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BEFORE THE
U.S. SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES**

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Chairwoman Murkowski, Ranking Member Cantwell and members of the Committee, I would like to thank you for the opportunity to speak about the transformational innovations occurring in advanced manufacturing at The Ohio State University and at universities nationwide. At the outset, I would like to thank Ohio Senator Rob Portman, a member of this committee, for his support and leadership on U.S. innovation. Just last week he convened leaders from academia, industry, and regional economic development agencies to discuss transportation and mobility innovation, and its importance to Ohio's and the nation's economy. We are fortunate to have Senator Portman, along with Senator Sherrod Brown, representing the Buckeye state in the United States Senate.

Innovation in the manufacturing sector is vital to maintaining U.S. leadership in the global economy and sparking continued economic growth in states like Ohio, Michigan and others battling back from the Great Recession.

As the largest industry sector in the state of Ohio, accounting for 17% of the state's GDP, manufacturing is critical to Ohio's economy and future growth. The manufacturing sector contributes over \$2 trillion to the U.S. economy and supports an estimated 18.5 million jobs, which is about one in six private-sector jobs. Manufacturing also accounts for a substantial amount of our nation's energy consumption. We use 25% of our energy in industrial processes and production, and another 27% to move people and goods.

The advanced manufacturing and materials research occurring at U.S. research universities builds the foundation for the cutting-edge technologies needed to ensure that American companies can efficiently produce goods, while minimizing impact to the environment, natural resource use and energy consumption. U.S. universities, including Ohio State, are global leaders in raw innovation, risk taking, IP production and talent creation. Universities play a catalyzing role in America's manufacturing resurgence, though we would be unable to carry out this critical work without a robust and sustainable investment from the federal government.

My testimony today will highlight the strides we are making in Ohio and across the nation in advanced manufacturing, fueled by public and private investment. I hope these examples of research and workforce development demonstrate the ability to leverage public investments in a commonsense manner to support innovation and economic growth both in our local communities and across the nation.

The National Network for Manufacturing Innovation

A powerful example of federal investment supporting U.S. growth of advanced manufacturing technologies and jobs is the National Network of Manufacturing Innovation, or NNMI. Ohio State faculty play an integral role in three of the eight current NNMI hubs, which bring together the federal government, U.S. industrial partners, venture capitalists, universities, and nonprofits across multiple states. I would like to thank this committee and your colleagues for your ongoing support of the NNMI. Please allow me to speak about the one I know best, the Lightweight Innovations for Tomorrow, or LIFT.

Ohio State, along with Columbus-based EWI and the University of Michigan, are co-founders of LIFT, which is a \$148 million high-tech national manufacturing consortium comprised of industry, universities and nonprofits. LIFT, which is based in Detroit and led by Executive Director Lawrence E. Brown, is expected to create 10,000 new jobs in the Midwest over the next five years while driving innovation and growth for a rapidly expanding lightweight materials industry. LIFT has initiated projects that are driven by industry needs and that engage some of the world's leading academic researchers to address those needs. The project selection process is driven by a rigorous planning and prioritization review to ensure that U.S. taxpayer dollars are invested prudently in the most important and broadly applicable industry needs.

One recently announced LIFT project is a joint aerospace collaboration with The Ohio State University and GE Aviation demonstrating the fact that public/private collaboration speeds up the solution process in advanced manufacturing. The GE Aviation-Ohio State project uses computer analytics to design and then to virtually test titanium's performance in aircraft engines in *silico* rather than in *vitro*. The advantage is that titanium, an expensive alloy, can be produced and thoroughly tested without cycling through a lengthy and expensive trial and error process of building, then breaking, a large number of test parts. This computer-based testing lowers cost and speeds up the design and manufacturing timetable, bringing new products to market faster and with lower design costs, thereby improving U.S. competitiveness in a global market. I think you would agree that this is a wise use of public dollars.

Beyond federal investment

As you well know, federal agencies support the bulk of basic or early stage research at U.S. universities and federal labs. You will be pleased to know that while federal funding is vital to our R&D efforts, universities also develop alternative funding streams through our own research investments and through industry partnerships to meet the needs of specific sectors.

For example, Ohio State established the Center for Design and Manufacturing Excellence (CDME) after determining industry needs for a product and process innovation center. CDME provides industry with a simple, expeditious way to access the vast array of intellectual research and physical assets of the university and surrounding research community. Building upon our success in standing up this center with university

investment, CDME was awarded \$6.8 million from the U.S. Department of Commerce and Department of Defense to foster economic stability and growth in Ohio by advancing the global competitiveness of existing defense and commercial manufacturing companies.

Ohio State professor Glenn Daehn and his research team at the Impulse Manufacturing Laboratory developed several new techniques for joining dissimilar materials by utilizing electrical energy from a capacitor bank. Funding from the U.S. Department of Energy and other federal agencies were used to develop the initial concept. Then, by working with CDME, Professor Daehn's team has been contracted by a commercial entity to design an Ultrafast Capacitor for use in a production manufacturing environment.

We have also directly invested heavily in advanced materials and manufacturing under the University's Discovery Themes initiative – a program that focuses on critical societal needs, reflecting Ohio State's mission as a public, urban, land-grant, research university. Each Discovery Theme includes hiring of faculty who will collaborate with existing resident experts across our departments and colleges to address grand challenges. One such grand challenge is the Materials and Manufacturing for Sustainability theme, in which we are hiring thirty new faculty members to accelerate advanced material design and manufacture. We will build on federal investments in the Materials Genome Initiative, whose goal is to accelerate the discovery, manufacture, and deployment of advanced materials in half the time, and at a fraction of the cost, as we currently do. Ohio State's Materials Innovation Greenhouse initiative will house a rapid prototyping and startup incubator on campus that enables materials scientists and engineers at Ohio State to accelerate the transition of their fundamental research results into the manufacture of new materials and to develop new manufacturing processes for joining of these new materials together into structures and products.

