University of Delaware | Center for Composite Materials
Internationally Recognized Excellence

UPDATE
JUNE 2016

CCM leads major DARPA program to revolutionize the manufacturing of composite materials with aerospace properties at automotive prices

COMPOSITES UPDATE

University of Delaware
Center for Composite Materials

The Defense Advanced Research Projects Agency (DARPA) has awarded the University of Delaware Center for Composite Materials (UD-CCM) a $14.9M three-year cooperative agreement for the Tailorable Feedstock and Forming (TFF) Program.

The objective of this program is to develop a novel low-cost carbon-fiber composite feedstock and manufacturing process. The new material, called TuFF (tailorable universal feedstock for forming), may potentially revolutionize the use of composite materials world-wide, as a cost-effective replacement for small metal parts meeting aerospace performance requirements.

Virginia Tech | Clemson University | Drexel University

TuFF

The objective of this program is to develop a carbon-fiber composite material, called TuFF (Tailorable Universal Feedstock for Forming)

The feedstock will consist of carbon fiber in a thermoplastic matrix with improved microstructural design, creating thin ply sheets that optimize formability of single and doubly curved parts with aerospace grade mechanical properties and damage tolerance.

Under the leadership of director Jack Gillespie, UD-CCM seeks to establish a semi-automated pilot plant to produce TuFF starting with carbon fiber precursors and ending with net-shape zero-waste formable feedstock blanks. The aim of the pilot plant is to demonstrate the feasibility and scale-up of novel technologies developed through this program with capacity to supply TuFF feedstock to designated industries for evaluation and prototype development.

The success of TuFF as a new material is expected to be transformative for complex curvature composite structures for aerospace and automotive applications in the defense and commercial sectors.

"UD-CCM is excited to lead a team of composite experts from Clemson University, Drexel University and Virginia Tech to develop a new composite material and manufacturing process," said Rob Adkinson, TuFF program manager.

"Bypassing all of the manufacturing problems associated with advanced composites, our approach will allow us for the first time to make composite parts having aerospace properties at automotive prices."

NEWS

UD-CCM collaborates with Industry and University Partners on DOE Vehicle Technologies Programs

Researchers at University of Delaware Center for Composite Materials (UD-CCM) have formed Industry and University Partnerships in two programs recently funded to design, manufacture, and demonstrate an ultra-light hybrid composite door through a Department of Energy program aimed at advancing fuel-efficient vehicle technologies.

UD-CCM is part of the Clemson University led team where researchers will use carbon-fiber-reinforced thermoplastic composites to fabricate a driver's side front-door assembly for a large original equipment manufacturer (OEM). The goal is to reduce the door's weight by 42.5 percent as automakers work to meet U.S. corporate average fuel economy (CAFE) standards. Fleets of vehicles are supposed to average 54.5 miles per gallon by 2025.

John W. Gillespie, director of UD-CCM, and assistant director Shridhar Yarlagadda issued a joint statement: "Clemson and CCM are establishing a strong partnership to merge auto systems design with composites materials, design and manufacturing to lightweight composites door for high-volume production."

UD-CCM is also part of the TPI Composites, Inc. led team where TPI's expertise in system design and as a Tier 1 supplier will be complemented by UD-CCM's modeling and simulation capabilities for HP-RTM, (High-Pressure Resin Transfer Molding) of carbon-fiber thermoset composites, material response and side-impact crash modeling of composites.

According to CCM assistant director Dirk Heider, the new carbon-fiber-reinforced doors have to match the current steel models with regard to all fit, function, and safety requirements. In addition, the new doors have to be producible at the required rate of 80,000-90,000 units per year.

"We will evaluate new material solutions and conduct a small number of sub-element tests to validate the approach and optimize our design," Heider says. "Final full-scale door testing will demonstrate that our design approach leads to a composite door meeting all performance targets, and full vehicle tests will demonstrate the form, fit and function of the proposed door."

