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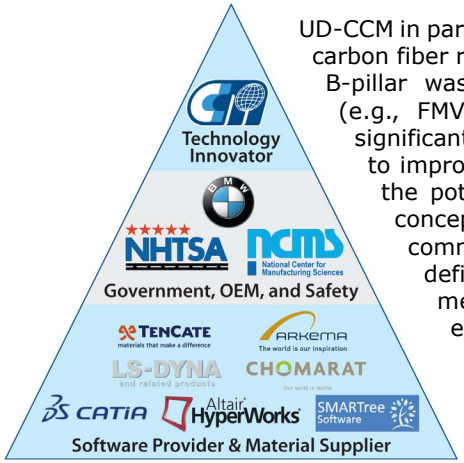
UPDATE
SEPTEMBER 2016

CCM-Developed Continuous Carbon Fiber Thermoplastic B-Pillar is a Finalist for Unsurpassed Innovation Award at 2016 CAMX

University of Delaware
Center for Composite Materials

COMPOSITES UPDATE

The University of Delaware Center for Composite Materials (UD-CCM) has been selected as a finalist in the category for the **Unsurpassed Innovation Award** at the 2016 CAMX. The flagship CAMX Award recognizes innovations that have the potential to significantly impact composites and advanced materials in the marketplace. This award is presented to the composites product that clearly demonstrates a novel design that incorporates low-cost materials for high-volume applications or with high performance applications with low-volume materials which delivers a product that is innovative and has the potential to either significantly impact existing or open new markets. UD-CCM will showcase a newly designed, fabricated and impact tested vehicle B-Pillar assembly at CAMX highlighting the materials, process and design innovations for high-volume automotive applications developed in this NHTSA program.



UD-CCM in partnership with **NCMS, NHTSA and BMW** investigated thermoplastic carbon fiber reinforced materials for vehicle sideframe structures. The proposed B-pillar was designed to meet structural and crash safety requirements (e.g., FMVSS 214 barrier) using thermoplastic composites which offers significant advantages (e.g., recycling, joining, >60% elongation leading to improved ductility and energy absorption) compared to thermoset with the potential for improved crash performance. Novel side-impact crash concepts maximizing crash performance have been developed and commercial available thermoplastic materials were characterized to define appropriate material models and to evaluate energy absorption mechanisms. Predictive engineering at all levels, from coupon to sub-element to full-scale, guided the material down-selection. The same CAE tools simulate full vehicle to component & test setup behavior and were used to optimize manufacturability and structural/crash performance. Sub-components and B-pillars have been fabricated using the stamp forming and infusion processes

TOP STORY
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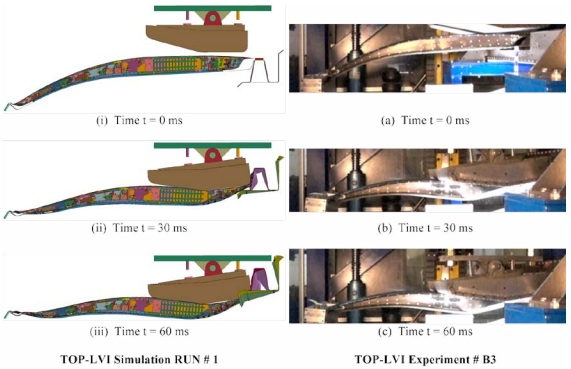
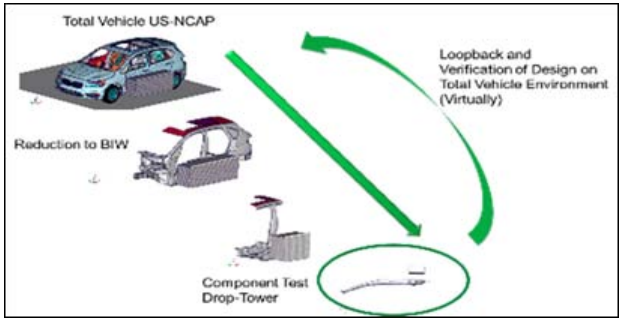
allowing scalability with the potential to meet automotive production rates in the future. UD-CCM's large drop tower was used to validate the predictive engineering tools and crash performance of the proposed B-pillars under realistic side-impact crash conditions.



