SPE COMPOSITES

FALL 2026

Composites Connection™

Official Newsletter of the SPE Composites Division

Reaching Over 1,000 Composites Professionals
In All Industries

spe COMPOSITES
FALL 2026

Composites Connection™
Advancing Composites Technology Worldwide

Chairman's Message:

Dale Brosius

Dear Composites Division members,

I hope all our members have had a great summer season and were able to get in some vacation time with family and friends. As I write this, we are quickly approaching September and the remainder of the calendar year, a usually busy time in the composites industry. And, like clockwork, the SPE Automotive Composites Conference and Exhibition (ACCE) will occur right after Labor Day, followed by CAMX two weeks later in Atlanta.

Speaking of SPE ACCE, the 26th edition will be held September 9-10, 2026, at its traditional home in Novi, Michigan. The event promises to once again deliver great content, novel insights, robust discussions and ample time for networking with fellow composites enthusiasts. Even though the event has been shortened by half a day to two full days, there is plenty of amazing technical content and lots of novel innovations in composites on display. We have four fantastic keynotes, including from the emerging market of Advanced Air Mobility.

Are we ready for "flying cars"? Ready or not, they are here, and to achieve the volumes and economics needed to make them both ubiquitous and viable, they will need to lean on higher rate processes and lower cost materials or interest and being deployed in automotive. You can learn more about both the needs of this market and the solutions at ACCE, as well as for vehicles that keep four or more wheels on the ground. Also, please consider being a sponsor and exhibitor at the conference. All net proceeds of the conference go to furtherance of educational support for students and professionals. Go to https://speautomotive.com/acce-conference/ for more information on sponsorship and to register for the event.

The merger of the Society of Plastics Engineers (SPE) with the Plastics Industry Association (PIA), the leading trade association representing plastic materials, continues apace. In the merger, SPE became a division of PIA, with continuing missions in education and professional development. Most of the integration of functional operations has been completed (think accounting, payroll, invoicing and other back operations), and the combined entity is working on the forward-facing side of the merger, including integrated events and having scientists to call on for advocacy across all types of plastics issues, including composites. One of the combined events will be that ANTEC (traditional SPE led) will be held jointly with the National Plastics Exhibition (PIA led) in Orlando, May 3-7, 2027. Details on the overall format are still being worked out, and more information should be available soon.

I hope to see you in Novi, Michigan in early September!

Best regards,
Dale Brosius
Chair, SPE Composites Division

55TH-ANNUAL

SPE AUTOMOTIVE INNOVATION AWARDS COMPETITION & GALA

HONORING THE BEST IN AUTOMOTIVE PLASTICS

NOVEMBER 4, 2026

Plastics: THE ROAD TO INNOVATION

CALL FOR NOMINATIONS

MOST INNOVATIVE USE OF PLASTICS AWARDS

The Automotive Division of the Society of Plastics Engineers (SPE®) is announcing a “Call for Nominations” for its **55TH-Annual Automotive Innovation Awards Gala,** the oldest and largest recognition event in the automotive and plastics industries. This year’s Awards Gala will be held Wednesday, **NOVEMBER 4, 2026** at the **Laurel Manor** in Livonia, Michigan. Winning part nominations in 10 different categories, and the teams that developed them, will be honored with a **Most Innovative Use of Plastics** award. A **Grand Award** will be presented to the winning team from all category award winners.

SPONSORSHIP OPPORTUNITIES This annual event currently draws over 600 OEM engineers, automotive and plastics industry executives, and media. A variety of sponsorship packages - including tables at the banquet, networking receptions, advertising in the program book, signage at the event and more are available. Contact Teri Chouinard of Intuit Group at **intuitgroup@gmail.com.**

For more info and to submit nominations, go to:
https://speautomotive.com/spe-automotive-div-innovation-awards/

CATEGORIES:

- AFTERMARKET & LIMITED EDITION VEHICLES
- BODY INTERIOR
- BODY EXTERIOR
- CHASSIS/HARDWARE
- SUSTAINABILITY
- PROCESS, ASSEMBLY AND ENABLING TECHNOLOGIES
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THE OLDEST AND LARGEST RECOGNITION EVENT IN THE AUTOMOTIVE & PLASTICS INDUSTRIES

ACCE Keynote Speakers

The executive planning committee for the SPE® Automotive Composites Conference & Expo (ACCE) has announced its keynote speakers for ACCE 2026, taking place September 9–10, 2026, in Novi, Michigan. The speakers and topics are:

Jeff Bosworth

Jeff Bosworth,
Senior Manager X-BAT Structures Lead at Shield AI,
will present:
Fly By: Aerospace Composites For an Automotive Audience.

This will be a high-level discussion of how composites are essential in making modern aircraft, especially Vertical Takeoff-and-Landing (VTOL), perform at a high level. Expect to learn about the basics of design philosophy, nuances of analysis, and multiple manufacturing techniques as well as some speculation about where the aerospace composites industry will go over the next decade.

The X-Bat is the world's first AI-Piloted (Unmanned) VTOL fighter jet. X-BAT completely reimagines airpower – from training and logistics to operations and operating costs. This marks the greatest transformation in military aviation since the first airplanes launched and landed from ships 115 years ago. With vertical takeoff and landing, long range, and full autonomy, X-BAT delivers combat power anywhere, anytime. This is the future of air power.

X-BAT will serve as the leading edge of a distributed unmanned fires network – capable of launching and recovering from ships, remote islands, or austere forward bases while eliminating dependency on traditional infrastructure. X-BAT can carry both air-to-air and air-to-surface weapons in its internal bays and carry large strike weapons on external hardpoints.

"The VTOL market is a great opportunity for automotive composites suppliers to expand," said Bosworth. "I believe this presentation will enlighten the industry to new opportunities for growth and be inspiring," added Bosworth.

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This Issue:

Dr. Paul E. Krajewski

Dr. Paul E. Krajewski,
Director of Materials and Manufacturing Systems Research, General Motors Global Research and Development Center, will present:
Automotive Materials Challenges and Opportunities.

The automotive industry is undergoing unprecedented change with electrification, autonomous driving, and smart manufacturing, all happening under the challenges of sustainability, increased global competition and changing market dynamics. One constant throughout these challenges is the role of materials to both enable technological innovation and ensure stable production. This talk will address the many ways the automotive industry will leverage materials and their supply chain for a sustainable automotive future. In addition, key opportunities for exploration and partnership will be described to help motivate future research agendas.

"Advancing automotive materials requires not only innovation, but a clear vision for future research and collaboration. I look forward to sharing insights on where the greatest opportunities lie and how we can collectively drive progress across the industry," said Krajewski.

Nobi Kawamura

Nobi Kawamura
Joby Aviation, Advanced Manufacturing, will present:
Advanced Air Mobility – At the Intersection of Automotive and Aerospace.

Following a distinguished 37-year career at Toyota leading advanced composites initiatives, Mr. Kawamura now supports Joby Aviation's efforts to develop and manufacture next-generation electric aircraft. Drawing on experience spanning automotive and aerospace, he will discuss how advanced composites are enabling the future of Advanced Air Mobility (AAM).

The emerging AAM market presents significant opportunities for composite material suppliers and manufacturers. While technically part of the aerospace industry, AAM—and particularly Urban Air Mobility— shares many characteristics with automotive manufacturing, including the need to safely and efficiently transport small groups of passengers at production volumes far greater than those of traditional aircraft. As the industry scales, manufacturers must also meet demanding quality, cost, and production targets familiar to the automotive sector.

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This Issue:

ACCE Keynote Speakers continued...

Joby Aviation is a pioneer in Urban Air Mobility and is currently certifying its first production aircraft, including conducting test flights in major metropolitan markets. To achieve high-volume manufacturing of lightweight, composite-intensive aircraft, Joby is leveraging technologies beyond those traditionally used in aerospace, including fast-curing thermosets, high-performance thermoplastics, and hybrid material systems.

During his keynote, Mr. Kawamura will share Joby's progress toward commercializing Advanced Air Mobility while outlining the challenges that remain—including scaling production, meeting certification requirements, and achieving aggressive cost targets. He will also highlight opportunities for innovative composite materials and manufacturing processes that can help shape the future of the industry.

Justine Johnson

Justine Johnson,
Michigan Chief Mobility Officer, Office of Future Mobility and Electrification (OFME), Michigan Economic Development Corporation (MEDC), will present:
The Next Generation of Mobility Starts In Michigan.

