1. **Research Title:** Development of Magnetic Nanomaterials for Power Applications

2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:** Electrical Engineering or Materials Engineering/Science (MS or Ph.D. level)

4. **Objectives:** The objective of this proposed project is to support the research and development of AFRL's advanced magnetic materials by investigating composition, processing, and fabrication of both electromagnetic (soft) and permanent (hard) magnets for Air Force applications. In particular magnetic nanocomposite research may lead to twice the energy product of the best current permanent magnets and increased magnetization of soft magnets at high frequencies.

5. **Description:** Magnets are used in virtually every warfighter weapon system used today. Motors and generators, actuators and traveling wave tubes, inductors and transformers all require some form of magnetic material. In the design of future air and space vehicles and directed energy weapons there is an even greater need for advancement of these hard and soft magnetic components as weapon systems become more-electric in nature and weight and volume are paramount. To enable the desired elimination of hydraulics from Air Force engines and associated electrical power units, and thereby the elimination of the liquid cooling function, many of the magnet applications will require optimized performance at elevated temperatures and under mechanical stress. Directed energy weapons will be advanced by not only improved magnets for power generation components but also from improved efficiencies of the passive electronic components such as transformers and inductors. If new magnetic materials can be developed that meet the magnetic and physical characteristics desired, then significant improvements in weapon system reliability, maintainability and supportability will be realized, along with a drastic reduction in the dependence on ground support equipment.

Graduate students under this research topic will work with Air Force Research Laboratory scientists and engineers in AFRL/PRPG utilizing characterization and fabrication equipment such as a vibrating sample magnetometer, hysterisesgraph, and melt spinner to investigate both hard and soft magnetic materials. Theory suggests that a 2X increase in energy product (up to >100MGOe) is possible for room temperature nanocomposite permanent magnets and as high as 30 MGOe for high temperature (450 °C) nanocomposite permanent magnets. Melt-spun nanocomposite precursors with various compositions will be processed. Time and temperature profiles will be established and correlated with extrinsic magnetic and physical properties. Students may also investigate soft magnetic materials that are capable of working at much higher frequencies than laminate Fe sheets, and have higher permeability than ferrites. Past approaches have pursued polymer coated Fe particles, but these were severely limited in temperature capability leading to elaborate cooling schemes and reduced power density. There has been some progress made along this path by using nanocomposite soft magnetic materials. To this end, the proposed work will involve developing uniform thin insulating coatings for nano-sized Fe particles, optimizing particle compaction into bulk material, and proof of concept testing in relevant prototype demonstrations. Students may investigate compositional control, processing parameters, and fabrication techniques required to produce optimized properties.

6. **Research Classification/Restrictions:** None.

7. **Eligible Research Institutions:**

[X] Universities (DAGSI)   [X] AFIT   [X] USAFA