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1. REPORT DATE (DD-MM-YYYY) 21-11-2017	2. REPORT TYPE Final Report	3. DATES COVERED (From - To) 1-Sep-2016 - 31-Aug-2017
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4. TITLE AND SUBTITLE Final Report: Acquisition of a Laser Rapid Manufacturing System, BEAM: Broadening Education through Advanced Manufacturing at UDC	5a. CONTRACT NUMBER W911NF-16-1-0546
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER 106012

6. AUTHORS	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES The University of the District of Columbia Computer Science and Information 4200 Connecticut Avenue NW Washington, DC 20008 -1122	8. PERFORMING ORGANIZATION REPORT NUMBER
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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	10. SPONSOR/MONITOR'S ACRONYM(S) ARO
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) 68905-MS-REP.1

12. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.
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13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.
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14. ABSTRACT
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15. SUBJECT TERMS
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16. SECURITY CLASSIFICATION OF:	17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Jiajun Xu
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU	19b. TELEPHONE NUMBER 202-274-5048

**RPPR Final Report**  
as of 01-Mar-2018

Agency Code:

Proposal Number: 68905MSREP

**Agreement Number: W911NF-16-1-0546**

**INVESTIGATOR(S):**

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Organization: **The University of the District of Columbia**

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Country: USA

DUNS Number: 137460275

EIN: 536001131

**Report Date:** 30-Nov-2017

Date Received: 21-Nov-2017

**Final Report** for Period Beginning 01-Sep-2016 and Ending 31-Aug-2017

**Title:** Acquisition of a Laser Rapid Manufacturing System, BEAM: Broadening Education through Advanced Manufacturing at UDC

**Begin Performance Period:** 01-Sep-2016

**End Performance Period:** 31-Aug-2017

**Report Term:** 0-Other

Submitted By: Jiajun Xu

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**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

**STEM Degrees:**

**STEM Participants:**

**Major Goals:** University of the District of Columbia (UDC), the nation's only urban land grant institution and a historically black college and university (HBCU), aims to infuse additive manufacturing to enhance both the research and education infrastructure. Currently, none of the ~100 HBCUs nationwide have the metal-based additive manufacturing equipment for both research and education purposes.

The major goal of this DoD HBCU/MI Instrumentation Grant Award titled "Acquisition of a Laser Rapid Manufacturing System, BEAM: Broadening Education through Advanced Manufacturing at UDC", is to acquire a Laser Rapid Manufacturing (LRM) System through this grant support. This system along with other on-going educational and research activities at UDC can allow UDC to establish itself as: 1) a lead HBCU institution in advanced manufacturing research and education and 2) a collaborator for novel research and educational development between aerospace, defense, energy, and medical sectors.

## RPPR Final Report as of 01-Mar-2018

Specifically, the proposed equipment will allow UDC faculty researchers to perform the following research goals:

1. Investigate the deposition, cladding, hardening and machining mechanisms for various materials, including, steel- and titanium-based alloys
2. Investigate and validate the methodology of surface finishing of electropolishing for 3D printed metal components
3. Investigate the in-process monitoring and control schemes for the optimum quality in laser cladding, laser deposition, laser hardening and surface engineering.

In addition, acquisition and use of the LRM equipment is aimed to result in the following educational and outreach goals:

1. Increase the number of women and underrepresented minorities becoming involved in STEM, specifically via exposure to advanced manufacturing technology in innovative manufacturing techniques
2. Improve the research and educational environment within the School of Engineering and Applied Sciences' (SEAS), bachelor's of science (BS) & master's of science (MS) programs, and future doctoral (Ph.D.) degree program.
3. Stimulation of engineering and technology curriculum development keeping it abreast with technological advancement.
4. Validation of numerical models that have benefits to manufacturing industries and the creation of competitive edge and technological support to aerospace, defense, energy sectors leading to pioneering the technologies of the future
5. Novel experiential learning and research opportunities for UDC undergraduate students and graduate students involving state-of-the-art experimental manufacturing systems.

**Accomplishments:** So far, we have achieved the major goals outlined in our proposal despite the delay in the procurement and installation of the Additive Manufacturing system at UDC. Progress against the goals for this period that were listed in the prior reporting period are listed briefly here and detailed in subsequent sections:

