

## **REU Site: Summer Academy in Sustainable Manufacturing**

### **Prof. Jeremy Lewis Rickli, Wayne State University**

Dr. Jeremy L. Rickli received his B.S. and M.S. Degrees in Mechanical Engineering from Michigan Technological University in 2006 and 2008 and received his Ph.D. in Industrial and Systems Engineering from Virginia Tech prior to joining Wayne State in 2013. At Wayne State, he has created the Manufacturing and Remanufacturing Systems Laboratory (MaRSLab). MaRSLab targets fundamental and applied research in manufacturing and remanufacturing processes and systems while encouraging considerations for sustainability and life-cycle thinking in design, manufacturing, use, and recovery. Specific research thrusts include: transforming manufacturing quality monitoring and remanufacturing core condition assessment via automated laser line scanning systems; remanufacturing core management considering uncertain core quality, quantity, and timing; and integrating design for disassembly and remanufacturing into CAD/CAM tools. He has collaborated in the past with industrial partners on projects involving residual stresses in lightweight aluminum alloy side rails, manufacturing process simulation, and enhancing end-of-life truck acquisition decisions. Dr. Rickli is also actively involved in outreach activities with Athletes for Charity STEM Youth Literacy Program, which provides Detroit Public Schools with STEM educational sessions.

### **Prof. Yinlun Huang, Wayne State University**

Yinlun Huang is Professor of Chemical Engineering and Materials Science at Wayne State University, Detroit, Michigan. His research has been focused on the fundamental study of multiscale complex systems science and sustainability science, with applied study on sustainable nanomaterial development, integrated design of sustainable product and process systems, and manufacturing sustainability. He has published widely in these areas. He directs the NSF funded Sustainable Manufacturing Advances in Research and Technology Coordination Network.

# **REU Site: Summer Academy in Sustainable Manufacturing - Year One**

## **Abstract**

The Summer Academy in Sustainable Manufacturing is a Research Experience for Undergraduates (REU) Site hosted at Wayne State University. The site offers unique summer undergraduate research experiences in the challenging field of sustainable manufacturing to local and national undergraduate students from two and four-year institutions. The objective of the program is to introduce undergraduate students to the forefront of sustainable manufacturing research and to provide students with the skills and pathways to pursue advanced degrees or careers in sustainable manufacturing. The intensive ten-week summer research and professional development experience hosts ten students per summer. NSF national priority areas such as advanced manufacturing and sustainability are addressed by four undergraduate research thrust areas. Thrust areas include: 1) nano-coating and lightweight materials and manufacturing, 2) energy storage materials, batteries, and inversion devices, 3) remanufacturing and sustainability assessment, and 4) chemical-energy-water nexus. In addition to faculty mentor led research projects, the program offers other learning activities such as; 1) research skill development seminars, local manufacturing plant visits, tutorials on the fundamentals of sustainable engineering, and an end-of-program research poster symposium. The first group of students was hosted at Wayne State in summer 2016 with two more programs scheduled for summer 2017 and 2018. In this poster, we present the 2016 group of undergraduate researchers and the results from recruitment activities, research projects, and surveys from the first year of the Summer Academy in Sustainable Manufacturing. Student recruitment was carried out nationwide and resulted in a diverse group of undergraduate researchers. Participant research activities culminated in an end-of-summer poster symposium and a final undergraduate research paper. Site evaluation was carried out with a student survey requesting participants to comment on the relevance of the program activities. Undergraduate research experiences were evaluated with the SURE surveys from Grinnell College. Evaluation results and the experience acquired during the first year of the Summer Academy in Sustainable Manufacturing will guide execution of years two and three.

## **Introduction**

In response to an urgent need to create effective undergraduate research programs focusing on sustainable manufacturing [1-3], Wayne State University (WSU) proposed and was awarded an NSF REU Site titled, Summer Academy in Sustainable Manufacturing (NSF #1461031). The Summer Academy in Sustainable Manufacturing offers unique summer research experiences in the challenging field of sustainable manufacturing to local and national undergraduate students from two and four-year institutions, especially underrepresented minorities. The site resides in the Southeastern Michigan Manufacturing Community, which was designated as one of the first 12 manufacturing communities under the national Investing in Manufacturing Communities Partnership (IMCP) initiative. The objective of the REU Site is to introduce undergraduate students to the forefront of sustainable manufacturing research and provide students with the skills and pathways to pursue four-year and graduate programs to become knowledgeable and capable engineers in the manufacturing industry of the future.



**Figure 1** REU Site: Summer Academy in Sustainable Mfg.

the Summer Academy in Sustainable Manufacturing website (<https://advancedmaterials.wayne.edu/summer-academy>).

