

Workshop Report

First Advanced Manufacturing Workshop in the Western United States - Advancing Innovations in Additive, Smart, and Functional Manufacturing

 Memorial Union, Oregon State University

 November 16, 2024

 8:00 AM – 5:15 PM (PST)

Organizers:

Dong Lin - Oregon State University

Karl Haapala - Oregon State University

Devin Roach - Oregon State University

This workshop was supported by the **National Science Foundation** and **Oregon State University**, and hosted at **Oregon State University**, with the goal of building collaboration and research vision for the western U.S. manufacturing community.

Report Date: April 2025

1 Introduction

1.1 Advanced Manufacturing in the Western U.S.

The Western United States, spanning from Colorado westward and including Alaska and Hawaii, hosts a dynamic and rapidly evolving ecosystem for advanced manufacturing research. Anchored by prestigious institutions such as Stanford University, UC Berkeley, University of Washington, Arizona State University, Oregon State University, University of Utah, and University of New Mexico, the region is particularly strong in additive manufacturing, semiconductor fabrication, and aerospace systems. These universities frequently collaborate with federally funded labs like Lawrence Livermore National Laboratory, Sandia National Laboratory, Los Alamos National Laboratory, Idaho National Laboratory, Pacific Northwest National Laboratory, National Renewable Energy Laboratory, and private tech leaders such as Intel, Apple, and SpaceX.

Federal initiatives such as the CHIPS Act, NSF's Future of Manufacturing, and energy-related projects from DoE and ARPA-E have fueled significant infrastructure and talent development in the West. The presence of national laboratories and defense contractors uniquely positions the Western U.S. to advance laser processing, high-energy systems, and materials science in harsh environments. These collaborations are supported by graduate programs that engage over 6,500 students annually and research budgets exceeding \$450 million.

Programs such as semiconductor workforce development, aerospace manufacturing hubs, and laser-enabled additive platforms are shaping the region's research direction. The Western U.S. also excels in combining academic research with commercialization efforts, often translating breakthroughs into venture-backed startups.

Table 1: Advanced Manufacturing Research Comparison.

Category	Western U.S.	Eastern U.S.
Top Institutions	Stanford, UC Berkeley, OSU, ASU, UW, CU Boulder, University of Utah, Boise State, UNR, UNM, University of Alaska	MIT, CMU, Georgia Tech, U. Michigan, UIUC, Purdue, Northwestern, Texas A&M, U. Wisconsin, U. Minnesota
Key Focus Areas	Additive manufacturing, semiconductors, aerospace systems, laser-based processing, advanced energy	Cyber-manufacturing, smart factories, bio-manufacturing, agricultural robotics, precision engineering, industrial automation
Industry Ties	Intel, Apple, SpaceX, Lockheed Martin, Boeing, Micron	GE, Ford, Medtronic, John Deere, Cargill, Siemens, Caterpillar, IBM, Dow, Raytheon
Major Federal Programs	CHIPS Act, DoE Labs, NSF Future of Manufacturing, ARPA-E, NASA	ARM Institute, AFROA, NSF ERCs, NIH Biomanufacturing, USDA Smart Ag, DoD Manufacturing Networks
Graduate Student Volume	~6,500+ in AM-related fields	~8,500+ in AM-related fields
Estimated Annual Research Budget	\$450M+ (combined)	\$600M+ (combined)
Specialized Programs	National lab-industry-academic hubs, semiconductor training, aerospace and defense manufacturing ecosystems	Industry 4.0 hubs, smart agriculture innovation, bio-fabrication centers, NSF ERCs

1.2 10-Year Comparison of U.S. Advanced Manufacturing Events: East vs. West

Over the past decade, the Eastern United States has hosted a greater volume and variety of advanced manufacturing events compared to the Western U.S., with an estimated 340 events versus 260. The East leads in major conferences like IMTS and ICAM, federal forums supported by institutes such as ARM and AFFOA, and a significant number of university-led workshops from institutions like MIT, CMU, and Georgia Tech. In contrast, the West has carved a strong niche in additive manufacturing, semiconductors, and aerospace applications, reflected in events like RAPID+TCT, WESTEC, and university workshops hosted by Stanford, OSU, and UC Berkeley. National labs in the West (e.g., Sandia, INL, LANL) also contribute heavily to specialized workshops and technology forums. While the East benefits from greater density and standardization-oriented events, the West showcases strong integration with high-tech industries and defense-related manufacturing.

Table 2: Advanced Manufacturing Events Comparison.

Category	Western U.S.	Eastern U.S.
Major Conferences (Recurring)	45	60
Specialized Workshops	60	75
Industry Summits	40	50
Academic Symposia	35	45
Federal/DOE/NIST-led Forums	30	40
University-Led Workshops	50	70
Total Estimated Events (10 yrs)	260	340

1.3 Workshop Objectives

The First Advanced Manufacturing Workshop in the Western United States was held on November 16, 2024, at Oregon State University (OSU) in Corvallis, Oregon. Organized by Dong Lin, Karl Haapala, and Devin Roach, with support from Oregon State University and the National Science Foundation (NSF), the workshop marked a foundational step toward strengthening the advanced manufacturing research community in the western region of the country.

The primary objective of the workshop was to bolster collaboration among western institutions and foster a strong, integrated research presence that complements and connects with the well-established manufacturing research ecosystems in the eastern U.S. While the eastern and midwestern regions have long been hubs for federally funded manufacturing initiatives, the western U.S. possesses unique capabilities and growing expertise that remain underrepresented at the national level. By bridging this divide, the workshop aimed to help balance the national advanced manufacturing landscape - ensuring that innovation, investment, and impact are shared more equitably across regions.

Specifically, the workshop sought to:

- Strengthen collaboration and interdisciplinary research among western institutions.
- Showcase regional innovation in areas such as additive manufacturing, smart manufacturing, materials science, and functional materials.
- Enhance the visibility and engagement of western researchers in NSF, NIST, and other federal manufacturing programs.

- Build meaningful connections with peers and centers of excellence in the eastern U.S., fostering national integration and cross-regional collaboration.
- Support early-career researchers through mentorship and partnership-building opportunities.
- Identify common challenges and shared priorities that can guide multi-institutional proposals, infrastructure planning, and workforce development across regions.

By building a stronger network within the West and creating intentional links to researchers and institutions in the East, this workshop laid the groundwork for a more unified, inclusive, and impactful national advanced manufacturing research ecosystem.

1.4 Workshop Format

The one-day event brought together participants from academia, national laboratories, and industry. The program included:

- Four technical sessions covering topics in advanced manufacturing, smart manufacturing, materials modeling, and additive manufacturing of functional structures.
- Keynote talk from Dr. Brian Paul to introduce the history and current advanced manufacturing research at Oregon State University.
- Invited talks from 14 distinguished speakers representing universities, federal labs, and industry. Speaker Distribution by State: Washington 3 speakers (PNNL, WSU x2), California: 2 speakers (UC Davis, SDSU), Arizona: 2 speakers (ASU, UArizona), Idaho: 2 speakers (INL, Boise State), Utah: 1 speaker (UU), Ohio: 1 speaker (CWRU), Massachusetts: 1 speaker (Civan Lasers U.S. base), Nebraska: 1 speaker (UNL), Iowa: 1 speaker (ISU).
- Panel discussions and group photo/networking sessions to promote community building.
- A concluding panel on future directions in manufacturing research and NSF engagement.

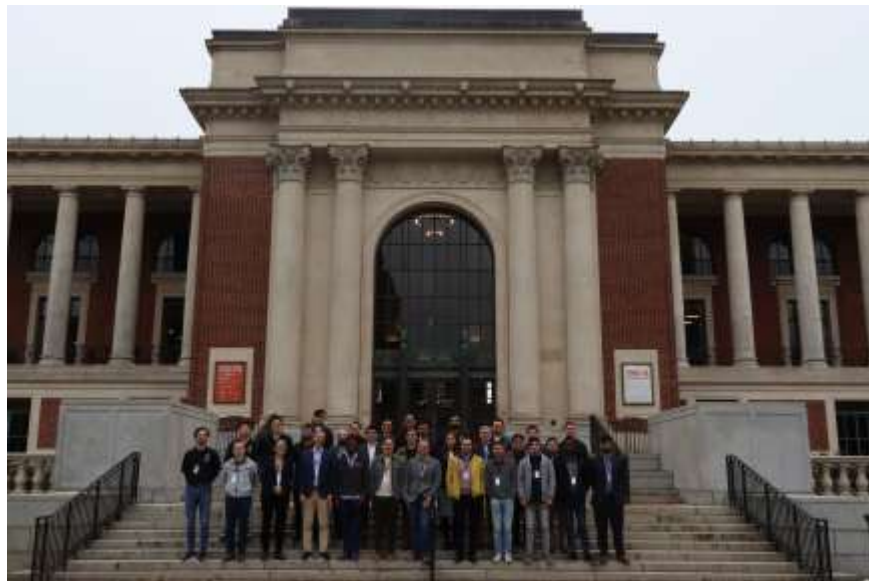


Figure 1. All the attendees of First Advanced Manufacturing Workshop in the Western United States: in front of Oregon State University Memorial Union.



Figure 2. Left: student volunteers. Right: reception table.

Speaker biographies and presentation abstracts were collected and included in this report to provide context and reference for future collaboration. The workshop agenda and full participant list are also provided in the appendices.

