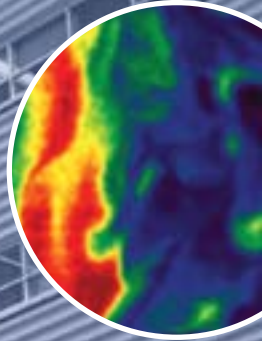




News from
The Department of Mechanical
& Aerospace Engineering



Fall 2012

Ahmet Selamet
Professor and Chairperson
Department of Mechanical
and Aerospace Engineering



A Message from the Chair

Now, with a little over a quarter of my first year as Chair of the Department of Mechanical and Aerospace Engineering passed, I've found one of the most fulfilling experiences in this leadership position to be the closer observation of the scientific and scholarly inquiries of our faculty and students, and the broad impact of their work on societal challenges. I am proud to be affiliated with a community of such prominent scholars contributing to the discovery in the fields of mechanical, aerospace, and nuclear engineering. In the pursuit of new knowledge, we look for collaborative opportunities with our peers across the university and the nation to enhance the innovative and interdisciplinary initiatives addressing the present and emerging needs of the society.

This year's edition of MAE News presents a set of selected diverse efforts within the department, starting with a pioneering approach that could form the foundation of new spin-thermal energy converters through the spin-Seebeck effect (featured in a recent issue of Nature). Other energy-related research findings are equally fascinating as we are learning more about: how experimental mechanics aids the design of solid oxide fuel cell components; how high-speed imaging in turbulent combustion paves the way to advancements in combustion systems; the characterization of advanced Li-ion batteries in relation to hybrid and electric vehicles; and a unique turbocharger laboratory to investigate and mitigate flow instabilities in compressors leading to more fuel-efficient engines.

The intrinsic mechanism of conversion of flow energy to acoustics is explored by supercomputers along with noise suppression techniques to develop next generation of quiet jet engines. The challenges of fluid-thermal-structural interactions are being examined to facilitate sustained hypersonic flight platforms. The Mechanics of Materials Laboratory continues to study a wide variety of materials, including metals, polymers, ceramics, composites, and foams, to further develop the knowledge base on their strain rates. Finally, an exciting update on how DNA origami is used to create novel nanoscale engineering devices.

The recent NSF awards will clearly enable several of our junior faculty in producing new fundamental knowledge. These efforts will be further strengthened by two new faculty members, Associate Professors Jinsuo Zhang and Vishnu Sundaresan, who joined the department at the beginning of the current academic year.

I look forward to continuing to share with you some of our cutting-edge research that will expand the frontiers of knowledge and produce practical discoveries.

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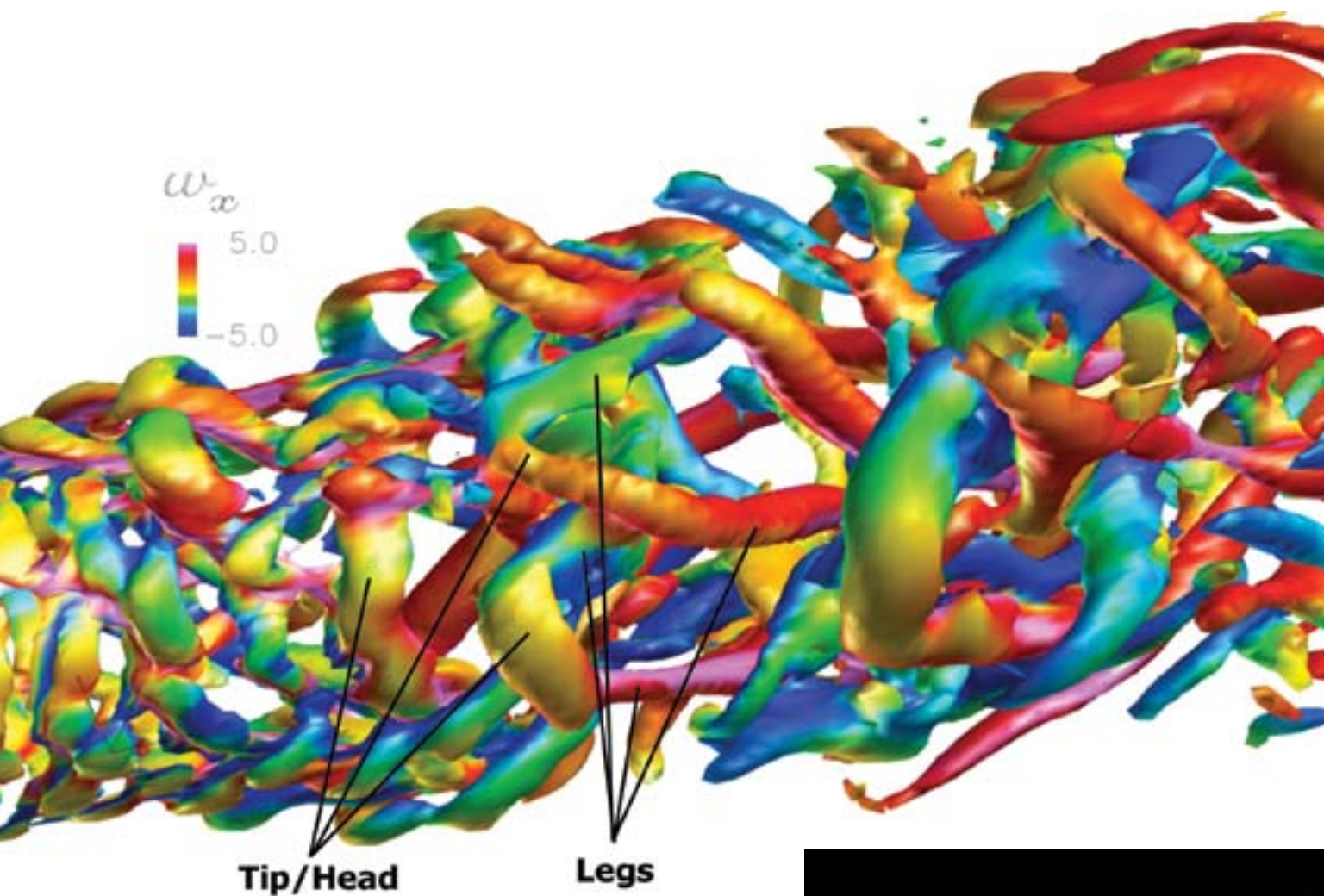
The thesis work of recent Ohio State graduate Christopher Jaworski (PhD ME), who was advised by Professor Heremans, was published in the prestigious journal Nature, and featured on the cover of the July 12, 2012 issue: Jaworski, R. C. Myers, E. Johnston-Halperin & J. P. Heremans, Giant Spin-Seebeck effect in a non-magnetic material, Nature, volume 487, pp 210-213 (2012)