1. Procurement and Installation of the Additive Manufacturing system:
  - a. at the time of grant submission, the UDC team performed a thorough study on the Additive Manufacturing systems available on the market. It was found that there was only one system that fell into the funding range of this grant and it was suggested in the proposal. After the grant was awarded, the PI was reached out by one of the vendors and was informed that they were able to offer one of their current model at a significant discount price that can fit within our budget. So the team reevaluated the two systems. After carefully considering various external feedbacks from academic and industrial partners, the UDC team decided to switch the vendor based on the long-term operational/maintenance cost and the availability of technical supports.
  - b. In addition, the UDC team was able to negotiate with the new vendor on obtaining an additional three-year premium maintenance plan for the system without additional cost
  - c. The request for switching vendor was submitted to program manager in Dec. 2016. The procurement request was made afterwards following University Procurement Policies. The system was initially scheduled to be delivered and installed by end of March. However, the vendor experienced delay in their production and the system was delivered to UDC in July. The installation was completed in August after the fall semester began and students returned to campus. We have been using this system since then, and we are now very familiar with the equipment operation (hardware and software).
2. Advanced Manufacturing focused curriculum update in mechanical engineering (ME) department:
  - a. So far, the ME department has fully taken advantage of the capability enabled by this new system at UDC. It has aligned its undergraduate curriculum to the focus on preparing more diversified workforce in advanced manufacturing through offering 4 technical electives in advanced manufacturing concentration( MECH 465 Advance Manufacturing, MECH 483 Robot Mechanics and Control, MECH 478 Mechatronics, MECH 495 Special Topics), and one Research Experience course in which students can do cutting-edge research with UDC faculty members using this system starting Fall 2017. So far, around 30 students have enrolled in these tech electives and research experience courses in Additive Manufacturing.
  - b. In addition, the new Master of Science program in ME also provides a concentrated area in advanced manufacturing that students can work on their thesis project using this system starting Spring 2018. It is designed to develop students expertise in nanomanufacturing, 3D printing, and advanced manufacturing. Students can choose research topics in additive manufacturing using the EOS metal additive machine. Link:<https://www.udc.edu/seas/ms-in-mechanical-engineering/>
  - c. All the curriculum improvement plan mentioned here has been evaluated and approved by the ME advisory board consisting members from various industry at the meeting held in September 2017.

## RPPR Final Report as of 01-Mar-2018

3. Advanced Manufacturing focused research engagement and collaboration:
  - a. the PIs have performed various preliminary studies and numerical modeling work while waiting for the system to be installed. Some papers have also been submitted and are currently under review.
  - b. Several experiments are being planned and materials and supplies are being procured to perform additional testing
  - c. Various collaboration and new initiatives have been established between the PIs and external collaborators, in which the following collaborations have been established: 1. the additive manufacturing group at National Institute of Standards and Technologies located at Gaithersburg, MD. 2. Research collaboration with Naval Surface Warfare Center, Carderock Division located at Bethesda, MD; 3. 3D medical application center of Walter Reed National Military Medical Center located at Rockville, MD.
  - d. Through the aforementioned new collaborations and initiatives, two externally sponsored senior capstone projects (one supported by Honeywell and the other one sponsored by Naval Surface Warfare Center) on additive manufacturing have taken place since August 2017
  - e. In addition, since last AMIE conference hosted at UDC, several new initiatives with other HBCUs and companies including: Hampton University, Alabama A&M University, North Carolina A&T University, Lockheed Martin and Northrup Grumman have been initiated and they are in the stage of drafting MOUs and further discussion.

#### 4. Additional Funding Support for Sustainable Research and Educational Activities using this Additive Manufacturing system at UDC:

- a. Additional external grant on additive manufacturing workforce development has been awarded to the PIs (sponsored by the department of energy), Additional funding at the amount of approximately \$200,000 to support and implement the Additive Manufacturing focused curriculum modernization.
- b. The PIs have also submitted several new grant proposals in the area of additive manufacturing to National Science Foundation, Department of Defense and Nuclear Regulatory Council (total amount approximately \$7.5 million)

#### 5. Community Engagement and Outreach Activities:

- a. Although the AM system has only been installed for less than three months on campus, it has been visited by a variety of audience including local public high school students and teachers, UDC students from other STEM and non-STEM majors, external collaborators, ~70 faculty and administrative members from over 20 HBCUs across the nation during the 2017 Advancing Minorities' Interest in Engineering (AMIE) conference hosted by School of Engineering & Applied Sciences at UDC on September 5-8. See attached file.
- b. A newsletter on this new instrument has been published and widely distributed among the community. This newsletter will get the word out about the instrument and our new capabilities in Additive Manufacturing. See attached file.

Right now, we are focusing on the following set of major activities and objectives:

- Further expand research activities on the science of Additive Manufacturing;
- Achieve new breakthroughs in the existing science areas;
- Enable new science communities who can benefit from accessing Additive Manufacturing research and educational capabilities at the University of the District of Columbia;
- Further engage underrepresented and minority groups;
- Further engage related international communities and organize the National & International Conference on Manufacturing;
- Add new capabilities to the Additive Manufacturing environment based on community requirements;
- Engage related communities for developing Additive Manufacturing education materials and strategies;
- Enhance research and education experience for undergraduate students; and
- Develop a campus-wide multi-disciplinary Additive Manufacturing center at the University of the District of Columbia for enabling Additive Manufacturing-related sciences and applications

## RPPR Final Report as of 01-Mar-2018

**Training Opportunities:** So far, seven undergraduate students( all of them are African Americans and one of them is female), three lab engineer and technical personnel, and six faculty members have been directly involved and trained on how to operate the AM system. Additional faculty and students will be trained in the near future as needed.