Michigan's leadership in mobility has always been built on innovation, manufacturing excellence and the ability to adapt as the industry evolves. In this keynote, Justine Johnson, Chief Mobility Officer at Michigan's Office of Future Mobility and Electrification (OFME), will explore how the state is building on that legacy to lead the next generation of transportation. She will discuss Michigan's approach to accelerating electrification, supporting advanced mobility technologies, strengthening domestic supply chains and creating the workforce needed to compete globally. Attendees will gain insight into how collaboration across industry, academia and government is helping position Michigan as the nation's proving ground for the future of mobility.

"Michigan has long been a global leader in transportation innovation, and the next chapter of mobility will be driven by strong collaboration across industry, government, and academia," said Justine Johnson, Michigan Chief Mobility Officer, Office of Future Mobility and Electrification. "I look forward to sharing how we're working to accelerate advanced mobility and electrification while strengthening Michigan's position as the place where the future of transportation is designed, tested, and built," added Johnson.

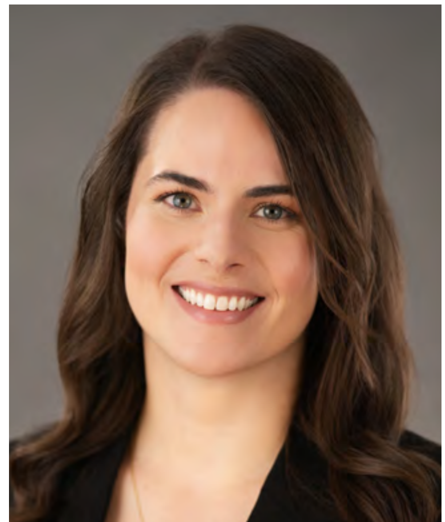
This Issue:

Welcome Sara to the SPE Board

The SPE Composites Board of Directors is pleased to welcome Sara Simon to the Board of Directors

Sara is Sector Manager for Polymers at NETZSCH Analyzing & Testing, where she leads global strategy and application development across thermoplastics, thermosets, composites, coatings, and adhesives. She has more than 10+ years of experience in automotive engineering, polymer processing, material characterization, and simulation-driven validation. At NETZSCH, Sara leads Proteus® Now Quantify, a machine-learning-based software platform for identifying and quantifying unknown polymer compositions. She collaborates closely with industry and research partners to advance analytical technologies and translate materials science into sustainable industrial solutions.

Sara has been actively involved with SPE through technical presentations and conferences since 2016 and has received several best paper and poster awards. She also serves as Technical Program Co-Chair for SPE ACCE 2026. As a board member of the SPE Composites Division, Sara brings an industry perspective grounded in customer needs, technology development, and commercialization. She aims to strengthen collaboration between academia and industry, accelerate the practical adoption of composite innovations, and engage and support the next generation of plastics and composites engineers.



Sara Simon Ph.D.

This Issue:

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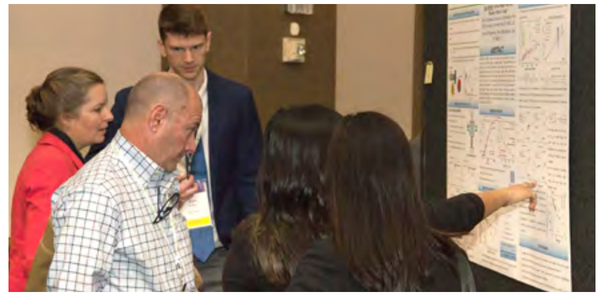
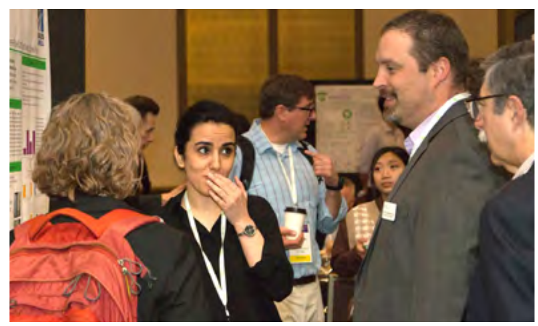
ANTEC 2026 in pictures





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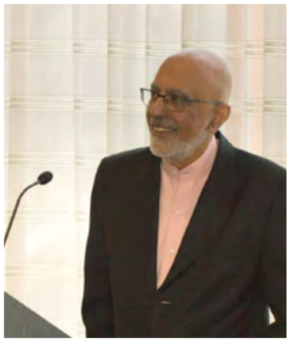
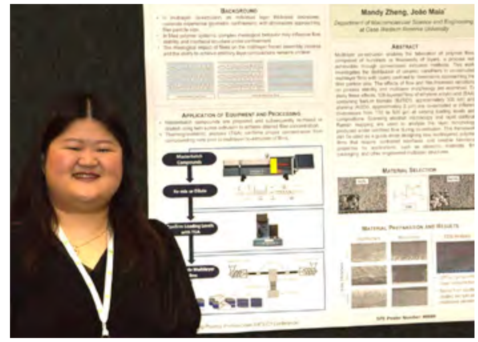
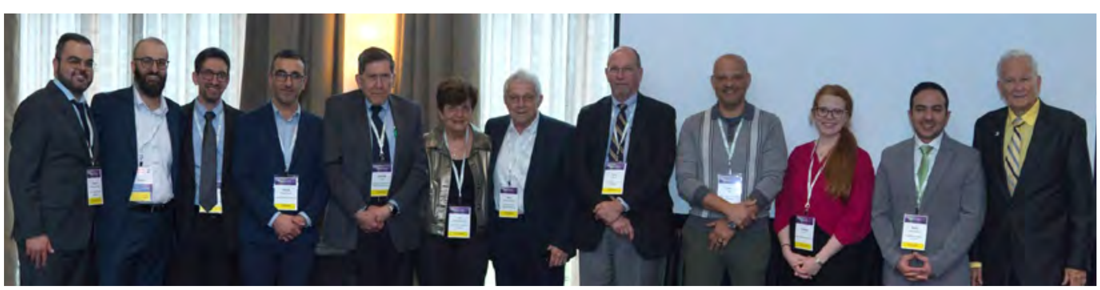
This Issue:

ANTEC 2026 in pictures continued...







This Issue:

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Scholarship Report

By: Vipin Kumar, Ph.D.

SPE Composites is committed to helping students take their education and research to the next level in composites and plastics engineering.

2026 SPE Composites Division, ACCE, and Dr. Jackie Rehkopf Scholars

SPE Composites is pleased to recognize six scholarship recipients whose studies and research are advancing the plastics and composites community. Their work ranges from automotive structural integrity and composites manufacturing to chemical upcycling, polymer fracture and durability, energy science, and sustainable polymer engineering.

The Harold Giles SPE Composites Division Scholarship supports Kunle Kazeem Adeyemo and Nathan Zook. The SPE Automotive and Composites Conference & Exhibition (ACCE) Scholarship recognizes Amy Kurr, Tata Serebryany, and Asal Yousefi Siavoshani. Carmen Byerly Dunn is the recipient of the Dr. Jackie Rehkopf Scholarship.

The following pages share messages of gratitude and brief profiles of each scholar. Their accomplishments, research goals, and commitment to education and professional service demonstrate the broad impact of SPE's investment in emerging plastics professionals.

Congratulations to all of the 2026 scholars.

Kunle Kazeem Adeyemo

Nathan Zook

Amy Kurr

Tata Serebryany

Asal Yousefi Siavoshani

Carmen Byerly Dunn

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Scholarship Report continued...

Kunle Kazeem Adeyemo

2026 Harold Giles SPE Composites Division Scholar

Michigan State University - Mechanical Engineering and Civil & Environmental Engineering

SCHOLAR'S MESSAGE
I am deeply grateful for the Harold Giles SPE Composites Division Award. As a dual Ph.D. student in mechanical and civil engineering at Michigan State University, this scholarship provides significant support as I work to advance the structural integrity of critical automotive applications. My goal is to bridge rigorous scientific research with innovative, real-world engineering solutions.

The award also helps me continue mentoring future engineers through undergraduate workshops and engineering-design outreach initiatives for K-4 through K-12 students. This support gives me confidence and motivation as I enter the final stages of my doctoral program.

With sincere appreciation,
Kunle Kazeem Adeyemo

PROFILE
Kunle Kazeem Adeyemo is a fourth-year dual-degree doctoral student in Mechanical Engineering and Civil Engineering at Michigan State University. He previously earned master's degrees in power engineering from Warsaw University of Technology and mechanical engineering from Michigan State University.

His work focuses on structural integrity for automotive applications, and he is active in student mentoring and engineering outreach.