"Investing in advanced vehicle technologies will improve the efficiency of today's vehicles while also supporting the next generation of hybrid and electric vehicles," said Energy Secretary Ernest Moniz in announcing the awards. "The deployment of these technologies will give Americans more options when they are choosing a vehicle, while also creating jobs and cutting harmful carbon emissions."

U.S. DEPARTMENT OF ENERGY

tpi

CLEMSON UNIVERSITY

NEWS

CCM Students and Staff Honored

On Friday, May 6, 2016 the Center for Composite Materials honored 17 individuals-fourteen students, two researchers and one administrator with seven different awards.

"We have over 60 graduate and undergraduate students who do research with affiliated faculty and staff at the Center for Composite Materials," says Associate Director Suresh Advani. "We are very proud of the interdisciplinary research conducted by our students in exploring new frontiers in composite materials, and the students selected for the awards have shown special initiative to deserve this honor.

R. L. McCULLOUGH SCHOLARS AWARD

The Scholars Award recognizes original contributions to the literature on composite materials. The tribute, consisting of a monetary award, is bestowed on a graduate student author of a paper accepted for publication in a refereed journal. Selection of the recipient for this award is based on the quality of the paper.

Recipient: Hongbo Dai, Ph.D.C.E.E.
Advisors: Professor Erik. T. Thostenson &
Professor Thomas Schumacher

Recipient: Michael Yeager, Ph.D.M.E.
Advisor: Professor Suresh G. Advani

PROGRESS AWARD

The Progress Award recognizes research contributions of students to the research goals of the Composites Center. The tribute, consisting of a monetary award, is bestowed on a graduate student author of a CCM Research Report, thesis, or dissertation. Selection of the recipient of this award is based on the quality of the report, thesis, or dissertation.

Recipient: Jiayin Wang, Ph.D.M.E.
Advisor: Professor Suresh G. Advani.

ACHIEVEMENT AWARD

The Achievement Award recognizes outstanding personal growth demonstrated by a Center-affiliated graduate student. The tribute, which consists of a monetary award, is bestowed on a graduate student who has demonstrated superior achievement.

Recipient: Hong Yu, Ph.D.M.E.
Advisors: Professor Suresh G. Advani & Dr. Dirk Heider

NEWS

OUTSTANDING SENIOR AWARD

The Outstanding Senior Award recognizes the contributions of students participating in the Undergraduate Research Program of the Composites Center. The tribute, consisting of a monetary award, is bestowed on an outstanding senior for cumulative contributions (service as well as research) to Center activities.

Recipient: Michael B. Carroll, Jr., B.M.E.
Advisor: Professor John W. Gillespie, Jr.

Recipient: Matthew J. Stevens, B.M.E.
Advisor: Dr. Bazle Z. Haque

UNDERGRADUATE RESEARCH AWARD

The Undergraduate Research Award is bestowed on a student in their junior year whose proposal to perform research on composite materials under the guidance of a UD-CCM affiliated faculty member is selected. The student is expected to enroll in UNIV 401 and UNIV 402 and write a senior thesis. Selection of the recipient for this award is based on the research objective and plan submitted by the student in a one-page abstract.

Recipient: Anthony J. Campanella, B.Chem.
Advisor: Dr. Joseph M. Deitzel

Recipient: Byron B. Fan, B.Ch.E.
Advisor: Dr. Joseph M. Deitzel

Recipient: Erin N. Hitchner, B.Ch.E.
Advisor: Dr. Joseph M. Deitzel

Recipient: Francis G. Klincewicz, B.M.E.
Advisor: Dr. Joseph M. Deitzel

Recipient: Evan M. Martz, B.Ch.E.
Advisor: Dr. Sanjib C. Chowdhury

Recipient: William J. Rocker, B.E.E.
Advisor: Dr. Dirk Heider

CCM SCHOLARSHIP AWARD

The CCM Scholarship Award recognizes research contributions of Postdoctoral Researchers or Research Professionals affiliated with CCM. Selection of the recipient for this award is based on publication of papers in high quality refereed journals and their impact on the research community of composite materials.