The B-pillar design was spatially optimized for energy absorption (ductility), stiffness, and strength while maintaining part producibility and vehicle integration. BMW established B-pillar performance metrics derived from full-vehicle crash simulations and other design and integration requirements. UD-CCM provided full range of capabilities in materials selection and evaluation, composite design, analysis and crash simulations, process development and manufacturing (tooling, part production, trimming), full-scale pillar assembly and high-energy impact testing. This project has demonstrated design, materials, manufacturing and joining methods with continuous carbon fiber thermoplastics, at TRL 4-7 to meet automotive industry and government safety specifications. Key achievements from this project include:

- Successful fabrication and manufacture of an all thermoplastic composite B-pillar that is 60% lighter than the existing metallic design while meeting project requirements for NHTSA FMVSS 214 side-impact crash
- State-of-the-art CAE tools were evaluated (with internally developed data translation) simulating full vehicle to component impact (Dassault Systemes CATIA, Altair HyperWorks & LSTC LS-DYNA)
- Innovative production methods were developed and demonstrated for this multi-material part that included infusion and thermoforming tailored blanks with the potential to meet 2 minute cycle times



- Adhesive bonding methods were developed and automated for dissimilar thermoplastics and steel interfaces
- Automated trimming of the thermoplastic components was developed and demonstrated without damage to the composite structure
- A test fixture was designed and integrated into UD-CCM's high-energy impact tower simulating the crash behavior during side-impact crash without using a full vehicle structure
- Multiple full-scale B-pillar assemblies (incorporating steel roof and frame rail) were successfully impact tested under 100% equivalent energy of FMVSS 214

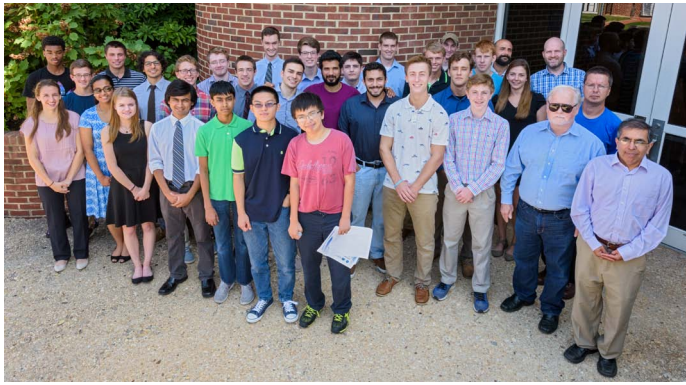
TOP STORY (Continued)

- The composite B-pillars response in the vehicle sub-component configuration satisfies all of the intrusion safety requirements
- All composite B-pillars exhibited rebound and post-impact structural integrity in terms of fully supporting the impactor dead weight of 568.80 kg
- The impact test was simulated and compared to the experimental data (deflection, load, and others) validating the predictive engineering approach
- Continuous carbon fiber thermoplastic composites are shown to exhibit improved ductility and energy absorption

This effort has demonstrated design, materials, manufacturing and joining methods with continuous carbon fiber thermoplastics, at TRL 4-7 to meet automotive industry and government safety specifications. Results of this program will be disseminated widely to the automotive industry and the technologies are being evaluated by BMW for future platforms.

NEWS

CCM Summer Undergrad Symposium



On August 12, 2016 students at the University of Delaware Center for Composite Materials participated in the Center's annual undergraduate research symposium. At the event, many of the 40+ students who worked in CCM's labs over the summer presented posters and delivered one-slide/two-minute summaries of their work to an audience of faculty, graduate students, staff researchers, and representatives from industry. Projects addressed subjects ranging from carbon nanotubes to designs for composite orthotics.

Awards were given based on audience evaluations. The following three students received prizes for their work:

First place: Tess Carella,
Fabric and Textile 3D Permeability Characterization Work-Station

Second place: Aris Mardirossion
Mechanism of Carbon Nanotube Film Growth By Electrophoretic Deposition

Third place: Francis Klincewicz
Mass Loss and Cure Modeling and Cure Cycle Selection for Anhydride-Cured Epoxy Resin

CCM undergraduate intern Tanmoy Sarker said, "This Internship has given me the chance to experience how engineering research with real-life applications is carried out every day. The internship provided me the knowledge and skills one could not simply get from sitting in a classroom."

Teachers participate in ASM Materials Camp

On July 14th the Center for Composite Materials hosted 20 educators from middle and high schools throughout Delaware attending the ASM Materials Camp.

The program was a collaboration between UD's Department of Materials Science and Engineering and the Brandywine Valley Chapter of ASM, an international association of materials scientists and engineers. Teachers learned the basics of materials science technology, focusing on instruction at a high school level, and worked hands-on with such materials as ceramics, metals, polymers and composites.

Stephen Brubaker said, "The tours give teachers an appreciation for the research and testing required for composite manufacturing."

