Research Title: Synthesis and Integration of Quantum Light Sources and Quantum Sensors

Individual Sponsor:

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Academic Area/Field and Education Level

Physics, Chemistry, Materials Science Engineering, Electrical Engineering, Mechanical Engineering, or equivalent (MS or PhD level)

Objectives: Develop scalable methods for fabrication of quantum light emitters (either single- or entangled-photon sources) and/or qubits for quantum sensing. Characterize relevant quantities such as second-order coherence, photon indistinguishability, and sensitivity of the emission to electric/magnetic field and strain. Develop scalable methods for deterministic placement of quantum emitters within photonic circuit integration of these emitters in integrated photonic circuits.

Description: Quantum networking and communications benefits from single- and entangled-photon sources that work at room temperature, with short excited state lifetimes. Quantum sensing applications rely on factors such as ground state electronic spins with long coherence times, optical spin-polarization effects, and electronic fine structures that are dependent on strain and electric / magnetic field interactions.

Single photon sources have been identified in, e.g., quantum dots, point defects in wide bandgap semiconductors, and in 2D materials. Entangled photon sources can be built up by coherently combining single-photons or by using nonlinear optical elements for photon pair production. This project seeks to develop entanglement generation sources with better than 1 kHz pair generation rates and two-photon state fidelities of greater than 0.97. For quantum sensing, this project will focus on the characterization of point defects in wide bandgap semiconductors such as diamond, SiC, □-Ga2O3, and AlN. Defects with one or more of the following characteristics are of interest: infrared photoemission, optically-detected magnetic resonance, and optomechanical coupling. These measurements are made by a combination of confocal microscopy and spectroscopy, single-photon counting, magneto-optical spectroscopy, acousto-optics, and electron microscopy. The results of these measurements will be used to refine theoretical models of novel defect centers being developed by collaborators.

The current state of the art in coupling point defects to photonic architectures involves top-down fabrication methods such as e-beam lithography and ion implantation. This research topic may also study ways to efficiently incorporate point defects during material synthesis or in post-processing, such as using rational design of defect molecules, e-beam chemistry, or laser annealing. Facile methods for integration of quantum emitters or qubits into photonic circuits will open new possibilities to use quantum networks and quantum sensors on Air Force platforms.

Research Classification/Restrictions: Unclassified, unrestricted.

Eligible Research Institutions: All U.S. institutions with graduation programs in the relevant academic areas listed above. Coordination with the topic sponsor is encouraged prior to proposal submission.

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