FY24/25 DAGSI Research Topic

1. **Research Title:** Nanoscale Vacuum Field Emission Devices
2. **Individual Sponsor:**

Dr. Harris J. Hall, AFRL/RYDI
AFRL/RYDI Bldg 620
2241 Avionics Circle
WPAFB, OH 45433-7333
harris.hall.3@us.af.mil

3. **Academic Area/Field and Education Level**
   Electrical Engineering (M.S. or Ph.D. level), Physics, Applied Physics (M.S. or Ph.D. level)

4. **Objectives:** The primary objectives of this research are to enable improved computational methods for predictive simulation based design of on-chip nanoscale vacuum field emission devices and experimentally explore novel device and circuit designs for sensing applications.

5. **Description:** In the last decade, on-chip devices that exploit nanoscale vacuum field emission have attracted interest for low power digital, RF amplification, and gas sensing applications because of their potential to exceed performance of traditional solid-state technologies - particularly in high temperature austere and space environments. Predictable device operation over long duration time scales and elevated temperatures is a key metric to enable technology transition. Our research team is exploring through both multi-physics simulation [1,2] and experimentation [3,4] lateral on-chip field emission devices using both traditional and non-traditional materials compatible with wafer-scale microfabrication methods. Computational methods for efficiently incorporating field emission and competing modes of carrier transport, simulation based design of 2,3, and 4-terminal devices, nanoscale device fabrication with non-traditional materials, and experimental characterization of fundamental emission mechanisms, devices, and circuits under a variety of environmental conditions is all within the scope of this topic.

   [1] J. Ludwick, et al , "A new multiscale approach to rapidly determine the local emission current density of nanoscale metallic field emitters," *Journal of Applied Physics*, 130, 144302, (2021).
   [2] N. Hernandez, et al "Semi-Analytical Model of an AlGaN/GaN Vacuum Field Effect Transistor", *Journal of Vacuum Science and Technology B*, (2022), 40(5), 053201.
   [3] J. O'Mara, et al "Effect of Dielectric Substrate on Gold Nanoscale Lateral Vacuum Emission Devices" *IEEE IVNC 2023*, Cambridge MA
   [4] N. Hernandez, et al "Exploring the Field Emission Capabilities of AlGaN/GaN Heterojunction Nanoscale Vacuum Devices" *IEEE IVNC 2023*, Cambridge MA

6. **Research Classification/Restrictions:** Unclassified/U.S. Citizenship required

7. **Eligible Research Institutions:** Universities (DAGSI), AFIT