High-power, high-efficiency wireless charging

A 20-kW wireless charging system developed by researchers at ORNL’s National Transportation Research Center (NTRC) has achieved 90% efficiency at three times the rate of the plug-in systems commonly used for electric vehicles today.

This ability can help accelerate the adoption and convenience of electric vehicles. Industry partners from Toyota, Cisco Systems, Evatran, and Clemson University International Center for Automotive Research contributed to the technology development.

“We have made tremendous progress from the lab proof-of-concept experiments a few years ago,” said Madhu Chinthavalli of ORNL’s Power Electronics and Electric Machinery Research Center. “We have set a path forward that started with solid engineering, design, scale-up, and integration into several Toyota vehicles. We now have a technology that is moving closer to being ready for the market.”

ORNL’s power electronics team achieved this world’s first 20-kW wireless charging system for passenger cars by developing a unique architecture that included an ORNL-built inverter, isolation transformer, vehicle-side electronics, and coupling technologies in less than three years.

To demonstrate the technology, researchers integrated the single-converter system into an electric Toyota RAV4 equipped with an additional 10-kWh battery.

The researchers are already looking ahead to their next target of 50-kW wireless charging, which would match the power levels of commercially available plug-in quick chargers. Providing the same speed with the convenience of wireless charging could increase consumer acceptance of electric vehicles and is considered a key enabler for hands-free, autonomous vehicles. Higher power levels are also essential for powering larger vehicles such as trucks and buses.

(continued on page 3: “Wireless”)

Increasing battery safety through high performance computing

Preventing thermal runaway, or the rapid overheating of a battery that can lead to fires or even explosions, is the focus of several efforts led by John Turner of ORNL’s Computational Engineering and Energy Sciences Group. Turner and his team are developing advanced numerical tools to simulate electric vehicle batteries in crashes to better understand the triggers for thermal runaway and to evaluate new battery technologies.

Standard tests of battery stability—like the nail penetration test where a metallic nail is driven through a charged cell with any resulting smoke or flame indicating a short or thermal runaway—are not truly representative of real-world conditions. There have been cases where lithium-ion batteries in cars involved in minor fender benders have appeared to be stable only to later develop problems. Said Turner, “They don’t have to be crushed to be damaged inside.” Clearly a better understanding of how batteries behave in abusive situations, particularly under mechanical abuse like that encountered in vehicle accidents, is needed.

(continued on page 2: “Battery”)

www.ornl.gov/transportation
Battery (Continued from page 1)

Developing software to virtually crash an automobile and predict the state of the battery afterwards is one of the goals of a new multi-lab effort funded by the Department of Energy (DOE) Vehicle Technologies Office (VTO). The Consortium for Advanced Battery Simulation (CABS), a collaborative effort that includes Sandia National Laboratories and Lawrence Berkeley National Laboratory, is developing an integrated software environment that includes the effects of microstructure and full geometric complexity.

In addition, as part of a multi-year partnership with the National Highway Traffic Safety Administration (NHTSA), Turner and his team are conducting physical experiments with battery pouch cells, crushing and pinching them to varying amounts and peeling them open to observe effects. The experimental data is being used to validate computational models and to gain insights that could inform future regulations about battery evaluation procedures.

A third related project, also funded by VTO, is led by Ford Motor Company and is focused on simulating the effects of mechanical abuse, with emphasis on commercial software tools such as LS-DYNA.

“High performance computing and these collaborations between government, industry, and national labs are accelerating the pace of discoveries related to battery safety and performance,” said Turner, “but there are still many questions to answer.”

Members of the energy storage modeling and simulation team include Srikanth Allu, Wael Elwasif, Sergiy Kalnaus, Abhishek Kumar, Damien Lebrun-Grandie, Srdjan Simunovic, Bruno Turcksin, and Hsin Wang.

Laser treatment, bonding potential road to success for carbon fiber

Joining carbon fiber composites and aluminum for lightweight cars and other multi-material high-end products could become less expensive and the joints more robust because of a new method that harnesses a laser’s power and precision.

The process, developed by an ORNL team led by Adrian Sabau, uses a laser to remove layers of material from surfaces prior to bonding. The laser penetrates into the top resin layer of composite, leaving individual carbon fibers exposed and increasing surface area for better adhesion and stronger joints.

Test results support Sabau’s optimism. Single-lap shear joint specimens showed strength, maximum load and displacement at maximum load was increased by 15%, 16% and 100%, respectively, over those measured for the baseline joints. Also, joints made with laser-structured surfaces can absorb approximately 200% more energy than the conventionally prepared baseline joints, researchers reported.

Sabau noted that the process also doubles the energy absorption in the joints, which has implications for crash safety and potential use in armor for people and vehicles. Tim Skszek of Magna International (Troy, Michigan), a project partner, shares Sabau’s enthusiasm.

“The results are most encouraging, enabling the automated processing of a multi-material carbon fiber-aluminum joint,” Skszek said. “With this work, we were able to focus on addressing the gaps in technology and commercial use, and we look forward to applying these findings to products.”

Other members of the research team include Claus Daniel, Dave Warren, Donald Erdman III, Jian Chen and John Henry of ORNL and Mary Caruso Dailey of 3M Co. This work is funded by DOE VTO. —Ron Walli
New technology keeps battery and fuel cell production rolling

As the researchers advance their system to higher power levels, one of their chief considerations is safety.

“The high-frequency magnetic fields employed in power transfer across a large air gap are focused and shielded,” said Chinthavali. “This means that magnetic fringe fields decrease rapidly to levels well below limits set by international standards, including inside the vehicle, to ensure personal safety.”