These students are currently either working as research assistants on additive manufacturing related research projects or teaching assistants on additive manufacturing related courses. They will help train other students enrolled in these courses.

The PIs are also planning to incorporate this AM resource into the ongoing summer workshops, in which many high school teachers and students will be exposed to metal-based additive manufacturing technique in addition to the plastic systems they have experienced previously at UDC.

Serious efforts are being made to engage a diversified group of audience in particular the underrepresented groups from local middle and high schools through the UDC college preparation program.

**Results Dissemination:** So far, no technical reports have been published and disseminated to the public since the system has also been in operation for less than three months.

However, several papers on modeling and simulation of AM process haven been submitted and currently under review. A newsletter on this new instrument has been published and widely distributed among the community. This newsletter will get the word out about the instrument and our new capabilities.

The system has been demonstrated to a broad audience through various community engagement activities as mentioned before. See attached file.

It is expected more peer-reviewed technical publications will be generated and disseminated to the community soon, and at least two technical reports on additive manufacturing related senior capstone projects will be completed by end of April 2018.

The PIs will do their best to make the research findings generated using this AM system available to the community as fast and broad as possible.

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

### **PARTICIPANTS:**

**Participant Type:** PD/PI

**Participant:** Jiajun Xu

**Person Months Worked:** 3.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

**Participant Type:** Co PD/PI

**Participant:** Devdas Shetty

**Person Months Worked:** 1.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

**Funding Support:**

**RPPR Final Report**  
as of 01-Mar-2018

Other Collaborators:

**Participant Type:** Co PD/PI

**Participant:** Pawan Tyagi

**Person Months Worked:** 1.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

**Participant Type:** Co PD/PI

**Participant:** Lara Thompson

**Person Months Worked:** 1.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

**Participant Type:** Co PD/PI

**Participant:** Kate Klein

**Person Months Worked:** 1.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

**Participant Type:** Technician

**Participant:** Pablo Guerrero E. Sanchez Guerrero

**Person Months Worked:** 2.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

**Participant Type:** Technician

**Participant:** Gebretensae Tzadu,

**Person Months Worked:** 1.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

**Participant Type:** Technician

**Participant:** Ha Hung

**Person Months Worked:** 1.00

Project Contribution:

International Collaboration:

International Travel:

**Funding Support:**

**RPPR Final Report**  
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National Academy Member: N  
Other Collaborators:

**Participant Type:** Undergraduate Student

**Participant:** Cyree Beckett

**Person Months Worked:** 2.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Undergraduate Student

**Participant:** James McLaurin

**Person Months Worked:** 2.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Undergraduate Student

**Participant:** Jaime Rios

**Person Months Worked:** 2.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Undergraduate Student

**Participant:** Victor Ramos

**Person Months Worked:** 2.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Undergraduate Student

**Participant:** tobias goulet

**Person Months Worked:** 2.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Undergraduate Student

**Participant:** Jelani Guise

**Person Months Worked:** 2.00

**Funding Support:**

Project Contribution:

International Collaboration:

**RPPR Final Report**  
as of 01-Mar-2018

International Travel:  
National Academy Member: N  
Other Collaborators:

**Participant Type:** Undergraduate Student

**Participant:** Netra Simmons

**Person Months Worked:** 2.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Participant Type:** Faculty

**Participant:** Abiose Adebayo

**Person Months Worked:** 1.00

**Funding Support:**

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:



Attachment:

The following pictures include the installation & training of the EOS M280 laser sintering system at UDC, Community Engagement & Outreach Activities in Additive Manufacturing during the grant period, and the Mechanical Engineering Curriculum Changes in Additive Manufacturing.