2 Workshop Invited Talks

This workshop contains four sessions with topics of 1) Advanced Manufacturing, 2) Smart Manufacturing, 3) Modeling, Manufacturing and Materials, and 4) Additive Manufacturing of Functional Structures.

2.1 Session 1: Advanced Manufacturing

Chair: Dr. Dong Lin, Oregon State University

The Advanced Manufacturing session highlighted a spectrum of innovative techniques and research breakthroughs that are shaping the future of materials processing, laser-based fabrication, and solid-phase materials processing. This session showcased innovative approaches that are advancing the capabilities of modern manufacturing. Topics included:

- Laser technologies with precise spatial, spectral, and temporal control, enabling applications in advanced materials processing, diagnostics, and energy systems.
- Dynamic beam laser systems that allow real-time shaping and steering of the laser profile, improving weld quality and additive manufacturing performance across challenging materials.
- A solid-state additive manufacturing process using laser-induced supersonic impacts to achieve high-strength metal bonding without melting, suitable for multi-material integration.
- Solid-phase processing techniques such as friction stir welding and shear-assisted extrusion that reduce energy use while enhancing grain refinement and recyclability in structural metals.

2.1.1 Dr. Yongfeng Lu – University of Nebraska-Lincoln

Talk Title: *Spectrally, Spatially, and Temporally Controlled Laser Processing and Characterization*

The speaker delves into his work on advanced laser technologies and their diverse applications across materials science, biomedical diagnostics, and manufacturing. He began by highlighting the transformative journey of laser and optics technology, evolving from rudimentary lenses to modern laser systems powered by quantum mechanics. This evolution has significantly impacted

various fields, enabling unprecedented precision and control in manipulating materials and energy. The speaker emphasizes how such advancements are at the forefront of solving complex challenges, such as fabricating ultra-precise targets for laser-driven nuclear fusion.

In materials science, the speaker discusses how lasers are redefining approaches to material enhancement and repair. For instance, lasers are used to induce diamond growth and tailor their structural properties to specific industrial needs.

He also describes his work on laser systems designed to address practical challenges, such as mitigating corrosion in naval environments. By developing portable laser technologies, they were able to repair and maintain ships without extensive downtime or heavy machinery. This showcases the laser's potential as a tool for precision manufacturing, environmental sustainability, and efficient maintenance.

Turning to biomedical applications, the speaker outlines how advanced laser techniques are revolutionizing diagnostics and healthcare. Lasers are employed to identify diseases at early stages, such as cancer, by analyzing molecular vibration modes that reveal detailed information about tissue and cell health. Similarly, laser technology has been instrumental in assessing liver health and other critical diagnostic fields. His presentation highlights cutting-edge imaging techniques, such as 3D and 4D imaging, used to study both laser fusion targets and biological cells. These technologies provide an unparalleled view of microscopic structures, aiding in medical research and patient care. The integration of machine learning further enhances these capabilities by analyzing vast datasets to uncover patterns, such as predicting heart attack risks or detecting cancer markers in blood samples with exceptional accuracy.

In closing, the speaker underscores the profound potential of combining laser technology with artificial intelligence to revolutionize science, engineering, and medicine. He stressed the importance of interdisciplinary collaboration in pushing the boundaries of what lasers can achieve in biomedicine, energy, precision machining, environmental protection, nuclear engineering, thermal management, photonics, microelectronics, data storage, and corrosion protection. These could open new frontiers of innovation, promising a future where laser technology plays a pivotal role in addressing humanity's most pressing challenges.

2.1.2 Ami Spira – Civan Lasers

Talk Title: *Dynamic Beam Lasers for Welding and Metal Additive Manufacturing (AM)*

Ami Spira's presentation introduced Civan Lasers' dynamic beam laser technology as a paradigm-shifting innovation for both welding and metal additive manufacturing. This technology is based on two core innovations: Coherent Beam Combining (CBC) and Optical Phased Arrays (OPA), which together allow for real-time, programmable control over laser beam shape, size, focus depth, and spatial steering.



Spira detailed four key capabilities of the dynamic beam system:

- Beam shaping for tuning energy distribution profiles,
- Shape frequency modulation for adjusting how rapidly beam shapes change,
- Shape sequencing for transitioning between multiple beam patterns within a single operation, and
- Focus steering using electro-optical controls for dynamic focal depth adjustment.

These features allow manufacturers to precisely control heat input and material interaction, resulting in reduced keyhole porosity, enhanced fusion quality, and the elimination of defects such as root cracks in deep welds. For example, aluminum-copper welds - known for high porosity - were significantly improved through rapid shape switching. In die-cast aluminum parts, spiral beam patterns mitigated typical cracking issues, while single-pass welding of thick steel sections was enabled by mid-process shape modulation.

In the context of additive manufacturing, Civan's laser systems offer dynamic control over melt pool morphology, allowing better control of thermal gradients and solidification microstructures. This capability is critical for tuning part properties such as grain orientation, residual stress, and surface quality. This technology holds particular promise for aerospace, maritime, and automotive industries, where high-performance components demand superior joint integrity and reproducibility.

Meanwhile, Civan has established demonstration labs in Detroit and Idaho, enabling prospective industrial partners to evaluate the technology without upfront purchase commitments. The company's future roadmap includes deeper integration with simulation software and AI to enable closed-loop process control, opening the door to intelligent, autonomous manufacturing systems.

2.1.3 Dr. Yiliang (Leon) Liao – Iowa State University

Talk Title: A Novel Solid-State Metal Additive Manufacturing Strategy: Laser-Induced Supersonic Impact Printing (LISIP)

Dr. Liao introduced a groundbreaking solid-state additive manufacturing technique known as Laser-Induced Supersonic Impact Printing (LISIP). This process merges the principles of cold spray and laser impact welding to enable fusion-free bonding of metals at ambient conditions using laser-driven mechanical forces.

The LISIP process begins with a nanosecond laser pulse striking a graphite layer, generating a high-pressure plasma. This plasma launches a thin metal flyer at supersonic speeds toward a target substrate. Upon impact, extreme shear rates and interfacial jetting remove oxides and activate adiabatic shearing, creating a robust metallurgical bond - without the thermal defects associated with traditional melting processes. The resulting joints are dense, strong, and capable of joining dissimilar metals like Al-Mg or Steel-Cu-Ti, which are typically incompatible in fusion-based AM.

Dr. Liao showcased a series of demonstrations that validated LISIP's potential across multiple scales and applications. His team successfully fabricated multi-layered micro-laminates using aluminum, copper, and titanium foils, and achieved localized metal deposition for microscale electronics and MEMS devices. Lap shear tests confirmed joint strengths as high as 18 MPa, with significant grain refinement at the interface - a key indicator of bond integrity.



Importantly, LISIP avoids problems such as porosity, cracking, and excessive thermal stress, making it particularly valuable for sectors like aerospace and biomedical engineering where material compatibility and structural precision are critical. Future research aims to scale the process using higher-power lasers, integrate hybrid manufacturing (e.g., subtractive + LISIP), and refine models linking microstructure evolution to mechanical performance. Dr. Liao's work represents a major step forward in solid-state AM, bridging gaps between performance, material diversity, and sustainability.

2.1.4 Dr. Tianhao Wang – Pacific Northwest National Laboratory (PNNL)

Talk Title: *Advanced Solid-Phase Processing and Manufacturing*

Dr. Wang's presentation centered on Solid Phase Processing (SPP) technologies developed at PNNL that offer sustainable, scalable alternatives to conventional melting-based manufacturing. These techniques, which include Friction Stir Welding (FSW), Additive Friction Surfacing, Cold Spray, and the proprietary SHAPE™ (Shear-Assisted Processing and Extrusion) process, operate at sub-melting temperatures to deliver high-strength, fine-grained metal products with lower energy consumption.



He began by discussing the historical limitations of traditional metallurgy - intense energy usage, multiple remelting steps, and limited control over final microstructure. In contrast, SPP methods use mechanical energy to create localized heating and plastic deformation, enabling precise tuning of grain structures and interfaces. This leads to superior mechanical performance, improved recyclability, and reduced environmental impact.

The SHAPE™ process was highlighted as particularly transformative. It enables extrusion of magnesium and aluminum alloys directly from scrap or powders into complex, net-shaped components. By eliminating casting, forging, and machining steps, SHAPE not only lowers cost but also enhances material circularity. Applications include structural tubes, battery enclosures, and lightweight aerospace components.

Wang also discussed additive friction surfacing, which deposits layers of material using a rotating consumable rod, similar to friction stir welding but with more control over thickness and deposition shape. His group's studies on tilt angle and rod geometry uncovered new insights into interfacial bonding and fracture mechanisms, with implications for coating technologies and multilayered AM.

Dr. Wang demonstrated that solid-phase manufacturing not only supports high-performance, defect-free production but also aligns with national goals for clean energy and sustainable manufacturing. PNNL's innovations are paving the way for new industrial standards in structural metals processing.

2.2 Session 2: Smart Manufacturing

Chair: Dr. Karl Haapala, Oregon State University

The Smart Manufacturing session showcased emerging technologies and research focused on digitizing and optimizing the manufacturing enterprise through artificial intelligence, data-driven decision-making, and human-centered design. The speakers highlighted the use of semantic models, energy analysis tools, and integrated sensing systems to create smarter, more

sustainable, and adaptive production environments. Together, these talks underscored the importance of interoperability, process transparency, and systems thinking in achieving the goals of Industry 4.0 and beyond.