Convenience and simplicity are at the heart of the ORNL system, which places a strong emphasis on radio communications in the power regulation feedback channel augmented by software control algorithms. The result is minimization of vehicle on-board complexity as ORNL and partners pursue the long-range goal of connected vehicles, wireless communications and in-motion charging. While the team’s initial focus has been static, or motionless, wireless charging, the researchers also evaluated and demonstrated the system’s dynamic charging capabilities.

DOE VTO provided funding for this competitively selected project as part of a broad portfolio in support of DOE’s EV Everywhere Grand Challenge, which aims to make plug-in electric vehicles as affordable to own and operate as today’s gasoline-powered vehicles by 2022.

“Wireless power transfer is a paradigm shift in electric vehicle charging that offers the consumer an autonomous, safe, efficient and convenient option to plug-in charging,” said David Smith, vehicle systems program manager. “This high-power wireless charging technology is a stepping stone toward electrified roadways where vehicles could charge on the go.”

Toyota provided several vehicles for the research, including RAV4s, a Scion and a Plug-in Prius. Discussions are currently underway with several automotive manufacturers about potential collaborations to further develop this technology. –Ron Walli

Wireless (Continued from page 1)

The process for evaluating roll-to-roll produced products, such as components for lithium-ion batteries and fuel cells, is about to get an overhaul thanks to a joint research effort from ORNL and National Renewable Energy Laboratory (NREL). Researchers David Wood, Claus Daniel, and Jianlin Li from ORNL and their colleagues from NREL have invented an infrared non-destructive evaluation (IR NDE) process.

Currently, many roll-to-roll production processes are interrupted by off-line examination to obtain key coating properties, with the section of electrode or other analyzed product destroyed after evaluation. With IR NDE, examination can be conducted at any point on the production line, while the product is in motion, and without destroying the integrity of the examined material.

In battery production, the cell performance and cycle life of a lithium-ion battery depend on the quality of the positive and negative electrodes that are used to fabricate the cell. During electrode manufacturing, it is hard to avoid certain coating non-uniformities that diminish performance and shorten the life span of battery devices.

IR NDE minimizes the cell rejection rate and promotes early detection of electrode property variations. Used with appropriate feedback loops to the mixing and coating deposition steps, the overall electrode scrap rate can be reduced as well. The infrared method checks a component’s key parameters, such as porosity or thickness of coating. These parameters ultimately impact the performance of a battery or fuel cell.

“With the IR NDE system, you can evaluate all of your material, as it moves down the production line, instead of doing spot checks,” explained Wood. “This will ensure a higher or more consistent performance from the product, save waste, and lower costs because this is a non-destructive process.”

In addition, Wood said he anticipates creating a system to complement the IR NDE that would send a signal when a product coating does not meet parameters.

ORNL research for lithium-ion battery analysis is funded by DOE VTO, while the Fuel Cell Technologies Office (FCTO) is funding NREL on fuel cell applications. Although the team’s current work is focused on batteries and fuel cells, Wood said IR NDE could be used for supercapacitors and other applications.

“This non-destructive evaluation method could apply to essentially any coating made by roll-to-roll processing,” said Wood. “It keeps production rolling, without compromising the integrity of the product or the examined material.”
DOE and DOT collaborate on SMART Mobility

A new initiative exploring the rapidly changing face of transportation marks the first time the Department of Energy (DOE) and the Department of Transportation (DOT) have joined forces to collectively study the mobility needs of the future.

SMART (Systems and Modeling for Accelerated Research in Transportation) takes an in-depth look at viewing transportation as a system and how developing more efficient ways to transport goods and people could have a significant impact economically, saving more than $70 trillion globally over the next 40 years.

Led by the Office of Energy Efficiency and Renewable Energy’s (EERE) Deputy Assistant Secretary for Sustainable Transportation, the initiative focuses on five key areas: behavior and decision science, multimodal, connectivity and automation, vehicles-infrastructure and urban science.

Transportation today is vehicle focused, with modes of mobility operating independently, disconnected and subject to the behaviors and decisions of the driver. Cities of the future will require a SMART focus, which means viewing transportation as a system, connected, automated, in concert across all modes, with managed behaviors and decisions.

ORNL's Keith Kahl leads the multimodal area, studying the many ways passengers and freight move from one point to another, taking into consideration the consumer/market preferences and seeking to assess energy and greenhouse gas implications (GHG).

Kahl's multi-laboratory team will also study the impact of freight flow increasing by 50% over the next 25 years and how the easing of intermodal barriers increases efficiency and alternative fuel opportunities. The multimodal area is expected to guide future city infrastructure planning and quantify energy savings from a systematic approach.

The new initiative also aligns with DOT’s Smart Cities strategy, which seeks to create fully integrated cities that use data, technology and creativity to shape how people and goods move in the future. Smart Cities will implement bold, data-driven ideas, making transportation safer, easier, and more reliable.

Kahl’s multimodal area will work with DOT to assess intermodal freight logistics and impacts from the trend of viewing mobility as a service.

“This is the first time we have participated in a joint initiative of this magnitude with DOE and DOT,” said Kahl. “Both organizations recognize that cities of the future will need more mobility options, with a focus on offering options that make better energy/GHG sense.”

Other ORNL team members for key areas include Andreas Malikopoulos, Connectivity and Automation; Diane Davidson, Multimodal; Scott Curran and Changzheng Liu, Vehicles-Infrastructure; Paul Leiby and Zhenhong Lin, Behavior and Decision Science; and Budhendra Bhaduri, Urban Science.