Four sustainable manufacturing technical areas, yielding interdisciplinary research projects, are targeted as the intellectual focus of the site: (1) nano-coating and lightweight materials and manufacturing, (2) energy storage materials, batteries, and inversion devices, (3) remanufacturing and sustainability assessment, and (4) chemical-energy-water nexus. Projects within these four focus areas addressed during the 2016 site program are listed in Table 1. This companion paper to the Summer Academy for Sustainable Manufacturing’s NSF Grantees Poster session describes the program, recruitment, and results of the first year of the three-year site. Additional program, faculty mentor, student participant, undergraduate research project, and application information can be found at

**Table 1** 2016 REU Site: Summer Academy in Sustainable Mfg. undergraduate research projects

Technical Area	2016 Undergraduate Research Project
Nano-coating and lightweight materials and mfg.	Formability of advanced high strength steels for automotive manufacturing
	Sustainable composite manufacturing
Energy storage materials, batteries, and inversion devices	Synthesis of electrocatalytically active niobium sulfide for lithium-sulfur batteries
	Steady-state kinetic isotope exchange
	Highly efficient DC-AC inverters for alternative energy systems
Remanufacturing and sustainability assessment	Condition assessment of end-of-use products for remanufacturing
	Cyberlearning and constructionism in learning for sustainable life-cycle engineering
Chemical-energy-water nexus	Environmental fate prediction via atom-based computer simulations
	Coal and biomass based transportation fuel manufacturing and sustainability assessment: A case study in Kentucky
	Predictive and historical analysis of an energy optimization tool for emissions control
	Integrated algae-wastewater systems for sustainable manufacturing and bioenergy production

### Program Overview

The site supports ten undergraduate students to travel to WSU for ten weeks from June to August to perform research with one or more faculty mentors from across the WSU College of Engineering. It is directed by Jeremy L. Rickli, Ph.D. and Yinlun Huang, Ph.D. J. Rickli is an Assistant Professor in the WSU Industrial and System Engineering Department and Y. Huang is a Professor in the Chemical Engineering and Materials Science Department. Details of faculty mentors and other senior personnel can be found at the site’s official website. WSU’s

Undergraduate Research Opportunities Program (UROP) also provided support for one WSU undergraduate student (underrepresented in STEM fields) to participate in the program, bringing the total students participating in the site to eleven (ten NSF supported students and one WSU UROP supported student). While continuously undertaking research in faculty mentor labs, undergraduate researchers participated in three research based seminars (RS), four general lectures (GL), two plant visits to BASF in Wyandotte, MI and Ford River Rouge Factory (PV), four research skill development seminars (SD), and three local cultural activities (CA). Table 2 describes each of the aforementioned activities. In 2016, cultural activities were tours of the Detroit Institute of Arts, Charles H. Wright African American History Museum, and the Ford River Rouge Museum/Factory.

**Table 2** Schedule for 2016 site program (SDS-Skill Development Seminar, RS-Research Seminar, GL-Group Lecture, PV-Plant Visit, CA-Cultural Activity)

<b>Week</b>	<b>Action/Event</b>
1 6/1-6/7	<b>Orientation and Information Week</b>
	1. Student registration
	2. Walking tour of WSU campus and Midtown Detroit
	3. WSU College of Engineering Dean's and chairs' overview of the college and participating departments.
	4. RS 1: Technical and Projects Overview
	5. SDS 1: Introduction to Academic Research, Responsibility, and Ethics (by the Office of Undergraduate Research at WSU)
	6. GL 1: "Fundamentals of Sustainable Manufacturing"
2 6/8-6/14	1. Students conduct research in faculty mentor labs.
	2. Weekly project review meeting (facilitated by site directors)
	3. SDS 2: Developing Academic Dialogue Skills
3 6/15-6/21	1-2. Same as Week 2, Activities 1-2
	3. RS 2: "Sustainable Manufacturing: An Industry Perspective" - Cristina Piluso (BASF): 1:45pm
4 6/22-6/28	1-2. Same as Week 2, Activities 1-2
	3. RS 3: Multidisciplinary/Interdisciplinary Research and Team work
5 6/29-7/5	1-2. Same as Week 2, Activities 1-2
	3. SDS 3: Communicating Research Methods & Results
6 7/6-7/12	<b>Mid-Term Progress Report</b>
	1. Mid-program presentation (2-slide, 5 minute presentations for economic and social impact advisors)
7 7/13-7/19	1. PV 1/GL 2: Chemical Manufacturing (BASF - Polyurethane Systems)
8 7/20-7/26	1-2. Same as Week 2, Activities 1-2
	4. Report preparation and poster development
	5. CA 1: Charles H. Wright Museum of African American History Museum

9 7/27-8/2	1-2. Same as Week 2, Activities 1-2
	3. GL 4: Multi-scale Sustainability Assessment
	4. SDS 4: Sustainable Minds Life Cycle Assessment tutorial session
	5. CA 2: Detroit Institute of Arts Tour
10 8/3-8/10	<b>Final Research Symposium Week</b>
	1. Submit final report on research and experience in the program
	2. Final poster presentation to university, college, industrial partners, and participating department administrators
	3. Poster presentation competition and best poster award ceremony.
	4. Farewell picnic
5. PV 2/CA 3: Ford River Rouge Factory Tour	

## Recruiting

WSU targeted sophomore, junior, and senior level undergraduate students from any engineering discipline with considerations for non-engineering disciplines if a significant interest in sustainability and manufacturing was evident. WSU College of Engineering communications department, professional engineering societies (Society of Manufacturing Engineers, American Institute of Chemical Engineers, etc.), Historically Black Colleges and Universities (HBCUs) with engineering programs, and the NSF REU program website were used to market the program nationally to interested undergraduate researchers.