The Giant Spin-Seebeck Effect

As 97 percent of the world's energy comes from thermal processes, new designs and materials that can convert waste heat into electrical power can help mitigate global climate change. Because large power plants are already very efficient, mobile applications for waste heat recovery constitute the "low-hanging fruit": indeed, smaller heat engines are generally less efficient than large ones, and the heat they reject comes at a higher temperature. Solid-state energy conversion technologies, such as thermoelectric systems, are particularly suited to mobile waste heat recovery because they have no moving parts, have an essentially infinite lifetime, and require no maintenance. Their most important advantage is their very high specific power, so that they can be built lightweight and compact. Unfortunately, the thermal efficiency of thermoelectric heat cycles is limited by the condition that the same material must have simultaneously a high electrical conductivity, a low thermal conductivity, and a high thermoelectric power (also known as Seebeck coefficient). At The Ohio State University, Professors Joseph Heremans (mechanical engineering) and Roberto Myers (materials science engineering) have pioneered a new approach: the spin-Seebeck effect is similar to the conventional thermoelectric power, but it involves two different materials that can be optimized separately.

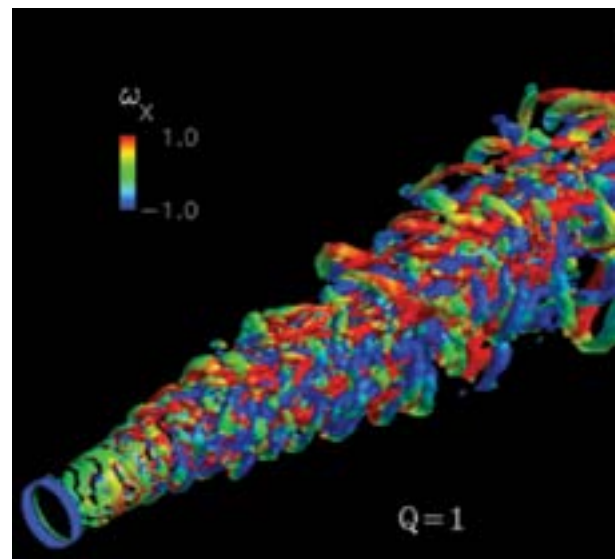
The spin-Seebeck effect is due to perturbations of magnetic ordering in a ferromagnet subjected to an applied temperature gradient. As these perturbations return to thermal equilibrium, they emit spin waves that are transmitted into an adjacent non-magnetic material (typically platinum, but tungsten could also be used). Here, the spin waves are converted into a voltage by another phenomenon known as the spin-Hall effect. First discovered using thin permalloy films in 2008 by the research group of E. Saitoh at Tohoku University in Sendai, Japan, the effect has since been observed on ferromagnetic insulators, and, at Ohio State, on magnetic semiconductors. The effect is small (on the order of $\leq 1 \mu\text{V K}^{-1}$) in ferromagnets. This year, a giant spin-Seebeck effect has been observed at cryogenic temperatures in a bulk non-magnetic semiconductor, InSb, where it reaches values ($\sim 8 \text{ mV K}^{-1}$) comparable to the highest classical thermopower.

The conduction electrons in InSb, when subject to a quantizing magnetic field at low temperature, are split by the Zeeman effect into spin-polarized spin-up and spin-down levels. Applying a temperature gradient to those creates a strong out-of-equilibrium distribution of electrons between these two levels by a combination of phonon-drag and strong spin-orbit interactions in InSb itself. Although such effect has so far only been observed at cryogenic temperatures, we suggest that the spin-Seebeck effect opens the way to a new class of spin-thermal energy converters, which, with much future research, may prove superior to classical thermoelectric heat cycles. In particular, the 8 mV K^{-1} mentioned above arises across a platinum bar which has high electrical conductivity. The device can therefore generate a much higher specific power than a conventional thermoelectric device, where the voltage is generated in a much less conductive semiconductor.



The highly resolved simulations show the existence of hairpin-like vortices

A jet generates noise through coherent structures of different sizes, strengths and longevity



Using Supercomputers to Study Jet Noise

The noise produced by commercial and military aircraft has many human and financial consequences. For example, people living near airports and military personnel who are required to spend large amounts of time near powerful and loud jet engines often suffer temporary or permanent damage to hearing. Although it is well known that flow turbulence has a direct influence on jet noise, the precise mechanism by which the flow energy is converted to noise is poorly understood. Researchers working in the High Fidelity Computational Multi-Physics Laboratory (HFCMPL) of the mechanical and aerospace engineering department are using supercomputers operated by the Department of Defense High Performance Computing Modernization Program (HPCMP) as well as the Ohio Supercomputer Center to understand the complex chaotic flow generated by jets. The simulations employ up to a thousand processors simultaneously to solve the non-linear governing equations (Navier-Stokes) with Large Eddy Simulations (LES). The results generate terabytes of data that are first validated by comparison to available experimental data and then analyzed to provide insights that are difficult if not impossible through physical experimentation alone.

One of the major findings of recent work has been the detection and detailed elucidation of hairpin-like vortices. This finding unifies turbulence in jets with that of in boundary layers, bringing an extensive knowledge derived in the latter field to enlighten the former. In the jet, these characteristic entities are responsible for entrainment and spreading of the jet, and also appear to be key features in noise generation, since the initiation of disturbances occurs here. Professor Datta Gaitonde and other researchers at Ohio State have also analyzed control techniques being tested at the

Aeronautical and Astronautical Research Lab using plasma actuators to inject small carefully tailored disturbances. Visualization of the simulations with advanced post-processing techniques reveals a rich variety of structures. By suitably changing the actuator strike sequence and frequency, new types of features, including rollers, "ribs", non-linearly interacting vortex rings and intertwined helices appear. These in turn enhance the near field pressure but can be inhibited by changing the frequency of the actuators. The success of these simulations has now brought the HFCMPL to the brink of innovative approaches to understanding noise synthesis. In particular, present and near future efforts will allow researchers to arbitrarily introduce disturbances of certain "colors" and track them through the turbulent flow, providing a clear understanding of how turbulent stresses filter the disturbance into the observed sound field. This in turn will provide clear and intelligently derived criteria for control techniques and trigger engineering successes to develop the next generation of quiet jet engines. The research has been funded by grants from the Air Force Office of Scientific Research. About six million supercomputing hours have been awarded by the Department of Defense High-Performance Computing Modernization Program and the Ohio Supercomputer Center for the research.