The combustion continuum: Research provides new perspective on ignition modes

Gasoline compression ignition modes are being viewed in a different light thanks to research from ORNL's Fuels, Engines, and Emissions Research Center (FEERC).

Low-temperature combustion (LTC) strategies have been widely studied due to their potential for high efficiency and low emissions of pollutants like NOx. Achieving LTC using gasoline compression ignition engines is a topic of broad interest and considerable efforts on the part of the research community.

Researchers Adam Dempsey, Scott Curran, and Robert Wagner provide a new perspective on gasoline compression ignition modes in their recent publication in the International Journal of Engine Research. The authors demonstrate that these modes, which have been previously studied as distinct methods for achieving combustion efficiency, are actually a spectrum driven by fuel stratification or the mix of fuel and air at the time of ignition.

“The level of fuel stratification for these advanced combustion modes is, in reality, a continuum ranging from fully premixed (i.e., homogeneous charge of fuel and air) to heavily stratified, heterogeneous operation,” explained Curran. “This perspective changes the way we think about approaches to achieving LTC and provides a missing link for the research community at large.”

The published findings are among the most-read articles for the journal online. This research was conducted with support from DOE VTO.
Take the wheel: Retired STP Director Ron Graves leaves legacy of innovation

Ron Graves at the Victory Circle area in Pocono with his current track car, a Porsche 911 GT2.

Sitting in the driver’s seat comes naturally to Ron Graves, the recently retired head of ORNL’s Sustainable Transportation Program.

Graves has logged more than 100 days on national racetracks like Daytona, Road Atlanta, and Pocono where he routinely reaches speeds of 175 mph in high performance driving events. He jokes that it is not the speed that is dangerous at these events; it’s the “sudden stops.”

His early race track skills were developed in a DeTomaso Pantera that he restored, rebuilding the engine, transmission, brakes and updating the original pumpkin orange paint to a shiny red. “Learning to drive fast in a car with bad brakes and diabolical handling has advantages in the long run,” he reflected.

This passion for cars is not only a hobby—it has driven Graves’ career.

“Being a gearhead has enhanced networking with automotive executives and technology leaders over the years,” said Graves. “Most of their leadership are ‘car people.’”

(continued on page 6: “Graves”)

Top R&D Hits

Below is a list of some of the more notable advancements from ORNL transportation R&D over the last 25 years. Please note: This is a sampling in no particular order.

- Material technologies in millions of vehicles on the road today
- Led national program of field experiments for methanol fuel
- Contributed to adoption of urea-SCR to reduce NOx
- Technology (SpaciMS) supported release of 2007 Dodge Ram compliant with 2010 regulations
- First application of chaos theory in engine electronic control
- Manage and host fueleconomy.gov
- Leader in high performance computing for transportation
- Exemplary record of working with industry
- NTRC built, designated as national user facility
- Neutron imaging of vehicle components and materials studies in VULCAN beam line
- 19 R&D 100 awards
- Caused shift in engine R&D from emissions compliance to efficiency
- First lab to demonstrate low-temperature combustion with no loss in engine efficiency
- Billion-Ton Studies, go-to lab on sustainability
- Higher performance enzymes for ethanol production
- Ionic liquid lubricants increase fuel economy
- Partnering with entire diesel engine industry to examine heat exchanger fouling
- Wireless charging for electric vehicles
- New capabilities – Vehicle Systems Integration laboratory, Battery Manufacturing Facility, Carbon Fiber Technology Facility, Vehicle Cyber Security laboratory
- Invented TMAC (testing machine for automotive crashworthiness)

(continued on page 10: “Top R&D”)

Daniel named Sustainable Transportation Program Acting Director

A familiar name and face in the transportation sector has assumed leadership duties with the National Transportation Research Center (NTRC). Former Deputy Director Dr. Claus Daniel has been appointed Acting Director for the Sustainable Transportation Program and the NTRC.

For the past five years, Dr. Daniel has served as Deputy Director of the Sustainable Transportation Program. He’s previously worked within ORNL in various research and managerial positions, serving as lead scientist in the Materials Science and Technology Division. He came to ORNL in 2005 as a Eugene P. Wigner fellow. Prior to ORNL, Dr. Daniel was a laboratory manager and teaching assistant at Saarland University in Germany where he worked in X-ray diffraction. He has also held research positions with international companies including Robert Bosch and Saint Gobain and collaborated with such industries as Honeywell, Dow, Wieland, Plansee, A123 Systems, and XALT Energy.

The NTRC and STP are pleased to welcome Dr. Daniel to his new role. He can be reached at danielsc@ornl.gov or (865) 946-1544.
Ron Graves is inducted into the Tennessee Automotive Manufacturers Association’s Hall of Fame with fellow honoree Gov. Phil Bredesen (left) by TAMA President Rick Youngblood.

In his 39 years at ORNL, Graves has worked closely with vehicle experts from across the industry through R&D partnerships and by personally serving on technical teams, working groups, and committees for the DOE, U.S. DRIVE, 21st Century Truck Partnership, the Coordinating Research Council, and the National Academy of Sciences.

He was the first ORNL staff member elected as a Fellow of the Society of Automotive Engineers International and has a slew of honors to his credit from DOE and organizations such as the Tennessee Automotive Manufacturers Association, which recently inducted him into their Hall of Fame for his positive impact on the state’s automotive industry.

The lab twice has contributed to the implementation of national clean fuel regulations and helped make ultra-low sulfur “clean diesel” a reality, saving hundreds of millions of tons of greenhouse gas emissions and virtually eliminating pollutants from diesel exhaust. His teams developed award-winning research instruments that industry cited as “helping tune engine combustion in ways not thought possible” and gave new insights on emission control chemistry.

