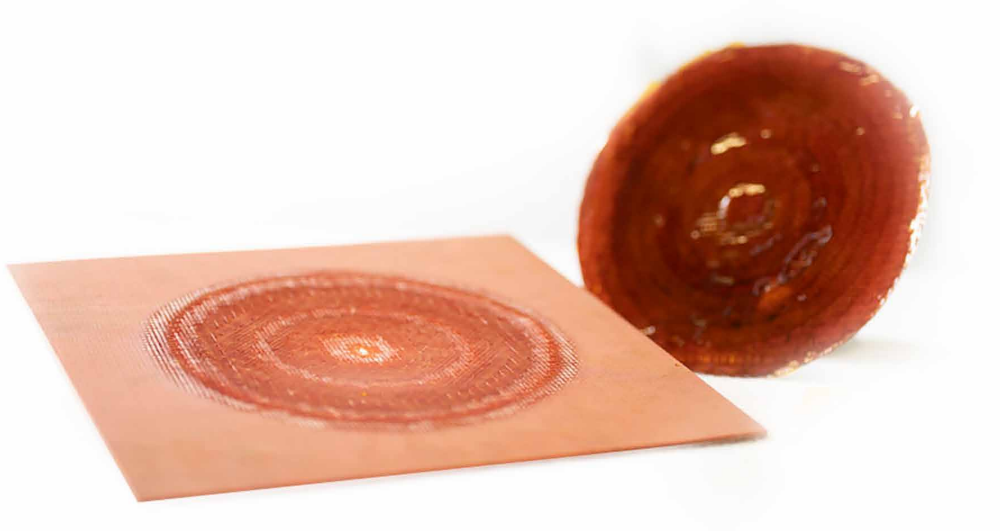
Vitrimer patch

The classic multi-stage repair process can be simplified by using an adhesive film or a benzoxazine-based coating. Final strength is achieved within 30 minutes, without the use of reactive resins. The adhesive film behaves mechanically like a cured duromer, but also provides a mechanism for chemical exchange reactions that require heat and pressure. The exchange mechanism thus enables adhesion without melting the polymer.

The advantages over the conventional process with prepregs or wet laminates are:

- Time savings during draping, consolidation and curing by handling cured and tack-free patches
- Greater occupational safety due to the reduction of hazardous substances, as the cross-linking and thus the polymerization already takes place during the production of the patches and no reactive substances are present
- Pre-applicable adhesive layer on all repair patches and polymeric substrates, e.g. as a coating
- High gap filling capacity due to shape adaptation when heated
- Can be used on complex geometries/curved surfaces due to its thermally induced flexibility; multiple forming is possible without damage
- Non-reactive at room temperature, therefore no refrigerated storage is required, which offers both logistical and energy benefits

Due to the flexibility and possibilities of benzoxazine chemistry, this technology can be based on renewable and sustainable raw materials in the future. It opens up a wide range of applications in various sectors such as the automotive, aerospace and shipping industries. Due to the intrinsic fire protection of benzoxazines, areas in the interior of various transportation systems could also represent a potential application in the future.



Vitrimer patch and stock. Repairs without reactive resin.

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM

Wiener Strasse 12
28359 Bremen
Germany

Institute Director
Prof. Dr. Bernd Mayer

Contact
Polymeric Materials and Mechanical Engineering
Dr. Christof Nagel
Phone +49 421 2246-477
christof.nagel@ifam.fraunhofer.de