1. **Research Title:** Unlocking High-Energy Density Artificial Muscles: Multiscale Investigation of Advanced Dielectric Elastomer Composites
2. **Individual Sponsor:**

Dr. Matthew J. Grasinger, AFRL/RXNP Bldg 654, Room 236
2941 Hobson Way
WPAFB, OH 45433
matthew.grasinger.1@us.af.mil

3. **Academic Area/Field and Education Level**

BS, MS, or PhD student in Mechanical, Chemical, or Composites Engineering Discipline

4. **Objectives:**
    a. Conduct hands-on electromechanical experiments to measure material behavior under various conditions.
    b. Learn and apply multiscale modeling techniques to connect material properties to device performance.
    c. Gain proficiency in state-of-the-art computational mechanics software (e.g., COMSOL Multiphysics).
    d. Inform and/or engage in the practical design and fabrication of advanced devices, such as multilayered actuators.
5. **Description:** Dielectric elastomers (DEs) are soft, electrically responsive materials at the forefront of innovation for applications like bio-inspired robotics, artificial muscles, and wearable electronics. The potential to create adaptable, high-performance soft robotic swarms is of particular interest for Department of Defense (DoD) strategies involving affordable mass and autonomous platforms. However, a principal challenge preventing their widespread adoption is the large voltage often required for actuation. This limitation stems from a key gap in our understanding of their dynamic behavior. While progress has been made, robust models for AC (alternating current) actuation are lacking, and there is an incomplete understanding of how the material's permittivity varies with both mechanical stretch and electrical frequency. This project will address these challenges directly. It will focus on a combination of experiments and modeling to investigate the complex, dynamic stretch-permittivity response in advanced polymer composites—elastomers enhanced with fillers like liquid metal droplets or carbon nanotubes (CNTs). The central hypothesis is that by understanding and controlling this relationship, we can leverage AC voltages to achieve extreme deformations and extract significantly more mechanical energy per applied volt. The proposed approach will integrate micro-mechanical constitutive models, computational simulations, and experimental validation to create a predictive framework for designing the next generation of powerful, efficient "artificial muscles."
6. **Research Classification/Restrictions:** US Citizens only
7. **Eligible Research Institutions:** Any
8. **PA Approval #:** AFRL-2025-4283