Nathan Zook

2026 Harold Giles SPE Composites Division Scholar

Pennsylvania College of Technology - Plastic Engineering Technology

SCHOLAR'S MESSAGE
I am honored and sincerely grateful to have been selected for the SPE Composites Division Scholarship. Receiving this scholarship is especially encouraging because it comes from professionals who have dedicated their careers to advancing composites technology.

Although my current role is in rotational molding, an internship with Ralph S. Alberts Company gave me hands-on experience in composites manufacturing, including vacuum resin infusion and hand layup. That experience deepened my appreciation for the precision, craftsmanship, and problem-solving required in the field. This award allows me to focus more fully on my education while continuing to build industry experience, and I hope one day to help future students pursue similar opportunities.

Sincerely, Nathan Zook

PROFILE
Nathan Zook is pursuing a bachelor's degree in Plastic Engineering Technology at Pennsylvania College of Technology while working full-time as a lead rotational molding operator at Playworld.

His academic and industrial experience connects plastics processing with practical manufacturing, and his composites internship exposed him to vacuum resin infusion and hand layup.

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This Issue:

Amy Kurr

2026 SPE ACCE Scholar - $2,000

University of Tennessee, Knoxville - Energy Science and Engineering

SCHOLAR'S MESSAGE

Thank you to the Society of Plastics Engineers Automotive Composites Conference & Exhibition for selecting me for the $2,000 ACCE Scholarship. I recently completed my Ph.D., accepted a postdoctoral position at the University of Tennessee, Knoxville, and am pursuing a full-time industry role. My involvement in SPE and the polymer and materials community has helped me build professional connections and secure multiple interviews.

I plan to use the scholarship to support travel to the 2026 International Materials, Applications, and Technologies Conference, where I will give a technical talk on engineering ethics. The award also supports continued manuscript preparation and collaboration across materials science, fire protection, automotive, and manufacturing communities.

Thank you, Amy Kurr

PROFILE

Amy Kurr recently completed her Ph.D. in Energy Science and Engineering at the University of Tennessee's Bredesen Center and has accepted a postdoctoral position at UT Knoxville.

She was recognized by ASM International with the Outstanding Graduate Student Award. Her current goals include publishing ongoing research, presenting at technical conferences, and moving into an industry position.

Tata Serebryany

2026 SPE ACCE Scholar

University of Washington - Chemical Engineering

SCHOLAR'S MESSAGE

Thank you so much for selecting me as a recipient of the SPE ACCE Scholarship. I appreciate your support and am honored to receive this recognition. In the Rorrer Lab at the University of Washington, I develop catalysts to chemically upcycle waste plastics into useful products. My current work focuses on depolymerizing polystyrene to recover styrene monomer, which can be reused to manufacture new plastics such as ABS.

This scholarship is meaningful because it shows that this work matters to people in industry. I am grateful to be part of a community committed to plastics development and innovation.

Sincerely, Tata Serebryany

PROFILE

Tata Serebryany is a Chemical Engineering Ph.D. student and NSF Graduate Research Fellow at the University of Washington.
His research centers on catalytic chemical upcycling of plastics, especially recovering styrene monomer from polystyrene for reuse in high-value products.

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This Issue:

Scholarship Report continued...

Asal Yousefi Siavoshani

2026 SPE ACCE Scholar

The University of Akron - Polymer Science

SCHOLAR'S MESSAGE

I am sincerely grateful to have been selected for the ACCE Scholarship. This support will help me continue my Ph.D. research at The University of Akron on the ductile-to-brittle transition, fracture behavior, and robust lifespan estimation for advanced polymer systems.

The funding will support the development of physics-based tools that can guide safer, more reliable lightweight designs for automotive and ground transportation applications. I also look forward to presenting my findings at the upcoming ACCE conference and engaging with industry leaders and peers.

Sincerely, Asal Yousefi Siavoshani

PROFILE

Asal Yousefi Siavoshani is a Ph.D. candidate in Polymer Science at The University of Akron. She specializes in engineering polymers, fracture mechanics, material durability, and polymer processing.

Her work connects fundamental fracture behavior with practical lifetime prediction for advanced polymer systems.

Carmen Byerly Dunn

2026 Dr. Jackie Rehkopf Scholar

The University of Southern Mississippi - Polymer Science and Engineering

SCHOLAR'S MESSAGE

I am especially grateful to have been selected for the Dr. Jackie Rehkopf Scholarship and for SPE's commitment to early-career polymer scientists. This support will positively affect my continuing education and future academic work in polymer science and engineering.

My graduate education at the University of Southern Mississippi reflects my desire to use fundamental science to address real sustainability challenges. As I enter my fifth year, I plan to pursue a postdoctoral position in polymer physics and continue developing as a researcher, mentor, and educator. I currently mentor four undergraduate students, and one of my long-term goals is to establish an endowment supporting early-career polymer scientists and stronger academic partnerships with the plastics industry.

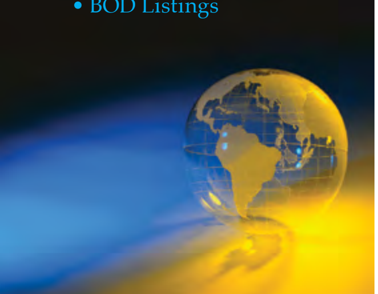
Sincerely, Carmen Byerly Dunn

PROFILE

Carmen Byerly Dunn earned a B.S. in Chemistry with a Polymer Science and Coatings emphasis from Missouri University of Science and Technology in 2022.

She is a Ph.D. candidate and NSF Graduate Research Fellow in the School of Polymer Science and Engineering at The University of Southern Mississippi. Her goals combine polymer research, sustainability, undergraduate mentorship, and academic-industry collaboration.

This Issue:



ACCE Award Winning Paper

Compression Properties and Impact Energy Absorption of Carbon Fiber-Reinforced Composite Honeycomb Core for Automotive Structural Applications

Rishabh Pammi, Guyuan Zhang, Waterloo Tsutsui, Garam Kim
Purdue University

Abstract

This study investigates the compression behavior and impact energy absorption characteristics of a novel carbon fiber-reinforced composite honeycomb core. Composite sandwich structures are widely used in the aerospace and automotive industries due to their high strength-to-weight ratios. While conventional cores such as aluminum and meta-aramid paper are commonly used, they present challenges such as corrosion, moisture absorption, and limitations in achieving higher strength-to-weight ratios. To address these issues, a carbon fiber-reinforced composite honeycomb core was designed, fabricated, and experimentally evaluated. Corrugated carbon fiber composite sheets were manufactured using carbon fiber composite prepreg via compression molding and then bonded with adhesive to form the honeycomb core. Composite face sheets were attached to the top and bottom surfaces using a film adhesive to create sandwich structures, which were subsequently machined to appropriate sizes for compression and impact testing. Comparative analysis with conventional meta-aramid and aluminum core specimens showed that the carbon fiber composite honeycomb core demonstrated superior performance in terms of compression modulus, compressive strength, and strength-to-weight ratio. Additionally, the carbon fiber core exhibited enhanced impact energy absorption, as indicated by higher reaction force, reduced impact depth, and minimized damage around the impacted area. The results provide insights into the potential applications and limitations of carbon fiber honeycomb cores, with recommendations for future improvements.

Introduction

Sandwich structures are a widely used class of lightweight materials composed of two highstrength face sheets separated by a low-density core. This configuration provides excellent mechanical performance, including high stiffness, superior strength-to-weight ratios, and enhanced energy absorption capabilities. These advantageous properties make sandwich structures, particularly those with fiber-reinforced composite face sheets, well-suited for aerospace, automotive, and marine applications, where weight reduction without compromising structural integrity is essential. The choice of core material plays a critical role in determining the overall performance of the sandwich structure. Commonly used core types include polymer foams, natural materials such as balsa wood, and engineered cellular structures like honeycomb cores. Among these, honeycomb cores are particularly favored due

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Winning Paper continued...

to their exceptional stiffness-to-weight ratio, fatigue resistance, and customizable architecture. Their cellular geometry allows for tuning of cell size, shape (e.g., hexagonal, square, circular), and orientation to meet specific mechanical requirements. In addition, honeycomb cores offer excellent formability (drapability), making them advantageous for complex, contoured structures. Previous studies have shown that honeycomb sandwich structures with fiber-reinforced composite face sheets can achieve five to ten times greater flexural stiffness compared to monolithic composite laminates of equivalent weight (Wang et al., 2018; Shirvani et al., 2023). These performance characteristics have led to their widespread use in aerospace components, including wing skins, fairings, rudders, and control surfaces, as well as in automotive structures such as door panels, hoods, and battery enclosures (Chandrasekaran & Arunachalam, 2021; Uddin et al., 2019). The selection of honeycomb core material is typically guided by the desired mechanical performance, environmental resistance, and manufacturing constraints.

