

# Sustainable Manufacturing

## Products, Processes, and Systems

Volume 8 Issue 1

Institute for Sustainable Manufacturing Newsletter

Fall 2021/Spring 2022

### A Message from the Director



The Institute for Sustainable Manufacturing (ISM) is approaching its tenth year of successful operation focusing on cutting edge research and applications in sustainable manufacturing covering products, processes, and systems. ISM faculty and researchers have been active in developing and implementing novel product/process design methodologies and establishing closed-loop sustainable manufacturing systems for improved resource efficiency, minimum waste generation, improved economic, environmental, and societal benefits, all aimed at achieving and advancing the circular economy for sustainable future. Over the years, ISM has made excellent progress with our overall mission of conducting academic research (basic and applied), offering educational programs, being engaged in innovation and developing intellectual properties, and providing industry outreach. Our research productivity with new funding, research publications, graduate student productivity has continued to increase. Here are some highlights of our achievements in 2021:

- ISM faculty has been highly productive in publication activities producing numerous high-impact journal publications, including invited special issue publications, delivering plenary keynote presentations and lectures, presenting at major international conferences, and serving on national and international level review panels, roundtables, project leaderships, etc. Their research work has also been recognized with awards by professional societies, academic and industrial organizations – details are on p. 2.

- In February 2021, ISM researchers launched a major international collaborative research project, IMPACT under the sponsorship of CIRP (International Academy for Production Engineering). This new collaboration involves about 55 researchers from 35 major research labs, universities, and industry groups, from 14 countries – details are on p. 2.
- A significant amount of new research funding has been generated by the ISM faculty from various agencies, industry groups and private foundations. Most notably, in May 2021 a group of four ISM faculty (Badurdeen, Schoop, Karaca and Jawahir) and a senior ISM researcher (Caudill) received large DoD funding for five research projects totaling over \$15M for five years (from the \$23.8M total commitment) on developing advanced materials and novel manufacturing technologies for DoD applications – details of this research program are on p. 3.
- Researchers from ISM continued collaboration with the sustainable manufacturing research group at the University of Bologna, Italy on Design Innovation for Next Generation Sustainable Products as well as with the Technical University of Berlin, Germany on Digitally-Integrated Sustainable Manufacturing for Value Creation.
- ISM Faculty continued offering courses for the Online Master's Degree Program in Manufacturing Systems Engineering, with more course options and enrollment. Also in collaboration with the Gatton College of Business and Economics, have developed a new Online Masters Program in Supply Chain Engineering (SCE). Prof. Badurdeen serves as the director of this program.

I. S. Jawahir, Director ISM

### Strategic Materials and Recovery Technologies (SMaRT) for Sustainable Manufacturing



Dr. Werner is an extractive metallurgist and founding member of "The Strategic Materials and Recovery Technologies (SMaRT) Center". Dr. Werner's

#### A Center of Excellence in Critical Materials

By innovating technologies, educational contributions, and research funding.



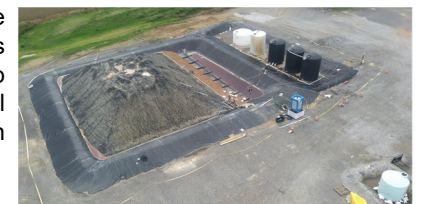
research focus is to close the loop of the circular economy by providing cross-disciplinary research focused on recovery, processing, purification and extraction of essential energy supporting materials. The objective of this work is 3-fold:

1. Develop technologies to overcome critical gaps to enhance the stability and sustainability of critical energy-dependent materials supply
2. Engage strategic partners to commercialize and scale technologies into the market place, and
3. Disseminate knowledge and skills through training, education and workforce development in the nascent field of "resource recovery" engineering.

In the last year Dr. Werner completed the construction of what is believed to be the world's first heap leach for the recovery of

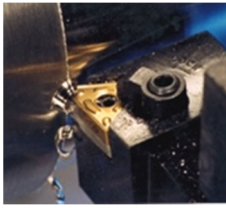
critical and rare earth elements from coal waste products, in partnership with the United States' only rare earth producer and the Department of Energy, as part of a feasibility study. Dr. Werner's contributions also include ongoing academic to industry collaborations for the recovery of non-ferrous and precious metals from a novel and patented process for closed loop recycling from various waste streams including E-Waste. Funding from private sources and the NSF for commercialization are leading to rich technology transfer opportunities to recover valuable metals in an ecofriendly and economically viable manner. This technology is currently being demonstrated in a continuous lab scale demonstration facility at UK.