Another example of an institutional investment is our Institute for Materials Research (IMR), which was created in 2006 as a campus-wide, multidisciplinary institute that works with Ohio State colleges and departments to facilitate, promote and coordinate research related to the science and engineering of materials. Led by Professor Steve Ringel, IMR has 222 faculty members at seven colleges who participate. IMR is the gateway to materials-allied research and education at Ohio State; and is responsible for the overall development, coordination and advancement of the Materials and Manufacturing for Sustainability (M&MS) Discovery Theme program. IMR Industry Challenge Grants are intended to strengthen new collaborations between university researchers and private industry partners in materials-allied research.

A final example of a critical relationship between the university, federal government and industry comes in the area of corrosion. The annual impact of materials corrosion on the U.S. economy is well into the hundreds of billions of dollars. The State of Ohio, and Ohio State in particular, is the historic home and continues to be a center of excellence in corrosion research. With multi-million dollar/multi-year support from the Department of Defense, a consortium of universities and military academies known as the Technical Corrosion Collaboration (TCC) serves to closely align the research goals of military

corrosion experts with those of university scientists, to address fleet sustainability while simultaneously training the next generation of corrosion engineers.

Workforce Development

To fully capitalize on a revitalized manufacturing sector and the large number of high-quality, in demand jobs it will generate, it is imperative that we have a workforce that is well-trained and prepared to fill these jobs. The LIFT Education & Workforce Development team led by Emily DeRocco has developed a federated model that informs national best practices on advanced manufacturing education career pathways. As part of LIFT education and workforce development efforts, the “LIFT Ohio Means Internships & Co-ops 2.5” initiative at Ohio State engages students in real-world work on advanced lightweight metal alloys, manufacturing technologies and design methods that are integral to advanced manufacturing. Out of the 80 internships, 30 are co-located internships involving students, faculty, and industry partners who work together to solve a specific manufacturing issue or project with defined statement of work with industry-driven deliverables. This industry-focused program also taps community college and technical centers and pilot’s novel approaches to developing the talent supply chain for manufacturers. These co-op and internship assignments develop a well-trained workforce while exciting students about the career opportunities in 21st century advanced manufacturing.

In Columbus, the Ohio State College of Engineering is nationally recognized for its commitment to undergraduate education. Our teaching methods—including practical, hands-on experience through project-based design courses; a focus on providing undergraduate research experiences; and individualized attention to students—have proven to effectively facilitate students' academic and, ultimately, career success.

Our college has also established the Department of Engineering Education (EED) to strengthen our support of undergraduate education and graduate-level research in engineering education as a growing discipline. The EED, led by Professor Monica Cox, advances the engineering profession and enables student success by developing and delivering state-of-the-art, innovative, multidisciplinary engineering courses and programs such as the First-Year Engineering Program, Multidisciplinary Engineering Capstone projects that focus on industry-driven solutions, and an Engineering Science Minor to broaden STEM exposure and understanding for non-engineering students.

Ohio State has a long history in supporting the materials workforce. Our welding engineering program was established in 1948. Currently we offer the only accredited B.S. Welding Engineering degree in the nation, and also have the only Welding Engineering graduate program, with both masters and PhD degrees offered. Materials joining is a critical enabling technology for manufacturing across a broad spectrum of industries, including the automotive, aerospace, defense, power generation, oil & gas, medical products, electronics, and many others. The economic benefit of new, advanced materials is sometimes often limited or delayed because we first need to figure out how to join them to other materials. Federal investments are directly addressing this challenge. A good example is the National Science Foundation support for the Industry/University

Collaborative Research Center (I/UCRC) known as MA2JIC: Manufacturing and Materials Joining Innovation Center. This center seeks to advance the science and technology of materials joining, with a focus on joining of advanced materials. This center is an outstanding example of a successful public-private partnership; federal funds from NSF provide for center administrative operations, and member companies contribute funds that are pooled to address pre-competitive research and technological advances of interest to them. More than 80% of the center's funds come from its over 40-plus members. It is one of the largest and fastest growing I/UCRCs in the nation.

Conclusion

Engagement with industry is the hallmark of our land-grant mission at The Ohio State University and our College of Engineering. Research and development partnerships with major automotive and aerospace companies date back to the 1940s. Industry's reliance on the engineering talent we produce has existed since Ohio State's birth in 1870.

I strongly believe that collaboration with industry is more important today than ever, and the federal government will continue to play an essential role in seeding the fundamental research and fostering this industry-university partnership. Universities are engines of discovery and talent development, and engines need fuel. Federal funding to support and refine fundamental and applied research is that needed fuel, and it catalyzes the innovation pipeline. Growing and sustaining the innovation ecosystem we envision for advanced manufacturing will require concerted efforts across government, industry, and academia.

Federal support for the advancement of manufacturing research at Ohio State and other research universities around the country has provided the U.S. with the critical resources needed to tackle the biggest challenges facing manufacturing companies. Government, universities, and industry must walk hand in hand to ensure the U.S. continues to be a beacon of economic prosperity and the undisputed champion of innovation.

Thank you, again, for this opportunity and I look forward to answering any questions you may have.