

# REPPERGER RESEARCH INTERN PROGRAM

RESEARCH PROJECT #: AFRL-RHD-26-01

## Nanoscale control and detection of biomolecular processes via light-matter interaction

**PROJECT DESCRIPTION:** Controlling biological processes with light is an emerging research field with wide spanning applications including sensing, medical applications, and control over biomanufactured materials. Advanced nano-optical materials promise new pathways to control the energy exchange between molecules within the cell and externally controlled radiation; thus, giving users unprecedented specificity over microscopic systems inaccessible through classical mechanics. This project will leverage microscopic optical devices combined with state-of-the-art spectroscopic techniques to control and sense biological processes. The research goal is to model light-matter interaction within confined optical fields, design nano-optical devices to enhance the rate of bio-produced materials, and modify spectroscopic signals obtained via infrared, Raman, and fluorescence spectroscopy to elucidate the underlying mechanisms. If successful, this project will increase the DoW's capability to optimize biological signals and byproducts leading to bolstered supply chains and improved biomolecular sensing.

**LEARNING OBJECTIVES:** 1) The student will gain a foundational understanding of quantum electrodynamics and their effects on molecular systems. 2) They will mathematically and computationally explore light-matter interactions using MATLAB or Python code and simulate near fields using finite element method (COMSOL). 3) Finally, they will gain an experimental insight into nano-optical systems, chemistry, and spectroscopic characterization.

**ACADEMIC LEVEL:** Masters; Doctoral

**DISCIPLINES NEEDED:** Physical Chemistry, Mathematics, Cell Biology, Bioengineering, Programming

**RESEARCH LOCATION:** Fort Sam Houston, Texas

**RESEARCH MENTOR:** Zachary Brawley, Ph.D.  
Materials Science and Engineering, Texas A&M University, 2023



Dr. Zachary Brawley is a Research Engineer at the Air Force Research Laboratory (AFRL), where he serves as a Principal Investigator. He earned his B.S. in Physics from the University of Central Arkansas in 2017, where he studied plasmonic substrates for sensor applications. Before graduate school, he worked at the Naval Research Laboratory developing fiber optic sensors. Dr. Brawley received a doctoral fellowship to pursue his Ph.D. at Texas A&M University in 2018, where his research centered on nanophotonic/molecular interactions, creating hybrid states that can alter chemical reactions. During his graduate studies, he also interned with Northrop Grumman Space Systems, advancing materials research for aerospace applications. Following his doctorate, he gained industry experience as a semiconductor wafer process engineer before joining AFRL. Dr. Brawley joined AFRL

in 2024, where he leads research at the intersection of physics, chemistry, and biology. Dr. Brawley has authored and co-authored 12 scientific articles since 2017 and presented at numerous photonic and defense conferences.