Recipient: Sanjib C. Chowdhury, Ph.D.
Advisor: Prof. John W. Gillespie, Jr.

DIRECTORS' AWARD

The Directors' Award recognizes outstanding personal growth demonstrated by a Center-affiliated employee or student. The tribute, which consists of a monetary award, is bestowed on an employee or student who has demonstrated superior progress.

Recipient: William R. Adkinson

Recipient: Sagar M. Doshi, Ph.D.M.E.

Recipient: Preston B. McDaniel, Ph.D.M.S.E.G.

Recipient: Robin M. Mack

NEWS

Composites Honor

Gillespie receives Wayne W. Stinchcomb Memorial Award from ASTM

John W. Gillespie Jr., director of the University of Delaware Center for Composite Materials, has been selected to receive the Wayne W. Stinchcomb Memorial Award from the American Society for Testing and Materials. The award includes delivering a keynote lecture at the American Society for Composites (ASC) conference in Williamsburg, Virginia, in September.

The award was established in memory of Wayne W. Stinchcomb, a fellow of ASTM and past chair of Committee D30 on Composite Materials.

Criteria include outstanding contributions in research, engineering or teaching the technology of composite materials, as well as service and other contributions in the area of composites.

Gillespie was recognized in particular for playing a key role in mentoring his students in his "career engagement in the academic world."

Erik Thostenson, now associate professor in the Department of Mechanical Engineering at UD, interacted with many of Gillespie's students while working on his Ph.D. in the 1990s.

"I was always impressed with his mentoring of students in his research group," Thostenson wrote in a letter of support for Gillespie's nomination. "His students were always extremely well prepared and had tremendous breadth and depth of knowledge in their research. He has high expectations of his students, and many of them have gone on to be leaders in industry, government and academia. I try to emulate his approach in preparing my own students for their careers."

John Gangloff, who served as president of UD's student chapter of SAMPE (Society of Advanced Materials and Process Engineering) several years ago, expressed gratitude for Gillespie's support of UD's participation in the SAMPE Student Composite Bridge Contest.

Now a science and technology policy fellow in the U.S. Department of Energy's Fuel Cell Technologies Office, Gangloff wrote, "Prof. Gillespie's advisement over the years greatly educated students about composite materials and processing beyond the classroom and led to experiences to build upon for their future careers."

Kuang-Ting Hsiao, who completed his doctoral research at CCM, credits Gillespie with creating a very dynamic research environment and encouraging researchers, scholars and students to communicate ideas and share results.

Hsiao, who is now professor of mechanical engineering at the University of South Alabama, also referred to Gillespie as "an extraordinary researcher and educator."

A Short Course on
Thermal Analysis

July 13-14, 2015 | 9am - 4pm
$300 for Industrial Full Attendee | $50 for Students *(if space is available)*
Does not include lunch

Description:
The course will include the basics of Thermal Analysis with morning lectures on differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and dynamic mechanical analysis (DMA). The afternoon sessions will have hands-on instruction by the vendors, with demonstrations on calibration and how to run experiments.

Participating Venders: *TA Instruments, Mettler Toledo, & NETZSCH Instruments*

July 13th Program

Location: Center for Composite Materials (CCM)
101 Academy Street
University of Delaware
Newark, DE 19716

8:45 - 9:00	**Registration**
9:00 - 9:10	**Opening Comments, Andrew McGhie (LRSM)**
9:10 - 10:25	**DSC Theory and Practice by Larry Judovits (Arkema)**
10:25 - 10:45	*Break*
10:45 - 12:00	**DSC Application and Use by Steve Sauerbrunn (CCM)**
12:00 - 13:15	*Lunch*
13:15 - 14:30	**Introduction to TGA, Janis Matisons (Gelest)**
14:30 - 14:50	*Break*
14:50 - 16:05	**Introduction to DMA, Sara Reynaud (Arkema)**

