Department of
MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

AEIL
Advanced Energy Innovations Lab

Self-Charging Battery

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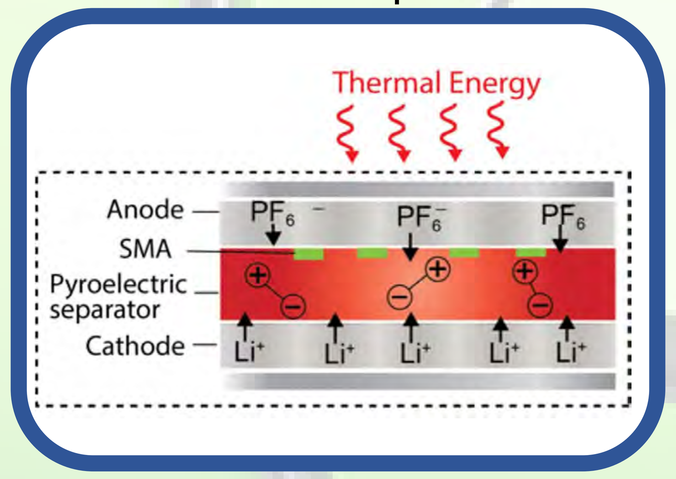
BACKGROUND

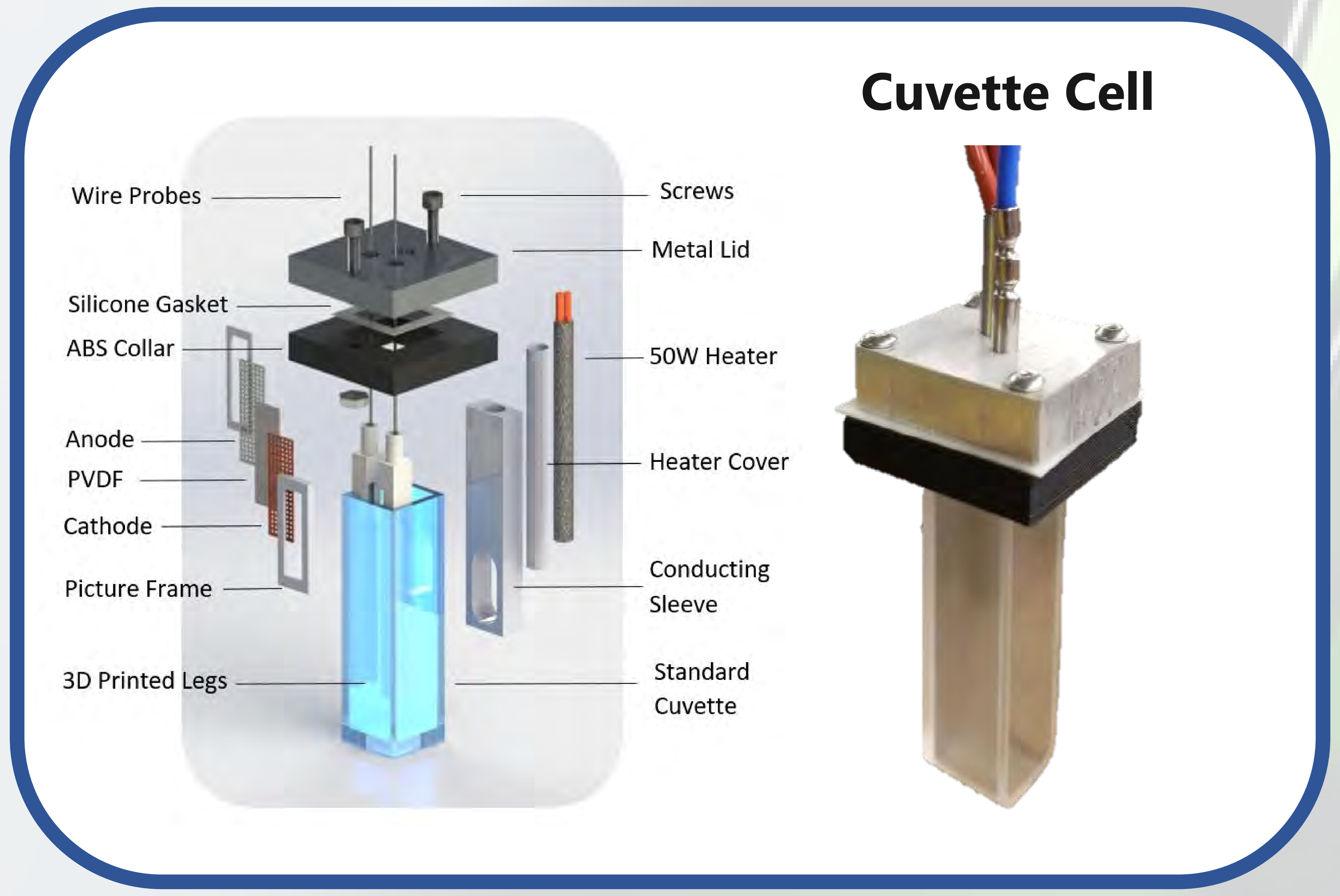
Global energy demands drive research institutions around the world to explore innovative new options for renewable energy. The Advanced Energy Innovations Lab (AEIL) at the University of Utah seeks to develop a "self-charging" power cell capable of converting thermal energy to electric energy using pyroelectric materials.