2.2.1 Farhad Ameri – Arizona State University

Talk Title: *Ontologies, Knowledge Graphs, and Semantic AI in Smart Manufacturing*

This presentation addressed a critical challenge in modern manufacturing: integrating heterogeneous information systems to enable intelligent, autonomous decision-making. The speaker introduced the concept of semantic AI and explained how ontologies and knowledge graphs serve as the backbone of semantic interoperability across machines, platforms, and organizational boundaries.

By formalizing entities and their relationships within a manufacturing system, ontologies enable machines to “understand” the meaning behind data, facilitating tasks such as planning, scheduling, inventory management, and real-time analytics. The talk detailed the design and application of the Supply and Demand Open Knowledge Network (SUDOKN) - a publicly accessible application-neutral knowledge graph that captures the capabilities and requirements of small and medium-sized manufacturers (SMMs). SUDOKN enables scalable AI solutions to match supply with demand and support distributed supply chains.

The presentation highlighted use cases ranging from automated guided vehicles (AGVs) in smart factories to pipeline monitoring in harsh environments. The integration of semantic and somatic AI was proposed as a hybrid solution to reconcile high-level reasoning (semantic) with data-driven perception (somatic), paving the way for resilient, intelligent manufacturing systems capable of adapting to uncertainty and complexity.

2.2.2 Hannah Budinoff – University of Arizona

Talk Title: *From Data to Decision for Additive Manufacturing: Improving Design for Sustainability with Energy Prediction Models and Decision-Making Tools*

This talk focused on empowering design engineers with predictive tools to assess and minimize the environmental impacts of additive manufacturing. The speaker presented a robust empirical study involving over 800 polymer AM builds across multiple platforms, materials, and design variables. The data was used to develop a semi-empirical energy consumption model for fused filament fabrication (FFF) processes.

The model was integrated into an open-source tool called Ecometrics3D, which enables users to upload CAD files and receive real-time energy consumption estimates based on parameters such as infill density, support structures, wall thickness, and layer height. This allows engineers to optimize designs for sustainability early in the design process, avoiding costly or inefficient iterations later in production.

The talk also explored preliminary work in metal additive manufacturing, particularly laser powder bed fusion (LPBF), where energy and material use are more difficult to predict due to complex thermal behavior and powder recycling dynamics. Future work will focus on improving energy models for LPBF and incorporating additional sustainability metrics, such as powder reuse rates



and emissions intensity. The speaker emphasized the potential for such tools to enable more sustainable design practices and inform lifecycle assessments across product development workflows.

2.2.3 Barbara Linke – University of California, Davis

Talk Title: *Research at the Linke Lab on Smart, Sustainable and Human-Centered Manufacturing*

This presentation offered a comprehensive overview of research initiatives combining sustainability, manufacturing process innovation, and ergonomics. The speaker began by framing the three pillars of sustainability—environmental, economic, and social—and discussed how smart manufacturing systems must be evaluated across all three domains.



Key projects included solar-powered 3D printing systems designed for use in disaster relief zones, where infrastructure is often limited. These systems integrate photovoltaic panels, battery storage, and mobile 3D printers to fabricate critical parts on-site, including medical components and repair tools. Another study examined sustainability trade-offs in polymer 3D printing using PolyJet, SLA, and FDM technologies, revealing that parts with the highest environmental impact were often preferred by users based on visual and tactile feedback—an important insight into the complexity of human-centered sustainability.

The talk also highlighted research into abrasive machining of advanced materials such as PEEK and cobalt-chrome, particularly for biomedical and veterinary implants. Studies investigated the effects of layer height and orientation on wear performance, friction energy, and surface roughness. The lab has also collaborated with industrial partners to assess surface quality in stainless steel processing, focusing on reducing bacterial adhesion for food and medical applications.

The final segment introduced direct sound printing, a novel technique invented by the speaker's colleague Mohsen Habibi that uses focused ultrasound waves to polymerize materials, eliminating the need for lasers or heating. This approach allows printing through opaque media or in constrained environments, opening new possibilities for in-body and remote manufacturing. The speaker concluded with a call for more shared data resources and open collaboration to accelerate the development of sustainable and human-centered manufacturing technologies.

2.3 Session 3: Modeling, Manufacturing and Materials

Chair: Dr. Yiliang Liao, Iowa State University

This session focused on the integration of advanced modeling tools, materials engineering, and manufacturing techniques to improve the design, performance, and sustainability of manufactured components. Presenters highlighted the use of high-fidelity simulations, precision machining strategies, and material-aware design approaches to address challenges in additive manufacturing, aerospace, and corrosion engineering. The talks reflected a strong emphasis on the convergence of computational science, mechanical engineering, and materials processing to enhance manufacturing outcomes at both the micro and macro scales.

2.3.1 Daniel Schwen – Idaho National Laboratory

Talk Title: *Modeling Microstructure Evolution, Material Performance, and Manufacturing with the Open Source MOOSE Framework*

This talk introduced the Multiphysics Object-Oriented Simulation Environment (MOOSE)—a powerful, open-source finite element platform developed by Idaho National Laboratory for simulating tightly coupled physical processes. Originally designed for nuclear energy applications, MOOSE has since expanded to encompass a wide range of materials and manufacturing simulations, including additive manufacturing (AM), soft robotics, biomechanics, and battery systems.



The speaker detailed how MOOSE enables multiscale modeling of thermal, mechanical, and chemical phenomena in AM processes, particularly laser powder bed fusion. The platform supports rapid prototyping of custom physics models and includes tools for uncertainty quantification, Bayesian inference, and surrogate modeling, making it well-suited for design optimization and digital twin applications.

Examples of MOOSE-based simulations included microstructure evolution under different laser parameters, phase-field modeling of solidification, and stress-strain behavior prediction. The talk emphasized the importance of open-source simulation tools in accelerating materials innovation and fostering collaboration across institutions and disciplines.

2.3.2 Dave Kim – Washington State University

Talk Title: *High-Precision Manufacturing and Fastening of Aerospace Materials*

This presentation explored the challenges of machining and joining advanced materials used in aerospace structures, with a focus on hybrid composite stacks such as carbon fiber-reinforced polymers (CFRP) and titanium. These material systems offer high strength-to-weight ratios but are difficult to process due to their anisotropy and dissimilar thermal properties.



The speaker presented research on optimized drilling techniques to minimize delamination and fiber pull-out, as well as on cold hole expansion and interference-fit joints that enhance fatigue life and structural reliability. Advanced fastening methods were shown to improve load transfer and reduce stress concentrations, making them critical for next-generation aircraft.

The talk also included strategies for improving trimming accuracy and surface integrity in CFRP components. Emphasis was placed on the integration of experimental data with simulation tools to guide process development and ensure quality assurance in high-precision manufacturing environments.

2.3.3 Patrick Kwon – San Diego State University

Talk Title: *Materials and Manufacturing*

The speaker addressed the often-overlooked disconnect between materials science education and real-world manufacturing challenges. By merging materials science with mechanical engineering in an interdisciplinary graduate program at San Diego State University, the research team aims to produce engineers equipped to handle complex material-process interactions.

Research examples included studies in machining and powder processing, where understanding phase transformations and microstructural evolution was essential to improving tool life, surface finish, and component durability. The presentation also covered recent work on metallic additive manufacturing, including innovations in binder jetting, selective laser melting, and a proprietary process known as Scalable and Expeditious Additive Manufacturing (SEAM).

The talk emphasized the need for deeper integration of materials science into manufacturing curricula and collaborative research, advocating for a systems-level approach to engineering education and innovation.



2.3.4 Shuaihang Pan – University of Utah

Talk Title: *Corrosion and Corrosion-Enabled Surface Quality Control for Advanced Manufactured Alloys*

This talk explored the dual role of corrosion in additive manufacturing (AM): both as a degradation challenge and as a tool for post-processing and surface modification. The speaker presented research on understanding how AM-induced microstructures affect corrosion behavior, with an emphasis on alloys produced via laser powder bed fusion and directed energy deposition.

A major focus was the development of corrosion-enabled manufacturing techniques, such as electrochemical machining (ECM) and electropolishing, to enhance surface quality and functional performance of AM parts. These methods offer fine control over material removal, improving surface smoothness and mechanical consistency without the need for mechanical finishing.

Through microstructural characterization and electrochemical testing, the research uncovered critical insights into how processing history influences corrosion resistance. The talk concluded with a discussion on integrating corrosion modeling with AM design tools, and the potential for collaboration across the western U.S. to advance post-processing technologies for next-generation materials.



2.4 Session 4: Additive Manufacturing of Functional Structures

Chair: Dr. Devin Roach, Oregon State University

The final session of the workshop focused on how additive manufacturing (AM) is enabling the design and fabrication of functional structures with tailored thermal, mechanical, and electronic properties. Presenters demonstrated how advanced materials, structural topologies, and multi-material printing processes are expanding the utility of AM in applications such as energy systems, soft robotics, and flexible electronics. The talks highlighted interdisciplinary approaches that integrate computational modeling, novel material development, and precision processing to unlock new performance capabilities.

2.4.1 Todd Otanicar – Boise State University

Talk Title: *Additively Manufactured Porous Media for Enhanced Transport*

This talk explored the use of additively manufactured porous structures to enhance heat and mass transport in thermal systems. The speaker compared traditional metal foams—commonly used in heat exchangers—with engineered lattice structures created through AM, focusing on improvements in thermal conductivity, pressure drop, and structural integrity.

Using computational modeling, the research team designed triply periodic minimal surfaces (TPMS) and other lattice geometries optimized for high surface area and low flow resistance. These structures offer more control over porosity and pore shape than foams, enabling performance tuning for applications such as solar receivers, electronic cooling, and chemical reactors.