- Installation & training of the EOS M280 laser sintering system at UDC

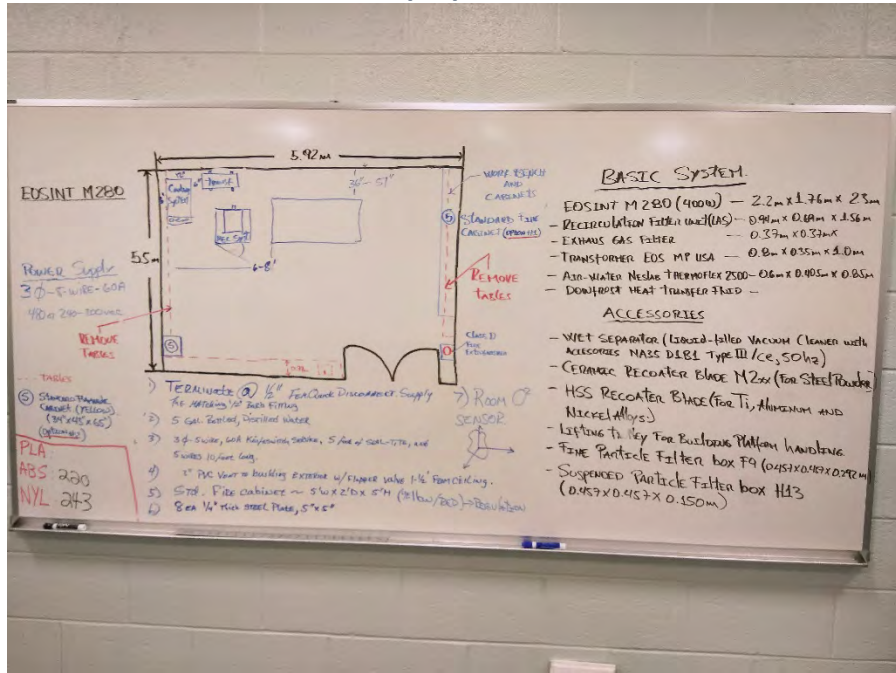
**UDC Additive Manufacturing lab before installation**



**UDC Additive Manufacturing lab after installation**



## Site-preparation



## Delivered AM system before installation



Sieve unit and controllers



Transformer module





### Installation



### Training



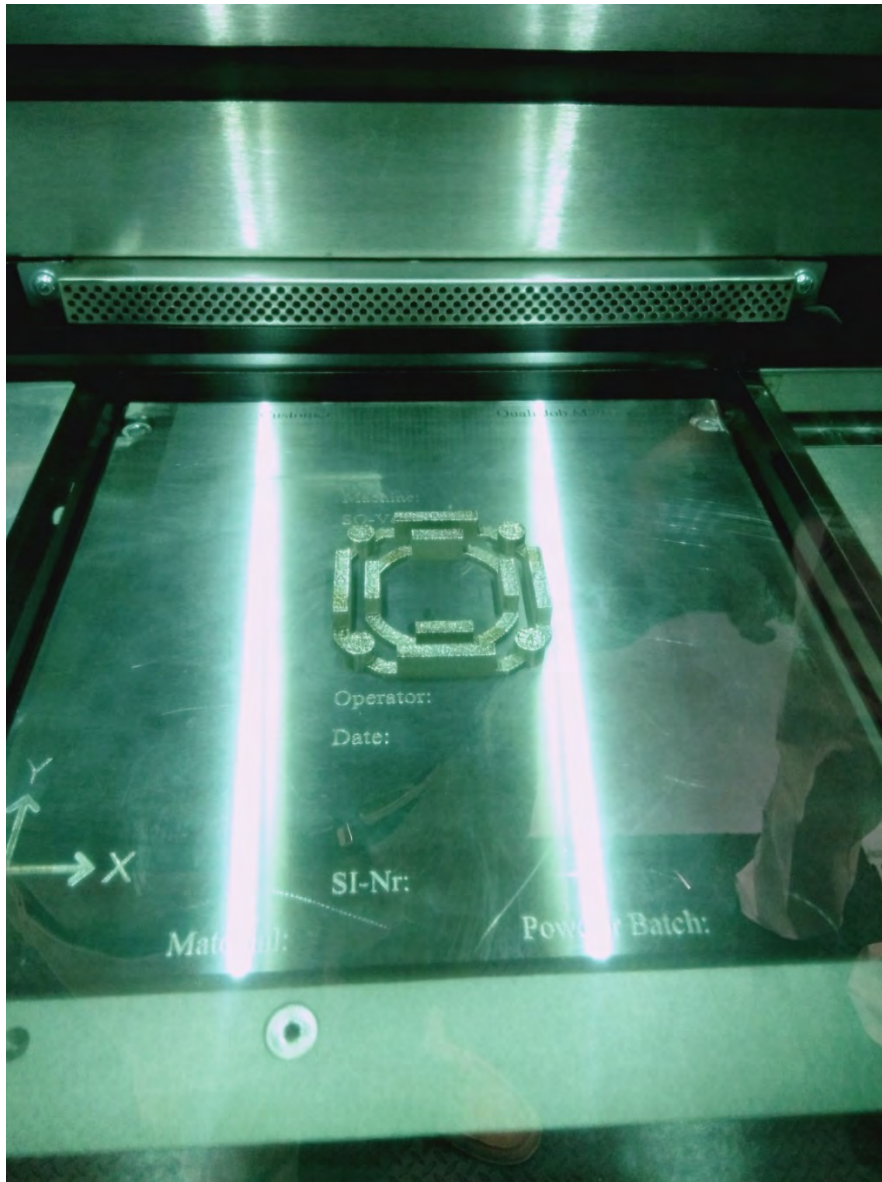
### Training



### Training



## First 3D Printed Part





- Community Engagement & Outreach Activities in Additive Manufacturing during the grant period