July 14th Program

Location: TA Instruments
159 Lukens Drive,
New Castle, DE 19720

9:00 - 11:30	**Hands-on Demos with Vender Dr. Kadine Mohomed (TAI)**

Location: Center for Composite Materials (CCM)
101 Academy Street
University of Delaware
Newark, DE 19716

13:15-15:45	**Hands-on Demos with Vendors, Kevin Menard (Mettler) & Hui Hu (Netzsch)**

Event Sponsored by:

TAFDV Thermal Analysis Forum of the Delaware Valley

Center for Composite Materials
Internationally Recognized Excellence

CLICK HERE FOR REGISTRATION FORMS

NEW PUBLICATIONS

Tamrakar, S., B. Z. (Gama) Haque, and J. W. Gillespie, Jr., "High rate test method for fiber-matrix interface characterization", Polymer Testing, 2016 52, pp.174-183. 2016 http://dx.doi.org/10.1016/j. polymertesting.2016.04.016

Haque, B.Z. (Gama), S. Chowdhury, and J. W. Gillespie Jr., "Molecular simulations of stress wave propagation and perforation of graphene sheets under transverse impact", CARBON, 2016, vol. 102, pp. 126-140. http://dx.doi.org/10.1016/j.carbon.2016.02.033

Sockalingam, S., J. W. Gillespie, Jr., S. Chowdhury, M. Keefe, "Recent Advances in Modeling and Experiments of Ballistic Fibrils, Fibers, Yarns and Flexible Textile Fabrics – A Review," Textile Research Journal, May 2016. http://dx.doi. org/10.1177/0040517516646039

Sockalingam, S. R. Bremble, J. W. Gillespie, Jr., and M. Keefe, "Transverse Compression Behavior of Kevlar KM2 Single Fiber," Composites Part A: Applied Science and Manufacturing, 81, pp. 271 – 281, February 2016. http://dx.doi.org/10.1016/j.compositesa.2015.11.03

Haque, B. Z., S. C. Chowdhury, and J. W. Gillespie, Jr., "Molecular Simulations of Stress Wave Propagation and Perforation of Graphene Sheets under Transverse Impact," Carbon, 102, pp. 126-140, 2016. http://dx.doi.org/10.1016/j.carbon.2016.02.033

Minnicino, M.A., Santare, M.H., "Predicting Microdroplet Force Response using a Multiscale Modeling Approach," Composites Part A, v. 80, p. 39-52, 2016. http://dx.doi.org/10.1016/j.compositesa.2015.10.005

Advani, S.G., C. L. Tucker, III, "Use of Centroidal Voronoi Diagram to find optimal gate locations to minimize mold filling time in resin transfer molding," Composites Part A: Applied Science and Manufacturing, v. 87, p. 243-255, 2016. http://dx.doi.org/10.1016/j.compositesa.2016.04.026

Lindemer, M. D., S.G. Advani, A.K. Prasad, "Hydrogen production via the heterogeneous hydrolysis of Zn vapor under a temperature gradient: Modeling and efficiency analysis," International Journal of Hydrogen Energy, 2016. http://dx.doi.org/10.1016/j.ijhydene.2016.04.201

Heidary, H., M. J Kermani, S.G. Advani, A.K. Prasad, "Experimental investigation of in-line and staggered blockages in parallel flowfield channels of PEM fuel cells," International Journal of Hydrogen Energy, v. 41, i. 16, p. 6885-6893, 2016. http://dx.doi.org/10.1016/j.ijhydene.2016.03.028

Yeager, M., Hwang, W. R., Advani, S.G., "Prediction of capillary pressure for resin flow between fibers," Composites Science and Technology, v. 126, p. 130-138, 2016. http://dx.doi.org/10.1016/j.compscitech.2016.02.014

Simacek, P. S.G. Advani, ""Equivalent" permeability and flow in compliant porous media," Composites Part A: Applied Science and Manufacturing, v. 80, p. 107-110, 2016. http://dx.doi.org/10.1016/j.compositesa.2015.10.006

NEW PUBLICATIONS

Simacek, P., J. Merotte, and S. G. Advani. "Compression Resin Transfer Molding Simulation for Net Shape Manufacturing of Composite Structures for Automotive Applications." SAMPE JOURNAL 52.1 (2016): 19-29.