The presentation also addressed the challenges of characterizing transport behavior in high-temperature environments and proposed experimental and modeling strategies for overcoming these barriers. The talk emphasized that porous AM structures represent a promising path toward compact, efficient, and customizable heat transfer systems.



2.4.2 Arda Gozen – Washington State University

Talk Title: *Extrusion-Based Additive Manufacturing of Parts with As-Designed Properties*

This presentation focused on the use of extrusion-based AM techniques—specifically fused filament fabrication (FFF) and direct-ink-writing (DIW)—to fabricate parts with spatially controlled mechanical and functional properties. The speaker outlined two primary research thrusts: (1) controlling filament deposition to influence microstructure, and (2) multi-material printing to achieve local property variation.

For the first area, studies revealed how printing parameters like nozzle temperature, feed rate, and raster pattern affect filament bonding, void formation, and anisotropy in polymer and metal parts. These insights are critical for enhancing mechanical performance and reliability.

In the second area, the team demonstrated a hybrid AM method that integrates soft and stiff materials into a single part, enabling the creation of components with visco-hyperelastic behavior. Applications include bio-inspired soft robotics and wearable devices. The speaker emphasized that additive manufacturing is evolving beyond shape control to include property-by-design capabilities, and future work will focus on integrating simulation, rheology, and machine learning to accelerate material and process optimization.



2.4.3 C. Chase Cao – Case Western Reserve University

Talk Title: Additive Manufacturing of Flexible and Stretchable Electronics from Low-Dimensional Nanomaterials

This talk showcased recent advances in the design, printing, and application of soft, stretchable electronics using additive and printed electronics techniques. The speaker presented novel conductive inks based on low-dimensional nanomaterials such as graphene, MXenes, and carbon nanotubes, which enable high-performance printing of sensors, transistors, and energy devices.



Demonstrated applications included smart packaging, health monitoring patches, self-powered sensors, and robotic skins. These systems offer advantages such as conformability, biocompatibility, and wireless functionality, and can be used in environments ranging from clinical diagnostics to structural health monitoring.

The speaker also discussed manufacturing innovations that enable multilayer integration, stretchability without failure, and improved resolution through aerosol jet and inkjet printing. Research was supported by NSF, DOE, and VA Medical Center programs, and highlighted the interdisciplinary nature of the work, blending mechanical engineering, electronics, and materials science. The presentation concluded with a vision for fully integrated, functionally graded electronic systems enabled by advanced AM technologies.

3 Panel Discussion

Moderator: Dr. Karl Haapala, Oregon State University

Panelist: Todd Otanicar; Yongfeng Lu; Patrick Kwon; Barbara Linke; Farhad Ameri

The workshop concluded with a panel discussion that brought together experts from academia, industry, and national laboratories to reflect on the key insights from the day's sessions and to discuss the broader challenges and opportunities facing the advanced manufacturing community in the western United States. The panel focused on identifying strategic directions for collaborative



Figure 3. Panel discussion. From left to right: Patrick Kwon, Yongfeng Lu, Barbara Linke, Todd Otanicar, Farhad Ameri, and Karl Haapala.

research, regional capacity building, and engagement with federal initiatives such as the NSF Future Manufacturing Program and the National Strategy for Advanced Manufacturing.

3.1 The panel discussion centered on three core themes:

3.1.1 Bridging Regional Gaps and Building Research Capacity

Panelists acknowledged the historical concentration of advanced manufacturing hubs in the eastern and midwestern United States, and emphasized the need to foster a more balanced national research ecosystem. The western U.S., while home to growing technical talent and innovation hubs, remains underrepresented in large-scale federal manufacturing programs. Panelists advocated for increased regional coordination and more targeted support for emerging institutions, particularly those in rural or underfunded areas.

Suggestions included the development of regional research consortia, seed funding mechanisms for cross-institutional proposals, and improved pathways for early-career researchers in the West to engage with national networks and leadership roles in manufacturing initiatives.

3.1.2 Enabling Convergent Research Across Disciplines

The panel emphasized that the future of manufacturing research will require strong convergence across disciplines—spanning materials science, mechanical engineering, data science, robotics, and sustainability. Several speakers noted the importance of developing integrated research environments that encourage collaboration among domain experts, especially in areas such as smart manufacturing, cyber-physical systems, and hybrid additive/subtractive processes.

The value of shared infrastructure and collaborative testbeds was also discussed, including the use of open-source modeling platforms, high-performance computing resources, and distributed fabrication labs that enable real-time experimentation and rapid prototyping.

3.1.3 Aligning with National Priorities and Workforce Needs

Panelists highlighted the importance of aligning academic research with national manufacturing goals, including decarbonization, supply chain resilience, and workforce development. The discussion included insights on how universities can play a more active role in developing micro-credentials, interdisciplinary training programs, and industry-aligned curricula to prepare the next generation of manufacturing professionals.

Panelists also expressed interest in fostering deeper engagement with federal agencies (NSF, DOE, NIST), particularly through participation in proposal reviews, roadmap development, and technology transfer initiatives.

3.2 Key Takeaways:

- There is strong momentum and untapped potential in the western U.S. manufacturing research community.
- Collaboration, convergence, and communication across institutions and disciplines are critical to future success.
- Targeted funding, shared infrastructure, and inclusive workforce development are necessary to sustain long-term impact.
- Continued coordination with federal programs and alignment with national strategies will enhance regional competitiveness.

4 Workshop Outcomes

4.1 Catalyzing National Collaboration through the Advanced Manufacturing Workshop

The inaugural Advanced Manufacturing Workshop in the Western United States served as a critical catalyst for national collaboration at the intersection of manufacturing and artificial intelligence. The event convened a diverse group of stakeholders from academia, national laboratories, industry—particularly small and medium-sized manufacturers (SMMs)—and federal agencies. These cross-sector discussions directly shaped the vision and scope of the subsequent NIST Manufacturing USA Institute proposal, PRIME-AI (Promoting Resilient Industries with Manufacturing and Emerging Artificial Intelligence).

The workshop laid the groundwork for a national institute proposal by identifying key technical and societal challenges in adopting AI across the U.S. manufacturing sector. Discussions emphasized the urgency of empowering SMMs with scalable AI tools, enabling trusted data sharing, strengthening supply chain resilience, and developing a digitally fluent workforce. These themes became the cornerstone of the PRIME-AI strategy.

4.2 Formation of the PRIME-AI Proposal Team

The leadership of three workshop organizers—Dr. Dong Lin, Dr. Karl Haapala, and Dr. Devin Roach—was instrumental in transforming the workshop’s discussions into a comprehensive federal proposal. Dr. Lin led the overall vision and served as principal investigator, guiding the proposal from conception to submission. Dr. Haapala played a central role in shaping industry engagement and translating the priorities of SMM stakeholders into technical thrusts, including the development of a national product-service marketplace. Dr. Roach led technical scoping

efforts for AI-enabled process qualification, contributing pilot studies that laid the foundation for PRIME-AI's research agenda.

A key outcome of the workshop was the formation of a national, cross-sector coalition that became the core team behind the PRIME-AI proposal. Post-workshop discussions among partners from Oregon State University, Arizona State University, UC Berkeley, the University of Dayton, and others led to a shared mission: to scale AI-driven solutions that support SMM innovation and resiliency. The momentum built during the workshop enabled rapid consensus on the institute's technical direction—particularly in metals manufacturing and AI-based infrastructure development.

4.3 From Vision to National Action

The workshop produced several tangible outcomes that significantly influenced the PRIME-AI proposal:

- **Stakeholder Alignment:** The workshop facilitated early alignment among key academic, industry, and government stakeholders, many of whom now serve as co-PIs, institutional leads, or advisory members within the PRIME-AI ecosystem.
- **Technical Pillars:** Breakout sessions and panel discussions identified six core technical areas - AI for design for manufacturing, process qualification, smart machines, supply chain visibility, workplace safety, and logistics networks - which now serve as the primary research thrusts of PRIME-AI.
- **Workforce Development Framework:** The workshop's EWD sessions helped shape PRIME-AI's strategy to build an AI-capable manufacturing workforce, emphasizing scalable training content and strategic partnerships with community colleges and minority-serving institutions (MSIs).
- **Network Expansion:** The event facilitated key relationships with national laboratories, NIST MEP Centers, and major technology providers (e.g., Autodesk, NVIDIA), all of whom are now formal collaborators in the proposal.

Through this convergence of vision, leadership, and strategic alignment, the Advanced Manufacturing Workshop established itself as more than a regional convening. It became the launchpad for a nationally coordinated effort to reshape the role of AI in U.S. manufacturing through the creation of PRIME-AI.

5 Future Perspectives

5.1 Sustaining the Network: Toward a Standing Committee

To build on the momentum from the First Advanced Manufacturing Workshop, a new advisory committee is being established. Key workshop speakers and participants—including Dr. Yiliang Liao, Dr. Farhad Ameri, Dr. Barbara Linke, and Dr. Todd Otanicar—are being invited to join this standing body. The committee will play a dual role: providing strategic guidance for the PRIME-AI initiative and shaping the agenda for future Advanced Manufacturing Workshops. As a bridge between convening events and long-term national initiatives, this group will help ensure that workshop outcomes inform future research directions, policy discussions, and funding strategies.