These efforts resulted in approximately 90 applications from 52 universities/colleges across 26 states. Within this pool of applicants; approximately 38% identified as white, 21% as African American, 17% as Asian-Pacific Islander, 8% Hispanic/Latino, and 17% chose not to identify. 49% of applicants were male, 47% were female, and 4% chose not to identify. The majority of applicants were sophomores - 37% and juniors - 31% versus freshmen - 12% and seniors - 13% (the remaining 6% were unknown or high school seniors). A significant portion of applicants came from chemical engineering programs - 39%. Undergraduate research participants that accepted an offer to participate in the program were from California Baptist University, Carnegie Mellon University, Michigan State University, New Mexico Institute of Mining and Technology, Princeton University, Rensselaer Polytechnic Institute, Tuskegee University, University of Kentucky College of Engineering – Paducah Campus, University of Miami (Ohio), University of Michigan, and Wayne State University. Six of the participants were female and five were male (one male was supported by the WSU UROP program), and were from chemical, mechanical, industrial and systems, biological, and environmental engineering programs.

## Results

The Summer Academy in Sustainable Manufacturing was, and is being, evaluated using SURE III Grinnell College surveys conducted by Professor D. Lopatto [4]. Three surveys, pre-flection, SURE III, and Follow-Up are given to undergraduate researchers participating in the program. Currently, the site has received pre-flection and SURE III feedback from 2016 undergraduate researchers. The Follow-Up survey for 2016 undergraduate researchers is given 6-9 months after

the research experience has completed, thus, it will be conducted sometime between February – April of 2017. An exit survey is given to participants in order to receive feedback on the Summer Academy in Sustainable Manufacturing structure and activities, and mid-program presentations are used to evaluate undergraduate researcher progress and student/mentor relationships during the summer program.

Pre-flection and SURE III survey results indicated that three 2016 participants that had not considered graduate education were considering or planning on a Ph.D. in a science field after the Summer Academy in Sustainable Manufacturing. All students were mildly to very satisfied with the experience, while 80% indicated they were likely to choose another undergraduate research experience. The full pre-flection and SURE III survey results are considerably more extensive and can be discussed upon request from interested parties. The Grinnell College undergraduate research survey for the 2016 site participants is not yet complete and will be finished once the Follow-Up survey is completed. Sample responses from the exit survey included, “I believe the project I worked on was perfect. It challenged me yet gave me time to figure things out before the end of the program” and “I loved all of them!” in regards to the cultural activities. Exit surveys also indicated that participants would have preferred to receive critical research material well before the start, which is a comment the REU Site will be addressing for the 2017 participants.

Outcomes of participant research projects were presented in poster format at an end-of-program poster symposium at WSU. Participants presented their research to REU faculty mentors, WSU graduate students, and WSU undergraduate students, and were judged by three WSU representatives for a best poster award. The winner of the best poster award was selected to attend the 2016 Council on Undergraduate Research REU Site poster symposium [5]. Undergraduate research projects from the 2016 program were also presented at the 2016 International Congress on Sustainability Science and Engineering (ICOSSE '16) [6,7] and the 2016 American Institute of Chemical Engineering (AIChE) Annual National Meeting - Sustainable Engineering Forum (SEF) poster competition [8]. The two students that presented at the ICOSSE '16 received NSF travel awards (NSF #1642400), and one of the students was awarded the Student Best Poster Presentation Award. In addition, the same student was awarded 2<sup>nd</sup> place for her poster presentation at the 2016 AIChE Annual National Meeting. A summary of the 2016 program was presented by the project PIs at ICOSSE '16 [9].

## **Conclusions**

This companion paper describes the first year of the three-year REU Site: Summer Academy in Sustainable Manufacturing. This Summer Academy offers unique summer research experiences in the challenging field of sustainable manufacturing to local and national undergraduate students from two and four-year institutions, especially underrepresented minorities. In year two, the site expects to equal or surpass the number of applicants for the 2016 program, and recruit a group of undergraduate researchers as engaged and excited about sustainable manufacturing research as the 2016 participants. Improvements expected to be implemented for the 2017 program include; (1) release of research critical material to participants two months prior to the start of the 2017 program, (2) involvement from Manufacturing USA institutes DMDII (Chicago, IL) and LIFT

(Detroit, MI) in the form of facility tours or talks, and (3) Increase the number of industry guest speakers.

## Acknowledgements

The REU Site is supported by NSF #1461031, “REU Site: Summer Academy in Sustainable Manufacturing,” Division of Engineering Education & Centers.

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