Tour to the AM laboratory during AMIE conference



Tour to the students and teacher from NAF - HD Woodson STEM High School



Tour to the faculty from Indian Institute of Technology





Tour to the scientists from Naval Surface Warfare Center at Cardrock MD



# SEAS

SPRING 2017

News from the School of Engineering and Applied Sciences

## Investing in Partnerships

Welcome to the 2017 issue of the SEAS Newsletter. This has been another exciting year for the School of Engineering and Applied Sciences (SEAS) as we continue to expand our facilities and strengthen our academic and research programs. The University of the District of Columbia (UDC) was founded in 1977 with the merger of three institutions: the District of Columbia Teachers College, the Federal City College, and the Washington Technical Institute. The world is different than it was 40 years ago, as is the school, which has grown in terms of students, faculty, and laboratories.



Our academic programs have evolved to address the ever-changing demands in engineering, computer science, and information technology. We have added new laboratories in biomedical engineering and advanced manufacturing. Our students continue to win awards and scholarships and tackle challenging real-world problems to develop innovative solutions. We have recruited highly qualified faculty with expertise in specialized areas. The school is moving to a higher level, not only in number and in quality of graduates, but also in quality, quantity, and impact of our research. The impact has become quite tangible for me as I watch our faculty and staff change the lives of students through the delivery of outstanding academic programs.

We are pleased to feature a few areas of faculty excellence and programs with multidisciplinary approaches.

Devdas Shetty, Ph.D.

Dean

**UNIVERSITY OF THE  
DISTRICT OF COLUMBIA**  
*SCHOOL OF ENGINEERING AND APPLIED SCIENCES*

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# Why Advanced Manufacturing Matters

The impact of manufacturing is huge and more important to the economy than most people know. According to the Bureau of Labor Statistics (May 2017), manufacturing accounts for 12% of the U.S. gross domestic product and two-thirds of all goods and services exported by the U.S.

**A major grant from the Department of Defense has allowed SEAS to acquire a Laser Rapid Manufacturing System with the capability of processing a variety of metals including steel, titanium, and Inconel for advanced manufacturing research and education.**

This additive manufacturing system will enhance our research and education capability in creating new processes of manufacturing and allow UDC to establish itself as a lead institution in advanced manufacturing research and education.

The insights gained from these capabilities will produce knowledge to impact the broad range of additive manufacturing-related fields such as aerospace, automotive, and biomedical. This grant will positively impact the technological education of underrepresented and minority students in STEM majors, providing relevant, hands-on research experiences.



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School of Engineering and Applied Sciences

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## SEAS Degree Programs

### UNDERGRADUATE

**Bachelor of Science in Civil Engineering (BSCE)**

**Bachelor of Science in Computer Science (BSCS)**

**Bachelor of Science in Electrical Engineering (BSEE)**

BSEE concentrations:

Electrical Engineering without Computer Engineering

Electrical Engineering with Computer Engineering

**Bachelor of Science in Information Technology (BSIT)**

BSIT concentrations:

System & Database Management

Web Design and Administration

Network and Computer Systems

Network Systems and Data Communications

Business Management

Multimedia and Criminal Justice

**Bachelor of Science in Mechanical Engineering (BSME)**

### GRADUATE

**Master of Science in Computer Science (MSCS)**

**Master of Science in Electrical Engineering (MSEE)**

### NEW 2017-2018

**Bachelor of Science in Biomedical Engineering (BSME)**

**Master of Science in Civil Engineering (MSCE)**

**Master of Science in Mechanical Engineering (MSME)**

- Mechanical Engineering Curriculum Changes in Additive Manufacturing

List of new technical electives for Additive Manufacturing Concentration in BSME

## Concentrations in Mechanical Engineering

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Minimum credit required to earn concentration: 12 Credit hours

### Advanced Manufacturing Concentration

	Courses	Credits
1	MECH 491 - Senior Design Project I (in Advanced manufacturing area)	3
2	MECH 492 - Senior Design Project II (in Advanced Manufacturing area)	3
3	Two electives from: MECH 465 Advance Manufacturing* MECH 483 Robot Mechanics and Control MECH 478 Mechatronics MECH 495 Special Topics: Nanotech Processes	6
	total	12

\*required of all ME students matriculating after Fall 2017; however, those graduating prior may use MECH 465 as an elective for the Advanced Manufacturing concentration.