Aluminum honeycomb cores and meta-aramid fiber reinforced phenolic resin composite, commonly known as Meta-Aramid paper honeycomb cores, are among the most widely utilized materials in advanced composite sandwich structures. Aluminum honeycomb cores are favored for their high stiffness, compressive strength, excellent thermal conductivity, and resistance to fire, high temperatures, and moisture absorption. These characteristics make them particularly suitable for high-performance applications in aerospace, defense, and automotive sectors. However, their primary drawback lies in their susceptibility to corrosive environments. Prolonged exposure to humidity, aviation fluids, and other aggressive agents can lead to interfacial corrosion, compromising the structural integrity of the core. For instance, Abot and Majd (2006) investigated the degradation of aluminum honeycomb sandwich panels under humid environments and observed gradual delamination and core-foil corrosion. Similarly, Soutis et al. (2005) reported significant mechanical property reductions in composite sandwich structures after exposure to salt fog and moisture, highlighting interface weakening and loss of compressive strength. More recently, Song et al. (2020) demonstrated that moisture-induced corrosion in aluminum cores accelerates damage propagation in hybrid laminates, particularly in carbon-fiber-reinforced structures, emphasizing the need for surface coatings and anodization to prevent electrochemical degradation.

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ACCE Award Winning Paper continued...

Meta-Aramid paper honeycomb cores, composed of aramid fiber paper impregnated with phenolic resin, are well known for their lightweight nature, excellent flame resistance, and superior dielectric properties. These characteristics have led to their widespread use in aerospace interior structures and radomes. Nonetheless, Meta-Aramid paper cores are vulnerable to moisture absorption and environmental degradation, which can impair long-term mechanical performance. Kim and Sterkenburg (2021) demonstrated that exposure to aviation fluids and humid conditions leads to a noticeable reduction in compressive strength, establishing a clear correlation between absorbed moisture and degraded mechanical behavior. In a related study, Zhou et al. (2018) found that Meta-Aramid paper honeycomb cores exhibited diminished mechanical performance when subjected to relative humidity levels above 75%, thereby reducing their energy absorption capabilities. Furthermore, Shafizadeh and Seferis (2022) conducted in-flight and long-duration service simulations, revealing the progressive deterioration of Meta-Aramid paper properties over time, prompting the use of moisture barriers and optimization of phenolic resin formulations. In a comprehensive review, Ahmad et al. (2020) emphasized that although Meta-Aramid paper

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offers excellent flame retardancy and electrical insulation, its tendency to absorb moisture remains a significant challenge in durability-critical applications.

Due to the structural and environmental limitations of conventional Aluminum and Meta-Aramid honeycomb cores, advanced fiber-reinforced composite honeycomb cores, particularly those reinforced with carbon fiber, have emerged as high-performance alternatives. These cores exhibit superior specific stiffness, dimensional stability, and resistance to corrosion and thermal cycling, making them ideal for aerospace, automotive, and defense applications. Their manufacturing methods differ notably from traditional expansion processes used for metal and aramid cores. Instead, carbon fiber cores are fabricated through prepreg layup, corrugation folding, compression molding, or additive manufacturing, allowing precise control of fiber orientation and core geometry for tailored anisotropic performance (Kondratiev et al., 2023). Mechanical testing confirms substantial advantages: transverse tensile modulus values up to 6425 MPa, shear moduli exceeding 1200 MPa, and the ability to reduce core density by over 50%, from 117 to 40 kg/m³, without compromising strength. Intermediate ply orientations (e.g., ±64°) have been shown to offer optimal balances between shear and tensile stiffness. Additionally, under low-velocity and oblique impacts, carbon fiber honeycomb panels demonstrate excellent energy absorption and damage resistance, supported by combined experimental and numerical analysis (Zhang et al., 2020). Recent advancements in 3D printing have further expanded the design space for these structures. Feng et al. (2023) demonstrated that fiber-interleaved 3D-printed carbon fiber cores achieved a 44% increase in elastic modulus and a 119% improvement in compressive strength compared to baseline designs. Complementing these findings, Naufal et al. (2024) provided in-depth characterization of Meta- Aramid honeycomb sandwich materials under mechanical loading, confirming degradation pathways due to environmental stressors. These studies collectively highlight the advantages of carbon fiber composite cores over traditional materials in dynamic environments.

While both the expansion and corrugation methods are widely used in honeycomb core production, their applicability to composite materials differs significantly from metals or aramid paper. For aluminum cores, the expansion process is typical: stacked sheets are prebonded with adhesive or spot welds and then expanded accordion-style to form hexagonal cells. Afterward, treatments such as heat curing, chemical cleaning, and anodizing are applied to enhance corrosion resistance and mechanical performance. For Meta-Aramid paper

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cores, composed of aramid paper impregnated with phenolic resin, expansion is followed by oven curing to harden the resin and stabilize the geometry. This method is cost-effective and scalable for dielectric-sensitive and aerospace applications (Liu et al., 2024; Naresh et al., 2024). However, for fiber-reinforced composite honeycomb cores, especially those made from carbon fiber prepregs, the expansion method is generally unsuitable due to the material's inherent brittleness, stiffness, and layered anisotropy. Instead, these cores are primarily fabricated using the corrugation method, where resin-impregnated composite sheets are folded into a wave-like pattern and then stacked and bonded. The corrugation process allows for custom cell shapes (e.g., triangular, square) and directional strength control but demands precise handling, especially during bonding and curing (Wei et al., 2020; Jegorova, 2015). Composite honeycomb cores often require autoclave curing or heated compression molding to maintain dimensional precision and fiber integrity. Compared to metals and Meta-Aramid paper, this process is more complex: it involves tooling challenges, strict temperature control, and pressure regulation to avoid delamination or weak bonds. Moreover, fiber orientation must be carefully designed to optimize load paths and prevent stress concentrations. These demands elevate cost and complexity, but also enable the creation of highly tailored, lightweight cores for aerospace, automotive, and defense applications (Chen et al., 2017; Alia et al., 2019).

Despite the inherent manufacturing complexities, the structural advantages of carbon fiberreinforced honeycomb cores, particularly under dynamic loading and impact-critical conditions, warrant continued development and investigation (Bai et al., 2024). In this study, a complete fabrication process for carbon fiber composite honeycomb cores was demonstrated. Carbon fiber prepreg materials were formed into corrugated sheets using compression molding, after which individual corrugated layers were bonded together to construct the honeycomb core. Composite face sheets were then adhesively bonded to both the top and bottom surfaces of the core to assemble a full sandwich structure. To evaluate mechanical performance, both quasistatic compression and low-velocity impact tests were conducted. For benchmarking purposes, aluminum and Meta-Aramid paper honeycomb cores, matched in cell size and thickness and combined with identical face sheets, were also tested under the same conditions. The comparative results provide valuable insight into the mechanical superiority and failure resistance of carbon fiber honeycomb cores. This work aims to address the industry's need for lighter, stronger, and corrosion-resistant core materials by presenting a scalable, highperformance alternative to conventional core systems.

Materials and Methods

The manufacturing process began with the preparation of carbon fiber composite prepreg sheets using Axiom AX-5201 plain weave fabric. A custom-designed aluminum mold measuring 203.2 mm by 152.4 mm, featuring a precise corrugated pattern matching a 6.35 mm cell pitch, was utilized for compression molding. Each prepreg sheet was carefully placed within the mold, and a uniform pressure of 125 psi (equivalent to 3 tons) was applied. The curing process adhered strictly to the manufacturer's recommended thermal cycle, involving incremental heating, a controlled dwell period at elevated temperatures, and gradual cooling. This meticulous curing protocol ensured proper resin flow, full consolidation of fibers, and minimized void content, ultimately producing corrugated sheets with consistent geometry and mechanical properties. Molded under a 3-ton load (125 psi) following the prepreg manufacturer's recommended cure cycle, single-layer prepreg sheets achieved a cured thickness of approximately 0.25 mm thicker than typical aluminum (0.1 mm) and Meta-Aramid paper (0.07 mm) cores (Figure 1).