Pyroelectric materials generate a voltage when heated or cooled at a fast rate, and can be used as the separator film between the anode and cathode of a battery. When exposed to fluctuating temperatures (i.e. a tire pressure sensor) a battery can theoretically charge without an external power source.



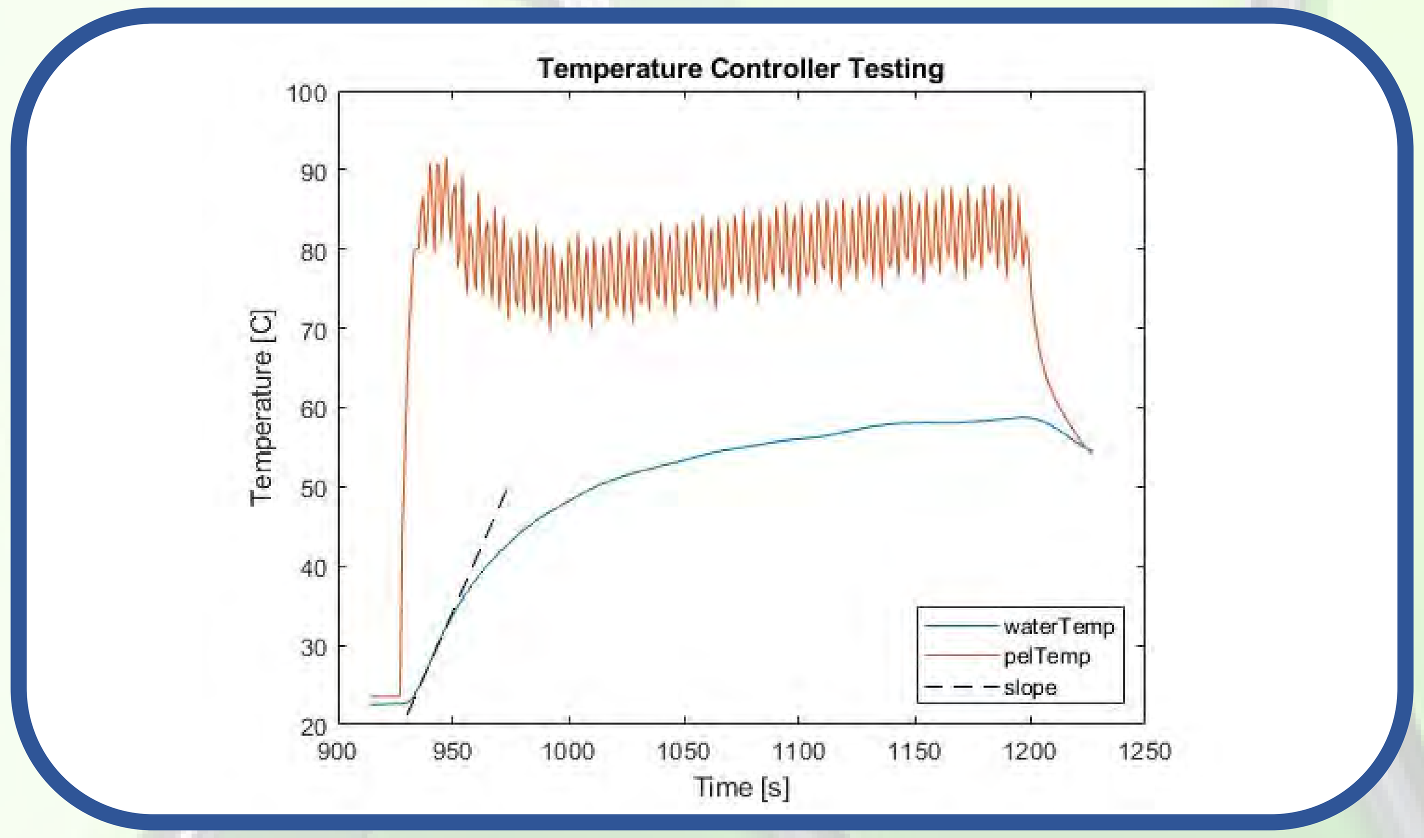
OUR TASK

Our senior design team was tasked with developing electrochemical test cells capable of repeatably measuring the state of charge of pyroelectric materials. The test cells must be resistant to high temperatures, completely airtight, and compact enough to fit in a UV VIS spectrometer. These unique requirements led us to develop two alternate cell designs: one using a standard scientific cuvette and the other based on a conflat disk.