The earth's resources are finite, and this work is essential to close the loop on the recovery of critical materials to support green energy production.

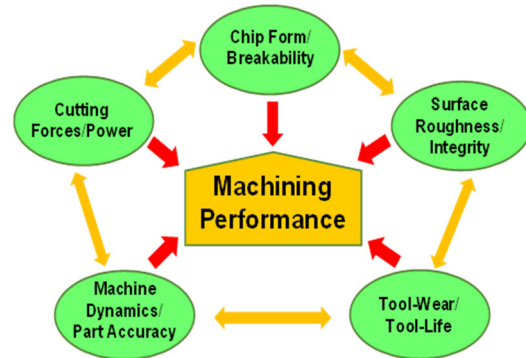


## ISM Leads IMPACT, a New Major International Collaborative Research Project

In February 2021, CIRP (International Academy for Production Engineering) at its Annual Meeting in Paris, France formally approved the formation of a new major international collaborative research project, IMPACT (Integrated Machining Performance for Assessment of Cutting Tools). A total of 55 researchers from 35 international research labs, including three leading cutting tool manufacturers, from 14 countries (Belgium, Canada, France, Germany, Israel, Italy, Japan, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA) participate in this endeavor.

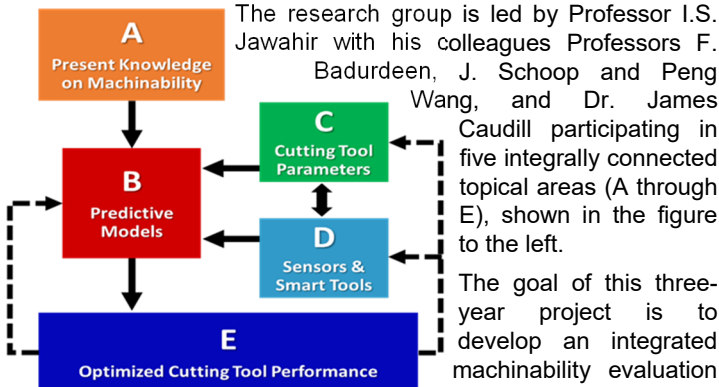


method to provide the overall performance of the machining system (work material, cutting tool and machine tool). The proposed new method will include the five interacting major machinability parameters shown in the figure below.



Advanced computational modeling and machine learning methods, in-situ material performance analysis, experimental data and optimization techniques will be used to develop a predictive performance model for IMPACT. A digitally-enabled predictive capability will be developed for determining the optimal machining performance of a machining system for a given machining operation.

Proposed collaborative research activities in all five topical areas are carefully planned within a three-phased project plan which is expected to reach IMPACT goals by 2024.



## Keynote Presentations, Panel Participations, Appointments and Awards

**Dr. I.S. Jawahir** has been selected to be awarded the **2022 SME Frederick W. Taylor Research Medal** by the Society of Manufacturing Engineers (SME) at the **SME International Awards Gala** on May 15, 2022 in Detroit, MI. This medal is part of the annual International Honor Awards, to recognize and honor an outstanding international researcher whose significant published research led to a better understanding of materials, facilities, principles, operations and their application to improve manufacturing processes.



**Dr. Fazleena Badurdeen** and her graduate students Ammar Ali and Christian Enyoghasi received the **Best Conference Paper Award** at the **International Conference on Resource Sustainability**, held virtually July 9-23, 2021 in Dublin, Ireland for a paper on *A Quantitative Approach for Product Disassemblability Assessment*.

**Dr. Julius Schoop** received the **2021 ASME Bluegrass Chapter Outstanding Faculty Award** in Mechanical Engineering.

**Dr. I.S. Jawahir** presented an **Invited Paper** on *Optimization of Sustainable Machining of Ti-6Al-4V Alloys* at the opening the **ASME Symposium on Sustainable Machining Processes** during the November 2021 **ASME-IMECE (International Mechanical Engineering Congress and Exposition)** and also participated and led a Roundtable Discussion Session on *Traditional Manufacturing Processes: Transformation and Trends in Industry*.