Shafique, A., S. Doshi, T. Schumacher, E.T. Thostenson, McConnell, J., "Novel self-sensing carbon nanotube-based composites for rehabilitation of structural steel members," 42ND ANNUAL REVIEW OF PROGRESS IN QUANTITATIVE NONDESTRUCTIVE EVALUATION: Incorporating the 6th European-American Workshop on Reliability of NDE, v. 1706, p. 120004, 2016 http:// dx.doi.org/10.1063/1.4940589

Dai, H., G.J. Gallo, T. Schumacher, E.T. Thostenson, "A Novel Methodology for Spatial Damage Detection and Imaging Using a Distributed Carbon Nanotube-Based Composite Sensor Combined with Electrical Impedance Tomography", Journal of Nondestructive Evaluation, 35 (2), 1-15, 2016. http://dx.doi.org/10.1007/s10921-016-0341-0

Zhang, D., D. Heider, and J. W. Gillespie, Jr., "Determination of Void Statistics and Statistical Representative Volume Elements (SRVE) in Carbon Fiber Reinforced Thermoplastic Prepregs," Journal of Thermoplastic Composite Materials, 2015. http://dx.doi.org/10.1177/0892705715618002

Tamrakar, S., Q. An, E. T. Thostenson, A. Rider, B. Z. Haque, and J. W. Gillespie, Jr., "Tailoring Interfacial Properties by Controlling Carbon Nanotube Coating Thickness on Glass Fibers using Electrophoretic Deposition," American Chemical Society Applied Materials & Interfaces, 8 (2) pp. 1501-1510, December 2015. http://dx.doi.org/10.1021/acsami.5b10903

McDaniel, P. B., J. M. Deitzel, and J. W. Gillespie, Jr., "Structural Hierarchy and Surface Morphology of Highly Drawn Ultra High Molecular Weight Polyethylene Fibers Studied by Atomic Force Microscopy and Wide Angle X-Ray Diffraction," Journal of Polymer Research, 69, pp. 148 – 158, 2015. http://dx.doi.org/10.1016/j.polymer.2015.05.010

Kubota, M., Prasad, A. K., Deitzel, J. M., Teather, E. W., & Advani, S. G. (2015). Thin polymeric film microstructure manipulation for diffused reflectance applications. Polymer Engineering & Science, 55(12), 2878-2883. http://dx.doi.org/10.1002/pen.24179

Obaid, A., D. Heider, J. W. Gillespie, Jr., "Investigation of Electro-Mechanical Behavior of Carbon Nanotube Yarns during Tensile Loading," Carbon, 93, pp731 – 741, November 2015. http:// dx.doi.org/10.1016/j.carbon.2015.05.091

Haque, B. Z. (Gama), M. A. Molla, and J. W. Gillespie, Jr., "Modeling Transverse Impact on UHMWPE Soft Ballistic Sub- Laminate," Journal of Thermoplastic Composite Materials, http://dx.doi.org/10.1177/0892705716637114

Haque, B. Z. (Gama) and J. W. Gillespie, Jr., "A New Penetration Equation for Ballistic Limit Analysis," Journal of Thermoplastic Composite Materials, 28.7 (2015): 950-972, http://dx.doi.org/10.1177/0892705713495430

NEW PUBLICATIONS

Sockalingam, S., J. W. Gillespie, Jr., and M. Keefe, "Dynamic Modeling of Kevlar KM2 Single Fiber Subjected to Transverse Impact," International Journal of Solids and Structures, 67-68, pp. 297 – 310, August 2015. http://dx.doi. org/10.1016/j.ijsolstr.2015.04.031

Yu, H., D. Heider, S. G. Advani, "A 3D microstructure based resistor network model for the electrical resistivity of unidirectional carbon composites," Composite Structures, v. 134, p. 740-749, 2015, http://dx.doi. org/10.1016/j.compstruct.2015.08.131

