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Scholarship Awards

Winners of SPE® ACCE Scholarships Sponsored by Michigan Economic Development Corp. Announced

THE *SPE ACCE Scholarship Awards* — sponsored by the Michigan Economic Development Corp. for the 2015-2016 academic year — have been won by **Márton Kardos** of *The University of Applied Sciences Hof* (Upper Franconia, Bavaria, Germany); **Christopher Boise** of *Baylor University* (Waco, Texas, U.S.A.); and **Nicholas Kamar** of *Michigan State University* (East Lansing, Mich., U.S.A.). The winning students submitted composites-intensive research projects that were judged to have the greatest potential impact on ground transportation by a panel of industry experts. Each student will return to present the results of his research at next year's SPE ACCE show, September 7-9, 2016.

Márton Kardos, won his SPE ACCE graduate scholarship with the topic: *Material Characterization and Draping Simulation of Thermoplastic Prepregs: The Influence of Temperature*. About his project and its potential impact on the automotive composites industry, Kardos says, "In order for composites to become practical and cost-effective enough to be used on high-volume automotive platforms (with production volumes of 200,000 or more units per year), molding cycles must be at or below 60 seconds. To meet such short manufacturing cycle times, continuous-fiber-reinforced thermoplastic composites have enormous potential. However, automotive engineers aren't as familiar with composites, and especially with fabric-reinforced thermoplastic composites, as they are traditional steel and aluminum. To reduce the time and cost associated with the trial-and-error (make-and-break) method of product development, it's vital to use computer simulation. However, to increase simulation accuracy, more studies are needed to investigate the influence of material properties on model parameters in order to close the gap between measured and predicted results. When forming a thermoplastic prepreg, it first must be heated above the matrix resin's melting temperature so the material is 'drapable' before it can be formed into a three-dimensional part. Cooling that occurs as the prepreg is moved from the preheating oven to the mold, and further cooling that occurs upon contact with the cool mold surface causes a change in the final part's mechanical properties. In order to improve the accuracy of draping simulation — which already allows for virtual prototyping of textile feedstock and thus can help reduce or eliminate the costly and time-consuming process of producing parts and physically testing them — it's important to be able to account for the temperature dependency of mechanical properties. The 2015 version of PAM-FORM software [ESI Group, Paris] allows this dependency to be modeled. However, determining bending, shear, and tensile properties at multiple temperatures can be quite laborious. Therefore, the goal of my project will be to see whether dynamic mechanical analysis

(DMA) results can be used to determine both the temperature-dependent properties as well as the viscoelastic behavior of a fabric-reinforced thermoplastic composites."

Kardos earned his Bachelor of Science degree at the Budapest University of Technology and Economics (Budapest, Hungary) in Mechanical Engineering with a specialization in Polymer Technology, and wrote his bachelor's thesis on the topic of "Development of Self-healing Composite Structures Reinforced with Hollow Glass Fibers." He then moved to Germany to pursue a composites-oriented path of study and is currently finishing his Master's degree at the University of Applied Sciences Hof in Composite Materials. While working on his Master's thesis, Kardos gained valuable experience in the field of thermoplastic composites by working in the Materials and Processes department at Volkswagen Group Research (Wolfsburg, Germany) on the topic of "Material Characterization and Draping Simulation of Thermoplastic Prepregs," as well as co-authoring an identically titled paper that he will co-present at the 2015 SPE ACCE. Kardos notes that he is an ambitious young engineer and upon graduation he looks forward to contributing to the dissemination of fiber-reinforced plastics in the automotive industry.



Christopher Boise won his SPE ACCE scholarship with the topic: *Investigation of Anisotropic Stiffness and CTE of Woven Composite Laminae Using Finite Elements*. About his project and its potential impact on the automotive composites industry, Boise notes, "Fabric-reinforced composites are often chosen for their favorable strength-to-weight ratio. Because of the heterogeneous nature of these composites, however, it becomes more difficult to predict how these materials will react to certain loading conditions — both mechanical and thermal. This is due to the fact that woven composites are orthotropic at best, react to loading in a viscoelastic (time-dependent) manner, and contain components with differing CTEs [coefficients of thermal expansion]. Further, in the composites industry today, there is virtually an infinite combination of fibers, matrices, and weaves which all have an effect on the thermo-mechanical properties of the resulting composite. A general method is required that — when given any combination of fiber, matrix, and weave — will accurately and quickly predict the resulting thermo-mechanical properties; this will allow for more efficient and effective automotive structural design. The primary objective of my proposed research is to construct the effective anisotropic stiffness and coefficient of thermal expansion tensors for woven composite lamina through the finite-element method (FEM) with a novel material-independent mesh. The resulting predicted tensors will be validated using in-house experimental measurements. After that measured results will be used to compare the effectiveness of existing micromechanical theories. Viscoelastic matrix studies also will be performed to identify appropriate bounds on the linear-elastic matrix assumption inherent in most micromechanical theories. Although many analytic models predicting anisotropic stiffness have been proposed based on the concept of representative volume elements