**Dr. Julius Schoop** presented at the **Indiana Defense Network's Technical Interchange Meeting** in June 2021.

**Dr. Julius Schoop** received a 5-year **NSF CAREER Award** for \$507,288 from 05/2022-05/2027 for *Thermomechanical Response and Fatigue Performance of Surface Layers Engineered by Finish Machining: In-situ Characterization and Digital Process Twin*.



**Dr. Peng Wang** and graduate students Matthew Russell, Chadwick Parrish and Evan King received the **Outstanding Technical Paper Award** in the Manufacturing Systems Track at the **49th North American Manufacturing Research Conference (NAMRC 49)** held virtually in June 2021 for a paper on *Stochastic Modeling for Tracking and Prediction of Gradual and Transient Battery Performance Degradation*.

**Dr. Peng Wang** was selected as a **2022 Society of Manufacturing Engineers (SME) Outstanding Young Manufacturing Engineer**. He will receive the award at the **NAMRC 50 Conference** to be held in June 2022 at Purdue University.

**Dr. Peng Wang** was appointed an **Associate Editor** for the **Journal of Intelligent Manufacturing and IEEE Sensors Journal**.



**Dr. I.S. Jawahir** delivered a **Plenary Keynote Presentation** on *Sustainable Manufacturing with Digital Integration for Advancing the Circular Economy: Product and Process Innovations* at the opening of the **7th International Multidisciplinary Engineering Conference** (Moratuwa Engineering Research Conference 2021 - MERCon 2021, sponsored by IEEE) held in Moratuwa, Sri Lanka in July 2021.



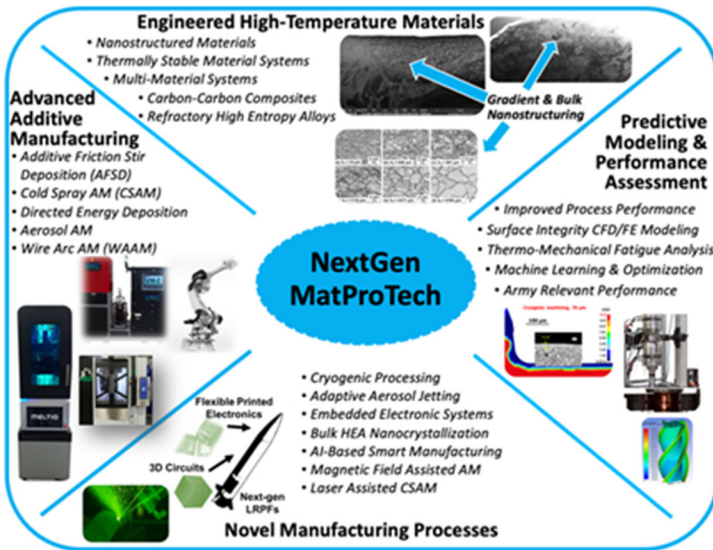
# Next Generation Materials & Processing Technologies” (NextGen MatProTech)

ISM in collaboration with the Army Research Laboratory (ARL) is engaged in a multi-year research program on developing next generation materials and novel manufacturing processes for Army modernization through fundamental research in four strategic areas shown in figure below.

A state-of-the-art AM research laboratory is currently being developed within ISM that will house several highly unique AM systems. The first of which will be operational in early summer (the remaining systems in the fall) and will include a MELD L3 AFSD system, CSAM system from VRC Metal Systems, MDDED system from Optomec, and a custom AJAM system.

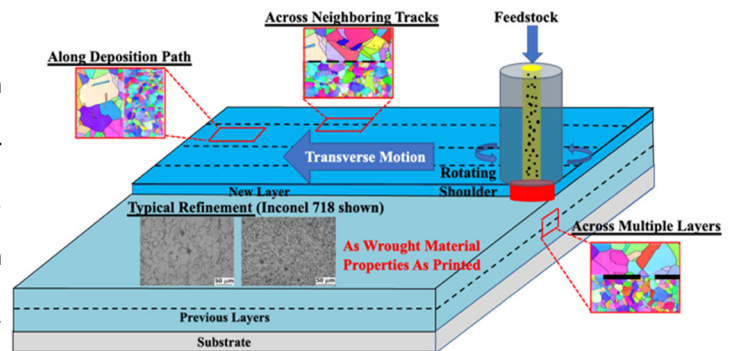
AFSD and CSAM are solid-state AM technologies based on plastic deformation at elevated temperatures, rather than melting and solidification. This provides highly stable and consistent manufacturing processes, where unwanted phase transformations and tensile residual stresses can be avoided, and site-specific material properties can be engineered in unique configurations.