### MSME

Link: <https://www.udc.edu/seas/ms-in-mechanical-engineering/>

## MASTER OF SCIENCE IN MECHANICAL ENGINEERING

The Master of Science in Mechanical Engineering (MSME) offers world-class higher education in a highly interactive and interdisciplinary learning environment. We prepare students to seek highly lucrative and exciting careers in national laboratories, federal organizations, and advanced industries

### SPECIALIZATIONS

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**Advanced Manufacturing/Nanotechnology:** *Are you interested in state of the art manufacturing?* This specialization will develop your expertise in nanomanufacturing, 3D printing, and advanced manufacturing. Students can choose research topics in nanotechnology and additive manufacturing. Our nanotechnology application laboratory houses a clean room and multiple resources. The advanced manufacturing lab holds equipment such as our EOS metal additive machine.

**Renewable Energy Science and Technology:** *Do you want to support sustainable human life and independency from fossil fuels?* We have state of the art resources to provide advanced education and experiential learning in solar cells, wind energy, fuel cells, and smart grid areas.

**Biomedical Engineering:** *Interested in enhancing human health with technology?* Our biomedical program allows you to develop novel biomedical devices to improve quality of life. Our state of the art biomedical engineering lab is equipped with advanced motion detectors, force plate, and sensors to conduct research on mobility and balance.

## FACULTY

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Our faculty value continued research, teaching, and mentoring students to become capable of solving the most challenging technological problems. MSME is supported by the following permanent faculty.

Segun Adebayo, Ph.D., Associate Dean, Department Chair, Professor of Mechanical Engineering

Pawan Tyagi, Ph.D., Graduate Program Director, Associate Professor of Mechanical Engineering

Kate Klein, Ph.D., Undergraduate Program Director, Associate Professor of Mechanical Engineering

Lara Thompson, Ph.D., Biomedical Engineering Program Director, Associate Professor of Mechanical Engineering

Jiajun Xu, Ph.D., Assistant Professor of Mechanical Engineering

## RESEARCH PARTNERS

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**T**Our faculty enjoy collaboration with institutions and industries such as the National Institutes of Standard and Technology, U.S. Food and Drug Administration, National Institutes of Health, Naval Research Laboratory, Kansas City National Security Complex, Oak Ridge National Lab, Northrup Grumman, and Lockheed Martin.

## GRANTS AND FUNDING

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The mechanical engineering faculty have federal grants and projects to support MS studies in our department. With the support of federal funding from the National Science Foundation, Air Force Office of Sponsored Research, Department of Energy, and Department of Defense grants, we have developed advanced laboratories and courses.

## RESEARCH LABS

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- **Advanced Manufacturing Laboratory:** Additive manufacturing equipment
- **Nanotechnology Application Laboratory:** Clean room and microfabrication equipment

UNIVERSITY OF THE DISTRICT OF COLUMBIA  
**School of Engineering and Applied Sciences**  
**Mechanical Engineering Department**  
Spring 2018

**MECH 465: ADVANCED MANUFACTURING**

**INSTRUCTOR:** Dean Devdas Shetty, Ph.D.

**OFFICE HOURS:** XXXX

**LECTURES:** W 4:00-6:50 PM Building/Room: 32/C01A Simulation Lab

**CATALOG DATA** This course will provide understanding of basic elements of advance manufacturing such as model based product design, metal and plastic 3D manufacturing.

**COURSE DESCRIPTION:** This advanced manufacturing course concentrates on additive manufacturing (AM). AM was introduced at the end of the 1980s as a Rapid Prototyping technique. Within the last 20 years it has developed dramatically and penetrated in almost every form of science and engineering. Today AM is not only a valuable tool for making models and prototypes but also a manufacturing method for final parts with extreme complexities and fabrication challenges. AM spreads throughout all disciplines and branches of industry, from art to biomedical applications and from architectural models to manufacturing aerospace engineering components. AM has started revolutionizing manufacturing technologies and is expected to shape our future in an unprecedented manner. This course will prepare the students for advanced careers related to AM. The teaching of the course will use a student-active learning approach. The students will read literature, discuss current AM-related problems, and do AM projects during the course. Three course projects, including a technology survey project, an application development project, and hands on 3D printing of student created 3D model are planned during this course. With these course activities students are expected to gain deep understanding of AM.

**COURSE OBJECTIVES:** Upon completion of this course the student will be able to:

- A. Describe various additive manufacturing processes
- B. Explain the theory behind plastic 3D printing
- C. Explain the theory behind metallic 3D printing
- D. Explain post processing technologies
- E. Explain product prototyping
- F. Explain the importance and elements of model-based enterprise

**TEXT BOOK:** [1] Ian Gibson, David W. Rosen, and Brent Stucker, Additive Manufacturing Technologies: Rapid prototyping to Direct Digital manufacturing, 10.1007/978-1-4419-1120-9, Springer Verlag US, 2010.

