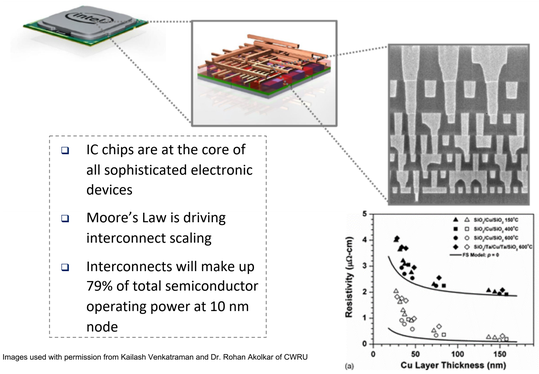
The Electrochemistry Lab at Columbia University
West Group

Investigation of New Interconnect Metals

- Cobalt will be investigated as a replacement for copper in IC chip interconnects
- Electrodeposition of single crystal interconnects will result in ballistic conductance

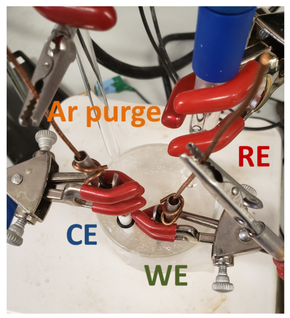
Issues at the Nano-scale: Resistivity

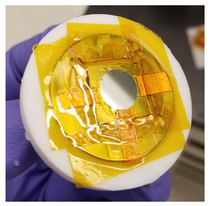


- IC chips are at the core of all sophisticated electronic devices
- Moore's Law is driving interconnect scaling
- Interconnects will make up 79% of total semiconductor operating power at 10 nm node

Images used with permission from Kailash Venkatraman and Dr. Rohan Akolkar of CWRU

Set-up for Co Electrodeposition

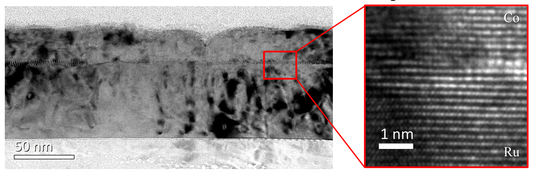




Substrate:

Ru [0001] sputtered epitaxially onto single crystal Al_2O_3 [0001]

Cross-sectional TEM of Epitaxial Co



- Bright-field TEM performed on electrodeposited Co
- HRTEM and electron diffraction prove epitaxial relationship between Co and Ru

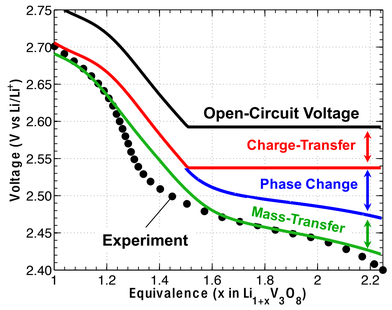
Electrodeposition on Patterned Substrates

Single crystal metallic interconnect will be grown in via, seeded by single crystal silicided Si substrate

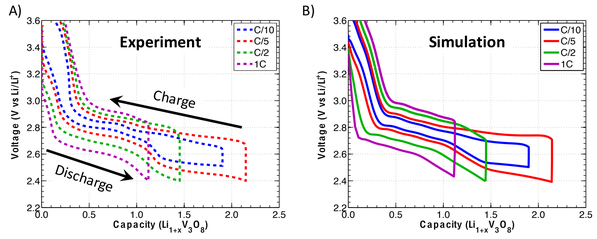
Single crystal, silicide substrate

Developing and Testing Physical Models

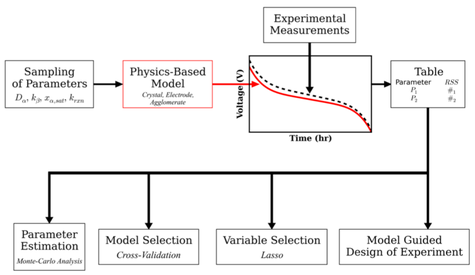
Understanding Limiting Processes



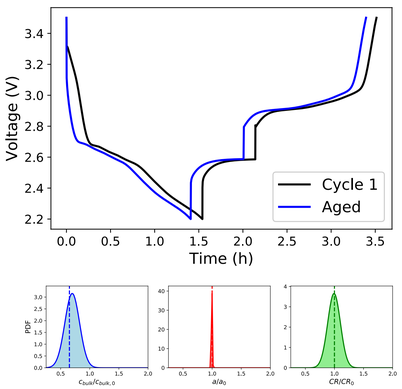
Building Physical Models

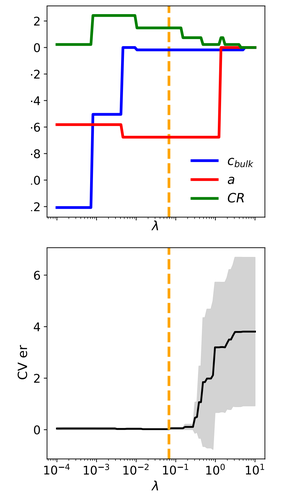


Algorithmic Model Development



Modeling Cathode Aging

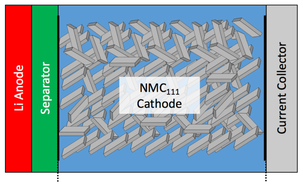


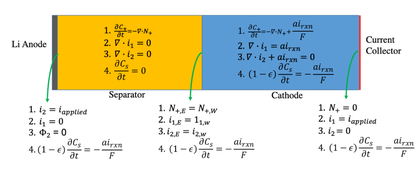


Simulation for State-of-art Battery

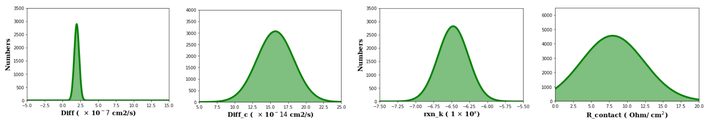
Experimental Set-up

Model Configuration



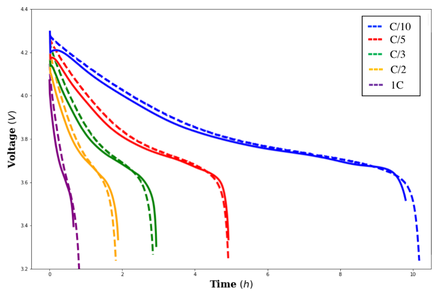


Parameter Estimation Using Data Science Technique



Parameter	Diff (cm^2/s)	Diff_c (cm^2/s)	Rxn_k	R_contact (Ω/cm^2)
Sobol Range	$(1\sim10)\times10^{-7}$	$(1\sim20)\times10^{-14}$	$1\times10^{(-7.5\sim-6.5)}$	1~20
MCMC Results	$(1.98\pm0.34)\times10^{-7}$	$(15.7\pm2.6)\times10^{-14}$	$1\times10^{-6.48\pm0.21}$	7.98 ± 4.38

Simulation Result Compared with Experiment Data



Characterization of Membranes