Testing Strain Rates is Priority of Mechanics of Materials Lab

The Mechanics of Materials Lab, led by Professor Amos Gilat, deals with the study of the deformation and failure of materials over a wide range of strain rates (with emphasis on high rates) at various temperatures and loading conditions. The lab is equipped with state-of-the-art testing machines and instrumentation for mechanical testing of materials in compression, tension, and shear loadings at strain rates ranging from 0.0001 to $10,000 \text{ s}^{-1}$ and temperatures from -150° to 1000°C . Quasi-static tests (strain rate up to 2 s^{-1}) are done with a hydraulic axial/torsional machine. High strain rate tests (strain rates from 400 to $10,000 \text{ s}^{-1}$) are done by using the Split Hopkinson Bar (SHB) technique. Intermediate strain rate tests (strain rates from 5 to 200 s^{-1}) are done with a new testing machine that provides accurate results (no ringing).

In addition to the standard methods for measuring forces (moments) and deformations (strains), the lab has two commercial Digital Image Correlation (DIC) systems that are used for measuring the full-field strain distribution on the specimen's surface as a function of time during most of the experiments (including high strain rate tests). DIC measurements provide accurate description of the state of stress and strain in the specimen, and especially the local failure strain at the location where the specimen breaks.

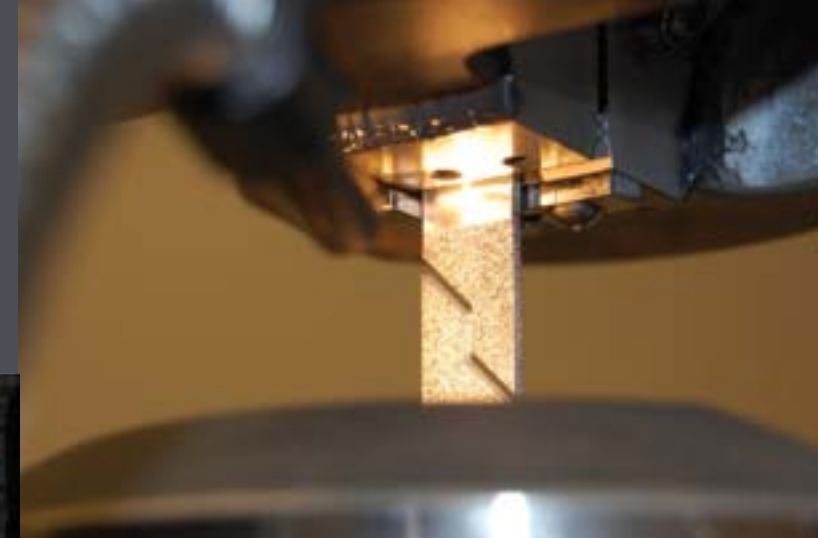
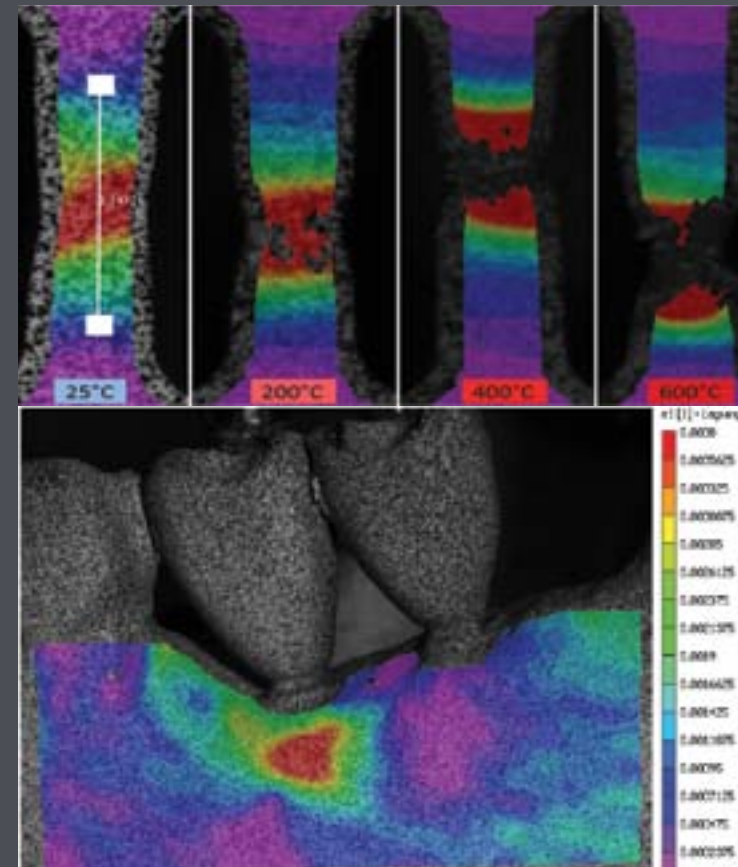
During the past 30 years the lab has been used for characterizing the deformation and failure of metals, polymers, ceramics, composites, foams, cloths, and other materials in numerous government and industrial projects. Often, the data is used for developing accurate constitutive equations for plasticity (viscoplasticity) and failure models that are implemented in numerical codes such as LS DYNA and ABAQUS.

Data during testing is recorded with state-of-the-art electronic digital data acquisition systems. Deliverables from each test are raw data records (loads cell, displacement, strain, temperature, etc.), and processed data (e.g. stress-strain curve from a SHB test). All results are provided in plots and in digital form (Excel spread sheets) such that they can be incorporated into the numerical codes.

An example of a current project is the development of MAT224 in LS-DYNA in which over 300 experiments have been conducted on specimens (all machined from the same 2024 aluminum plate) loaded with a wide range of stress states. These experiments included:

- Uniaxial tension and compression, and pure shear, all at various strain rates ranging from 0.0001 to 5000 s^{-1}
- Tensile tests of flat and round notched (various size notches) specimens.
- Plane strain tests of wide flat and notched (various size notches) specimens.
- Combined biaxial tension-torsion of tubular specimens.
- Dynamic and quasi-static punch tests of thin-flat plates with punches of different geometries.
- Uniaxial tension and compression, and pure shear tests at constant strain rate and various temperatures ranging from -50°C to 450°C .

Pictured are various material testing equipment and full-field strain measurements obtained by Digital Image Correlation.



Experimental Mechanics is Helping to Design Solid Oxide Fuel Cell Components

With their high efficiency and low emissions, solid oxide fuel cells (SOFCs) have the potential to radically alter the production and distribution of electricity. The majority of SOFC developers are targeting systems that operate at temperatures of 700-850°C, a range that enjoys several advantages over other fuel cell types. However, these high temperatures also pose several challenges related to materials and materials failure.

