Recyclable Composites: The future of lightweight materials

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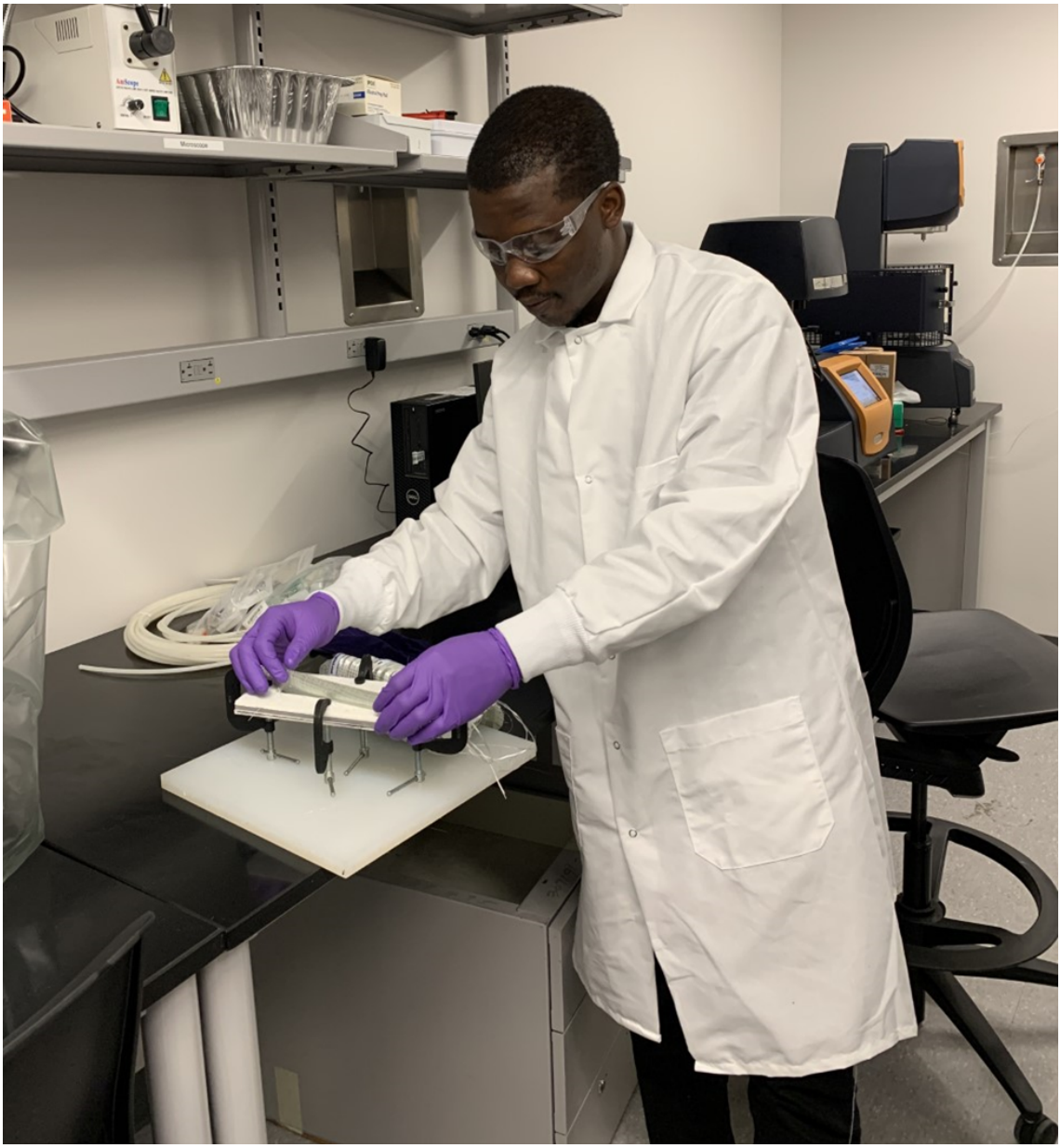
Award Title:	RII Track-1: Louisiana Materials Design Alliance (LAMDA)
NSF Award Number:	NSF OIA-1946231
Principal Investigator:	Michael Khonsari
Lead Institution Name:	Louisiana State University
Award Start Date:	07/01/2020
Award End Date:	06/30/2025
Highlight Submission Date:	3/11/2021

What is the outcome or accomplishment?
Researchers with the Louisiana Materials Design Alliance (LAMDA) developed a new self-healable and recyclable fiber reinforced thermoset shape memory vitrimer composite laminate. In this study, they used pre-tensioned shape memory alloy (SMA) reinforcing fibers called "z-pins" to control delamination, which is cracking at the interface between neighboring layers, and used the thermoset shape memory vitrimer for molecular-scale healing of the delamination. The team found significant enhancement in low velocity impact tolerance, and high healing efficiency even under repeated impact damage and healing cycles for the laminated composite.