5.2 Advancing Regional Engagement and Institutional Inclusion

Attendees of the first workshop expressed strong enthusiasm for continuing the initiative and convening a second event to sustain the collaborative momentum. Looking forward, one of the key priorities is to broaden geographic and institutional representation, particularly from

underrepresented western states such as Alaska, Hawaii, Nevada, Montana, and Wyoming. These regions hold untapped potential in both academic research and industrial capabilities, and their involvement will enrich the diversity of perspectives and expand the reach of the network.

5.3 Strengthening National Laboratory and Industry Partnerships

Deeper engagement with national laboratories such as Lawrence Berkeley National Laboratory, SLAC National Accelerator Laboratory, and the National Renewable Energy Laboratory will be essential for providing cutting-edge infrastructure and technical expertise to support emerging research. At the same time, expanded collaboration with industry partners - especially those in aerospace, energy, semiconductors, and defense manufacturing - ensure alignment between academic innovation and practical deployment. These partnerships are vital for translating research into real-world manufacturing solutions.

5.4 Expanding Topical Breadth and Research Frontiers

Future workshops should broaden the scope of discussion to include emerging areas in advanced manufacturing, such as:

- Artificial intelligence and machine learning in manufacturing
- Hybrid additive/subtractive processes
- Sustainable and circular materials
- Photonic and quantum manufacturing
- Secure and intelligent cyber-physical systems

Addressing these topics will ensure that the workshop series remains at the forefront of innovation and responds to evolving industry needs.

5.5 Inclusive Workforce Development and Research Participation

To promote equitable growth and long-term workforce development, future efforts will place stronger emphasis on engaging early-career researchers, community colleges, and minority-serving institutions (MSIs). By integrating these voices into both workshop programming and research planning, the initiative can better reflect the full diversity of talent and perspectives across the western United States.

5.6 Building a Nationally Integrated Ecosystem

While the Western U.S. network continues to grow, maintaining close coordination with institutions and networks in the Eastern U.S. will be critical. Opportunities for co-hosted workshops, shared research testbeds, and collaborative federal proposals can help create a balanced, bi-coastal innovation ecosystem. Strengthening cross-regional ties will amplify national competitiveness and ensure the U.S. remains a global leader in advanced manufacturing.

Appendix A: Brief Biographies of Three Organizers

- **Dong Lin:** Dr. Lin has focused on metal additive manufacturing, metal matrix composites, and 3D printing of functional structures. He successfully printed the world's first truly 3D graphene aerogels, which received a Guinness World Record: World's lightest material (0.5 mg/cm^3) via 3D printing. His research outputs have been highlighted by ~136,000 websites, including *Science Daily*, *Materials Today*, and *MSN*. He has published 83 peer-reviewed journal articles, many of which appear in top journals, including *Advanced Materials*, *Nature Communications*, *ACS Nano*, *Small*, and *Acta Materialia*. He received the NSF CAREER Award. Dr. Lin also received the ASME Chao and Trigger Young Manufacturing Engineer Award. He has also been honored with the Outstanding Associate Editor Award from *Journal of Manufacturing Processes*, Outstanding Paper Award from the SME 49th North American Manufacturing Research Conference (NAMRC), and Best Organizer of Symposium & Sessions (BOSS) Award from ASME of Manufacturing Engineering Division. In 2021, Dr. Lin was selected to participate in the NAE European Union-U.S. Frontiers of Engineering symposium.
- **Karl Haapala:** Dr. Haapala conducts research in smart and sustainable manufacturing, life cycle engineering, and engineering education within the Industrial Sustainability Lab. He also directs OSU's Energy Efficiency Center and U.S. DOE Industrial Training and Assessment Center. Haapala aided preparation of three successful DOE IAC/ITAC proposals at ~\$2M each (5-year performance periods). He has received grants totaling more than \$39M as PI and co-PI in collaboration with researchers and practitioners from academia, national labs, and industry. His work has appeared in over 170 refereed proceedings and journal articles, receiving four best paper awards and four fast-tracked to journals. Dr. Haapala is a recognized leader within ASME and SME. He has served as an Associate Editor of the ASTM Journal of Smart and Sustainable Manufacturing Systems since 2015 and for the ASME Journal of Manufacturing Science and Engineering (2016-2022). He received the 2015 SME Young Manufacturing Engineering Award, 2016 OSU Industry Partnering Award, 2019 Fulbright-Tampere University U.S. Scholar Award, and the 2024 ASME Kos Ishii-Toshiba award, recognizing his impacts in academia and industry.
- **Devin Roach:** Dr. Roach has developed groundbreaking additive manufacturing methods for the fabrication of fiber-reinforced composites, advanced polymers, stretchable electronics, and printed soft robotics. His doctoral research set the stage for significant advancements in the field of multi-material additive manufacturing. He undertook a postdoctoral fellowship at Sandia National Laboratories, where his research focused on the rapidly evolving domain of artificial neural networks. There, he spearheaded research integrating AI with advanced manufacturing, focusing on real-time optimization techniques. His work in this area was particularly innovative, as he developed sophisticated computer vision-driven manufacturing process qualification systems using invertible neural networks, enhancing precision and efficiency in manufacturing processes. His research has been widely recognized and cited, with over 2,500 citations in leading journals such as *Advanced Functional Materials*, *ACS Applied Materials & Interfaces*, *npj Advanced Manufacturing*, and *Additive Manufacturing*, reflecting his significant impact on the field.

Appendix B: Workshop Agenda

The 1st Advanced Manufacturing Workshop in the Western United States

Oregon State University

Memorial Union

November 16, 2024

8:00-8:30am: Light Breakfast

8:30-8:35am: Welcome Introduction: Karl Haapala and Dong Lin

8:35-8:45am: Opening Remarks: Brady Gibbons, Associate Dean for Research, College of Engineering

8:45-9:00am: **Keynote Talk: Introduce the history of OSU Advanced Manufacturing**
Brian Paul, Professor Emeritus, School of Mechanical, Industrial, and Manufacturing Engineering

9:00-10:40 Session 1: Advanced Manufacturing
Session Chair: Dong Lin

Spectrally, Spatially, and Temporally Controlled Laser Processing and Characterization
Yongfeng Lu, University of Nebraska-Lincoln

Dynamic Beam Lasers for Welding and Metal Additive Manufacturing (AM)
Ami Spira, Civan Lasers

A Novel Solid-State Metal Additive Manufacturing Strategy: Laser-Induced Supersonic Impact Printing (LISIP)
Yiliang (Leon) Liao, Iowa State University

Advanced Solid-Phase Processing and Manufacturing
Tianhao Wang, Pacific Northwest National Laboratory

10:40-11:00am: Coffee break

11:00-12:15pm: Session 2: Smart Manufacturing
Session Chair: Karl Haapala

Ontologies, Knowledge Graphs, and Semantic AI in Smart Manufacturing
Farhad Ameri, Arizona State University

From Data to Decision for Additive Manufacturing: Improving Design for Sustainability with Energy Prediction Models and Decision-Making Tools
Hannah Budinoff, University of Arizona

Research at the Linke Lab on Smart, Sustainable and Human-Centered Manufacturing
Barbara Linke, University of California, Davis

12:15-12:25pm Group Photo

12:25-1:30pm Lunch

1:30-3:10pm: Session 3: Modeling, Manufacturing and Materials.
Session Chair: Yiliang Liao

Modeling microstructure evolution, material performance, and manufacturing with the open-source MOOSE framework

Daniel Schwen, Idaho National Laboratory

High-precision manufacturing and fastening of aerospace materials

Dave Kim, Washington State University

Materials and Manufacturing

Patrick Kwon, San Diego State University

Corrosion and Corrosion-enabled Surface Quality Control for Advanced Manufactured Alloys

Shuaihang Pan, University of Utah

3:10-3:30pm: Coffee break

3:30-4:45pm: Session 4: Additive Manufacturing of Functional Structures.

Session Chair: Devin Roach

Additively Manufactured Porous Media for Enhanced Transport

Todd Otanicar, Boise State University

Extrusion-based additive manufacturing of parts with as-designed properties

Arda Gozen, Washington State University

Additive Manufacturing of Flexible and Stretchable Electronics from Low-Dimensional Nanomaterials

C. Chase Cao, Case Western Reserve University

4:45-5:15pm: Panel Discussion:

Strengthening collaborative advanced manufacturing research across the Western United States

Moderator: Karl Haapala

Panelist: Yongfeng Lu; Barbara Linke; Farhad Ameri; Patrick Kwon

Appendix C: Brief Abstract and Biographies of 14 Invited Speakers

Spectrally, Spatially, and Temporally Controlled Laser Processing and Characterization

Yongfeng Lu

Department of Electrical and Computer Engineering,
University of Nebraska-Lincoln

Lasers can be used to deliver energy with extremely wide spectral, spatial, and temporal ranges. Laser-matter interactions can be spatially, spectrally, and temporally controlled and optimized to produce and characterize materials with desired efficiency and accuracy. These laser properties have provided many opportunities for material science and engineering which unique applications in manufacturing, energy, and biomedicine. In this presentation, the speaker will introduce his lab's research activities in processing and characterizing materials in various forms, including metals, polymers, diamond, carbon nanotubes, carbon nanofibers, graphene, gallium nitride, and biomedical materials, with focus on applications in energy and biomedicine. The talk will cover the following research areas:

1. Energy coupling using resonant vibrational excitation of molecules (e.g., formation of diamond structures and boron/nitrogen doped diamonds);
2. Laser-assisted micro/nanofabrication and additive manufacturing (e.g., target fabrication for laser fusion);
3. Laser-assisted optical spectroscopy, imaging, spectrometry, artificial intelligence in spectroscopic imaging (cancer diagnostics, nuclear forensics, and corrosion detection);
4. Energy devices and applications (supercapacitors, bolometers, nuclear fusion and fission, algae-based bioenergy); and
5. Biomedical applications (fat-liver disease, peripheral arterial disease, breast cancers, traumatic brain injury, pancreatic cancers, and cardiac artery disease).