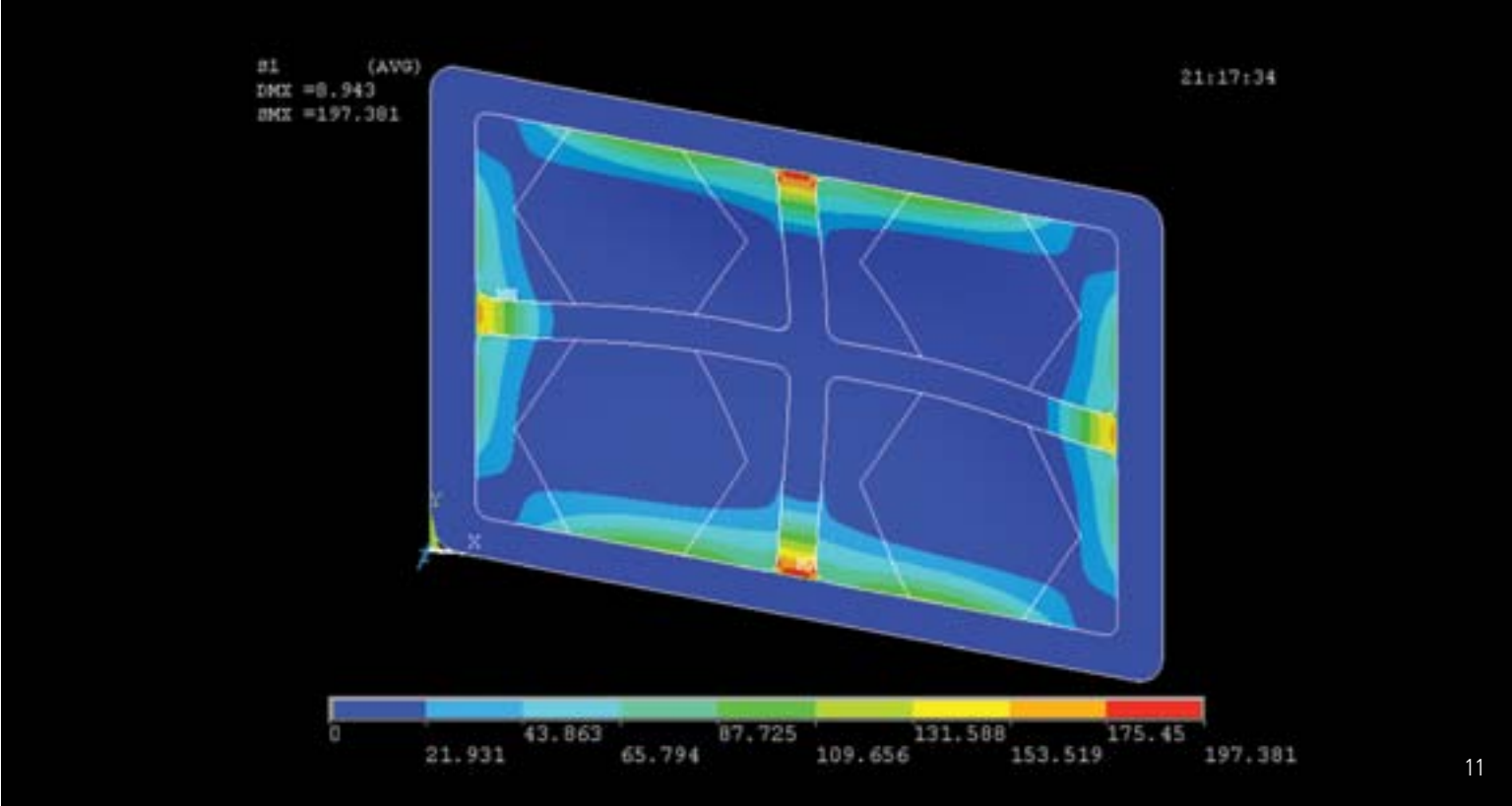
The building-blocks of an SOFC stack are thin, multi-layer ceramic oxide electrolytes, porous cermet composite electrodes, expanded metal spacers, and oxide-coated stainless steel interconnects. Glass or composite/glass seals serve as electrical insulators as well as barriers to gas flow. These SOFC component materials have been traditionally selected for their electrochemical properties, cost, and ease of manufacturing. More recently it has been recognized that the loads needed to hold everything together and the thermal stresses associated with thermal expansion differences are causing unacceptable performance losses during operation and with on-off cycling.

In collaboration with NexTech Materials Ltd. and with funding from the National Science Foundation and the Ohio Department of Development, the students in Associate Professor Mark Walter's

Experimental Mechanics of Materials Laboratory have been testing various SOFC components. Temperature-dependent material properties have been determined for the thin ceramic electrolytes, ceramic/glass composite seals, and compliant metal spacers. These properties are measured with sonic resonance methods and with instrumented compression, tension, and bending experiments. The properties are used in finite element models of stack assemblies. For example, the illustration (opposite, bottom) shows how stresses develop in electrolyte membranes with ribs that provide mechanical support. Additional experiments have been performed to characterize the interface toughness between the anode and electrolyte and between oxide coatings and stainless steel interconnects. Many of the experiments use acoustic emission sensors to monitor when sub-critical damage occurs during the loading processes.

The results of these experiments have led to design changes in components built by NexTech Materials. This work is helping to make commercially viable SOFCs a near-term possibility.

PhD candidate Ryan Berke compares damage in representative SOFC electrolyte samples (top) with first principal stresses predicted in finite element model (bottom).