As STP Director from 2010-2016, Graves implemented expanded uses of ORNL big science tools to vehicle technology barriers along with new work for DOT in transportation cyber security and battery safety, helping materials researchers’ innovations continue to have impact on millions of vehicles.

Though he tends to downplay his pivotal role, Graves has been a key driver behind the creation of ORNL’s engines and emissions research capabilities as well as the growth of its $65 million Sustainable Transportation Program.

He was there in the beginning. Before ORNL established the National Transportation Research Center, Before DOE was formed. It was Graves who made the quiet suggestion to lab leadership in the late 70’s that ORNL could contribute in addressing the transportation-related national challenges of petroleum dependence and declining air quality.

Graves took some time recently to answer a few questions about his history with DOE and the development of the Sustainable Transportation Program. In the conversational excerpts below, he shares his historical perspective along with how he sees transportation evolving into the future.

How did you get started in vehicle research?

I did engine, fuels, and vehicle R&D while an undergraduate and grad student. I participated in the Urban Vehicle Design Competition of 1972, one of the earliest student vehicle design competitions. When I was hired in at ORNL, I was in the Reactor Division. My early work focused on thermodynamic analysis of advanced power systems for the grid and coal combustion. That background in thermodynamics would prove useful later for more engine R&D.

There was no vehicle program at the lab at that time. I had a great supervisor who let me start an internal transportation working group, and we got a little funding for background studies, visits to industry, and writing seed money proposals.

How did transportation research at ORNL grow from there?

We got seed money to do experiments with coal-derived diesel fuel in a small engine. Looking back, it was not the best science, but it was enough to get the notice of leaders at the lab and DOE and helped us start in a new field.

ORNL was awarded leadership of the DOE alternative fuels program, exploring synthetic fuels, alcohols, and natural gas. DOE agreed to build a moderate lab capability at ORNL as part of this initiative. It was the beginning of what we now call the Fuels, Engines, and Emissions Research Center. When we started, we were in a repurposed “abandoned” building on the Y12 site.

In parallel, David Greene was initiating what became the Center for Transportation Analysis, and Tony Schaffhauser and his team were building a program on high-temperature ceramics for advanced engines that would give rise to the High Temperature Materials Laboratory. Thomas Zacharia and others led computational work on crash modeling in the 90s, bringing ORNL computational capabilities to prominence.

Research capabilities and industry partnerships expanded from there, even before an integrated transportation program was established at ORNL. I am grateful for (continued on page 7: “Graves”)

Ron Graves in the early 1980s with a display on the Alternative Transportation Fuels Utilization Program.
having the opportunity to lead ORNL’s entire Sustainable Transportation Program for six years. We made great strides and impact by marshalling researchers and capabilities from across the laboratory, applying big science tools like Titan and the Spallation Neutron Source along with materials characterization and vehicle-specific capabilities to discover new knowledge and deliver solutions for industry not achievable by any single group or discipline.

How have things changed over your career in transportation R&D?

For a long time, a key goal of DOE was to “turn the corner” on gasoline consumption. That meant to see consumption stop increasing and actually decline. I thought that would never happen during my career, but it is reality for cars. Corporate Average Fuel Economy Standards, E10 fuel, and vehicle technology have worked. Fuel consumption and GHG emissions from freight trucks are the fastest growing source now.

The computational controls in cars and trucks are mind-boggling compared to 1980, as is the computational power we have to support R&D. Cars and trucks are 99% cleaner in terms of emissions. Lead in gasoline is almost gone worldwide. Cars are much safer and much more numerous. With nearly twice as many cars on the road, congestion is worse.

Can you share a couple of high points?

There are so many facets of transportation that have been touched by ORNL, it deserves a separate article. I was lead author on DOE’s first heavy truck R&D plan in 1982, and that DOE program is still active under the banner of 21st Century Truck and SuperTruck, where we were on two industry teams in the last few years. Another is the Vice Presidential Award received by ORNL researchers from across the laboratory in 1997 along with four other national labs, Ford, GM, and Chrysler. The honor was in recognition of achievements in exhaust aftertreatment emissions controls research. ORNL is still a leader in R&D in this field.

Of course, the ORNL research that led to new EPA rules to reduce diesel sulfur in 2000 had huge lasting impact. DOE considers it one of the all-time greatest contributions to the transportation system. Explaining why combustion engines were not constrained by the “Carnot efficiency” was also provocative and impactful and helped revitalize engine R&D.

The construction of the National Transportation Research Center in 2000 and its certification by DOE as the only national user facility dedicated to transportation has been vital to our achievements and impact.

More recently, I would highlight our development of wireless charging technology for electric vehicles, impacts in battery technology coming from the Battery Manufacturing Facility, new aluminum alloys for next-generation engines, and powertrain test procedures for heavy-duty trucks—the last of which were cited by the EPA in a recent proposed rulemaking. ORNL also manages fueleconomy.gov, DOE’s most visited website. Of course the 3D printed Shelby Cobra brought tremendous positive attention to ORNL’s additive manufacturing innovations and the power of STP and the Manufacturing Demonstration Facility (MDF) working together.

Where do you see things headed, in terms of transportation and related research?

Autonomous vehicles appear poised for deployment, but with challenges like cyber security and uncertain impact on GHG. Freight movement needs a paradigm shift. We’ve come a long way in making vehicles more efficient, but those vehicles enter a suboptimal system. Looking at transportation as a system could yield significant gains in energy efficiency.