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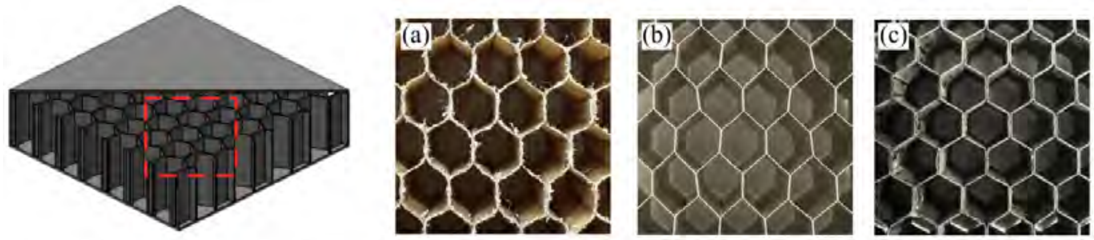

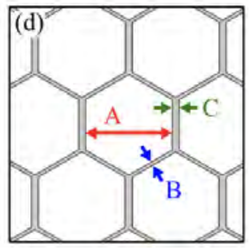

	Meta-Aramid Paper	Aluminum	CF-Composites
A. Cell Size	4.4 mm	4.6 mm	6.4 mm
B. Wall Thickness Single	0.07 mm	0.1 mm	0.25 mm
C. Wall Thickness Double	0.15 mm	0.18 mm	0.6 mm

Figure 1. Images of (a) meta-aramid paper, (b) aluminum, and (c) carbon fiber composite honeycomb cores. (d) Cell size and wall thickness of each core.

Post-curing, the corrugated composite sheets were precisely trimmed into strips measuring 12.7 mm wide using a surface grinder equipped with a diamond cutting wheel, ensuring accuracy and consistency. Each strip underwent meticulous surface preparation, including gentle sanding and cleaning with isopropyl alcohol to enhance adhesive bonding efficiency. Bonding involved applying a thin layer of Axiom AX-2114 film adhesive uniformly across the bonding interfaces. The strips were then methodically stacked using a specialized bonding jig that incorporated aluminum inserts placed within each cell to maintain structural integrity and geometric precision during the adhesive curing cycle. This fixture provided uniform compression, preventing dimensional variations or misalignments during consolidation.

Once the adhesive was fully cured, the temporary aluminum inserts were carefully removed, and any residual adhesive on the surfaces was meticulously cleaned. The resulting core structures were visually inspected and dimensionally validated to ensure compliance with design specifications. To complete sandwich panel fabrication, thin two-ply (0°/90°) carbon fiber laminates, also prepared from the Axiom AX-5201 prepreg and independently cured following the same meticulous curing procedure, were bonded to both upper and lower surfaces of the composite core using the same film adhesive. Care was taken to maintain the minimal thickness of the face sheets, emphasizing performance variations directly attributable to core material and geometry.

For comparison purposes, aluminum and Meta-aramid paper honeycomb core specimens were fabricated following identical procedures, employing the same face sheets, adhesives, and machining protocols. Standardized specimen dimensions were precisely achieved using the same surface grinding setup. Each specimen was measured and weighed to ensure dimensional consistency and accurate density calculation prior to mechanical testing. Figure 2. illustrates the core fabrication process.

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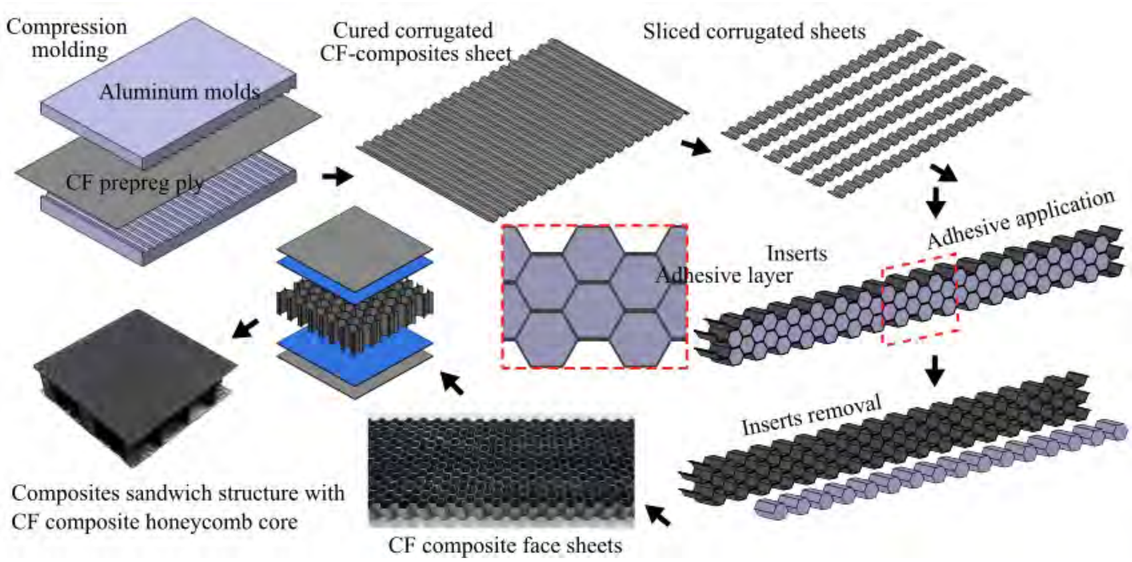

Figure 2. Fabrication process of the carbon fiber composite honeycomb core.

Mechanical tests conducted included flatwise compression according to ASTM C365 and impact resistance tests following ASTM D7766 Procedure C and ASTM D7136 guidelines. These standardized testing protocols provided reliable benchmarks for comparative analysis of mechanical performance.

The carbon fiber composite honeycomb core was manufactured using Axiom AX-5201 carbon fiber plain weave prepreg. Corrugated sheets with a 6.35 mm pitch were created using compression molding in a custom aluminum mold, applying 125 psi (3 tons) and curing per manufacturer guidelines. Resulting prepreg sheets were approximately 0.25 mm thick, notably thicker than aluminum (0.1 mm) and Meta-aramid paper (0.07 mm) cores. Corrugated sheets were cut into 12.7 mm-wide strips, sanded, cleaned, and bonded using Axiom AX-2114 film adhesive. Temporary aluminum inserts ensured core uniformity during curing. Excess adhesive was

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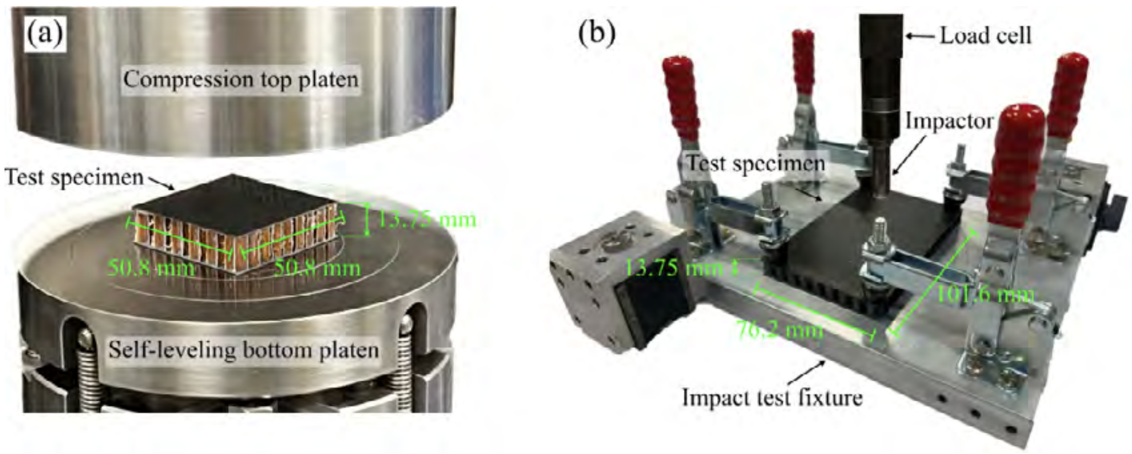

Figure 3. Mechanical test setup for (a) compression test and (b) Impact resistance test.

removed post-bonding, and composite face sheets (two-ply, 0°/90°) were bonded to core surfaces. Sandwich panels with aluminum and Meta-aramid paper cores were identically fabricated for performance comparison.

Mechanical characterization comprised flatwise compression (ASTM C365) and low-velocity impact tests (ASTM D7766 Procedure C referencing ASTM D7136). Compression tests employed 50.8 mm × 50.8 mm specimens loaded in an MTS 810 universal testing system with a 22.24 kN (5-kip) load cell at a 0.5 mm/min crosshead speed (Figure 3a). Ultimate compressive strength, 2% deflection stress, and compressive modulus were recorded. Six samples per core type were tested. Strength-to-weight and stiffness-to-weight ratios were also computed. Impact resistance tests were conducted using an Instron 9250HV drop-weight impact tower with a hemispherical striker tip. Specimens (76.2 mm × 127.0 mm) were impacted at energies of 5 J, 7.5 J, and 10 J, achieved by adjusting impactor mass and drop height (Figure 3b).

