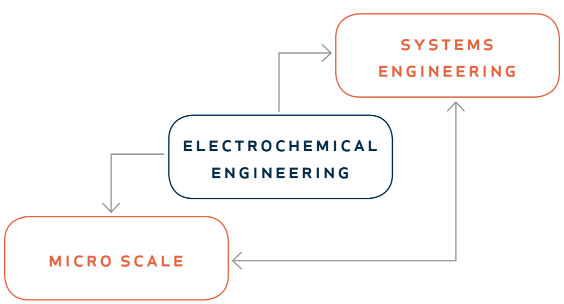
Lab Goal

To model, analyze and design cost-effective, energy-efficient and environmentally benign electrochemical systems, in particular devices such as batteries, solar cells, fuel cells and sensors.

About the Lab

The lab has active projects to perform fundamental research that ranges from quantifying material durability (funded by the American Chemical Society) to micro controller development for battery management system design for electric vehicles (funded by the U.S. Department of Energy). Our group addresses both depth and breadth in electrochemical energy systems. We seek to maximize the efficiency of existing technology (for example, Lithium-ion batteries) while striving to address fundamental issues in new electrolytes and materials (for example, flow batteries for gridscale applications, funded by SunEdison). In addition, we address issues on energy system integration. In particular, we aim to arrive at optimal control and sizing of solar-storage hybrids by implementing detailed microscale models for these hybrid systems

Since the group's initiation at WUSTL in Fall 2009, it has received 14 externally funded grants/contracts ranging from $35,000 to $3.2 million.



Modeling, Analysis & Process-control Laboratory for Electrochemical systems

Sponsors

arpa·e

NSF

U.S. DEPARTMENT OF ENERGY

SunEdison®

Missile Defense Agency – Department of Defense

HYUNDAI

ACS PRF

National Reconnaissance Office – United States of America

McDonnell Academy Global Energy & Environmental Partnership

I-CARES International Center for Advanced Renewable Energy and Sustainability

Contact Information

Venkat Subramanian
Washington University in St. Louis
Department of Energy, Environmental & Chemical Engineering
Phone: (314) 935-4622
Email: vsubramanian@seas.wustl.edu
www.maple.eece.wustl.edu

Washington University in St. Louis
School of Engineering & Applied Science

Modeling, Analysis & Process-control Laboratory for Electrochemical systems

www.maple.eece.wustl.edu

Need for Next Generation Energy Storage Systems

Cost

» Li-ion and other advanced battery chemistries are still expensive for many applications. Standard commercial Li-ion batteries cost $350-$750 per kWh.

Safety

» Thermal runaway can lead to internal cell damage and explosion.

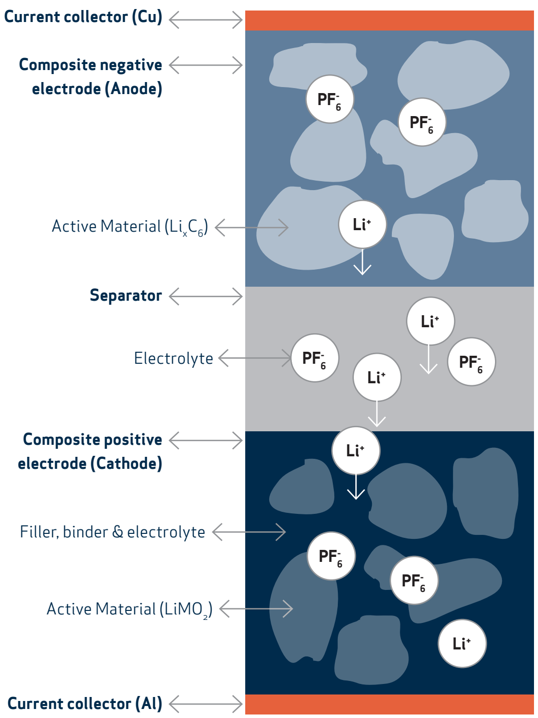
Life

» Capacity fade can lead to reduced cycle life and under utilization.

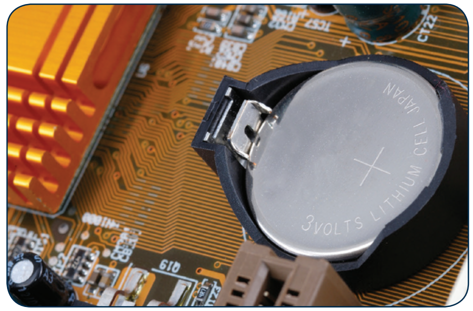
What affects these factors?

» Problems are caused at electrode surface of the battery.

» Therefore, the solution needs to incorporate detailed physics at the electrode level.



Multi-Scale Approach



MARKET LEVEL
COST
LIFE
SAFETY

SYSTEM LEVEL
UNDER UTILIZATION
CAPACITY FADE
LOW ENERGY DENSITY
THERMAL RUNAWAY

SANDWICH LEVEL
SEI LAYER GROWTH
SIDE REACTIONS
NON-UNIFORM CURRENT
LOSS OF PARTICLES
OHMIC RESISTANCE
MASS TRANSFER RESISTANCE

Research & Application

Group Projects

» Advanced battery management systems (BMS) and battery control

» Reformulated Li-ion battery models (fastest code reported in literature)

» State and Parameter estimation for batteries

» Redox-flow battery modeling, electrolyte synthesis and characterization

» Solar-battery hybrid system modeling

» Electric vehicle battery reuse

» Kinetic Monte Carlo simulation for solid-electrolyte layer growth

» Optimal battery-charging protocol

BMS Project

» Current US-DOE ARPA-E grant to integrate faster physics-based models and codes into BMS to enable accurate State of Charge and State of Health

» Pushing the limit of simulation capability and model predictability

» Maximize state estimation efficiency and accuracy

» Goal: Enhanced battery control will allow for increased efficiency, utilization and life while reducing cell cost.