For vehicles, I think we are working on the right things… lightweighting, batteries, hybrid systems, engines. 3D printing seems to have tremendous potential to improve materials and components for vehicles. More broadly and philosophically, I think society needs to be more determined and passionate about combating global warming contributions from transportation, for example, being more aggressive on renewable fuels. As a nation and society, we eventually became convinced about eliminating lead in gasoline, about adding vehicle safety equipment, about eliminating diesel soot, and we made huge strides to fix these issues. We still seem a little tentative on climate change.

Ron Graves at the Pocono finish line.

ORNL’s Sustainable Transportation Program and National Transportation Research Center thank Graves for his decades of service and hope he continues putting the pedal to the metal, logging more miles on his favorite racetracks.
Briefs:

**Researchers spearhead new SAE Range Extender Symposium**

Downtown Knoxville will be home to a two-day symposium November 2-3, 2016, focusing on range extenders for electric vehicles (REx). SAE International hosts the event organized locally by ORNL's Robert Wagner and Scott Curran with assistance from MAHLE Powertrain. Session topics include policy and regulation, driving and design, and implementation of prime movers for REx applications; unique and advanced primer movers; recent powertrain advances for enabling REx; infrastructure role on range extender options; and the future of REx from a prime mover perspective. Reuben Sarkar, DOE Deputy Assistant for Transportation, will deliver the keynote address. Other speakers include J. Gary Smyth, Executive Director of Global Research and Development for General Motors Company, and Ian Wright, Founder and CEO of Wrightspeed and cofounder of Tesla. To register, visit sae.org/events/rex.

**Small Business Voucher pilot awardees collaborate with ORNL**

In the first round of Small Business Voucher pilot awards, DOE awarded 33 projects with a total funding of $6.7 million. Nine of the projects will enlist the support of researchers and facilities at ORNL. The selected small businesses will be afforded access to world-class laboratory resources to help move their innovative ideas and technologies closer to the marketplace. ORNL's Sustainable Transportation Program will work with the following pilot businesses in these areas:

- **Treadstone Technologies, Princeton, NJ; Fuel cells**, evaluating a new metal bipolar plate manufacturing process for creating cheaper more durable fuel cells;

- **Cool-X, Amherst, Massachusetts; Vehicles**, developing an alternative engine oil treatment that uses nanodiamonds and similar nanoparticles to clean engines from the inside, removing gunk, polishing surfaces, reducing friction and wear, and increasing fuel efficiency;

- **United Silicon Carbide, Monmouth, NJ; Vehicles**, improving battery structure and design through a silicon carbide metal oxide semiconductor transistor that offers a solution to switch-off power loss and light load efficiency problems.

**ORNL licenses iDriving technology**

A New Mexico-based small business has licensed ORNL's iDriving (Intelligent Driving) patent pending software. SanTed Project Management LLC manages projects in transportation, construction and military applications. The company will use iDriving within the trucking industry. Developed by ORNL's Andreas Malikopoulos, iDriving identifies the driving style factors that impact fuel economy and provides real-time feedback to enable drivers to alter their driving styles in response to actual driving conditions to improve fuel efficiency.

**Diagnostic makes cover of ACS journal**

ORNL researchers Bill Partridge, Jae-Soon Choi, and Josh Pihl coauthored a perspective article featured on the cover of the American Chemical Society Catalysis journal. Titled “Evolution and Enabling Capabilities of Spatially Resolved Techniques for the Characterization of Heterogeneously Catalyzed Reactions,” the article summarizes uses and specialized versions of unique diagnostic technology called spatially resolved capillary inlet mass spectrometry (SpaciMS), which ORNL invented in partnership with Cummins, Inc. SpaciMS enables scientists to capture data about reactions happening inside the catalyst. Consideration of these intracatalyst reactions is now considered standard by the catalyst research community across the world. The laboratory received a 2008 R&D 100 award for SpaciMS in collaboration with partners from Cummins, Queen's Belfast University, and Hiden Analytical.

**Find-A-Car goes mobile with new app**

ORNL's Center for Transportation Analysis (CTA) has completed development of the first Apple and Android smartphone apps for the Find-a-Car section of fueleconomy.gov. Similar to the web version, the app features information about fuel economy, manufacturers' suggested retail prices, annual fuel costs, and GHG emission scores. Find-a-Car is free in the Apple App store and the Google Play store. The mobile app was developed through the Fuel Economy Information Project, which is funded by DOE VTO.
Researchers invent tougher plastic with 50% renewable content

A better thermoplastic made by replacing styrene with lignin has been developed through ORNL research. Lignin is a brittle, rigid polymer that, with cellulose, forms the woody cell walls of plants. By replacing styrene with lignin, researchers have invented a solvent-free production process that interconnects equal parts of nanoscale lignin dispersed in a synthetic rubber matrix to produce a meltable, moldable, ductile material that is at least 10 times tougher than thermoplastic polymer, also known as ABS. The resulting thermoplastic—called ABL for acrylonitrile, butadiene, lignin—is recyclable, as it can be melted three times and still perform well. The results, published in Advanced Functional Materials, may bring cleaner, cheaper raw materials to diverse manufacturers. Principal investigator Amit Naskar led the research, which was funded by ORNL’s Technology Innovation Program.

