1. **Research Title:** Nonlinear Optical Metasurfaces

2. **Individual Sponsor:**

Dr. Jonathan Slagle, AFRL/RXEP
2179 12th St. B652 R122
Wright-Patterson AFB, OH 45433
Jonathan.Slagle@us.af.mil

3. **Academic Area/Field and Education Level:** Optical Sciences, Electro-Optics, or Physics (MS or PHD)

4. **Objectives:** Fundamental exploration of both second and third order optical nonlinear susceptibility of functional materials combined with structured optical design (i.e. 1D and 2D nonlinear optical metasurfaces). The primary objective is to validate rigorous physical modes and numerical simulation with fabrication and experimental results. This may include 1) theoretical understanding and numerical simulation, 2) fabrication utilizing thin film and/or lithographic techniques, 3) linear characterization such as SEM and ellipsometry, and 4) nonlinear optical characterization.

5. **Description:** Both second and third order optical nonlinearity is useful for numerous photonic applications. State-of-the-art (SotA) bulk nonlinear media is approaching a diminishing return with respect to materials discovery, i.e. structure/property enhancement. In this project, our goal is to accelerate beyond the SotA by creating structured optical metasurfaces that enhance nonlinearities at the nanoscale. Optical metasurfaces have already shown great promise as a means for enhancing local field effects through strong resonant phenomena (e.g. epsilon near zero effects, bound states in the continuum, exceptional points, among others). Unfortunately, while strong resonances can enable optical nonlinearities at ultralow power levels, the nature of the trapped field means that the extraction efficiency is too low for practical applications. In this project, we aim to explore mechanisms that enable both large optical nonlinearities as well as practical efficiency with a specific interest in devices for free space. This will be accomplished by optimizing the nonlinear optical metasurface designs with rigorous physical models, machine learning, and constituent material surveys. Theory and numerical conceptual designs will then be fabricated using lithographic patterning and/or thin film deposition, characterized with appropriate microscopy and linear optical techniques, and then ultimately tested in nonlinear optical experiments.

6. **Research Classification/Restrictions:** Not Classified. Only US Citizens will be considered.

7. **Eligible Research Institutions:** All

DISTRIBUTION STATEMENT A. APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED, Case Number: AFRL-2023-4159