The resulting damage characteristics were statistically analyzed, and strength-to-weight and stiffness-to-weight ratios were employed for a comprehensive performance comparison across carbon fiber composite, aluminum, and Meta-aramid paper honeycomb cores, particularly emphasizing suitability in weight-sensitive automotive applications.

Results and Discussion

In compression testing, the carbon fiber composite honeycomb core showed superior compressive strength and stiffness. Figure 4(a) presents stress–strain plots, averaged over six specimens per group, with standard deviations. The carbon fiber composite core's ultimate compressive strength averaged 9.87 MPa (SD = 1.01 MPa), significantly outperforming aluminum (5.81 MPa, SD = 0.10 MPa) and Meta-aramid paper cores (2.40 MPa, SD = 0.08 MPa), representing a 70% increase over aluminum and a 311% improvement over Meta-aramid paper (Figure 4b). The carbon fiber cores also achieved a higher 2% deflection strength, averaging 8.55

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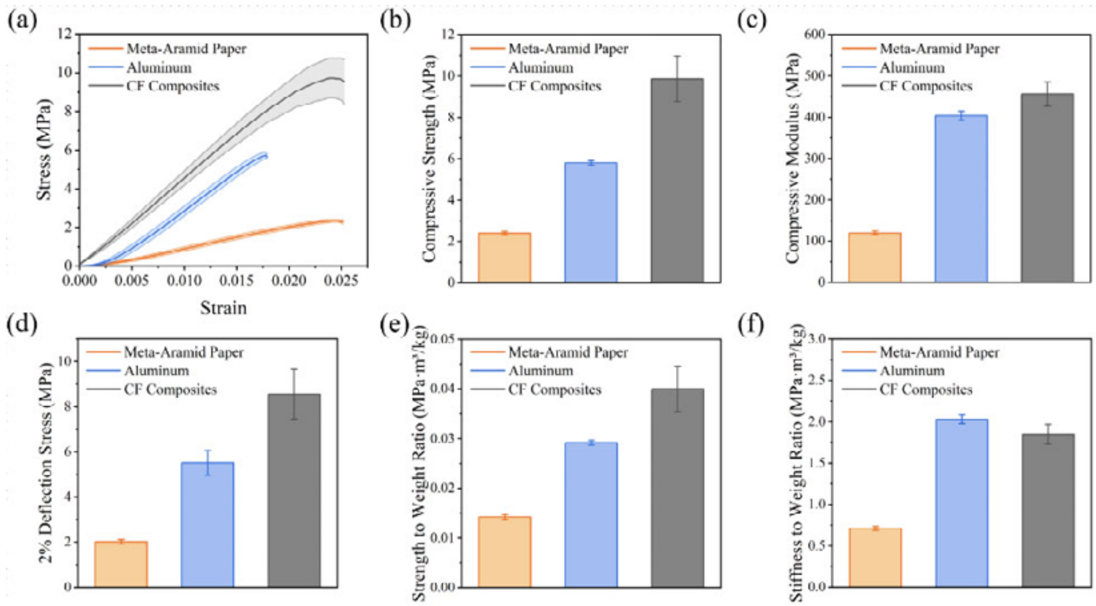

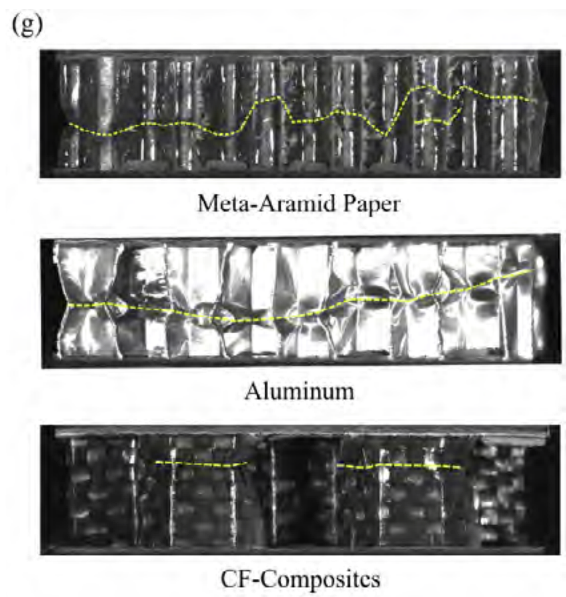

Figure 4. Compression test results for carbon fiber composite, aluminum, and Meta-aramid paper honeycomb cores: (a) average stress–strain curves with standard deviation, (b) ultimate compressive strength, (c) 2% deflection strength, (d) compressive modulus, (e) strength-toweight ratio, (f) stiffness-to-weight ratio, and (g) observed failure modes for each core material.

MPa (55% higher than aluminum, 323% higher than Meta-aramid paper; Figure 4c), and a superior compressive modulus of 456.55 MPa, outperforming aluminum by 13% and Meta-aramid paper by 281% (Figure 5d).

The carbon fiber composite cores exhibited the highest density (247 kg/m³), higher than aluminum (199 kg/m³) and Meta-aramid paper (169 kg/m³). Consequently, the carbon fiber cores achieved the highest strength-to-weight ratio of 0.040, surpassing aluminum (0.029) and Meta-aramid paper (0.014) (Figure 5e). However, the aluminum core presented a slightly superior stiffness-to-weight ratio (2.03), marginally above carbon fiber (1.85), yet significantly higher than Meta-aramid paper (0.71) (Figure 5f). Despite minor differences in stiffness-toweight ratios, carbon fiber cores clearly demonstrated superior overall structural efficiency.

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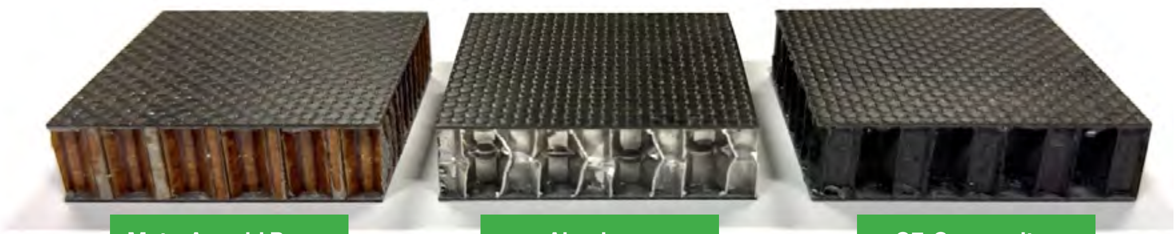

Figure 5. Samples after Compression Test.

Compression failure modes varied distinctly among the cores (Figure 4g). Meta-aramid paper cores exhibited ductile and progressive buckling with irregular failure lines. Aluminum cores showed ductile yet uniform deformation and global buckling. In contrast, carbon fiber cores displayed localized brittle fracture, typical of stiff, low-toughness composites, with failures concentrated at specific regions due to minor manufacturing-induced height variations.

Impact testing further underscored the superior performance of carbon fiber cores. Load– displacement plots for impacts at 5 J, 7.5 J, and 10 J energies (Figure 6a–c) revealed the carbon fiber cores consistently achieved the highest peak loads: at 5 J (1,232.15 N; 36.8% higher than aluminum and 211% higher than Meta-aramid paper, Figure 6d), at 7.5 J (1,328.59 N; 40.1% above aluminum and 133.4% above Meta-aramid paper, Figure 6e), and at 10 J (1,675.68 N; 84.5% above aluminum and 197.9% above Meta-aramid paper, Figure 6f).