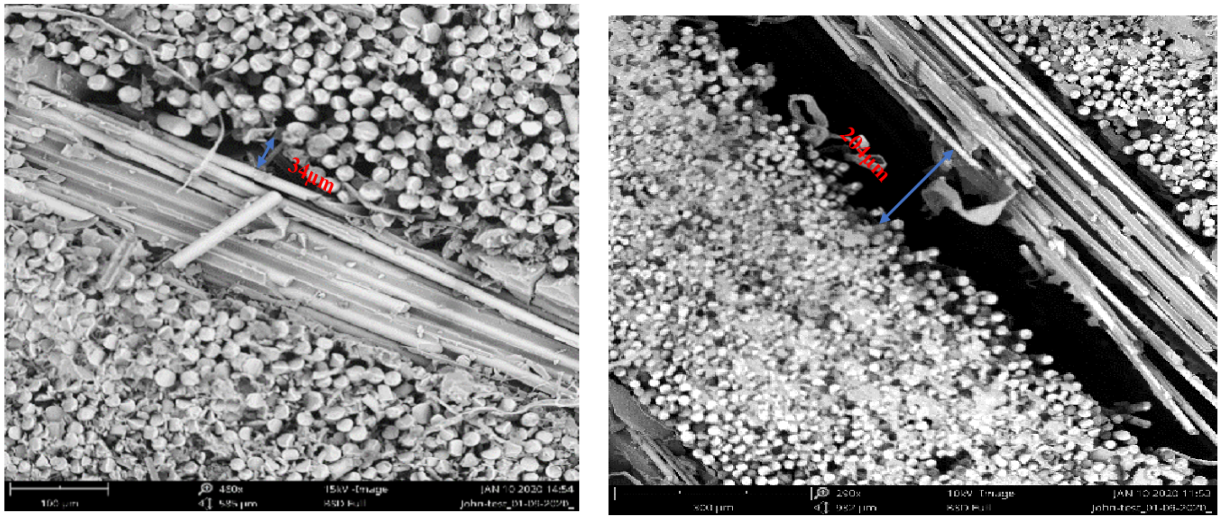
What is the impact?
In recent years, self-healing and recycling of fiber-reinforced polymer composites have become a popular topic of research. However, most of the studies are either focused on damage healing of pure polymers or limited to damage healing of polymer composites with microscale cracks. In this study, by a novel combination of SMA z-pins and thermoset shape memory vitrimers, we are able to repeatedly heal wide-opened delamination in glass fiber reinforced vitrimer composites. The combination of SMA, shape memory and thermoset vitrimer opens up a new opportunity to develop the next generation of laminated composites for lightweight structural applications.

What explanation/background does the lay reader need to understand the significance of this outcome?
Continuous fiber-reinforced polymer composite laminates have been widely used in lightweight load-bearing structures. It is well known that laminated composite is vulnerable to impact damage. For example, even a drop of a hammer during a routine inspection of laminated composite structures represents a low-velocity impact event, which may induce delamination, matrix cracking, matrix/fiber interfacial debonding, and fiber fracture. Among them, delamination can reduce the compressive load carrying capacity of the composite by over 50%. On the other hand, recycling of the end-of-service laminated composites poses a solid waste disposal issue. Therefore, how to make a laminate composite that is self-healable, recyclable, and impact tolerant is highly desired. In this study, we used a combination of SMA z-pins and thermoset shape memory vitrimer to prepare SMA z-pinned, continuous glass fiber reinforced vitrimer laminated composite. The results show that SMA-pins have significantly reduced the delamination opening (from > 0.2 mm for those without SMA z-pins to < 0.03 mm for those with

SMA z-pins), and the vitrimer matrix can be healed and recycled repeatedly under multiple low-velocity impact cycles.



Mr. John Konlan, a Ph.D. student in the Department of Mechanical & Industrial Engineering at Louisiana State University, is examining the self-healing composite laminate.



Delamination induced by low velocity impact: (left) with SMA z-pins and (right) without SMA z-pins.