USNA Chemistry Department

Purdue University Internship Projects

Summer 2022

10 January 2022

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 and on a separate document on the chemistry internship website.

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.
- LT Snyder cmsnyder@usna.edu

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1. **Engineering off-the-shelf CAR-T and CAR-NK cells from human stem cells for targeted cancer therapy (Prof Xiaoping Bao, Davidson School of Chemical Engineering)**

   Block: 1

   Preferred academic background: Chemical Engineering, Biomedical Engineering, Biology, or other related majors are preferred.

   Cancer is a major threat for humans worldwide, with over 18 million new cases and 9.6 million cancer-related deaths in 2019. Although most common cancer treatments include surgery, chemotherapy, and radiotherapy, unsatisfactory cure rates require new therapeutic approaches. Recently, adoptive cellular immunotherapies with chimeric antigen receptor (CAR) engineered T and natural killer (NK) cells have shown impressive clinical responses in patients with various blood and solid cancers. However, current clinical practices are limited by the need of large numbers of healthy immune cells, resistance to gene editing, lack of in vivo persistence, and a burdensome manufacturing strategy that requires donor cell extraction, modulation, expansion, and re-introduction per each patient. The ability to generate universally histocompatible and genetically-enhanced immune cells from continuously renewable human pluripotent stem cell (hPSC) lines offers the potential to develop a true off-the-shelf cellular immunotherapy. While functional CAR-T and NK cells have been successfully derived from hPSCs, a significant gap remains in the scalability, time-consuming (5 or more weeks), purity and robustness of the differentiation methods due to the cumbersome use of serum, and/or feeder cells, which will incur potential risk for contamination and may cause batch-dependency in the treatment. This project thus aims to develop a novel, chemically-defined platform for robust production of CAR-T and CAR-NK cells from hPSCs.

2. **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.

3. **Symmetric Asymmetric Lifecycle Engagement (SCALE) (Dr. Peter Bermel)**
Block: 1
Preferred academic background: Electrical Engineering, Computer Engineering, or other related majors are preferred.
SCALE will provide mentoring, internship matching and targeted research projects for college students interested in three microelectronics specialty areas: radiation-hardening, heterogeneous integration/advanced packaging, and system on a chip.

4. **Radiation-Hardened Technologies (Dr. Allen Garner)**
Block: 1
Preferred academic background: Electrical Engineering, Nuclear Engineering, or other related majors are preferred.
Radiation in natural and manmade environments can greatly affect the operation and long-term performance of microelectronics. Radiation hardening is making electronic components and circuits resistant to damage or malfunction caused by high levels of ionizing radiation. Transient effects include single-event effects like memory bit flips; permanent effects include single-event latchups that prevent individual devices from operating. In these projects, students will explore the underlying failure mechanisms for electronics exposed to radiation, methods to predict failure rates, and a range of mitigation approaches for radiation damage, which include radiation-hardening by process and radiation-hardening by design.

5. **Heterogeneous Integration/Advanced Packaging (Prof Ale Strachan and Prof Ganesh Subbarayan)**
Block: 1
Preferred academic background: Materials Engineering, Mechanical Engineering, or other related majors are preferred.
The rapid increase in chip performance associated with Moore's law has also raised interest and expectations around creating packaging devices with improved size, weight, and power. To keep sizes manageable while improving functionality, complex packaged electronics like iPhones require similar components to be compressed together horizontally and vertically, and combined with dissimilar components providing complementary functions. Significant challenges in heterogeneous integration to be addressed in research include maintaining the reliability of connections such as solder bumps, managing thermal cycling, and limiting damage from mechanical stress that can cause failures.

6. **System on Chip (Prof Anand Raghunathan and Prof Mark Johnson)**
Block: 1
Preferred academic background: Electrical Engineering, Computer Engineering, or other related majors are preferred.
Moore's law has led to an exponential increase in the number of devices that can fit onto a single chip. This has led to a new era where most electronic systems contain chips that integrate various (hitherto discrete) components such as microprocessor, DSPs, dedicated hardware processing engines, memories, and interfaces to I/O devices and off-chip storage. Most electronic systems today - cell phones, iPods, set-top boxes, digital TVs, automobiles - contain at least one such System-on-chip (SoC). Designing SoCs is a highly complex process. Before entering the traditional VLSI implementation process (RTL, logic & physical design), student designers will perform the challenging tasks of developing a functional specification, partitioning and mapping of functions onto hardware components and software, developing a communication architecture to interconnect the components, functional/performance/power analysis and validation, and more.

7. Smart Soft Contact Lens for Military-Relevant Visual Dysfunction (Dr. Chi Hwan Lee)

Block: 1

Preferred academic background: Biomedical Engineering, Mechanical Engineering, or other related majors are preferred.

The prevalence of visual dysfunction related to a military-relevant traumatic event, including photophobia, visual acuity, cranial nerve palsy, and visual field defect, affect a large number of Service members and Veterans, and, if untreated, these issues may cause permanent visual impairment or even blindness. Importantly, patients with a visual dysfunction may benefit from visual rehabilitation using the Glasgow coma scale (GCS), a 15-point scale based on measures of verbal, motor, and eye-opening reactions to various light stimuli. Electrophysiological examination of the retinal function in response to a light stimulus, known as an electroretinogram (ERG) signals, has been used to assess the effectiveness of the GCS in clinics, and it is also used as an indicator of the prognosis of patients at discharge from hospital. Therefore, this effort has the potential to significantly benefit Service members and Veterans that have experienced military-relevant trauma. However, current treatments are limited by the fact that the rigid form factor of current corneal sensors produces a mismatch with the human cornea which is soft, curvilinear, and exceptionally sensitive. In turn, these ERG measurements require the use of topical corneal anesthesia and a speculum for pain management and safety. In addition, current visual rehabilitation primarily relies on large, expensive pieces of equipment (e.g., a Ganzfeld stimulator) that are only available in urban medical facilities. However, it is not always feasible or economically-viable for patients to make frequent visits to a clinic to receive proper examinations and visual rehabilitations. This is particularly true for patients who have limited mobility or live in rural areas. To address this unmet clinical need, we will design, fabricate, and validate a smart soft contact lens sensor built on commercially available disposable soft contact lenses that can safely and comfortably interface with the human cornea, allowing for home-based portable monitoring of ERG signals in austere environments and prolonged field care settings. During this proposed project, we will (1) establish an optimal set of materials, device layouts, and assembly strategy for the production of the soft contact lens-based corneal sensor applicable to human eyes, without the use of topical corneal anesthesia or a speculum, and (2) simultaneously conduct comprehensive pilot pre-clinical studies to validate their long-term biosafety and performance in a standard clinical setting. The successful completion of these tasks will provide important insights for subsequent clinical studies in near term over the following 2 years that will be design for validating the utility of the corneal sensor in tele-monitoring of patients with a visual dysfunction. This will eventually, in the next another 2 years, lead to the development of effective tele-rehabilitation protocols by which the patient-collected ERG data will be shared with a clinician from a distance via an encrypted cloud server.