Study Tour showcases opportunities for a sustainable bioeconomy

An ORNL team led by Virginia Dale organized and hosted a Bioenergy Study Tour of the Southeastern United States, highlighting regional bioenergy resources and innovations developed by DOE BETO and the national laboratories. A Tech-to-Market initiative, the tour included stops at NTRC, old growth forests, switchgrass fields, the biomass cogeneration plant at Savannah River Site, and a wood pellet production operation. The five-day tour showcased sustainable practices such as using waste wood residues for bioenergy and spurred science-based discussion among attendees, including researchers from across the national laboratory system, landowners, industry leaders, and stakeholders from the worldwide bioenergy community. The event received coverage from Ethanol Producer Magazine, and USAgNet. A recap of the journey is available on Storify.

New market acceptance modeling tool available online

A new MiniTool that offers a web-based lite version of MA3T (Market Acceptance for Advanced Automotive Technologies) has been released and demonstrated by ORNL researchers Zhenhong Lin, Fei Xie, and Rick Goeltz. MA3T is a market dynamics model that estimates demands for advanced vehicle powertrain technologies in response to assumptions on technology, infrastructure, consumers, and policies. The MiniTool provides a more user-friendly interface for non-technical users to quickly use the model. Through a web browser, MiniTool users can easily modify input scenarios, such as battery cost or infrastructure deployment, and immediately observe the effect on market shares. To view the tool, visit http://teem.ornl.gov/minitool. This research was funded by DOE VTO.

ORNL signs exclusive carbon fiber processing license with RMX Technologies

ORNL has signed an exclusive license agreement with Knoxville-based RMX Technologies for a process that will dramatically reduce the time and energy needed in the production of carbon fiber. ORNL/RMX plasma processing technology is a new approach to the oxidation stage of carbon fiber conversion process. ORNL/RMX plasma processing technology cuts processing time by a factor of 2.5 to 3 times. The technology also reduces unit energy consumption by 75% and lowers production costs by 20%, while maintaining or improving the resulting carbon fiber quality. Plasma oxidation can be used to produce all grades of carbon fiber from low-end industrial to high-end aerospace grades. Lowering the cost and expanding the use of strong, lightweight carbon fiber will improve the energy efficiency of products including cars, trucks, and aircraft without sacrificing safety. ORNL’s research in plasma oxidation of carbon fiber was led by Felix Paulauskas and funded by DOE VTO.
Green, Storey, Szybist, Thomas, and Wissink receive SAE International honors

SAE International honored five ORNL researchers at SAE World Congress. **Johnny Green** was elected Fellow. **John Storey**, **Jim Szybist**, and **John Thomas** received the Forest R. McFarland Award for their contributions in facilitating the exchange of technical information through planning and organizing technical panels and sessions for the SAE Engineering Meetings Board. Storey was honored for organizing a special particulate matter panel at the 2015 SAE World Congress. Szybist was recognized for his leadership in organizing the high-efficiency engine session, and Thomas was selected for his contributions to SAE in leading the development of a new session on whole vehicle fuel economy. Postdoc **Martin Wissink** won the Myers Award for his outstanding student paper, titled “Direct Dual Fuel Stratification, a Path to Combine the Benefits of RCCI and PPC.” Wissink is the first-ever two-time winner of the Myers Award.

Ford Motor and DowAksa carbon fiber team wins Detroit Free Press Automotive Award

Two companies that collaborated with ORNL on carbon fiber processing research have been awarded the Detroit Free Press Automotive Difference Maker award. **Ford** and **DowAksa** were recognized for their ambitious program to build lighter, stronger cars by transforming carbon fiber from a super-expensive material used for fighter planes into one that is affordable for mass-market cars and trucks. Ford and DowAksa are partners in the Institute for Advanced Composites Manufacturing Innovation, which is developing carbon fiber for automotive use. The Automotive Difference Maker award recognizes companies, leaders, and individuals who have made a profound impact on how vehicles are developed, bought, and sold.
Researchers receive DOE Distinguished Achievement Awards

The Department of Energy recently awarded ORNL researchers with Distinguished Achievement Awards for accomplishments in wireless charging and hydrogen infrastructure technologies. The awards were given at the Annual Merit Review in Washington, D.C.

The wireless power transfer team was honored by DOE VTO for developing and demonstrating the world’s first high-power (20-kW) wireless charging system for passenger cars. The technology achieves 90% efficiency at three times the rate of the plug-in systems commonly used for electric vehicles today. Team members include Steven Campbell, Paul Chambon, Madhu Chinthavali, Omer Onar, Burak Ozpineci, Larry Seiber, David Smith, Lixin Tang, Cliff White, and Randy Wiles.

DOE FCTO recognized the H₂ at Scale Lab Team, a group of researchers from across the national laboratory system focused on a new initiative to scale up hydrogen technologies for not only vehicles but also other energy sectors, such as the grid. The initiative aims to achieve deep decarbonization while meeting society’s multi-sector energy demands. ORNL’s David Wood participates as a member of the H₂ at Scale team. Bryan Pivovar of NREL received individual recognition along with the honor bestowed on the team.

Daniel receives Gilbreth Lectureship Award

STP Acting Director Claus Daniel has been awarded the Gilbreth Lectureship Award from the National Academy of Engineering (NAE) in recognition of his outstanding contributions to the field of materials science and his presentation on the challenge of manufacturing lithium-ion batteries at the 2016 NAE National Meeting. The Gilbreth Lectures were established in 2001 by the NAE Council as a means of recognizing outstanding young American engineers and making them more visible to the NAE membership.

DOE honors ORNL’s Green Transportation Team with 2016 Sustainability Award

DOE recognized ORNL’s efforts and commitment to sustainability with the 2016 Sustainability Award for “Driving Future Sustainability.” The laboratory’s green fleet management has increased alternative fuel usage in the ORNL fleet by 227% with a 57% decrease in fleet petroleum consumption. ORNL has been performing successful transportation-based research, development, and demonstration activities for decades with ORNL materials and technologies in millions of vehicles on the road today, enabling gains in durability and efficiency. Team members include Lynn Cox, Scott Curran, Ernie Ford, Johney Green, Melissa Lapsa, Lonnie Love, and Teresa Nichols.