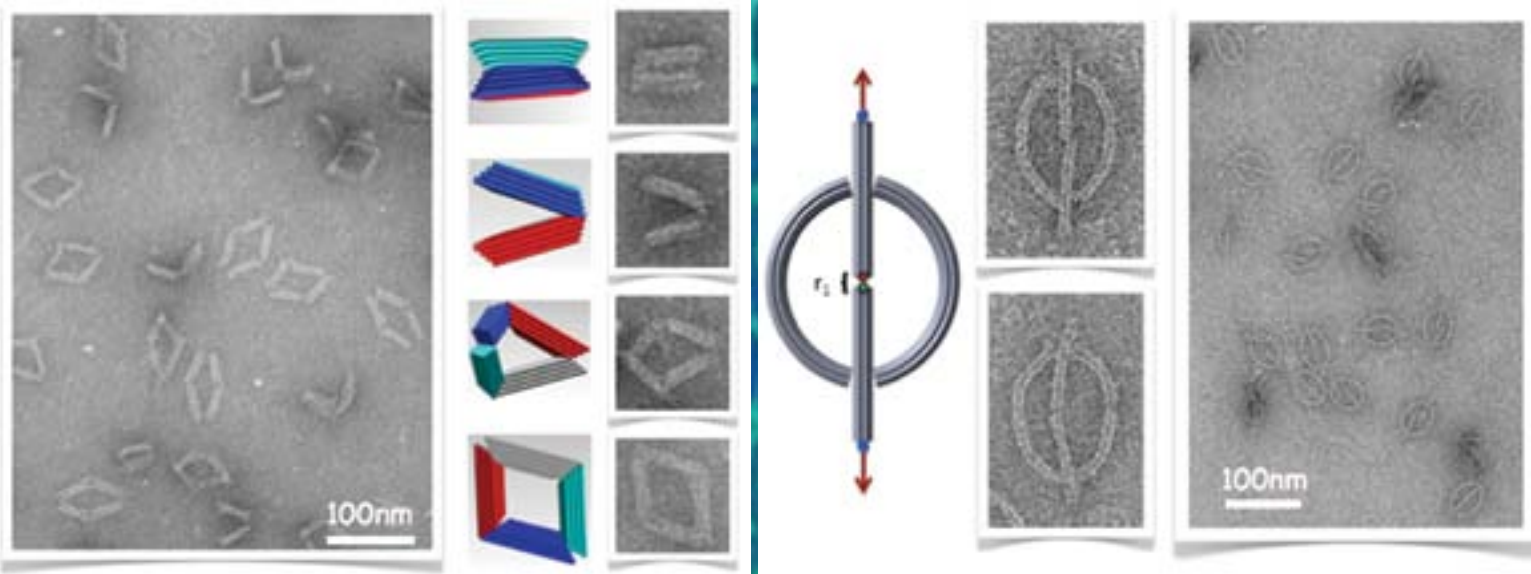
Engineering at the Nanoscale with DNA Self Assembly

The National Science Foundation recently awarded The Ohio State University two research grants totaling \$575,000 to create novel nanoscale engineering devices using a recently developed biomolecular nanotechnology termed DNA origami. DNA origami is an approach that enables the fabrication of three-dimensional objects with unprecedented geometric complexity on the scale of 10-100nm via molecular self-assembly. This technology has opened new pathways for achieving engineering functionality at the molecular scale. An Ohio State research team led by Carlos Castro, an Assistant Professor in the Department of Mechanical and Aerospace Engineering, is using this technology to design, prototype, and implement novel nanoscale devices and machines to probe the physical properties of molecular and cellular systems.

Despite having demonstrated great promise for fabrication of nanoscale objects including gears, containers, tubes, and even smiley faces, currently the engineering functionality of DNA origami structures is limited owing to a lack of controlled moving parts. The vast majority of DNA origami research to date has utilized static structures. In a collaborative effort with Haijun Su, also an assistant professor of mechanical engineering at Ohio State, Castro’s research lab is developing a framework to integrate controlled moving parts into DNA origami design for the assembly of nanoscale machines and mechanisms. Resembling the concept of links and joints in macro scale kinematic design, this work will create DNA Origami Mechanisms and Machines (DOMM) that are comprised of multiple links connected by joints. These joints are designed to function similar to their macroscopic

counterparts (i.e. hinges, spherical joints, prismatic joints) by strategic placement of flexible (single-stranded DNA) and stiff (double-stranded DNA) domains. These DOMM together with nanoactuators, nanosensors and controllers will enable design of future nanorobots that can be applied to numerous fields ranging from self-assembling computers and chemical compounds to autonomous medical robots for drug delivery.

Other projects in Castro’s Nanoengineering and Biodesign Lab seek to develop devices to probe the physical interactions used by biological cells to navigate and communicate with their local environment. Cells generate internal pushing and pulling forces that are transmitted to the external environment via cell-substrate attachment points made by adhesion molecules embedded in the cell membrane. Individual adhesion molecules are only capable of transmitting forces on the scale of 10-100 picoNewtons. However, current methods to measure these forces can only achieve nanoNewton resolution, and therefore can only capture the effective behavior of large collections of these adhesion molecules. Castro’s lab is developing a single molecule force sensor constructed from DNA origami to directly measure the picoNewton scale forces transmitted by individual cellular adhesion molecules. This approach will capture a new regime of biophysical behavior and will reveal valuable insight into the molecular mechanisms that drive processes such as wound healing and cancer metastasis.