Bio: Dr. Yongfeng Lu is currently the Lott Distinguished Professor of Engineering at the University of Nebraska-Lincoln (UNL). He received his bachelor's degree from Tsinghua University (China) in 1984 and M.Sc. and Ph.D. degrees from Osaka University (Japan) in 1988 and 1991, all in electrical engineering. From 1991 to 2002, he was a faculty in the Department of Electrical and Computer Engineering at National University of Singapore. He joined the Department of Electrical Engineering at UNL in 2002. He has more than 30 years of experience in processing and characterization of micro/nanostructured materials. His group has research projects funded by NSF, AFOSR, ONR, DTRA, DOE, DOT, NCESR, NRI, private companies, and foundations, with research expenditures over \$40 million in recent years. His research has led to several commercialization and product developments. Dr. Lu has authored or co-authored 604 journal papers and 524 conference papers (H-index: 79). He served as the President of the Laser Institute of America (LIA) and the President of International Academy of Photonics and Laser Engineering (IAPLE, UK). He has been elected to SPIE fellow, LIA fellow, OSA fellow, and IAPLE fellow. He has also served as chair and general chair for major international conferences in the field including the general congress chair for the International Congress of Applications of Lasers and Electro-Optics in 2007 and 2008, and general co-chair for LASE in Photonics West 2014-2017. He is also the recipient of the prestigious Schawlow Award of LIA in 2016.

Dynamic Beam Lasers for Welding and Metal Additive Manufacturing (AM)

Ami Spira, VP Marketing
Civan Lasers

Dynamic Beam Lasers represent a cutting-edge advancement in laser welding and metal additive manufacturing (AM), offering unparalleled control and precision. Unlike traditional laser systems, dynamic beam lasers employ Coherent Beam Combining (CBC) and Optical Phased Arrays (OPA) to dynamically shape and steer the laser beam in real-time. This capability allows for precise manipulation of the beam profile, enabling optimized heat distribution and improved material interactions. As a result, these lasers can significantly enhance the quality of welds and additive layers by reducing defects such as porosity, cracking, and spatter, leading to stronger, more consistent joints and printed structures.

In welding applications, dynamic beam lasers allow for faster processing speeds and deeper penetration while maintaining high-quality weld seams. This adaptability makes them suitable for a wide range of materials, including those that are difficult to weld with conventional lasers. In metal AM, the real-time beam shaping enhances powder melting uniformity, leading to smoother surfaces, improved mechanical properties, and reduced post-processing requirements.

The ability to rapidly switch between beam shapes based on process needs opens up new possibilities for tailored welding patterns and customized layer-by-layer building in AM. Consequently, dynamic beam lasers are positioned to drive innovation in industries such as maritime, aerospace, automotive, and defense, where strength, and efficiency are crucial. This technology thus represents a transformative tool for high-performance manufacturing and complex metal fabrication.



Bio: Ami Spira serves as the General Manager of Civan Lasers USA, overseeing the company's operations across North America since January 2024. His focus lies in expanding Civan's market footprint, leading key strategic initiatives, and fostering regional growth. Before assuming this leadership role, Ami was the VP of Marketing at Civan Lasers. Ami has held various leadership and marketing positions throughout his career, contributing to his expertise across multiple companies. He holds a Master of Arts in Law from Bar-Ilan University and a bachelor's degree in business administration and management from Reichman University.

A Novel Solid-State Metal Additive Manufacturing Strategy: Laser-Induced Supersonic Impact Printing (LISIP)

Yiliang (Leon) Liao, Associate Professor

Department of Industrial and Manufacturing Systems Engineering, Iowa State University

Abstract: In this work, we present a novel solid-state metal additive manufacturing (AM) process called laser-induced supersonic impact printing (LISIP). This method harnesses laser shock-induced impact loading to initiate the adiabatic shearing phenomenon at metal-metal interfaces, enabling solid-state three-dimensional (3D) printing of metallic materials. The design of LISIP draws inspiration from techniques such as cold spray, explosive welding, and laser impact welding. We conducted an experimental investigation to evaluate the capabilities of LISIP, focusing on 3D micro-lamination of metallic structures, the additive manufacturing of dissimilar materials, and on-demand direct writing across various length scales, from micrometers to centimeters. The materials used in our experiments included steel, copper, aluminum, titanium, and magnesium alloys, employed as foils and substrates. The mechanisms involved in LISIP including the laser-matter interaction and adiabatic shearing bonding were discussed.



Bio: Dr. Yiliang (Leon) Liao is an associate professor in the Department of Industrial and Manufacturing Systems Engineering at Iowa State University. Dr. Liao's research is mainly focused on advanced manufacturing process innovation and advanced materials processing towards applications in biomedical, energy storage, structural engineering, and soft robotics.

Advanced Solid-Phase Processing and Manufacturing

Tianhao Wang, Materials Scientist
Pacific Northwest National Laboratory

Abstract: Building on a rich history of materials science research and engineering development, Pacific Northwest National Laboratory (PNNL) is paving the way for adoption of new manufacturing methods that could revolutionize the energy, automotive, aerospace, and other industries. Solid phase processing (SPP) has the potential to significantly decrease the energy used in manufacturing and deliver higher-performing components—all at a lower cost. This scalable approach produces metal and composite products that, in some cases, simply cannot be made by conventional means.

Historically, metal alloy and composite production has required that the metal first be melted and then subjected to several energy intensive steps, such as heat treatment, forging, rolling, and drawing, to produce end products. With SPP, metals are not melted, resulting in a significant decrease in the energy intensity of alloy and component manufacture. SPP applies mechanical energy—in the form of high shear strain—to the metals to create friction heat for deformation. This process enables the microstructure of the metal to be tailored to yield superior properties. As a result, SPP can circumvent the constraints imposed by conventional manufacturing methods and produce materials and components with truly extraordinary properties. This talk will provide an overview of solid-phase processing capabilities and their applications in the advanced manufacturing of various materials.



Bio: Dr. Wang is a Materials Scientist in the Applied Materials and Manufacturing Group at Pacific Northwest National Laboratory. He received his Ph.D. in Materials Science and Engineering from the University of North Texas in 2018, and his B.S. and M.S. degrees from Harbin Institute of Technology in 2012 and 2014, respectively. His current scientific interests focus on solid phase welding and processing techniques including Friction Stir Welding, Friction Stir Processing, Shear Assisted Processing and Extrusion (ShAPE™), and Additive Friction Surfacing.

Ontologies, Knowledge Graphs, and Semantic AI in Smart Manufacturing

Farhad Ameri, Associate Professor
Chair, Manufacturing Engineering Program
School of Manufacturing Systems and Networks
Ira A. Fulton Schools of Engineering, Arizona State University
Investigator, Semantic Computing Lab
Mesa, AZ, Technology Center

Abstract: The core promise of the Industry 4.0 paradigm is to establish an ecosystem of smart, interoperable, and connected software and hardware systems that collectively enable autonomous design-to-fabrication processes. The factories of the future, shaped by the Industry 4.0 roadmap, are characterized by flexible automation, real-time connectivity, and decentralized decision-making. Achieving this vision requires the integration of disparate data repositories and the formalization of knowledge models to ensure that heterogeneous yet relevant systems can communicate, interpret, and act on information meaningfully and accurately. However, information integration remains costly, time-consuming, and fragile due to a lack of interoperability. This talk introduces semantic knowledge models, with a focus on ontologies and knowledge graphs, and explores their role in enabling semantic interoperability and distributed intelligence in cognitive manufacturing systems and supply chains. A case study will be presented on the creation of the Supply and Demand Open Knowledge Network (SUDOKN), which represents the capabilities of small and medium-sized manufacturers (SMMs). The SUDOKN knowledge graph is designed to be an open-source, public, and application-neutral resource, supporting AI-powered supply chain analysis solutions.



Bio: Dr. Farhad Ameri, an Associate Professor at Arizona State University's School of Manufacturing Systems and Networks, heads the Semantic Computing lab. His research focuses on knowledge representation and reasoning (KRR), neuro-symbolic AI, ontology engineering, and semantic interoperability in smart manufacturing systems and digital supply chains. With a doctorate in Manufacturing Engineering from the University of Michigan, Ameri actively contributes to advancing digital transformation in cyber-physical production systems. He is a founding member of the Industrial Ontology Foundry (IOF) and a member of the Board of Directors of the Knowledge Graph Alliance (KGA). Ameri's research, supported by federal agencies such as NSF, NIST, Mx/D, and DHL, and industrial sponsors, drives innovation in the field.