NEWS

CCM Affiliated SAMPE Students and Delaware Aerospace Academy Cadets Design "Space Beams"

Also in July, CCM affiliated undergraduate and graduate student members of the Society for the Advancement of Material and Process Engineering (SAMPE) participated in the Delaware Aerospace Academy Destination Moon themed camp. The camp provides hands-on training and experiences in aerospace-related activities and fields for students in seventh, eighth and ninth grades. The Cadets' tour of the Composites Manufacturing Science Laboratory included demonstrations and explanations of popular composites manufacturing processes. After the tour, the cadets were introduced to the design of composite sandwich structures, which are used frequently in aerospace applications. Next, the cadets designed and constructed their own composite sandwich "space beams" from kits supplied by SAMPE-UD. Materials in each kit included steel, aluminum, glass-fiber-reinforced epoxy, and carbon/epoxy for the face sheets and high-grade foam, polystyrene foam, and balsa wood for the core.

After a night of brainstorming, the cadets assembled their "space beams" using epoxy as an adhesive with the help of our SAMPE volunteers. These beams were then tested in 3-point bending at UD-CCM. The load-to-weight ratio tests were performed and videotaped by SAMPE-UD students, who then compiled a report for each beam, and explained its failure mode to the cadets later that evening. The highlight of the cadets' evening was seeing their beams catastrophically broken.

The most satisfying moment for the SAMPE volunteers was receiving the cadets handwritten thank you notes which expressed how the Space Beam challenge had sparked their enthusiasm for learning more about advanced materials and aerospace engineering. Sagar Doshi, the president of the SAMPE UD student chapter says, "One of the main goals of the SAMPE student chapter is to reach out to undergraduate and high school students to ignite an interest for advance materials and processes."

NEWS

Mechanical Engineering Turns 125

The Department of Mechanical Engineering at the University of Delaware will launch a year-long celebration of its 125th anniversary during Welcome Weekend, Aug. 27 and 28, with a reception in the Design Studio for all incoming ME freshmen.

Events throughout the year will include a homecoming tailgate, a senior design celebration, an industry day, an ME "build-a-thon" during Engineers Week, and a special celebration for ME graduates at Commencement. The year will culminate during Alumni Weekend 2017, with events aimed at reconnecting with alumni.

"We've worked hard to plan events for everyone — from incoming students and industrial partners to alumni and the broader community," says Jill Higginson, associate professor and ME125 chair. "It's been interesting to see how the department has evolved over the years while retaining its roots with common elements in the curriculum."

Led by Higginson, the ME125 committee, which includes faculty, staff, alumni and graduate and undergraduate students, also worked with the College of Engineering Communications Team to create a "Look Book" that provides a view into ME's past and present through photographs and anecdotes.

"The materials that we accessed to create the book provided us with profound insights into where we started in 1891 and how far we've come in terms of technology, diversity, facilities, and hands-on learning opportunities for our students," says Suresh Advani, department chair and George W. Laird Professor.

"We're proud that we've been 'building engineers for 125 years,' and we look forward to engaging our alumni and the greater community as we develop new strategies for educating the engineers of the 21st century."

For more information about the anniversary events, visit the website and follow the celebration on Facebook.

Article courtesy of: UDaily

NEWS

From Short Fiber and Hybrids to Nanocomposites and Additive Manufacturing:

A Tribute to Professor Hiroshi Fukuda by Professor Tsu-Wei Chou

The Japan Society for Composite Materials (JSCM) was founded in 1975, just a year after the Center for Composite Materials was established at the University of Delaware, and CCM's early years witnessed a steady stream of visiting researchers from Japan, beginning with one exceptional scholar: Professor Hiroshi Fukuda.

Four decades later, the JSCM invited CCM's Tsu-Wei Chou to deliver a tribute to Fukuda at a special memorial session of the 17th US-Japan Conference on Composites Materials, held at Hokkaido University in Sapporo, Japan, from August 1–2, 2016.

Chou's presentation drew a clear line from Fukuda's pioneering research on short fiber and hybrid composites in the 1970s to current work in the field on nanocomposites and additive manufacturing as well as functional and pseudo-ductile materials.

A composites pioneer himself—whose work has spanned the early days of ceramic-matrix composites to modern investigations into the use of additive manufacturing to shape preforms—Chou started his presentation by talking about the "special friendship" between American and Japanese composites researchers.

"Professor Fukuda loved working here, and he encouraged others to come after him and work at CCM," said Chou.

The list of those who followed him reads like a Who's Who of composites in Japan, including Takahashi Ishikawa, who won the Medal of Excellence in Composites in 2007 and credited his time at UD with triggering his interest in the mechanics of textile composites.