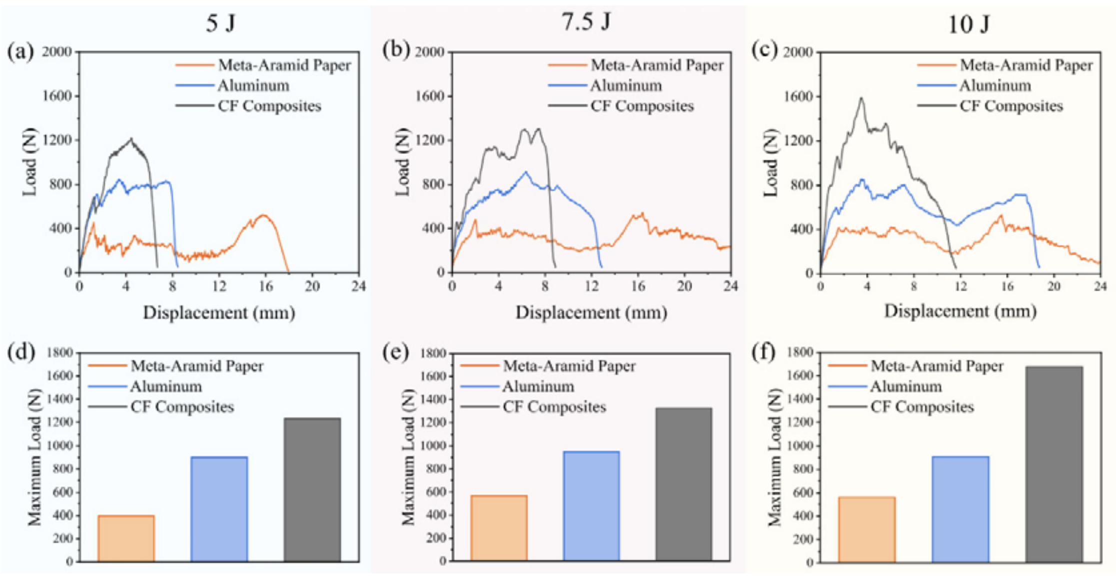

Figure 6. Impact test results at 5 J, 7.5 J, and 10 J energy levels for carbon fiber composite, aluminum, and Meta-aramid paper honeycomb cores: (a)–(c) load–displacement curves showing impact response at each energy level; (d)–(f) bar charts comparing peak impact loads for each core material across corresponding energy levels.

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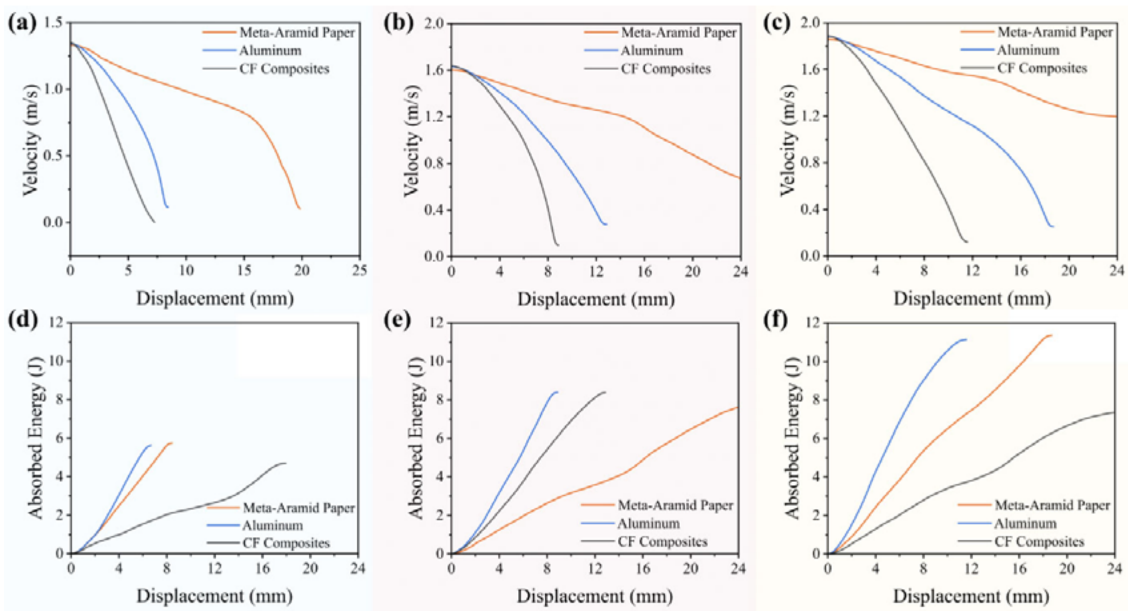

Figure 7. Energy absorption and impact velocity reduction across core types at three energy levels: (a)–(c) velocity–displacement curves showing impactor deceleration; (d)–(f) energy–displacement plots illustrating absorbed energy distribution for carbon fiber composite, aluminum, and Meta-aramid paper honeycomb cores.

Carbon fiber cores absorbed impact energy over shorter displacements compared to aluminum and Meta-aramid paper, confirming their superior impact resistance and stiffness (Figures 7a–f). Figures 4, 6, and 7 illustrate key findings detailed herein, emphasizing the composite core's suitability for high-performance automotive structural applications.

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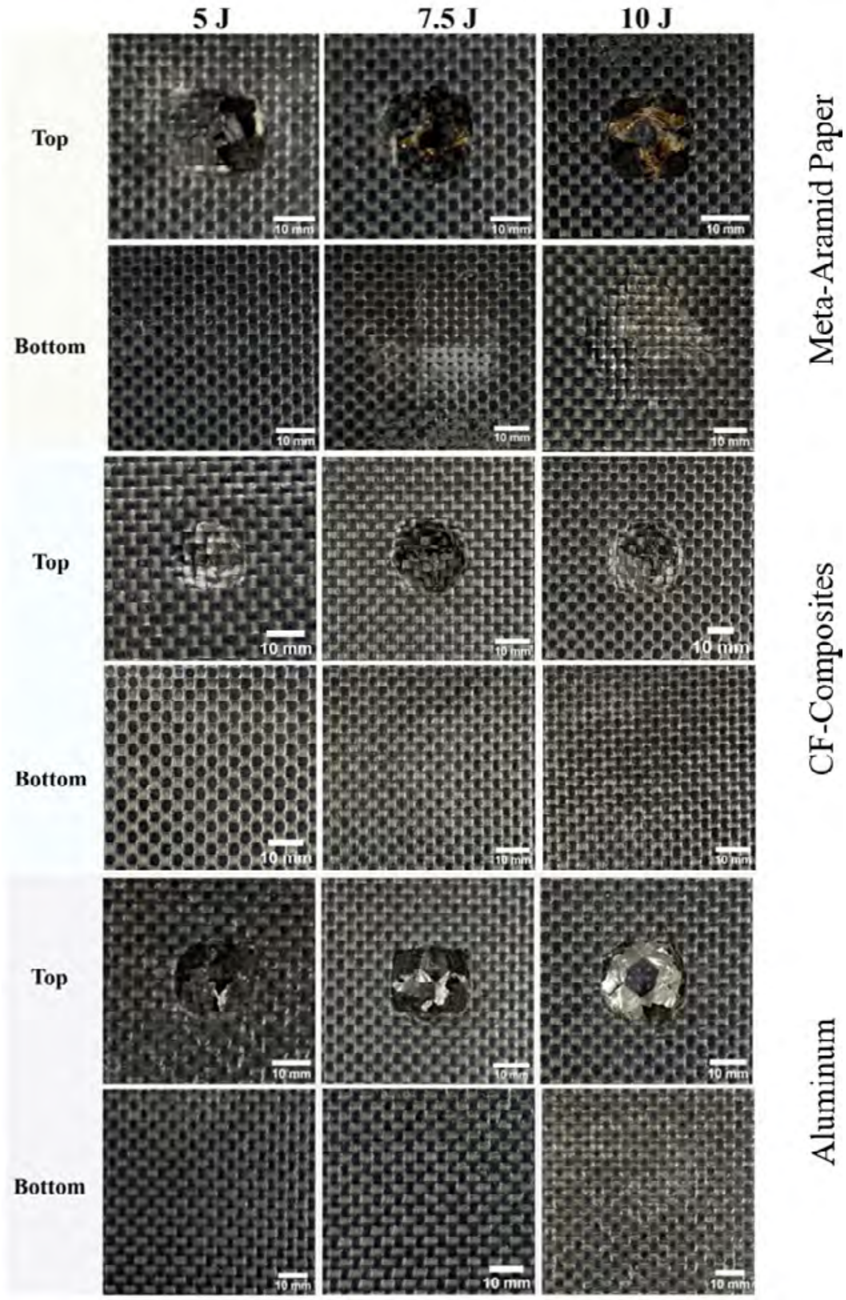

Figure 8. Post-impact surface damage images.

The post-impact bottom surface images of dent profiles at 5 J, 7.5 J, and 10 J for meta-aramid paper, aluminum, and carbon fiber composite honeycomb cores are represented in Figure 8. Dent diameters were manually measured using the ASTM D7766/D7766M-16 protocol, with maximum damage width determined from four opposing radial measurements at 0°, 45°, 90°, and 135°.