From Data to Decision for Additive Manufacturing: Improving Design for Sustainability with Energy Prediction Models and Decision-Making Tools

Hannah D. Budinoff, Assistant Professor

Systems and Industrial Engineering

Member, BIO5 Institute

Joint Faculty Member, School of Mining and Mineral Resources

University of Arizona

Abstract: To inform sustainable decision making in manufacturing, designers need reliable estimates of the environmental impact and cost associated with manufacturing their designs. Life-cycle assessment and cost estimation methods depend on energy consumption data, which is often lacking for products made via additive manufacturing. While some predictive models for energy consumption exist, they are typically developed using a small number of experimental data. Generalizable models that can offer accurate predictions for a range of machine types, materials, part geometries, and process parameters are needed. Focusing on polymer material extrusion, we have combined new experimental data with existing literature to create a comprehensive database of several hundred unique energy-consumption measurements, including data from desktop and large industrial printers. Using this expanded dataset, we introduced a new semi-empirical model for energy prediction. Model performance is benchmarked against several existing empirical and physics-based models. Model performance and ease of implementation of current and proposed models is compared. The best performing model was incorporated into a plugin to a commonly used slicing software to integrate energy consumption predictions into the build preparation workflow. Preliminary work related to laser powder bed

fusion and metal feedstocks will be discussed. This work demonstrates the role that predictive modeling and interactive tools can play in tandem in enhancing sustainable decision-making in the engineering design process.



Bio: Hannah Budinoff is an Assistant Professor of Systems and Industrial Engineering at the University of Arizona. She holds a Ph.D. and M.S. in Mechanical Engineering from UC Berkeley and a B.S. in Mechanical Engineering from the University of Arizona. Her research interests include automated manufacturability analysis with a focus on additive manufacturing processes, design and development of design support tools, and engineering identity and design skill development. Budinoff actively collaborates with government, academic, and industry researchers supported by funding from a range of sources including NSF, NIST, and DoD agencies.

Research at the Linke Lab on Smart, Sustainable and Human-Centered Manufacturing

Barbara S. Linke, Dr.-Ing. habil., Professor
Mechanical and Aerospace Engineering
University of California, Davis

Abstract: Barbara Linke heads the Manufacturing and Sustainable Technologies Research (MASTeR) Laboratory at UC Davis, which is concerned with sustainability of manufacturing operations and machine tools. She investigates physical mechanisms in abrasive machining, additive manufacturing, and other processes to evaluate their impact on the product life cycle and to digitize the process knowledge to enable smart, sustainable and human-centered manufacturing in the age of Industry 4.0/5.0. This presentation shows examples of surface finishing for food safety, abrasive finishing of 3D printed metal and PEEK implants, capturing of operator expertise in manual grinding and other manual processes, and design of mobile and solar-powered 3D printing systems.



Bio: Professor Dr.-Ing. habil. Barbara S. Linke is a faculty member of the Mechanical and Aerospace Engineering Department and a principal investigator at the Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center, both at the University of California, Davis. She completed her Diplom, doctorate, and Habilitation in mechanical engineering at the RWTH Aachen University, Germany. She worked as research associate at the Laboratory for Machine Tools and Production Engineering WZL at the RWTH Aachen University and as postdoc at the University of California, Berkeley before joining UC Davis in 2012. She served as vice-chair of undergraduate studies in her department at UC Davis from 2019-22 and as executive committee member of the Manufacturing Engineering Division of the American Society of Mechanical Engineers (ASME) from 2019-2024. Her research interests include sustainable manufacturing, transportation research, abrasive machining technologies, part quality, smart and data-driven manufacturing, among others.

Modeling microstructure evolution, material performance, and manufacturing with the open source MOOSE framework

Daniel Schwen, Distinguished Scientist
Idaho National Laboratory

Abstract: Idaho National Laboratory's open-source finite element Multiphysics Object-Oriented Simulation Environment (MOOSE) is a compelling simulation platform for research and development. MOOSE allows for quick and flexible implementation of tightly coupled physics. The

driver for the development of MOOSE has been nuclear energy modeling and simulation, an intrinsically multi-scale and Multiphysics problem, spanning the engineering scale of nuclear reactor internals down to the microstructure of nuclear fuel and structural materials, and covering physics as diverse as thermal transport, neutronics, continuum mechanics, fluid flow, and thermochemistry. Applications of the MOOSE framework have become increasingly broader due to its flexibility and extendibility, ranging from soft robotics, biomechanics, battery research, geo-mechanics and -thermal modeling, to additive manufacturing methods.

This talk will present an overview of MOOSE capabilities and applications in materials modeling and additive manufacturing, with an excursion into the integrated tools for uncertainty quantification, Bayesian inference, and surrogate modeling. Get MOOSE at <https://mooseframework.inl.gov/>



Bio: Dr. Schwen is a Distinguished Scientist and group lead in the Computational Mechanics and Materials Department at Idaho National Laboratory, a Department of Energy nuclear lab. He works on numerical method development for materials modeling and mechanics at the meso- and engineering scale. Dr. Schwen is a main contributor to INL's open-source MOOSE framework, the lead developer of the mesoscale NEAMS-funded MARMOT tool, the MyTRIM binary collision Monte Carlo code, and the MARMOT-MyTRIM coupling application Magpie. He has implemented core multiphase modeling and mechanics coupling

functionality into MOOSE/MARMOT and designed novel rapid model development capabilities. His expertise is in the area of multiscale modeling, with a focus on using mesoscale phase field modeling, thermodynamic database coupling, and developing simulation tools to bridge from the atomistic to the macroscale. Dr. Schwen has experience in modelling materials under irradiation and thermodynamic modeling.

High-precision manufacturing and fastening of aerospace materials

Dave Kim, Professor
Mechanical Engineering Program Coordinator
Washington State University

Abstract: High-precision manufacturing is essential but challenging in modern aircraft construction and maintenance due to the introduction of new aerospace materials and the ever-increasing need for exceptional structural integrity. Hybrid composites like carbon fiber-reinforced polymers (CFRP) titanium stacks are favored for their high strength-to-weight ratio, which enhances fuel efficiency and aircraft performance; however, manufacturing processes must meet strict tolerances to avoid defects such as delamination or fiber pull-out, which could compromise safety and durability. Additionally, advanced fastening technologies, including cold expansion or interference-fit joints, can improve the structural integrity of aircraft structures. The talk will cover the following research areas:

- Drilling of CFRP/Ti stacks
- Interference-fit joints in CFRP
- Cold hole expansion in aluminum alloys
- Trimming of CFRP

Bio: Dr. Dave Kim is Professor and Mechanical Engineering Program Coordinator in the School of Engineering and Computer Science at Washington State University Vancouver. Dr. Kim's areas of expertise include precision manufacturing processes, advanced composite materials, and the structural integrity of structural joints, particularly in aerospace and marine applications. In addition to his technical research, Dr. Kim has made significant contributions to educational



research, focusing on writing pedagogies in engineering labs. His group has research projects supported by numerous grants from institutions such as NSF, US Army, Joint Center for Aerospace Technology Innovation, City of Portland, Korea Evaluation Institute of Industrial Technology, and Boeing, with \$2.7 million in research expenditures. He authored over 200 peer-reviewed papers in high-impact journals and conferences. Dr. Kim has received many honors throughout his career, including the Chancellor's Award for Research Excellence at WSU Vancouver, the institution's highest research honor, and Best Paper Awards from an ASEE Conference and International Journal of Naval Architecture and Ocean Engineering. He has chaired the ASEE Manufacturing Division, the SME Portland Chapter, and the Southwest Washington MESA Executive Board. He received his B.S. and M.S. in Mechanical Design at Sungkyunkwan University, Korea, and a Ph.D. in Mechanical Engineering in 2002 from the University of Washington, Seattle.

Materials and Manufacturing

Patrick Kwon, Chair and Professor
Department of Mechanical Engineering
San Diego State University
San Diego, CA

Abstract: A typical mechanical curriculum focuses on various disciplines such as mechanics, design, manufacturing, thermodynamics, fluids mechanics, etc., with typically only one course in materials science. However, the graduated mechanical engineer working in manufacturing arena must choose materials for their designs and work with chosen materials under various temperatures and temperature change in time and space as well as the physical and chemical interactions with the other materials needed to process the given material. Given the likelihood of such scenario, did we educate mechanical engineers with a right set of knowledge and skills? At San Diego State University (SDSU), we have basically merge two programs, materials science and mechanical engineering, into a graduate program in advanced manufacturing. The faculty members at SDSU consist of both materials scientists and mechanical engineers, expecting to provide the synergistic expertise in manufacturing. On my research, the examples in machining and powder processing are demonstrated to show how materials science knowledge is intertwined in understanding manufacturing. This talk will introduce the individual research of the faculty members in ME at SDSU whose research focuses on advanced manufacturing.



Bio: Prof. Kwon has received his B.S., M.S. and Ph.D. in Mechanical Engineering from University of Michigan (Ann Arbor) in 1983, MIT in 1985 and University of California (Berkeley) in 1994, respectively. He started his academic career as an assistant professor in Department of Materials Science and Mechanics (MSM) at Michigan State University (MSU) in 1996 and transferred to Department of Mechanical Engineering in 2000 with the dissolution of MSM. He was promoted to Professor in Department of Mechanical Engineering at MSU in 2009. He has served as Associate chair for graduate studies in Department of Mechanical Engineering between 2017 and 2023. After almost 30 years at MSU, he became the chair of mechanical engineering department at San Diego State University (SDSU) in 2024. In term of his professional service, he served as associate editor for ASME Journal of Manufacturing Science and Engineering between 2009 and 2015 and for International Journal of Precision Engineering and Manufacturing since 2012. He has been serving NAMRI/SME as a board member since 2022. In research, he has made fundamental contributions in understanding tool wear mechanisms and minimum quantity lubrication in machining and powder processing in metals and

ceramics. Recently, he has worked on metallic additive manufacturing including improving Binder Jet Printing, Selective Laser Melting, and Electron Beam Melting and developed a new process called scalable and expeditious additive manufacturing (SEAM) while still working on machining research.

