AIMS^2 Research Project in Manufacturing Systems Engineering program

Research Duration: Fall 2017 – Spring 2018

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Title of Project: **Additive Manufacturing for Lightweight Metal Matrix Nanocomposite and Functional Tissue Engineering**

Goals and Objectives of the Project, Expectations and Outcomes

Describe briefly what students can expect to learn by participating in this project.

There are two ongoing projects at the Laboratory of Additive and Sustainable Manufacturing in Manufacturing Systems Engineering program:

Project A: Additive Manufacturing for Lightweight Metal Matrix Nanocomposite

Lightweight materials, such as aluminum (Al) and its alloys, have been extensively used in today's society for energy savings and environmental sustainability because of their high specific stiffness, high specific strength, corrosion resistance, and good ductility. While there is a strong demand for significantly stronger and more thermally-stable lightweight metals, conventional synthesis and processing techniques provide only marginal improvements in performance. First, nanoparticle reinforced metals have emerged as an important class of materials that offer significantly enhanced mechanical, thermophysical, and electrical properties, to name a few. Second, Additive Manufacturing, or 3D Printing, has emerged as a potent platform that can be used to accelerate materials innovation and build high performance products that have traditionally been impossible to fabricate because of the variety in material compositions and/or of their complex geometries. Laser additive manufacturing (LAM), with its intrinsic layered rapid melting and solidification at a cooling rate about 103 to 107 K/s, has been applied to directly produce functional materials/components that can potentially meet the demanding requirements from aerospace, defense, automotive and biomedical industries. It is thus of significance to unleash the unusual properties of nanoparticle reinforced metals and the disruptive capabilities of LAM for high performance lightweight materials, such as aluminum. For these reasons, the fabrication of near net shape Metal Matrix Nanocomposite (MMNC) printed via selective laser melting (SLM) technology will allow researchers to find new methods of developing 3D printed lightweight metal parts. The Renishaw AM400 with the resolution of 20 microns demonstrates the possibility of using SLM technology. By using metallographic observation, surface coatings and surface finish processes, it is capable to produce mechanical properties and surface finish specifications that adhere or surpass to current aerospace standards.

Project B: Additive Manufacturing for Functional Tissue Engineering

One of the foremost challenges facing scientists and researchers today in the field of three-dimensional (3D) bioprinting is the formation of viable and structurally sound tissues and organs. The ever-growing demand for tissue and organ transplants has driven researchers to develop several different approaches to address this challenge. 3D bioprinting has opened the doors to new methods of printing, especially the methods used for tissue engineering and the production of artificial organs and tissues. Having the capability to 3D print functional artificial tissues on demand is extremely beneficial for studying all aspects of these tissues and organs which may ultimately eliminate the need for donors. Scaffold-based techniques provide an ideal support for cell adhesion, proliferation, distribution, and invasion. The structure of the scaffold can be modulated in order to re-create biological environments by arranging the scaffold's spatial organizations that may be similar to in vivo tissues or organs.

A better understanding of the flow parameters that causes rupture is crucial. Therefore, the production of an aneurysm blood vessel model can allow researchers to find new methods of testing and analyzing this naturally occurring abnormality. The Aneurysm model is a complex structure due to the bulge created on the artery. This work explores three different method for bioprinting aneurysm models: micro extrusion, ink-jetting and UV based digital light printing (DLP). The use of a hydrogel as support bath allows this method to be implemented with other hydrogels that are printed within the hydrogel support bath which maintains the intended structure while printing.