Rider, A.N. E. Yeo, J. Gopalakrishna, E.T. Thostenson, N. Brack. "Hierarchical composites with high-volume fractions of carbon nanotubes: Influence of plasma surface treatment and thermoplastic nanophase-modified epoxy", Carbon 94 (2015): 971-981, http://dx.doi.org/10.1016/j.carbon.2015.07.076

Gallo, G. J., and E. T. Thostenson. "Spatial damage detection in electrically anisotropic fiber-reinforced composites using carbon nanotube networks." Composite Structures (2015). http://dx.doi.org/10.1016/j.compstruct.2015.07.082

Dai, H., E. T. Thostenson, and T. Schumacher. "Processing and Characterization of a Novel Distributed Strain Sensor Using Carbon Nanotube-Based Nonwoven Composites." Sensors 15.7 (2015): 17728-17747. http://dx.doi.org/10.3390/s150717728

Quan, Z., A. Wu, M. Keefe, X. Qin, J. Yu, J. Suhr, J.H. Byun, B.S. Kim, and T.W. Chou. "Additive manufacturing of multi-directional preforms for composites: opportunities and challenges." Materials Today 18, no. 9 (2015): 503-512. http://dx.doi.org/10.1016/j.mattod.2015.05.001

Mäder, E., Liu, J. W., Hiller, J., Lu, W., Li, Q., Zhandarov, S., & Chou, T. W. (2015). Coating of carbon nanotube fibers: variation of tensile properties, failure behavior and adhesion strength. Frontiers in Materials, 2, 53. http://dx.doi.org/10.3389/fmats.2015.00053

Yu, J., Wang, L., Lai, X., Pei, S., Zhuang, Z., Meng, L., Huang, Y., Li, Q., Lu, W., Byun, J.H. and Oh, Y., Yan. Y., Chou, T.W., 2015. A durability study of carbon nanotube fiber based stretchable electronic devices under cyclic deformation. Carbon,94, pp.352-361. http://dx.doi.org/10.1016/j.carbon.2015.07.009

Meng, F. C., Lu, W. B., Li, Q. W., Byun, J. H., Oh, Y., & Chou, T. W. (2015). Graphene-based fibers: a review. Advanced Materials, 27(35), 5113-5131. http://dx.doi.org/10.1002/adma.201501126

Deitzel, J., P. McDaniel, and J. W. Gillespie, Jr., Chapter 10: High Performance Polyethylene Fibers. In Structure and Properties of High-Performance Fibers; Bhat, G., Ed; Elsevier, November 2015.

DeLuca, M., Felker C., Heider, D., Pandey, G., Abu-Obaid, A., Thostenson, E., Gillespie, J., System and methods for use in a structure, 9,329,021, May 3, 2016

NEW CONFERENCES

Sockalingam, S., M. Keefe, and J. W. Gillespie, Jr., "Transverse Compression Response of Ultra-high Molecular Weight Polyethylene Single Fibers," SEM XIII International Congress, Orlando, Florida, June 6-9, 2016.

McDaniel, P., J. Deitzel, J.W. Gillespie, Jr., "Understanding the Evolution in Meso/ Nanostructure in UHMWPE Fibers" APS Meeting Abstracts, March 2016

Haque, B. Z. (Gama) and J. W. Gillespie, Jr., "Progressive Composite Damage Modeling in LS-DYNA using MAT162: Part A – Properties and Parameters," American Society for Composites 30th Technical Conference, Michigan State University, September 28-30, 2015.

Haque, B. Z. (Gama) and J. W. Gillespie, Jr., "Progressive Composite Damage Modeling in LS-DYNA using MAT162: Part B – Model Validating Experiments," American Society for Composites 30th Technical Conference, Michigan State University, September 28-30, 2015.

Haque, B. Z. (Gama), M. A. Ali, and J. W. Gillespie, Jr., "Modeling Transverse Impact on Multi-Layer UHMWPE Soft Ballistic Armor Pack (SBAP)," American Society for Composites 30th Technical Conference, Michigan State University, September 28-30, 2015.