AFSD will be used to develop novel nanostructured and functionally graded materials, with an emphasis on high entropy alloys and immiscible systems. CSAM research will focus on developing models to describe the influence of velocity gradients within the supersonic flow field on the resulting material properties and defect generation in Nb-based materials systems. MDDED and AJAM are being utilized to for groundbreaking research into the generation of highly specialized alloys and next generation electronic systems, respectively. SMART AM tools are being developed for each of these technologies and integrated across shared process-physics.



ISM is coordinating 5 of the 7 projects in this research program:

1. Thermally-Stable Nanostructure Generation in Additive Friction Stir Deposition (AFSD) - PI: I.S. Jawahir
2. SMART AM through In-situ Monitoring and Control of Fusion-Based and Solid-State Technologies - PI: F. Badurdeen
3. Magnetic Assisted Directed Energy Deposition (MDDED) - PI: H. Karaca
4. Cold Spray Additive Manufacturing (CSAM) of High Temperature Materials - PI: J. Caudill
5. Aerosol Jetting AM (AJAM) of Advanced Electronics - PI: J. Schoop

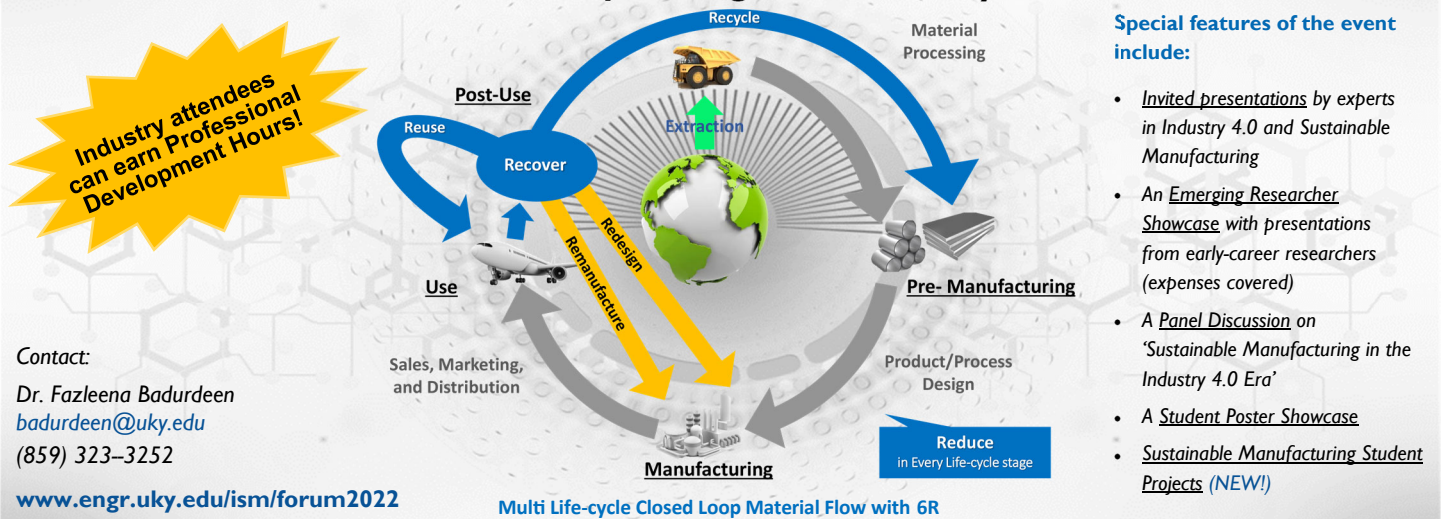


Site-Specific Process Control and Material Refinement in AFSD

## 7<sup>th</sup> International Forum on Sustainable Manufacturing

Organized by the Institute for Sustainable Manufacturing at the University of Kentucky  
Woodward Hall, Gatton College of Business & Economics, University of Kentucky, Lexington, KY  
**October 27-28, 2022**

