INDUSTRIAL SOLUTIONS LABORATORY

Company Information

Company Name	*UNC Charlotte*	**Date Submitted**	*04/29/2025*
Project Title	*Advanced Additive Manufacturing and Post-Processing of Bioactive Silicon Carbide Spinal Implants for Enhanced Osseointegration (UNCC_ME_BIO_SPINAL)*	**Planned Starting Semester**	*Fall 2025*

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills.

Discipline	Number	Discipline	Number
Mechanical	4	Electrical	
Computer		Systems	

Project Requirements:

Degenerative disc disease is a leading cause of chronic back pain, often necessitating lumbar interbody fusion surgery. Spinal cages—interbody fusion devices—are widely employed to restore spinal stability and facilitate bone growth. Recent advancements in Additive Manufacturing (AM) have revolutionized the design and fabrication of such implants, enabling complex geometries, integrated porous structures, and patient-specific solutions that were previously unattainable through conventional manufacturing.

This research proposes the use of bioactive Silicon Carbide (SiC), a mechanically robust and biocompatible material, for the fabrication of spinal cages via AM. SiC offers superior wear resistance, bioactivity, and mechanical properties that can be tailored to emulate natural bone. By leveraging AM, the project aims to create monolithic implants with optimized porosity and surface architecture to enhance biological fixation and promote tissue ingrowth. Following additive manufacturing, targeted post-processing—specifically precision machining—will be employed to refine surface quality and geometry in critical fusion zones. As SiC is a highly abrasive and hard material, identifying optimal machining strategies and parameters will be a central focus. The research will evaluate the interplay between surface finish, mechanical integrity, and biological performance.

Research Objectives:

1. **Design and fabricate spinal implant prototypes** using AM with bioactive SiC, incorporating tailored porosity and bone-mimetic structures.
2. **Develop and optimize machining strategies** for SiC to achieve the required surface precision in biologically active regions.
3. **Characterize the surface morphology and structure** using SEM and FTIR to assess the effects of post-processing.
4. **Evaluate bioactivity and bone tissue integration** through in vitro testing, simulating physiological conditions.

Significance and Innovation:
This project addresses a critical need for durable, bioactive spinal implants with enhanced integration and mechanical compatibility. While AM has advanced the development of complex implant geometries, the use of Silicon Carbide in biomedical applications remains underexplored due to its machining challenges. This research uniquely combines AM with post-processing strategies to overcome material limitations and push the boundaries of orthopedic implant design.

Student and Researcher Training:
The project will provide valuable interdisciplinary training in advanced manufacturing, materials science, and biomedical engineering. Team members will gain experience in:

- Additive manufacturing techniques for ceramics
- Precision machining of hard biomaterials
- Surface and structural analysis (SEM, FTIR)
- Bioactivity evaluation via in vitro assays

Expected Deliverables/Results:

- A validated AM and machining workflow for SiC-based spinal implants.
- Enhanced understanding of SiC surface behavior in biological environments.
- A new generation of interbody fusion cages with improved osseointegration potential.
- High-impact publications and contributions to biomaterials and AM research communities.

Disposition of Deliverables at the End of the Project:

Students are graded based on their display and presentation of their team's work product. It is mandatory that they exhibit at the Expo, so if the work product was tested at the supporter's location, it must be returned to campus for the Expo. It is also a mandatory part of this Program that the Industry supporter attend the 2 expos to grade their team's performance. After the expo, the team and supporter should arrange the handover of the work product to the industry supporter. This handover must be concluded within 7 days of the Expo.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- Biomedical concentration