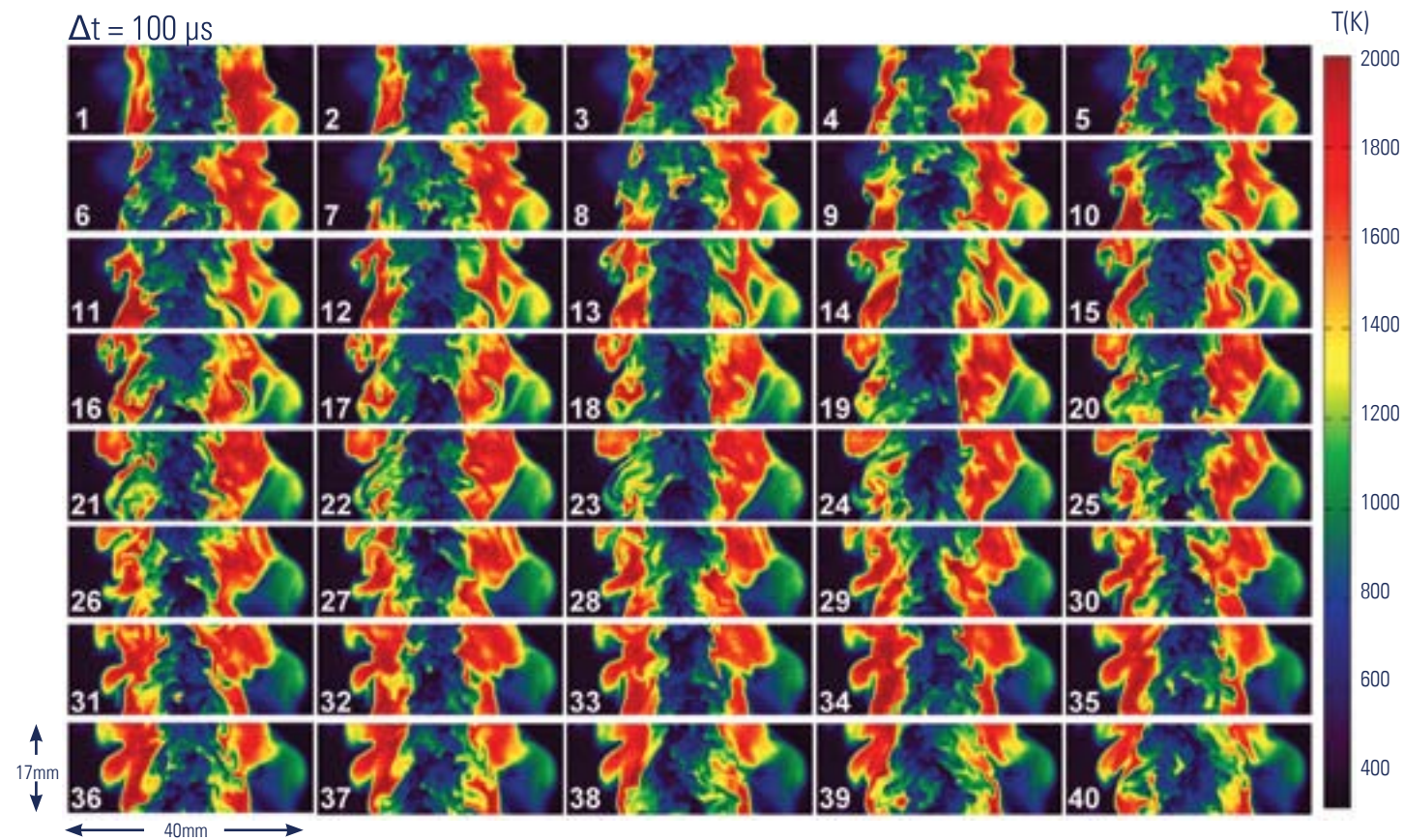
Nanoscale 4-bar Linkage Mechanism

Molecular Force Sensor

A nanoscale DNA 4-bar linkage prototype mechanism has been assembled in Dr. Castro’s lab. This linkage translates between a closed bundle and open frame configuration with a specific kinematic motion path. (right) Researchers within the Nanoengineering and Biodesign Lab have developed a molecular force sensor that incorporates curved DNA origami bundles that function similar to macroscopic leaf springs. This sensor will be implemented to measure the physical interactions of biological cells with their local environments during processes such as wound healing and cancer metastasis.



Novel laser system (HEPBLS) used to investigate turbulent combustion dynamics



This work has been sponsored by the National Science Foundation and the Air Force Office of Scientific Research. The research team consists of Assistant Professor Jeffrey Sutton; graduate students Michael Papageorge, Thomas McManus, and Kathryn Gabet; and post-doctoral researcher, Frederik Fuest.

High-Speed Imaging of Turbulent Combustion Dynamics

Turbulent combustion processes currently account for the majority of the world’s energy usage with applications ranging from power generation to transportation to industrial processing. In recent years, the push for advancements in combustion systems that can simultaneously increase efficiency and decrease harmful emissions has become an international priority. However, rapid advancements are quite challenging due to the complex nature of the turbulent flows and chemical reactions that comprise the combustion environments found in modern energy-conversion systems. As one example, the chemistry and the fluid mechanics change on very short timescales can range from nanoseconds to milliseconds (1/1,000,000,000 to 1/1,000 of a second). In order to understand the governing physics and chemistry, new tools are needed that capture detailed aspects of the turbulent flowfield and chemically-active molecules in “real time”.

Recently, researchers at Ohio State developed a new laser system that provides a burst of hundreds to thousands of high-energy laser pulses suitable for non-intrusive laser diagnostics within combustion systems at acquisition rates of more than 10,000 images per second (Opt. Lett. 2012, 37, p.3231). The high-energy pulse burst laser system (HEPBLS) achieves unprecedented performance with burst sequences that equal or exceed previous systems with more than 15 times higher output energies. Such high energy levels enable a broad range of two- and three-dimensional measurement capabilities of velocity, temperature, and active combustion species that were not previously possible at ultra-high recording rates

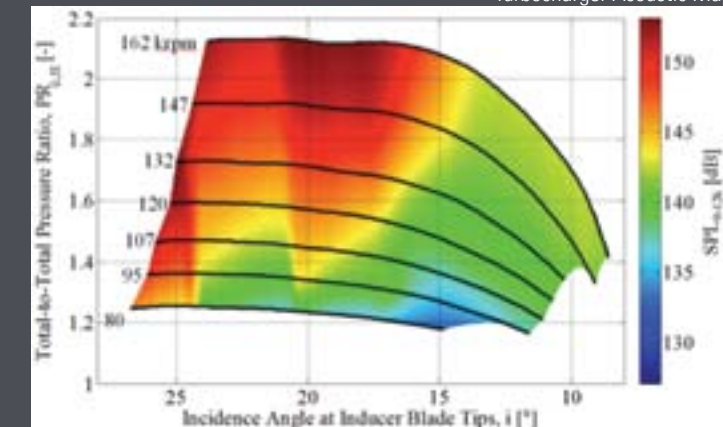
Over the past four years, Ohio State researchers, led by Assistant Professor Jeffrey Sutton, have focused on experimentally investigating the dynamic interaction between turbulence, reactive species transport, and reaction rates in turbulent flames. In many cases, Sutton and his group have developed and applied new high-speed imaging diagnostics in turbulent combustion environments for the first time. Using the advanced HEPBLS and high-framing rate cameras, Sutton and his group acquire hundreds of sequential snapshots of turbulent reacting flow physics in less than one-one hundredth of the time it takes an average person to blink. An example of a recently-recorded temperature sequence obtained within a highly turbulent non-premixed flame is shown on the page opposite. From the images, new features such as the formation of “flame holes” (cold gas pockets surrounded by hot gas) and the upstream propagation of a high-temperature reaction zone are clearly seen, showing the time-varying (dynamic) nature of thermal mixing and the introduction of steep thermal gradients, which lead to higher levels of pollutant output. Image sequences, such as these, are providing a new understanding of the flame dynamics that govern combustion system performance.

Instabilities in Turbochargers

Downsized and turbocharged spark-ignition engines are embraced in recent years by auto makers to simultaneously deliver fuel economy and performance. While benefiting from the recovery of exhaust gas enthalpy toward improving the fuel conversion efficiency of the engine, contemporary turbochargers are also pushing the boundaries by requiring the centrifugal compressors to efficiently deliver increasingly elevated levels of boost pressure over extended flow ranges. Professor Ahmet Selamet and his team at The Ohio State University's Center for Automotive Research are conducting fundamental turbocharger research to understand and model the compression system instabilities (surge), which currently limit compressor operation at low flow rates – a range crucial for engines. Another current research effort is aimed at characterizing the source of broadband flow noise, which is encountered when centrifugal compressors operate under unfavorable (separated) flow conditions. The discoveries from the present research are providing valuable insight into the complex compressor flow-field behavior and advancing the predictive capabilities for turbochargers in engine simulation tools.

