USNA Chemistry Department

Purdue University Internship Projects

Summer 2021

17 December 2020

Purdue University, West Lafayette, Indiana.

Chemical Composition Analysis of Naval Tactical Fuels, and Engineering of Batteries, Solar Cells, Radar and Turbine Systems

This internship will involve hands-on laboratory work conducting experiments and simulations for a variety of renewable energy and electronics projects. The students will gain significant experience in a laboratory environment. It is expected that the student will conduct experiments/perform simulations with the aid of a mentor in the host laboratory's group (likely to be a graduate student or post-doctoral research scientist). At the conclusion of the internship, the student will present his or her work to the wider Purdue student body and faculty. Internship projects center around the chemistry of batteries, thermal management of electronic systems, radar cooling designs, and turbine engineering. Specific projects are listed below.

https://www.purdue.edu/?_ga=2.14380727.1863141713.1607565799-1166996221.1607565799

- Dates: Block 1
- Eligible for PTE credit: yes
- Qualifications: Rising 1/C or 2/C. Majors: chemistry, mechanical engineering, aerospace engineering, electrical engineering, or other related disciplines.
- Funding: Fully funded.
- Application: Submit online chemistry application. Specific project(s) must be entered on application.
- POC: Prof McClean mcclean@usna.edu

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1. **Advanced, Safer Li-ion Batteries (Dr. V. Pol)**
   Block: 1
   Preferred academic background: Chemistry, Chemical Engineering, Materials Engineering, etc.
   Cadet/Midshipman will work with a team to understand fundamentals of lithium ion batteries and its working principles. Team develops electrode materials, electrolyte and advanced separator to make the advanced batteries. Thermal safety aspects of novel batteries is studied employing differential scanning calorimetry and multimodal calorimetry.

2. **Low Temperature Batteries for Defense Applications (Dr. V. Pol)**
   Block: 1
   Preferred academic background: Chemistry, Materials Engineering, Chemical Engineering, Environmental Engineering, etc.
   Cadet / Midshipman will work with a team to develop battery materials, electrolyte and cell design architectures that works in the range of 50^{o}C to – 120^{o}C.

3. **Molecular Engineering of Highly-Stable High-Performance Lead-Free Perovskite Solar Cells (Prof. Letian Dou)**
   Block: 1
   Preferred academic background: Chemistry, Materials Science, Chemical Engineering or Electrical Engineering students are preferred.
   The ability to harvest solar energy efficiently with a light-weight portable device is critically important for the future warfare. Previous technologies suffered from either low-portability (e.g., Si solar cells) or low power conversion efficiency (e.g., organic solar cells). Halide perovskites are a new type of soft semiconductor that show great promise. Tremendous progresses have been made in achieving highly efficient thin film solar cells. Using the lead-based perovskites such as $(CH_3NH_3)PbI_3$ as the solar absorber, certified power conversion efficiency of 25.5% has been demonstrated. The poor stability of the perovskite materials, as well as the use of toxic elements (Pb), are the major obstacles for the real-world application of this new type of solar cell. In this project, we will apply organic chemistry and nanotechnology principles to design novel intrinsically stable

lead-free organic-inorganic hybrid perovskite materials. High-performance, light-weight, and flexible solar cells based on these new materials will be fabricated and characterized.

4. Thermal Management of Electronic Systems (Dr. J. Weibel)

Block: 1

Preferred academic background: Mechanical Engineering, Aeronautical Engineering, Chemical Engineering, Materials Science, or other related disciplines.

The continued miniaturization of electronic devices, with expanded functionality at reduced cost, challenges the viability of products across a broad spectrum of industry applications. Proper thermal management of electronic devices is critical to avoid overheating failures and ensure energy efficient operation. Research projects in the Cooling Technologies Research Center (CTRC) are exploring new technologies and discovering ways to more effectively apply existing technologies to address needs in the area of high-performance heat removal from compact spaces. One of the distinctive features of working in this Center is training in practical applications relevant to industry. Projects involve both experimental and computational aspects, are multi-disciplinary in nature, and are open to excellent students with various engineering and science backgrounds. Multiple different research project opportunities are available based on student interests and preferences.

5. Radar Cooling System Design Tool and Prototype (Dr P. Bermel)

Block: 1

Preferred academic background: Mechanical or Electrical Engineering, but other engineering or related backgrounds would also be considered.

Naval radar engineers need a method to provide greater power efficiency to radar systems in order to improve specific weight and power in unmanned aerial platforms. To achieve this, we will create both an adjustable cooling model to optimize the power efficiency and a prototype to examine the resulting performance. This will involve modeling and measuring the power amplification efficiency, component heating, and estimating the mean time to failure for a given configuration. This will allow end users (e.g., the system designers) to select a cooling system configuration best suited for a given use case.

6. Measurements in a Turbine Facility (Prof James Braun and Prof Paniagua Guillermo)

(https://engineering.purdue.edu/PETAL)

Block: 1

Preferred academic background: Aero, Mechanical or Industrial Engineering with courses in thermo fluids, fluid mechanics or aerodynamics.

- Testing of low Reynolds turbine profiles
- Investigation of the blade-row interactions in a 2stage turbine
- Aero-thermal effect of the turbine tip gap flows
- Stator rim-rotor platform leakage effects on the rotor
- Effects of acoustic and pulsating flows in high work turbines

Within the different tasks we will design and characterize fast-response instrumentation for aero and heat transfer measurements. The test articles will be investigated in several test rigs, including the demonstration in linear, annular and rotating facilities. Research will also focus on the data reduction and analysis of the measurements and integration with our Computational Fluid Dynamics tools, including uncertainty quantification.