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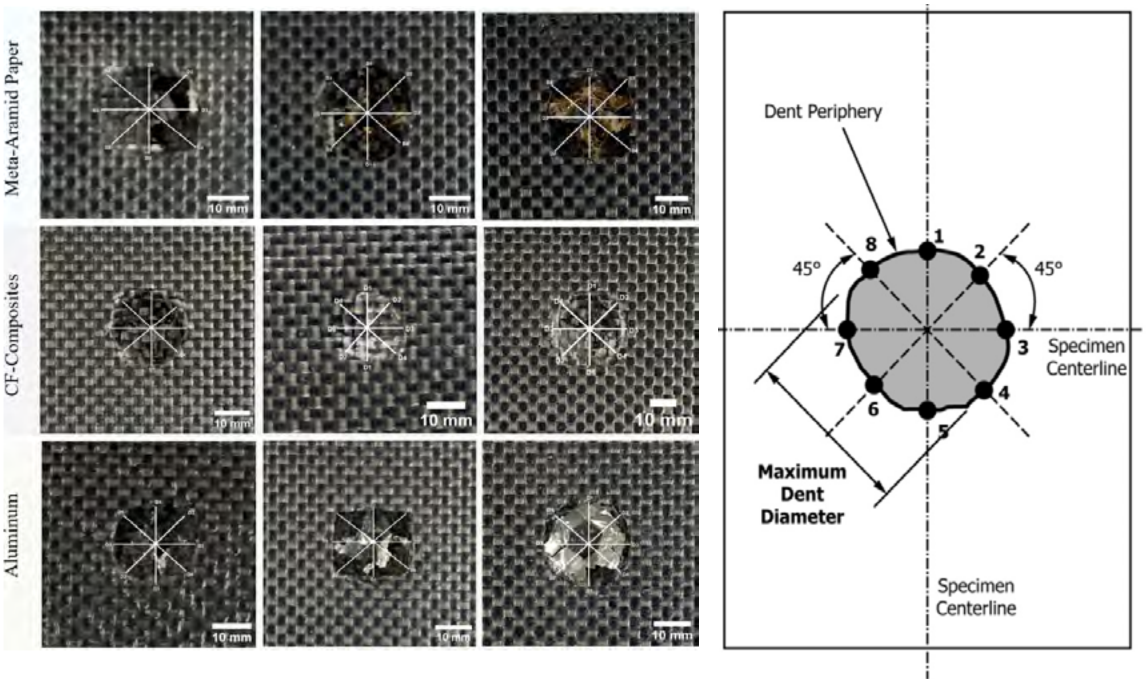

Figure 9. Dent diameter measurement method for post-impact specimens. (Left) Schematic illustration of ASTM D7766/D7766M-16. (Right) Reference image showing guideline placement for dent diameter measurement, reproduced from ASTM D7766/D7766M-16.

To quantify the extent of surface damage following impact, dent diameters were measured manually according to the procedure outlined in ASTM D7766/D7766M-16. After each impact test, the bottom face of the specimen was visually inspected, and the periphery of the dent was marked. As illustrated in Figure 9., eight equally spaced radial lines were drawn at 45° increments, centered around the specimen's geometric midpoint.

A digital caliper was used to measure the linear distance across the dent along each of the four opposing diameters (0°–180°, 45°–225°, 90°–270°, and 135°–315°). The maximum dent diameter was then selected from these four measurements as a conservative representation of total damage spread. This standardized method ensured consistent damage quantification across all samples and impact energy levels, allowing for direct comparison of the relative damage resistance of meta-aramid paper, aluminum, and carbon fiber composite honeycomb core. Dent diameter measurements from post-impact specimens at 5 J, 7.5 J, and 10 J for metaaramid paper, aluminum, and carbon fiber composite honeycomb cores are represented in

Figure 10. The table presents radial damage diameters (D_1–D_4) measured at 0°, 45°, 90°, and 135° following ASTM D7766/D7766M-16 guidelines, while the bar graph shows average dent diameters with standard deviation. Carbon fiber composite cores consistently exhibited the smallest dent diameters across all energy levels, confirming superior impact resistance and damage tolerance.

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Impact	Core Material	D_1	D_2	D_3	D_4
5 J	Meta-aramid paper	16.88	17.63	16.28	18.80
	Aluminum	14.99	15.35	15.59	16.85
	CF-composites	10.55	10.13	11.35	10.65
7.5 J	Meta-aramid paper	17.63	17.98	15.72	17.82
	Aluminum	15.59	18.97	16.94	18.25
	CF-composites	14.08	15.57	14.23	15.30
10 J	Meta-aramid paper	16.27	17.14	16.89	19.55
	Aluminum	15.28	17.06	16.68	16.91
	CF-composites	14.62	15.08	14.86	15.44

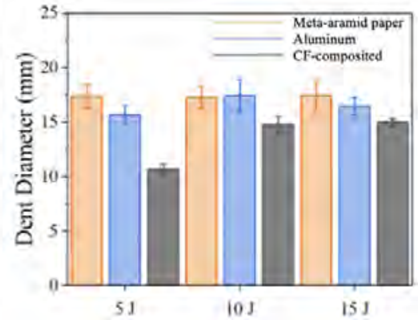

Figure 10. Dent diameter measurements from post-impact specimens.

Summary and Next Steps

This study successfully fabricated and evaluated a carbon fiber-reinforced composite honeycomb core, benchmarking it against traditional aluminum and Meta-aramid paper honeycomb cores. The carbon fiber composite core was produced via compression molding, cutting, and adhesive bonding of corrugated prepreg sheets. Mechanical testing, including quasi-static compression and dynamic impact assessments, demonstrated that the composite core significantly outperformed conventional cores. Specifically, it achieved a 70% higher compressive strength, 55% higher 2% deflection strength, and 13% greater compressive modulus than the aluminum core. Despite its higher density, resulting in a slightly lower stiffness-to-weight ratio compared to aluminum (1.85 vs. 2.03), it consistently exhibited a superior strength-to-weight ratio (0.040 vs. 0.029), indicating enhanced structural efficiency. In impact tests at energies of 5 J, 7.5 J, and 10 J, the carbon fiber core consistently provided superior resistance. It absorbed impact energy efficiently, displaying minimal penetration depth and significantly smaller damage areas than aluminum and Meta-aramid paper cores. These results underscore its excellent damage tolerance and energy absorption under dynamic loading conditions.

However, several challenges remain, including limited formability for complex shapes and variability arising from manual fabrication processes. Addressing these manufacturing challenges through increased automation and optimization of production techniques will enhance the core's broader applicability. Future research should further explore alternative core geometries, such as auxetic designs, to improve drapability and manufacturability. Moreover, detailed damage analysis using advanced 3D scanning methodologies (ASTM D7136) is recommended to comprehensively quantify damage characteristics and validate the composite core's superior performance in structural integrity and impact resistance. Such analyses are scientifically validated and crucial for accurately assessing structural health post-impact, providing valuable insights into material optimization for lightweight structural applications. Overall, the carbon fiber composite honeycomb core developed in this study presents significant potential for high-performance automotive and aerospace structures, offering superior mechanical performance and environmental durability compared to traditional core materials.

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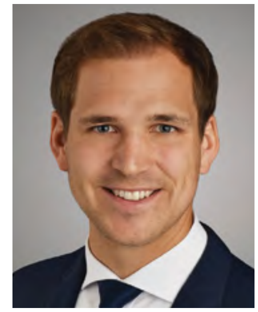

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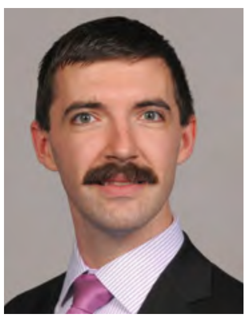

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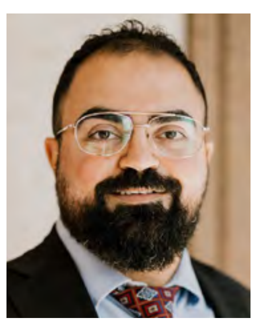

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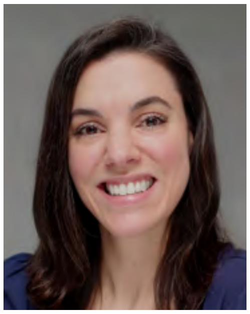

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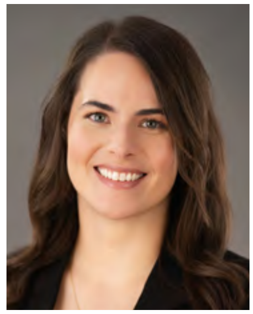

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SPE COMPOSITES

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