Thanks in part to contributions from Ford Motor Company, the recently developed turbocharger laboratory contains a novel bench-top experimental facility, which was designed in-house to perform detailed studies of the compressor flow-field in isolation from the wave dynamics in engine breathing system. This unique facility offers precise flow control, allowing for steady-state performance and acoustic mapping of compressors and turbines with a level of detail not achieved to date. More importantly, time-resolved internal pressure and temperature measurements have shed new light into the dynamics of compressor flow-field breakdown under adverse pressure gradients, resulting in flow separation and noise generation. Eventually, separation degrades pressure rise to the

Turbocharger Acoustic Map



point where the compression system becomes unstable and couples with the connected geometry to produce large-scale fluctuations of mass flow rate and pressure. Meticulous experimental techniques and extensive development in the treatment of compressors in engine simulation codes have allowed the team to lead the modeling of surge in centrifugal compression systems, through research funded by BorgWarner Inc.

With the knowledge acquired from experimental work in the turbocharger facility, the team continues to explore numerous techniques to mitigate broadband compressor flow noise at the source and extend the stable operating range of compressors. The progress achieved in their surge prediction capability now allows the extension from the bench-top setup to the newly installed twin-turbocharged Ford 3.5L V6 TiVCT GTDI engine, which is currently being instrumented for time-resolved breathing system measurements to further the understanding of instabilities with engines.



Instrumented Turbocharger



Ford 3.5L V6 TiVCT GTDI Engine

Electrochemical Characterization and Modeling of Advanced Li-ion Batteries

Lithium-ion batteries are an integral part of the vehicle electrification process that the automotive industry is pursuing to improve the energy efficiency of passenger cars. Significant research efforts are today dedicated to improving the state of the art in Li-ion batteries, ranging from advanced cathode and anode materials, to the development of a fundamental understanding of the aging processes leading to capacity and power fade. The Ohio State University is leading in the area of advanced battery technologies, fostering diverse, multi-disciplinary research initiatives.

Assistant Professor Marcello Canova is developing a research program on advanced electrochemical energy storage systems that connects the fundamental characterization of cell components and materials to the system-level analysis and modeling, with focus on performance, life and aging characterization. Central to this activity is the new Battery Prototyping and Characterization Laboratory, which complements the testing facilities at Ohio State's Center for Automotive Research (CAR) by characterizing the physical and electrochemical properties of cathode and anode materials and for Li-ion cells and evaluating their influence on the performance and durability of batteries for hybrid and electric vehicles.

The laboratory includes equipment for fabrication and testing of prototype coin cells, which includes a MBraun LABstar glovebox, a Gamry Reference 600 Potentiostat and a high precision THT Isothermal Battery Calorimeter connected to a programmable load and supply. This equipment is used to conduct electrochemical and thermal analysis of Li-ion battery materials, characterizing the open-circuit potential and capacity, cell electrical dynamics and efficiency of cathodes and anodes, gaining insights on the electrochemical and physical processes occurring during charging and discharging operations.

The activity feeds the development of first-principles electrochemical models, which predict the cell terminal voltage and state of charge starting from a physical description of the charge and mass transport phenomena. Analytical model-order reduction methods are then used to produce computationally efficient models that are used to solve important control problems in Li-ion battery systems, such as "state of charge" and "state of health" estimation, or charge and thermal management in battery packs. Another important aspect of this research is the ability to convert system-level degradation data into physical parameter trends, providing valuable insight towards the development of mechanistic aging models.

The research program developed by Canova is highly synergistic with the on-going activities at CAR, oriented to the system-level optimization and control of advanced energy storage systems, and is integral to large programs such as the US-China Clean Energy Research Center – Clean Vehicles Consortium. At the same time, on-going collaborations with research groups in material science, chemistry and nuclear engineering allow for exploring exciting research opportunities bridging the fundamental physiochemical studies on Li-ion bettery materials to the system-level modeling, and optimization and control problems in the field of advanced energy storage systems for automotive applications.



Example of fabricated coin cell for half-cell experiments.



Chamber of the calorimeter, used for thermal and electrical test of battery coin cell.

Fluid-Thermal-Structural Interactions

A long sought after aerospace capability is sustained flight at hypersonic conditions, which can be characterized as starting around four times the speed of sound. Such a capability is desired for more efficient access to space, as well as reducing trans-global flight times to a few hours. However, there are a litany of well-documented technical challenges and knowledge gaps that have prevented the development of this type of aerospace vehicle.

The structural system in particular has prevented significant growth of the technology. This is due to the need to withstand simultaneous action of severe fluctuating pressure and thermal loads, while also remaining light weight enough for sustained flight, and durable enough for reusability. These characteristics provide the ingredients for challenging and exciting research problems on multi-scale, multi-physics interactions between the environment, structure, and materials of the vehicle. The problem is especially formidable since these interactions are dependent on the operational history of the system. In other words, the structural characteristics evolve continuously due to the action of environmental loads, temperature dependence in material properties and the accumulation of damage. At the same time, the environment's action on the structure is dependent on both the mission and on changes to the structural characteristics (as a structure deflects and gets hotter, the flow field around it changes). This creates an extremely arduous complication where fluid-thermal-structural interactions must be sequentially tracked over the operational life of a vehicle. Compounding this is the fact that these interactions at flight conditions cannot be replicated in ground-based facilities.

The CAEL (Computational AeroElasticity Laboratory), directed by Associate Professor Jack McNamara, is seeking to enable sustained hypersonic flight platforms by tackling these broad research challenges. One important area of research is characterizing the strength and type of energy transfer mechanisms between the fluid and the solid. Another is the development of novel model reduction and coupling reduction strategies to enable multi-scale analysis over long durations. The first seeks to leverage sophisticated mathematical techniques to extract the most important features of a physical system. The second seeks to establish only the most relevant physical interconnections at the most appropriate time intervals. Understanding the flow physics within the boundary layer is a critical consideration in high-speed flows since it enables prediction, and control, of the heat and pressure loads. In this area, the CAEL is focused on assessing how boundary layer stability and induced loads interact with a thermo-mechanically compliant surface. Related to this is an effort to understand and model the long duration response of surface panels to shock-boundary layer interactions

Research at the CAEL on hypersonic fluid-thermal-structural interactions is supported by the Air Force Office of Scientific Research, the Air Force Research Laboratory, the U.S. Department of Defense, NASA, the Dayton Area Graduate Studies Institute, and the Ohio Supercomputing Center.