HEATING

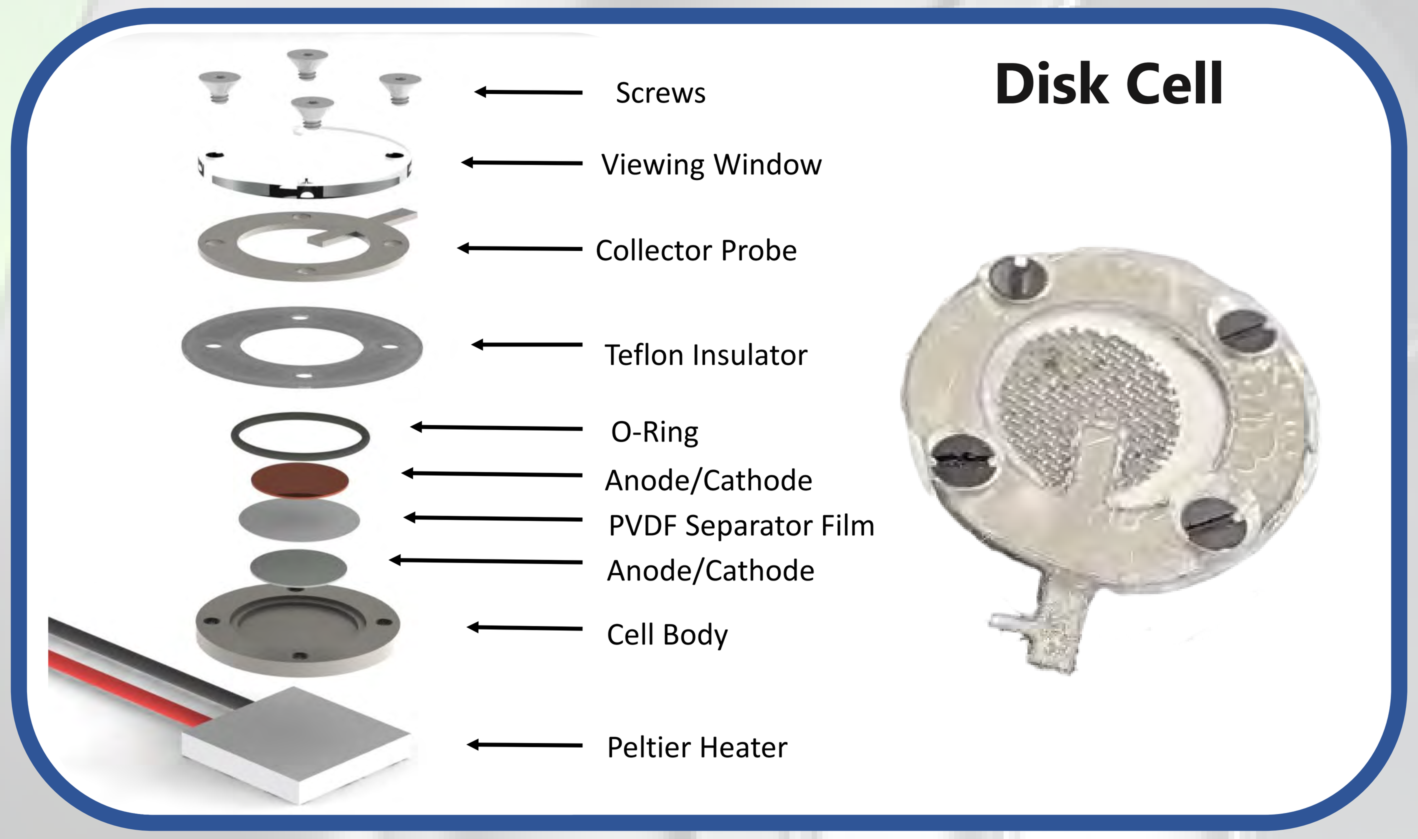
A different heating method was selected for each cell design. The cuvette cell uses a cylindrical cartridge heater, and the disk cell uses the hot side of a Peltier. The goal was to increase the temperature of the pyroelectric material as fast as possible. The maximum temperature of the cell was constrained by the electrolyte at 60°C. If surpassed, the electrolyte would vaporize into a toxic gas. Initial heat testing was done with water where the maximum temperature was far exceeded. These tests showed the need for a temperature controller.



SEALING

The disk cell lid consists of a sheet metal conductor adhered to a viewing window with epoxy. The lid is screwed down onto the cell body with an O-ring compressed in between. The cuvette cell uses a two-piece lid that sandwiches a silicone seal via screws on the lid. The inputs are sealed with RTV sealant. Seal integrity was tested by submerging each cell in water, internally pressurizing each cell with helium, then checking for bubbles in the water around the cell to identify a leak. The cuvette cell held to 40 psi and the disk cell held to 30 psi with no apparent leaks.

Metric	Target	Achieved	
		Disk	Cuvette
Heat Rate [°C/sec]	>1.00	0.67	0.80
Sealing [psi]	>20	30	40
Max Temperature [°C]	<60°	58°	52°



TEMPERATURE CONTROL

The temperature control was implemented using an Arduino board controlling a relay. The relay was attached to the power supply and was used as a temporary switch for the heater. Using different time intervals, the Arduino board switches on and off the power to the heater to sustain the heater at a steady temperature.

During testing it was found that thermal runaway occurs when the time interval is kept constant. We decided to move the interval to decay exponentially, so after every interval, the time on and off decreases less than the prior interval. With this addition, the heater successfully provided a high ramping rate as well as maintained our desired temperature.

CONCLUSION

After several design iterations, our team has successfully developed two independent pyro electrochemical battery cells. Both are capable of measuring state of charge using UV vis spectrometry. The two cells are each heated by different methods and have different heat rates. Output voltage has not been tested but our heating tests with water give an adequate heat rate for electrical discharge of the cells when exposed to temperature gradients. Using temperature controllers and relays, we will be able to fine tune our heating methods to provide maximum voltage and long duration current.