[2] A. Gebhardt, Understanding Additive Manufacturing, ISBN:9781569905074, Hanser Publications, 2012.

**PREREQUISITE:** 1. Course on Materials Science (MECH205)  
2. Course on Engineering Drawing with Autocad/Soldworks/CREO (MECH 107)

### **COURSE OUTLINE:**

**Module 1:** Survey of the applications of additive manufacturing in aerospace, biomedical, architecture, automobiles, defense, and novel areas enabled by the 3D manufacturing.

**Module 2:** Elements of advance manufacturing: model-based enterprise and new product development using rapid prototyping.

**Module 3:** Plastic 3D printing: Scope and advantages, mechanism of plastic 3d printing, analysis of 3D printer construction. Hands on activity: Design and build a component using 3D printer.

**Module 4:** Metal 3D printing: Scope and advantages, mechanisms of metal 3D printing, analysis of the components of representative metal 3D printers. Visit our metal 3D printer and/ or have a demo session; (design and build a component using metal printer if feasible).

**Module 5:** Metal 3D printing: Study the powder production, method of powder characterization, and reusability. Study the physics of energy transfer to metal powder for creating 3D printed parts. Study the impact or growth direction on 3D build quality, managing residual stress in 3D-printed parts, and methods of quality control.

**Module 6:** Surface finish and surface modification: Challenges and current state-of-the-art in improving surface finishing technologies. Scope of doing laser hardening to enhance wear resistance, integrating thermoelectric effect based cooling or power generation system, and mounting smart sensing systems to add intelligence to the AM products.

**Module 7:** Team project: In the first two weeks student teams will be asked to conceive an idea/project to address a problem using 3D printing. Subsequently, students will design, build, and test their 3D-printed component. At the end of the semester students will present their team experience, lessons learned, and future outlook about advance manufacturing. During final presentation day KCP/ORNL/Y12 representative will have opportunity to serve as evaluator for the student projects and give a brief presentation about their work, career and internship opportunities.

### **Relationship of Course to Program Objective:**

This course will satisfy the following ABET program outcomes:



- a) an ability to apply knowledge of mathematics, science, and engineering
- b) an ability to design and conduct experiments, as well as to analyze and interpret data
- c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability
- e) an ability to identify, formulate and solve engineering problems.
- h) the broad education necessary to understand the impact of engineering solutions in a global, economic environmental and societal context
- i) a recognition of the need for, and an ability to engage in life-long learning

### **Class Attendance Policy:**

Attendance is strongly recommended to achieve the objectives of the course. Students will receive a grade of F in the class after three unexcused absences. The instructor reserves the right not to admit students who are late to class.

### **General Policies:**

1. In class, participation will be judged by the quality of class room work, participation in discussions, and other activities.
2. Attendance in tests is mandatory. Absence from an examination will not be excused except in cases of an illness or other emergency that is verified by appropriate written documentation. For example, in case of illness a written statement from a physician is required with inclusive dates under care.
3. Unexcused absence from an examination will result in a grade of zero. It is the student's responsibility to see the instructor as soon as possible in regard to an excused absence. All make up work must be scheduled no later than the last day of classes in the semester.
4. Students are responsible for all material covered in the class as well as announcements for homework assignments, assignment due dates, and test dates.
5. If a class is missed due to school closure, the regularly scheduled test or lecture will occur the next time the class meets.
6. Late submission of assignments is not allowed. Homeworks will be collected at the beginning of class on the due date. Please clearly print your name, course number, homework number and date of submission. You need to make a folder of your home assignments and provide to instructor at the end of the course. This folder will be kept for ABET accreditation.
7. Cell phones must be turned off while in lecture.
8. Use restrooms prior or after class-unless there is an emergency.
9. The instructor reserves the right to alter the mentioned policies as circumstances may dictate. If such a change is made, the students will be notified in class.

**Grading Policy:**

Attendance, in class participation	15 points
Major Examinations and conceptual quizzes	30 points
Experiments & Reports	10 points
Research term paper	15 points
Final Examination	<u>30 points</u>
	100 points

Final grade will be based on:

(100 - 90)	-	A
(89 - 70)	-	B
(69 - 65)	-	C
(64 - 55)	-	D
(50 - 0)	-	F

**UNIVERSITY POLICIES**

**Americans with Disabilities Act:**

If you are a student who is disabled as defined under the American Disabilities act and requires assistance or support services, please seek assistance through the Disability Resource Center, Building 44, Room A-39 (202-274-6417).

**Academic Honesty:**

The University will not tolerate cheating or attempt to cheat in oral or written assignments on the part of University students. Such instances will be reported by the instructor to Department Chair Person for disciplinary action.