Artist Graham Warwick's rendition of the FALCON (Force Application Launch CONus) hypersonic cruise vehicle.

Wang Receives NSF CAREER Award



Assistant Professor Junmin Wang has received a prestigious 2012 National Science Foundation (NSF) Faculty Early Career Development (CAREER) Program award. The five-year, \$400,000 award aids Wang's research for "Integrated Estimation and Control of Over-Actuated Electric Lightweight Vehicles (LWV) for Safe and Sustainable Mobility." Wang's award is funded by the NSF Division of Civil, Mechanical, and Manufacturing Innovation. The research has the potential to dramatically improve the safety of LWVs and thus further enable their widespread popularization, which, in-turn, could positively impact energy and environmental (including greenhouse gas) concerns in the nation's transportation sector. In addition, the research could further advance the current control of other over-actuated systems such as aerospace, robotic, and biomedical systems.

Heremans Named AAAS Fellow



Department of Mechanical and Aerospace Engineering Professor and Ohio Eminent Scholar Joseph Heremans was elected a Fellow of the American Association for the Advancement of Science (AAAS) for his distinguished contributions to the field of thermal engineering, specifically the development of high-efficiency thermoelectric materials and the discovery of thermal spin-polarization in semiconductors. He and 19 other Ohio State faculty members, who were elected as AAAS Fellows, were recognized at the annual AAAS this past February.

The AAAS Fellow recognition is bestowed on individuals who have been nominated by peers, in the same academic discipline, for their meritorious efforts to advance science or its applications. Ohio State has now achieved a decade of leadership in election of AAAS Fellows.

Four ME Faculty Receive NSF Grants



Assistant Professor Haijun Su has been awarded a three-year grant of over \$300,000 to develop a set of tools for designing high precision flexure mechanisms. The award is funded through the National Science Foundation’s Division of Civil, Mechanical, and Manufacturing Innovation. The goal of the research is to speed up the innovative design process and shorten the research and development cycle of devices such as nanopositioners, nanomanipulators, and MEMS scanning mirrors.

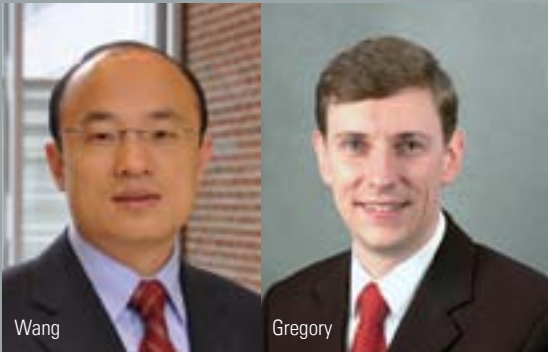
Assistant Professors Carlos Castro and Haijun Su have received a three-year grant of \$400,000 from the National Science Foundation (NSF), for the project entitled “Design of DNA Origami Machines and Mechanisms.” Castro, who is named the principal investigator, and co-investigator Su, expect their research to facilitate future application of DNA origami machines. As part of the project, a computer aided design and simulation program will be developed that facilitates conceptual mechanism design and automates the integration of DNA origami links and joints.

Assistant Professor Marcello Canova and Electrical and Computer Engineering Associate Professor Andrea Serrani have received a NSF award for research that may lead to better fuel economy and emissions control while shortening the development and integration of new engine technologies. Their research project, funded in the amount of \$239,801 through the NSF Division of Civil, Mechanical, and Manufacturing Innovation, is entitled, “Control of Over-Actuated Nonlinear Systems with Application to High-Efficiency Internal Combustion Engines.”

Associate Professor Sandip Mazumder has received a three-year NSF grant of \$400,000 for the project entitled “Large-Scale Computation of the Phonon Boltzmann Transport Equation.” His research will be conducted in collaboration with Ohio State’s Computer Science and Engineering Professor Ponnuswamy Sadayappan, who is the co-principal investigator.

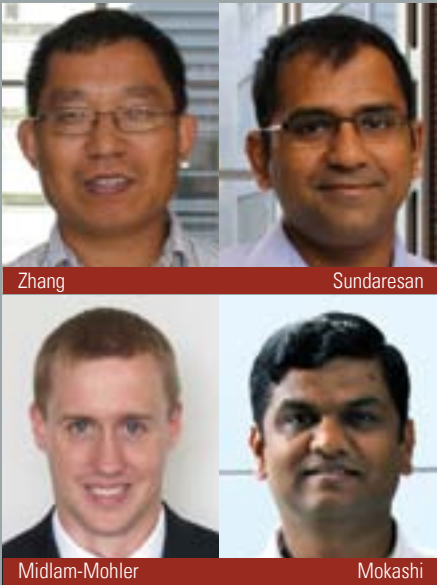
Wang and Gregory Receive SAE Ralph R. Teetor Educational Awards

Assistant Professors Junmin Wang and James Gregory are both recipients of the 2012 SAE Ralph R. Teetor Educational Award. The honor was made in recognition of their outstanding contributions to SAE’s engineering education initiatives.



In conveying the award, SAE representatives relayed to Gregory and Wang that the credentials and standards of excellence in education of this year’s candidates were extremely high and competition was keen. In addition, each was praised for his outstanding contributions as one of the top engineering educators. The awards were presented at the April 2012 SAE World Congress. Earlier this year, Wang also received a prestigious 2012 National Science Foundation (NSF) Faculty Early Career Development (CAREER) Program award. And in October of 2011, Gregory was notified of his inclusion in the Army Research Office’s Young Investigator Program.

New Faculty Join Department



Associate Professors Jinsuo Zhang and Vishnu Sundaresan joined the Department of Mechanical and Aerospace Engineering this fall. Zhang, who joined the Nuclear Engineering Program faculty, comes to Ohio State from the Los Alamos National Laboratory (LANL). He received his PhD from Zhejiang University in China and began working at LANL in 2005. His research interests include nuclear reactor materials, advanced nuclear reactor design, advanced fuel cycle technology, nuclear coolant/ material interactions, material degradation, and risk/failure analysis.

Sundaresan was previously a ME faculty member at Virginia Commonwealth University and prior to that served as a research scientist at Virginia Tech, where he earned his PhD. In 2011, he received a National Science Foundation CAREER award from the NSF’s Civil, Mechanical, and Manufacturing Innovation, Sensors and Sensing Systems Division for research in Ionic Transistor Devices for Sensing and Controlled Actuation .

In addition, the department has added two assistant professors of practice. Shawn Midlam-Mohler and Prasad Mokashi began instructing ME classes this fall. Midlam-Mohler is also an Associate Fellow at Ohio State’s Center for Automotive Research and Mokashi had been a lecturer for the department.



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