(RVEs), they may make assumptions that oversimplify the model and thus predict properties that are not accurate for the composite. Many existing methods based on FEM have been developed, but these methods also may have issues replicating the RVE of a woven composite due to its complex geometry — especially for more complex weaves such as satin and twill types. These issues are becoming more important to the automotive industry as the design of structural components in vehicles transition away from traditional isotropic materials like aluminum and steel and towards more anisotropic composite materials in order to produce lighter, more energy-efficient vehicles."



Boise graduated *magna cum laude* from Baylor University in May 2014 with a Bachelor's of Science degree in Mechanical Engineering and a minor in Mathematics. He is currently one year into his master's studies in Mechanical Engineering at Baylor where he has been studying property predictions of woven-fabric composite materials using analytic and finite-element methods. Upon graduating, he hopes to bring this research into the aerospace and automotive industries, where composite materials are becoming more common, in order to design safer, more energy-efficient transportation.

Nicholas T. Kamar won his SPE ACCE scholarship with the topic: *Toughening Fiber Reinforced Epoxy Polymer Composites with Graphene Nanoplatelets and Block Copolymers*. About his project and its potential impact on the automotive composites industry, Kamar says, "Glass and carbon fiber-reinforced epoxy composites have high strength/weight ratios and can lightweight ground and air vehicles to improve fuel efficiency while maintaining safety standards. Although fiber-reinforced plastics (FRPs) are strong and stiff, their chemically cross-linked epoxy matrices are brittle and have a low resistance to crack initiation and propagation. In automotive crashes or bird-impact events in jet engines, a structural composite component must have some energy-dissipative mechanisms to prevent catastrophic failure of the composite. Hence, considerable research over the last 30 years has been done to increase FRP fracture toughness. However, current methods employed to increase FRP toughness often negatively impact composite strength and stiffness. Due to their outstanding thermal, electrical, and mechanical properties, carbon-based nanomaterials have shown considerable promise as additives to epoxy polymers and FRPs to improve composite mechanical properties and fracture toughness. Therefore, we will investigate graphene nanoplatelets (GnPs) as additives to FRPs. Another aspect of the project involves use of a nanostructured thermoset as matrix material in FRPs. In epoxy resin, the triblock copolymer (pol)styrene-block-(poly)butadiene-block-(poly) methylmethacrylate (SBM) can self-assemble by attractive and repulsive forces between polymer chains to form rubbery adducts and interpenetrating networks with domains on the nanoscale. This work will advance knowledge of toughening mechanisms in FRPs for automotive and aerospace applications. Nanoscale self-assembly and carbonaceous nanomaterial additives may provide finer control of the nano and micro scales in FRPs, which will allow for large increases in impact toughness and resistance to crack propagation while maintaining composite strength and stiffness for lighter and safer ground and air vehicles."

Kamar earned a B.S. degree in Chemistry from Grand Valley State University in 2011. He currently is a third-year doctoral student at Michigan State University (MSU) where he works as a graduate research assistant at both MSU's Composite Vehicle Research Center (CVRC) and its Composite Materials and Structures Center (CMSC). His research is focused on toughening fiber-reinforced epoxy composites with graphene nanoplatelets and block copolymers. To date he has one journal publication titled "Interlaminar reinforcement of glass fiber/epoxy composites with graphene nanoplatelets." During the summer of 2015, Kamar interned at General Electric Aviation (GEA) in Cincinnati, Ohio, U.S.A., where he worked as a materials applications engineer in the Materials Production and Engineering Department. His work for GEA included failure analysis of bird-impact-tested fan blades for the new GE9x turbine engine, as well as investigation of novel manufacturing methods toward increasing GE9x fan-blade efficiency. After completing his Ph.D., Kamar hopes to continue working on composite materials in the aerospace industry.