Transportation seminars highlight vehicle cyber security and fuels R&D


Brian West, deputy director of ORNL’s Fuels, Engines, and Emissions Research Center, will present the next Transportation Science Seminar, “Fuels R&D to Support Informed Decision-Making,” on July 15, 2016, from 10–11 a.m. in the Joint Institute for Computational Sciences auditorium. West will discuss the laboratory’s rich history in fuels R&D and the research that informed EPA’s rulemakings on ultra-low sulfur diesel fuel and the use of 15% ethanol in gasoline. West will also describe recent research that may have future impact on the US fuel pool.

To view past presentations, please contact Kim Askey at askeyka@ornl.gov or (865) 946-1861.
Visits and Events:

• ORNL had a strong presence at the EERE National Lab Impact Summit, an event designed to celebrate recent national laboratory successes and to bring industry and government leaders together to formulate the next stage of clean energy technology innovation. ORNL's Thomas Zacharia, Johney Green, and Claus Daniel participated on panels. The Additive Manufacturing Integrated Energy (AMIE) demonstration project was on display in addition to ORNL's 3D printed Willys army jeep and a Formula E race car powered by battery materials developed at the laboratory's Battery Manufacturing Facility in partnership with XALT Energy. For a recap of the event, visit http://energy.gov/eere/technology-to-market/national-lab-impact-summit.

• Devinn Lambert, Technology Manager at the DOE Bioenergy Technologies Office, visited ORNL to get an update on research focused on sustainability and algae resources for biofuels. As part of the visit, Lambert toured NTRC, the MDF, aquatic labs, and the Walker Branch Watershed.

• ORNL hosted a DOE VTO Technical Review Meeting on the current status and future directions in magnesium corrosion research. DOE Technology Development Manager Will Joost kicked off the meeting, which included presentations from industry leaders and academia along with ORNL researchers.

• Jefferson Lab displayed the AMIE printed utility vehicle and printed Willys jeep as part of the public open house, which drew a record crowd of 12,000. The event received coverage in the Daily Press and Richmond Times-Dispatch.

• ORNL Commercial Motor Vehicle Roadside Technology Consortium (CMVRTC) team members, led by Gary Capps, demonstrated a production version of the Wireless Roadside Inspection (WRI) system to Federal Motor Carrier Safety Administration (FMCSA) personnel before beginning a field operations project phase. FMCSA staff viewed the software user interfaces for motor carriers and law enforcement and then rode along in Tennessee Highway Patrol vehicles equipped with the WRI system to see how it would function under real-world vehicle inspection conditions. The vision for the WRI system is to automate many of the approximately 3.2 million manual commercial motor vehicle inspections conducted each year in the United States and bolster the total number of inspections from the current number of 3.2 million to billions.

• Peter Faguy, DOE Technology Manager for Applied Battery R&D, visited ORNL to discuss current and future research in energy storage technologies.

• The Battery Materials Program (BMR) in the DOE VTO organized a workshop at the National Transportation Research Center to discuss current research and emerging trends in the area of high energy density cathode materials for advanced lithium-ion batteries. Workshop participants included scientists from multiple national laboratories and academia as well as members of the U.S. DRIVE electrochemical energy storage team. The DOE team was led by BMR program manager Tien Duong and included Patricia Smith and Jack Deppe. Jagjit Nanda headed the workshop organization locally.
• As a Tech-to-Market initiative, ORNL hosted a booth at SAE World Congress along with Pacific Northwest National Laboratory. The display featured the printed utility vehicle from the AMIE demonstration, and the wireless power transfer coils that enable the vehicle to share power with the printed AMIE house. Propulsion materials were also featured, including powertrain components made with ORNL-developed alloys. Power electronics and electric machinery, energy storage technologies, carbon fiber spools, and multi-material joining samples were also on display for the estimated 11,000 attendees.

• DOE Supervisory Program Manager Felix Wu visited ORNL to meet research staff and tour facilities focused on lightweighting, including the Carbon Fiber Technology Facility (CFTF).

• Robert Wagner accompanied leadership from Southwest Research Institute to Japan to meet with eight companies from the Japanese automotive industry. Wagner was an invited expert to discuss DOE and ORNL advanced engine and fuels research, including the new DOE initiative on the co-optimization of fuel and engine technologies.

• ORNL, NREL, and Argonne participated in a joint educational program at the Work Truck Show and the Green Truck Summit. The purpose of the session, “Meet the Engineering and Research Departments You Didn’t Know You Had,” was to connect industry to the R&D capabilities at the national laboratories.

• More than 140 researchers from industry, national laboratories, and universities participated in the ORNL-hosted 19th Cross-Cut Lean Exhaust Emissions Reductions Simulations (CLEERS) Workshop in Ann Arbor, Michigan. CLEERS addresses emissions control challenges for lean, fuel-efficient vehicles.

• Robert Wagner, director of FEERC, was a co-organizer of the 2016 SAE International High Efficiency IC Engines Symposium held in Detroit. The symposium had more than 180 attendees and included a presentation by ORNL’s Jim Parks on “Emission Challenges for Advanced Combustion Engines.”

