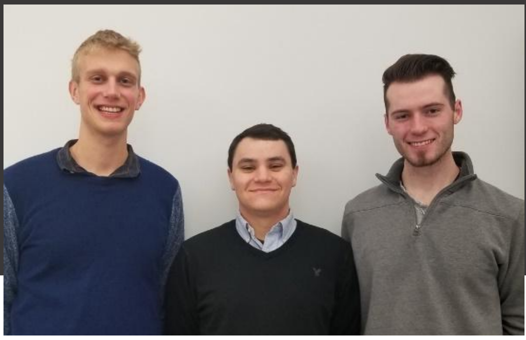


*Pictured from left to right: Elijah Anderson, Alexander Lavoie, and Mitchell Pavao.*

ELECTRICAL AND COMPUTER ENGINEERING

**TEAM:** 1916

**SPONSOR:** Undersea Warfighting Development Center

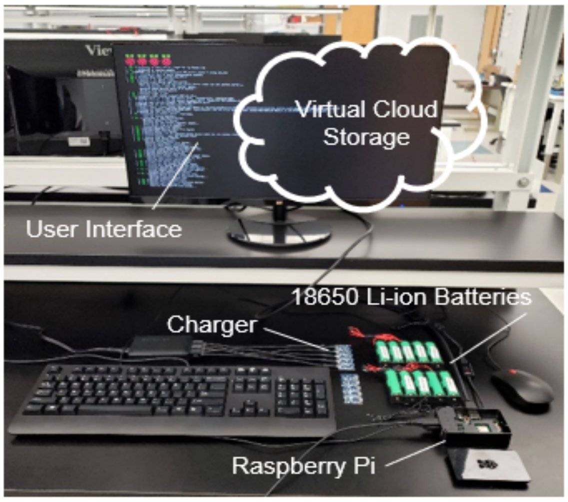
**ADVISOR:** Prof. Sung-Yeul Park

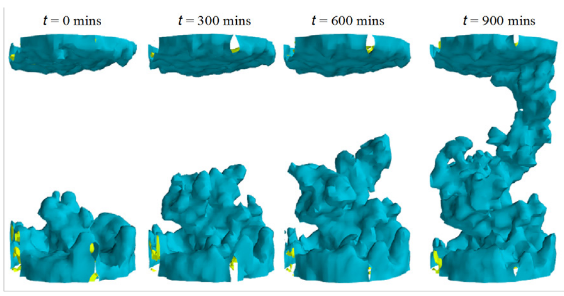
# Advanced Energy Production and Storage

Lithium-ion batteries are an enticing power storage method with the highest energy density available on the market. However, lithium-ion batteries are known to be dangerous and unpredictable, as they can deteriorate rapidly with little to no warning. This process is known as thermal runaway. Once this occurs, it is rarely contained to one cell and the entire system is at risk of catastrophic damage. Due to the demand of portable and safe energy storage as seen in the electric vehicle industry, there is considerable interest in better understanding the degradation mechanisms of these batteries.

Our project began with research regarding causes of battery failure. We found that the solid electrolyte interphase, or SEI, has a large impact on a battery's operating characteristics. The SEI is a film a few nanometers thick found on the anode. Most of its growth occurs during the initial charge/discharge cycles of the battery. After the initial stage, current flux through the anode is responsible for SEI growth. As the SEI grows, the permeability of lithium ions decreases, which results in capacity loss through irreversible lithium plating. While capacity loss is undesirable, the real problem occurs in tandem with SEI growth. During this process, dendrites tend to form on the anode as well. Dendrites can puncture the separator and result in a short circuit, which leads to thermal runaway. Detection of the SEI or dendritic growth can be difficult using today's battery management systems. In order to better assess the internal state of batteries, a non-invasive technique known as electrochemical impedance spectroscopy can be used. With the impedance spectrum of a battery it's possible to gain insight into the internal characteristics of a battery, such as its SEI layer.

Our project will feature a TP4056 CCCV battery charger to charge 2500mAH Samsung 18650 Li-Ion batteries. During the charge phase, we will take current and voltage measurements using an INA219 which features a 12-bit ADC and I2C for use with a Raspberry Pi. The Pi will be responsible for sending these measurements to Microsoft's cloud platform, Azure. With the data in the cloud, we will perform state of charge (SoC) calculations and create state of health (SoH) profiles based upon the voltage, capacity, and number of charge cycles for each battery. In the future, the SoH profile will also include impedance spectroscopy measurements for more accurate assessment of the battery's internal state to ensure safe operation.




*3D MRI image depicting gradual dendrite growth in a Li-ion battery.*