### Sustainable Manufacturing in the Industry 4.0 Era



## International Visiting Scholars



**Germán González Fernández** received his B.Sc. in Mechanical Engineering from the Polytechnic School of Engineering in his hometown of Gijón, Spain and his M.Sc. in Mechatronic Engineering from the Karlsruhe University of Applied Sciences, Germany. In 2016 he joined IDEKO, the research center of DanobatGroup in Spain, where he worked on novel techniques for chatter suppression in machine tools. Since 2018, he has been a research associate while pursuing his doctorate at the Institute for Production Sciences (wbk) at the Karlsruhe Institute of Technology in Germany. His current research interests are modeling of machining operations, surface integrity after machining and digitalization of machine tools and processes. Germán visited ISM from February - April 2022 and conducted research with Dr. Julius Schoop.

## International Collaborations

- IMPACT - a CIRP sponsored international collaboration with 55 researchers from 35 research laboratories from 14 countries. **I.S. Jawahir, Fazleena Badurdeen, Julius Schoop, James Caudill and Peng Wang** (UK) participate in and lead this project.
- Design Innovation for Next Generation Sustainable Products – Collaboration with University of Bologna (UB), Italy. **Fazleena Badurdeen** and **I.S. Jawahir** (UK); Prof. G. Campana and Dr. B. Cimatti (UB).
- Digitally-Integrated Sustainable Manufacturing for Value Creation – Collaboration with Technical University of Berlin (TUB), Berlin, Germany. **I.S. Jawahir** and **Fazleena Badurdeen** (UK); Prof. G. Seliger, Prof. F. Dietrich and Dr. P. Bilge (TUB).
- DFG Priority Program SPP 2086: Surface Conditioning in Machining Processes – International fellowship and collaboration with various leading German research institutes under the leadership of Karlsruhe Institute of Technology (KIT), Germany. **Julius Schoop** (UK), Prof. Volker Schulze (KIT).

## About the Institute for Sustainable Manufacturing

Details about our new projects, lab facilities, books, recent publications, patents, and more can be found on our [website!](#)

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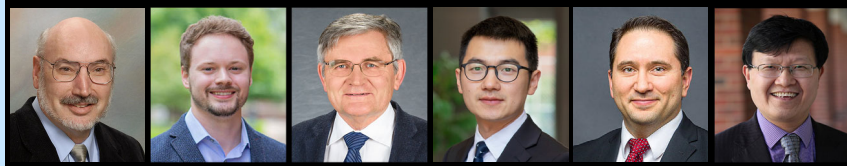
### Journals

International Journal of  
Sustainable Manufacturing  
[www.inderscience.com/ijsm](http://www.inderscience.com/ijsm)  
Journal of Machining Science  
and Technology  
[www.tandfonline.com/toc/lmst20/current](http://www.tandfonline.com/toc/lmst20/current)

### ISM Faculty and Research Staff



F. Badurdeen J. Caudill L. Holloway I.S. Jawahir H. Karaca W. Li



K. Rouch J. Schoop D. Sekulic P. Wang J. Werner Y. Zhang

### ISM Staff



A. Price



D. Harrod

## New Supply Chain Engineering Master's Program (MS-SCE)

UK's online MS-SCE degree will prepare you to apply scientific and mathematical principles to design, evaluate and improve transformational and logistical functions within an enterprise and among its partners across the supply chain.

### Features of the MS-SCE program

- University of Kentucky's MS-SCE and MS in Supply Chain Management programs are the only known programs in the country—and perhaps in the world—that incorporate overlapping curricula from engineering and business & economics colleges to develop future supply chain engineers and managers.
- The program is 100% online. You can pursue your degree part-time while working full-time.
- Requires five consecutive semesters to complete with two courses per semester.
- Offers fixed tuition whether you live in Kentucky or are from another state.
- No GRE score is required for admission, and No thesis is required to obtain the degree



For additional details contact: Dr. Fazleena Badurdeen at [badurdeen@uky.edu](mailto:badurdeen@uky.edu) or (859) 323-3252