• Researcher Brian West testified at an Illinois state capitol hearing on ethanol. He was invited by Illinois State Senator and Chairman of the Illinois Agriculture Committee, Bill Cunningham, to testify about E15 (15% ethanol blended with gasoline). Senator Cunningham wanted to educate his colleagues on the issues surrounding E15 as they consider state legislation to encourage its use.

Media

• Wired Magazine featured the Additive Manufacturing Integrated Energy project, which pairs a printed building with a printed utility vehicle and a wireless power transfer system that allows the two to share energy to maximize efficiency.

• ORNL’s new production method for carbon fiber received widespread media coverage from outlets including Materials Today, Composites World, and IEEE’s Engineering 360. The process, developed at the Carbon Fiber Technology Facility with funding from DOE VTO and the Advanced Manufacturing Office, could reduce the cost of carbon fiber by 50% and the energy used to produce it by more than 60%, thus addressing a major roadblock to greater carbon fiber use in reinforced composites in the automotive industry, for example. The process is currently available for licensing.

• A new collaboration between DOE VTO, ORNL, Ford, and Xerox PARC to create high-energy, high-power battery production for long-range electric vehicles received coverage on Green Car Congress and Electric Vehicle News. The partners are developing pouch cells with a 20% improvement in energy density (Wh/kg) and a 30% reduction in costs using PARC’s novel co-extrusion printing technology, providing faster, more efficient roll-to-roll production.
• *MotorWeek*, television’s longest-running automotive series, interviewed Brian West for a segment highlighting fuel-saving driving tips for hybrid and plug-in vehicles. The tips were based on research conducted by ORNL staff including West, John Thomas, and Shean Huff for FuelEconomy.gov. The *MotorWeek* segment (Episode 3537, “Improved MPG”) aired on PBS stations across the country and is viewable online at [http://www.motorweek.org/features/auto_world/improved-mpg](http://www.motorweek.org/features/auto_world/improved-mpg).

• Brian West was quoted in *Hart Energy’s Downstream Business* article about the challenges and opportunities for adoption of high-octane fuels—primarily mid-level ethanol-gasoline blends.

• The website *InsideEVs* recently used two facts from the VTO Transportation Fact of the Week website. The weekly transportation facts are created by CTA staff members Stacy Davis, Bob Boundy, Sheila Moore, and Susan Williams and posted on the VTO website at [http://energy.gov/eere/vehicles/transportation-fact-week](http://energy.gov/eere/vehicles/transportation-fact-week).

• The Environmental Protection Agency and NHTSA jointly published a notice in the *Federal Register* seeking comments on their proposal to tighten greenhouse gas emissions regulations for trucks. ORNL and the powertrain test procedures developed in the Vehicle System Integration Laboratory were cited in the proposal, which received coverage from the *Commercial Carrier Journal* and *Transport Topics*.

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**Patents**

**Vehicle to wireless power transfer coupling coil alignment sensor**

*US 9,260,026*

Paul H. Chambon, John M. Miller, Perry T. Jones, and Clifford P. White have developed a non-contacting position-sensing apparatus that can be used for both stationary and in-motion wireless power transfer from a charging station to a vehicle in order to ensure proper alignment between a primary coil in a charging device and a secondary coil in the vehicle. The apparatus can be used in a garage equipped with a charging station. The vehicle can be parked within alignment tolerances above a transmit pad without the need for external guides or wheel chocks. The non-contacting position sensing apparatus includes at least one vehicle-mounted receiver coil that is configured to detect a net flux null when the vehicle is optimally aligned relative to the primary coil in the charging device. The work was conducted with support from DOE VTO.

**Gas-cooled traction inverter**

*US 9,320,179*

Madhu S. Chinthavali has invented a modular circuit card configuration for distributing heat among a plurality of circuit cards. Each circuit card includes a housing adapted to dissipate heat in response to gas flow over the housing. The circuit cards are adapted to operate together to convert a power input to at least one power output, and the plurality of housings is adapted to dissipate heat from the inverter circuit cards in response to gas flowing over the plurality of housings. The plurality of modular inverter circuit cards is adapted to operate together to supply AC power to an electric motor in a vehicle, and are interchangeable with each other. If one modular inverter circuit card is interchanged with another modular inverter circuit card, the traction inverter produces a substantially similar supply of AC power. A gas-cooled traction inverter operates using a three dimensional heat spreading technique. The work is conducted with support from DOE VTO.
Outreach:

**ORNL hosts students for My Brother’s Keeper event**

ORNL hosted a group of Austin-East High School students as part of My Brother’s Keeper, a White House initiative designed to help underrepresented minorities focus on future success in science, technology, engineering, and mathematics through community engagement. Students participated in speed mentoring Q&A sessions with staff and participated in tours of the Additive Manufacturing Integrated Energy (AMIE) printed house and utility vehicle, led by Roderick Jackson and Scott Curran.

**Toops mentors Intel Science Talent Search finalist, National Junior Science winner**

Researcher Todd Toops served as a mentor to Thomas Colburn, an Oak Ridge High School senior named one of 40 finalists in the prestigious Intel Science Talent Search. Colburn was the first finalist from Oak Ridge High School and the only Tennessean in the competition. For the past 2 years, Toops has worked with Colburn on the project “Enhanced Decomposition of Plastic Waste” through Photocatalysis inspired by the prevalence of plastic waste in the environment. Colburn’s project earned first-place divisional honors in the National Junior Science and Humanities Symposium, Chemistry Division, a tri-service U.S. Army, Navy, and Air Force program designed to encourage student research in the STEM (science, technology, engineering, and mathematics) fields. In addition to the award, Colburn also received a $12,000 academic scholarship.

Thomas Colburn participates in the Intel Science Talent Search.