Corrosion and corrosion-enabled surface quality control for advanced manufactured alloys

Shuaihang Pan, Assistant Professor
Department of Mechanical Engineering, University of Utah

Abstract: Corrosion is an inevitable alloy degradation, with a complex microstructure dependence by various advanced/additive manufacturing (AM) processes. In this long-term battle, corrosion study yields many insightful learnings. As a coin of two sides, the materials removal nature by corrosion also triggers huge interests of using it as a way for non-traditional manufacturing. The successful practices include electrochemical machining (ECM), electropolishing (EP), etc., to obtain a higher AM parts' quality. However, the less controllable nature of corrosion and related electrochemical processes make the techniques risky and unsatisfactory. With this, Dr. Pan will talk about his journey of exploring the fundamental corrosion mechanisms in novel alloys fabricated by various AM processes and how to solve the corrosion problems via a clear link with the understanding of alloys' microstructures. With this detailed "processing-structure-performance" relationship, Dr. Pan will cover corrosion-enabled technique with a focus of ECM innovation for a better AM parts' surface quality and materials removal control. After this, he wishes to discuss about the potential fusion with the efforts from Oregon region.



Bio: Dr. Shuaihang Pan received his Ph.D. degree (2021) in Mechanical Engineering from the University of California-Los Angeles and a B.S. degree (2016) from Shanghai Jiao Tong University, respectively. He is now the assistant professor at the Department of Mechanical Engineering at the University of Utah, leading the research lab LoAM (<https://loam.mech.utah.edu/>). His research focuses on AM and anti-degradation performance design for metallic systems.

Currently, he has published over 50 peer-reviewed papers, 4 invited reviews, and 2 patents, with >2000 citations. His conference talks at WTC (2017), NAMRC (2019), and TMS (2020 and 2022) attract more attention to his research. With these achievements, he received the 2019 and 2021 Best Review/Research Paper Award of Journal Friction and the 2019 NSF Travel Grant Award. Dr. Pan is now serving the Editorial Board for Friction (2023-), Surface Technology (2021-), and Tungsten (2022-2024). He is recently invited to the SME NAMRC Scientific Committee (2024-2026) to assist with NAMRC arrangement. With years of research experience, he is actively collaborating with professors, scholars, and engineers from universities of OSU, UF, and ASU, etc., national labs of INL and BNL, and industries of Mayo and Medtronic for more exciting opportunities in AM and novel materials design.

Additively Manufactured Porous Media for Enhanced Transport

Todd Otanicar, Professor
Department of Mechanical and Biomedical Engineering
Interim Associate Dean for Research Affairs, College of Engineering
Boise State University

Abstract: Porous media represents an attractive area for a number of heat transfer applications due to the high surface area to volume ratio that can be achieved. Recently, porous foams have garnered substantial interest because of their relative ease of manufacture and extremely high specific surface areas, leading to extremely high heat transfer coefficients. While foams are attractive, using additive manufacturing allows for the specific design of highly controlled surfaces that can enhance heat transfer, maintain structural integrity, and lower pressure drop relative to a foam. Additionally, foams have limited room for optimization outside of porosity and pore cell size. Because of these limitations, there is substantial interest in pursuing additive manufacturing (AM) techniques to build lattice structures where multiple geometric properties can be manipulated simultaneously to achieve optimal thermal, hydraulic, and structural properties. Optimal, mass-efficient, lattice geometries can be produced and simulated using computational modeling tools. In particular, the use of lattice structures with triply periodic minimal surfaces (TPMS) have been proposed because of the large control of the resulting structure. While such approaches are useful for predicting thermal, hydraulic, and structural properties extending these models to high temperatures has been limited both computationally and experimentally. Here, we will discuss gaps and opportunities for using AM for enhancing transport in porous media applications.



Bio: Dr. Todd Otanicar is a Professor at Boise State University in the Department of Mechanical and Biomedical Engineering. His research focuses on the intersection of thermal transport and advanced energy systems. His research has been supported by DOE, NSF, NASA, ARPAE and DOI. He has served as Chair of the Mechanical and Biomedical Engineering Department at Boise State University and is a licensed professional engineer.

Extrusion-based additive manufacturing of parts with as-designed properties

Arda Gozen, George and Joan Berry Associate Professor,
School of Mechanical and Materials Engineering

Affiliate Faculty, Gene and Linda Voiland School of Chemical Engineering and Bioengineering
Washington State University

Abstract: Additive manufacturing (AM) challenges the conventional design and manufacturing paradigms by unlocking unprecedented levels of design complexity for a broad range of materials. This advancement has been improving most engineering applications by reducing material use and part weight and the need for complex assemblies. In addition to the expansion of geometric design space, AM carries a significant potential to dictate the functional properties of the printed parts through precise spatial control of the material composition and structure. In this talk, ongoing research efforts at Manufacturing Processes and Machinery Lab at Washington State University towards realizing this capability will be presented. With an emphasis on extrusion-based AM processes, two main research thrusts will be covered: (1) understanding and controlling the process mechanisms that dictate the geometry and microstructure of each deposited filament and (2) integration of multiple different materials in a single part, strategically designed to exhibit desired spatial properties. Regarding the former, the studies on the mechanisms through which polymer composite inks and molten metals flow through the nozzles and are deposited and how the mechanisms influence the part structure and functional properties will be discussed. For the latter, a hybrid AM method combining direct-ink-write and fused filament fabrication to generate soft-material composites with spatially controlled visco-hyperelastic properties will be presented. Finally, insights will be provided regarding future research towards a new paradigm in which not only part geometry, but also the spatial distribution of part properties can be designed for additive manufacturing.



Bio: Dr. Arda Gozen is the George and Joan Berry Associate Professor at the School of Mechanical and Materials Engineering of Washington State University. He obtained his Ph.D. degree in mechanical engineering in 2012 from Carnegie Mellon University where he also worked as a post-doctoral research associate. Prior to his Ph.D. studies, Dr. Gozen obtained his B.S. degree from Middle East Technical University, Ankara, Turkey. He is the recipient of 2019 NSF CAREER and WSU Voiland College of Engineering and Architecture Junior Faculty Research awards. He is the author of over 30 journal publications, numerous conference proceedings and holds 2 patents. His research interests include micro- and nano-scale manufacturing, soft-materials and rheology, flexible-stretchable devices, mechatronics and instrumentation, dynamic systems

and controls, and precision engineering.

Additive Manufacturing of Flexible and Stretchable Electronics from Low-Dimensional Nanomaterials

C. Chase Cao, Assistant Professor
Mechanical and Aerospace Engineering
Electrical, Computer and Systems Engineering
Case Western Reserve University
Investigator, Advanced Platform Technology (APT) Center
Louis Stokes Cleveland VA Medical Center

Abstract: Flexible and stretchable electronics have garnered significant attention over the past decade due to their potential applications in personalized health monitoring, artificial skins, implantable devices, human-machine interfaces, and smart agriculture. Considerable efforts have been dedicated to enhancing the functionality, robustness, and reliability of these devices through innovations in materials, manufacturing, and design. In this talk, I will present our recent advances in designing, manufacturing, and optimizing emerging electronics using additive manufacturing and printed electronics technologies. Specifically, I will discuss the development of novel inks and manufacturing techniques for printed flexible and stretchable electronics - including sensors, transistors, and energy storage devices such as supercapacitors and batteries - based on low-dimensional nanomaterials. I will also highlight their applications in smart packaging, health monitoring and diagnostics, and smart infrastructures. Additionally, I will cover our progress in self-powered sensing systems and human-machine interfaces (HMI) for controlling soft robotics, as well as our development of robotic skins to enhance robotic intelligence and functionality.



Bio: Dr. C. Chase Cao is an Assistant Professor in Mechanical and Aerospace Engineering, with secondary appointments in Electrical, Computer and Systems Engineering, and Civil and Environmental Engineering at Case Western Reserve University (CWRU). He directs the Laboratory for Soft Machines and Electronics (SME Lab) at the Case School of Engineering and is an Investigator of the Advanced Platform Technology (APT) Center at Louis Stokes Cleveland VA Medical Center. Dr. Cao earned his Ph.D. in Mechanical Engineering from the Australian

National University (ANU) and completed his postdoctoral training in Mechanical and Electrical Engineering at Duke University. His research interests include soft robotics, self-powered soft electronic systems, multifunctional materials and structures, and 3D & 4D printing techniques. Dr. Cao has authored over 80 scientific papers in peer-reviewed journals, including *Nature Biotechnology*, *Matter*, *Advanced Materials*, *Advanced Functional Materials*, *Soft Robotics*, *IEEE T-RO*, *IEEE RA-L*, *ACS Nano*, *Biomaterials*, and *Extreme Mechanics Letters*. He also holds seven U.S. patents, one of which was licensed to a startup company and later acquired by a major

corporation. His research has been funded by various agencies, including the NSF, USDA, DOE, DOT, MEDC, and Swagelok. Dr. Cao serves as the President of the Electronic Materials Technical Committee within the ASME Material Division. He is an Associate Editor for *Frontiers in Robotics and AI*, *Frontiers in Mechanical Engineering*, and *IEEE Robotics and Automation Letters (RA-L)*, and serves on the editorial boards of several journals, including *Advanced Electronic Materials*, *Sensors*, *Micromachines*, *Soft Science*, and *Forces in Mechanics*.