Chowdhury, S. C., J. Staniszewski, E. M. Martz, R. H. Ganesh, S. Sockalingam, B. Z. (Gama) Haque, T. A. Bogetti, and J. W. Gillespie, Jr., "A Computational Approach for Linking Molecular Dynamics to Finite Element Simulation of Polymer Chains in Polyethylene Fibers," American Society for Composites 30th Technical Conference, Michigan State University, September 28-30, 2015.

Chowdhury, S. C., R. M. Elder, T. W. Sirk, B. Z. (Gama) Haque, J. W. Andzelm, and J. W. Gillespie, Jr., "Effect of Cross-Linker Length on Epon 828 Resin Properties using Molecular Dynamics Simulation," American Society for Composites 30th Technical Conference, Michigan State University, September 28-30, 2015.

A Short Course on

Progressive Composite Damage Modeling in LS-DYNA Using MAT162

Bazle Z. (Gama) Haque, PhD
Senior Scientist, University of Delaware Center for Composite Materials (UD-CCM)
Assistant Professor of Mechanical Engineering, University of Delaware, Newark, DE 19716
P: (302) 831-6805 | E: gama@udel.edu

Upcoming Workshops:
Tuesday, July 12, 2016 | 9am-5pm
Tuesday, November 15, 2016 | 9am-5pm

Cost: $595 per person
Includes: Coffee, Lunch, Parking, CD with course Content

Description:
Progressive damage modeling of composites under low velocity impact and high velocity impact is of interest to many applications including car crash, impact on pressure vessels, perforation and penetration of thin and thick section composites. MAT162 rate dependent progressive composite damage model in LS-DYNA is considered as the state of the art. This short course will include the theory and practice of MAT162 composite damage model with applications to low and intermediate impact velocities, understanding the LS-DYNA programming parameters related to impact-contact, damage evolution, perforation and penetration of thin- and thick-section composites with and without curvature. The following topics will be covered in this one-day short course with illustrative examples. A CD with content of the course will be provided.

Topics Covered in this Short Course:

Introduction to LS-DYNA
Writing a structured LS-DYNA keyword input deck from scratch for a unit single element (USE) under tension, compression, and shear

Introduction to Continuum Mechanics and Composite Mechanics
Concepts of large deformation finite strain theory
Deformation gradient
Cauchy-Green strain tensors
Piola-Kirchhoff and Cauchy stress
Stiffness matrix for orthotropic and anisotropic composite materials

Composite Material Models in LS-DYNA for Shell and Solid Element

Theory and Practice in MAT162 Progressive Composite Damage Model
Unit Single Element analysis

Low Velocity Impact (LVI) and Compression after Impact (CAV) Applications
For Shell and Solid Elements

Perforation Mechanics of Thin-Composites with MAT162 and Solid Elements

Penetration Mechanics of Thick-Composites
Depth of Penetration Experiments
Ballistic Impact Experiments

Application of MAT162 in Engineering and Research Problems
Impact on Composite Cylinders and Spheres with and without Internal Pressure and/or Blast Pressure
Penetration and Perforation of Sandwich Composites
Normal and Oblique Impact
Multi-Hit Ballistics
Meso-Mechanical Modeling of Woven and 3D Composites

CLICK HERE TO REGISTER

CONSORTIUM NEWS

We would like to thank Orbital ATK Flight Systems Group on becoming our newest consortium member.

We would also like to thank Fenner Precision, NETZSCH Instruments North America, Inc, and Sabic Innovative Plastics for their recent 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

This is a newsletter publication of the
UNIVERSITY OF DELAWARE
CENTER FOR COMPOSITE MATERIALS

201 COMPOSITES MANUFACTURING SCIENCE LABORATORY
UNIVERSITY OF DELAWARE
NEWARK, DE 19716-3144
P: 302.831.8149
F: 302.831.8525
W: WWW.CCM.UDEL.EDU