**Equal Opportunity and Affirmative Action:**

The University of the District of Columbia actively subscribes to a policy of equal opportunity in education.

**Sexual Harassment and Racial Discrimination Policy:**

It is the policy of the University of the District of Columbia that sexual harassment and racial harassment in any of its students, staff, and applicants for admission to the University are prohibited.

## List of on-going senior capstone projects on Additive Manufacturing

### Project 1: Robust coatings on additive manufacturing metal components

**Project Description:** Coatings on AM components needed for: corrosion resistance, fatigue strength, high temperature application. AM component surfaces are rough. High adhesion between film and AM components need to be engineered



#### Project Objectives:

- Optimizing AM component surface to increase adhesion with nickel and chrome films.
- Apply design of experiment to find suitable nickel, chrome coatings
- AM Samples will be printed here at UDC

#### Member of the Team:

Robert Stephenson, Nitt Chuenprateep, Rudolph Knott, Antione Reddick

**Faculty advisor:** Jiajun Xu, Pawan Tyagi

### Project 2: Parametric study of additive manufacturing produced parts

**Project Description:** The U.S. military is highly interested in Additive Manufacturing. Unlike traditional manufacturing, AM has the ability to create a physical object from a digitally encoded design through the deposition of material via a 3D printing process eliminating excess material waste. This ability to exchange AM design and manufacturing capabilities via file sharing has created an enormous potential and with incredible ramifications for reducing shipping and production costs, slashing production-to-end-user cycle times, dramatically improving material used/wasted ratios, and significantly reducing the logistics footprint. Currently, UDC is collaborating with Naval Surface Warfare Center, Carderock Division to perform a parametric study of thermal and mechanical properties of AM produced parts. Testing will be done at state-of-the-art additive manufacturing (AM), the Manufacturing, Knowledge and Education (MAKE) Lab located at NSWCCD.

#### Project Objectives:

- 1) design and manufacturing of AM produced parts

- 2) characterization of their thermophysical and solid-mechanical properties (i.e., coefficient of expansion, conductivity, density, heat transfer film coefficient, specific heat & radiation heat transfer emissivity, ultimate strength, yield strength, elongation & Poisson ratio)

Students will work with Naval scientist and engineers to perform a parametric study. There is potential for this work to be presented at conferences and/or lead to paper publication.

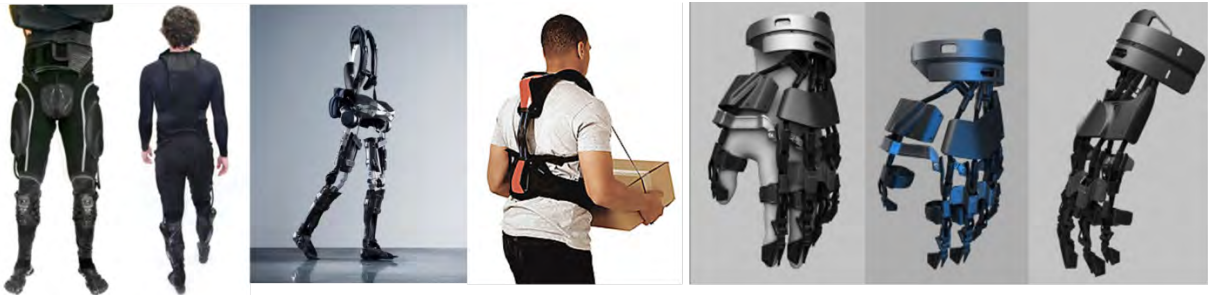
**Member of the Team:**

Henock Argaw, Lonika Behera, Mehdi Badache, Karemouse Welezane

**Faculty advisor:** Jiajun Xu, Devdas Shetty

**Project 3: Exoskeleton system design**

**Project Description:** “Exoskeleton” is a general term for robotic devices that can be either attached to or worn by humans to greatly enhance their strength and/or mobility. Such systems may reduce injury while increasing performance and productivity, regardless of one’s gender or physical size/strength. There are a large range of exoskeleton applications from able-bodied persons (e.g., war fighters and soldiers) interested in augmenting their performance, to mobility- impaired persons (e.g., paraplegic individuals). Leading towards exoskeleton design and build, the design team will assess their goals & who is the system’s end-user (e.g., exoskeleton/supportive suit for industrial workers), as well as what materials should be used and why.



**Project Objectives:**

The end goal is a functional exoskeleton system, or system component. Prior to build, the team will clearly map-out their objectives, materials needed, and design. Once built, they will then establish metrics to assess their final design. There is potential for this work to be presented at conferences and/or lead to paper publication.

**Member of the Team:**

Dilnesa, Ahmed Furshuti, Saud, Fahad Almahmoud, Ahmad Albluwi

**Faculty advisor:** Lara Thompson, Devdas Shetty