Fukuda's visit and collaboration with CCM researchers gave rise to a number of joint papers in the ensuing years.

"He had not only a good ability in applied mechanics but also a great sense for identifying key problems to analyze," Chou said. Those problems included length and orientation in short-fiber composites, which Chou described as a "new and exciting field in the late 1970s."

"Now, we're seeing that what Hiroshi did 35 years ago has direct relevance to what we're doing today," Chou said.

"Additive manufacturing is a popular high-tech twenty-first century approach, but we are still dealing with the typical short-fiber composite problems because the wires used in printing are mostly reinforced with short, rather than continuous fibers," he continued. "Hiroshi would have loved to research this problem."

Chou drew a similar parallel between the hybrid composites of the 1980s and modern functional composites such as wire-shaped stretchable supercapacitors.

NEWS
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"Most hybrids today basically serve as functional materials—it's the same idea but on a larger scale," he said. "The stress-strain curve of a pseudo-ductile composite is precisely what Hiroshi simulated years ago with hybrid composites."

So Fukuda's legacy includes the effort he contributed in establishing the U.S.-Japan Conference on Composite Materials as well as the research foundation he laid and the people he encouraged to come to CCM for further collaborations that built on that foundation.

"He was truly a scholar and a gentleman," Chou said. "He is greatly missed in the world of composites."

U.S. Sen. Tom Carper visits CCM

On Aug. 23, U.S. Sen. Tom Carper (D-Del.) returned to his alma mater to tour research labs and meet with faculty, students and industry partners in the University of Delaware's Center for Composite Materials (CCM), where director Jack Gillespie and assistant directors Dirk Heider and Shridhar Yarlagadda presented highlights of composite research innovations, including automotive applications aimed at advancing fuel-efficient vehicle technologies, orthotics for Wounded Warriors, and novel low-cost carbon-fiber composite feedstock and manufacturing process targeted to revolutionize the use of composite materials world-wide as a cost-effective replacement for small metal parts.

NEW PUBLICATIONS

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Gallo, Gerard J., and Erik T. Thostenson. "Spatial damage detection in electrically anisotropic fiber-reinforced composites using carbon nanotube networks." Composite Structures 141 (2016): 14-23. http://dx.doi.org/10.1016/j.compstruct.2015.07.082

Michael J Deluca, Christopher J Felker, Dirk Heider, Gaurav Pandey, Ahmad Abu-obaid, Erik T Thostenson, John W Gillespie Jr "System and methods for use in monitoring a structure." U.S. Patent No. 9,329,021. 3 May 2016.

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S.M. Doshi, E.T. Thostenson (2016). Novel Carbon Nanotube-Based Non-Woven Composite Sensors: Processing, Characterization and Potential Applications. American Society for Composites 31st Technical Conference and ASTM Committee D30 Meeting, Williamsburg, Virginia, September 19-22, 2016.

NEW CONFERENCES

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R. Ganesh, S. Sockalingam, B.Z. Haque, J.W. Gillespie Jr. (2016) A Finite Element Study of Dynamic Stress Concentrations Due to a Single Fiber Break in a Unidirectional Composite. American Society for Composites 31st Technical Conference and ASTM Committee D30 Meeting, Williamsburg, Virginia, September 19-22, 2016.

S. Sockalingam, J.W. Gillespie Jr., M. Keefe. (2016) Role of Inelastic Transverse Compressive Behavior on Kevlar KM2 Single Fiber Transverse Impact. American Society for Composites 31st Technical Conference and ASTM Committee D30 Meeting, Williamsburg, Virginia, September 19-22, 2016.

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CONSORTIUM NEWS

We would like to thank Highland Composites and Meggitt Polymers & Composites on becoming our newest consortium members.

We would also like to thank Composite Sourcing Solutions, Kuraray America, Inc, Orbital ATK, and The Boeing Company for their membership renewal and all our current members for continuing to participate in CCM's research and development activities.

To learn more about the benefits of becoming a member, please visit us on the web at http://www.ccm.udel.edu/industry/industry-partnerships/

CELEBRATING OVER 40 YEARS OF SIGNIFICANT CONTRIBUTIONS TO COMPOSITES SCIENCE AND TECHNOLOGY, THE EDUCATION OF STUDENTS, AND THE CREATION AND TRANSFER OF TECHNOLOGY TO INDUSTRY.

42nd Anniversary
Celebrating 42 years of significant contributions to science and technology, the education of students, and the creation and transfer of technology to industry
1974-2016

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