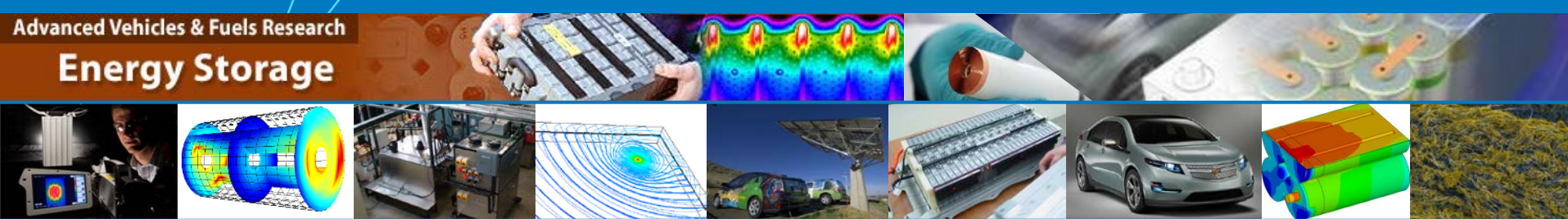


# Effect of Aging on the Mechanical Properties of Li-Ion Cell Components - A Preliminary Look

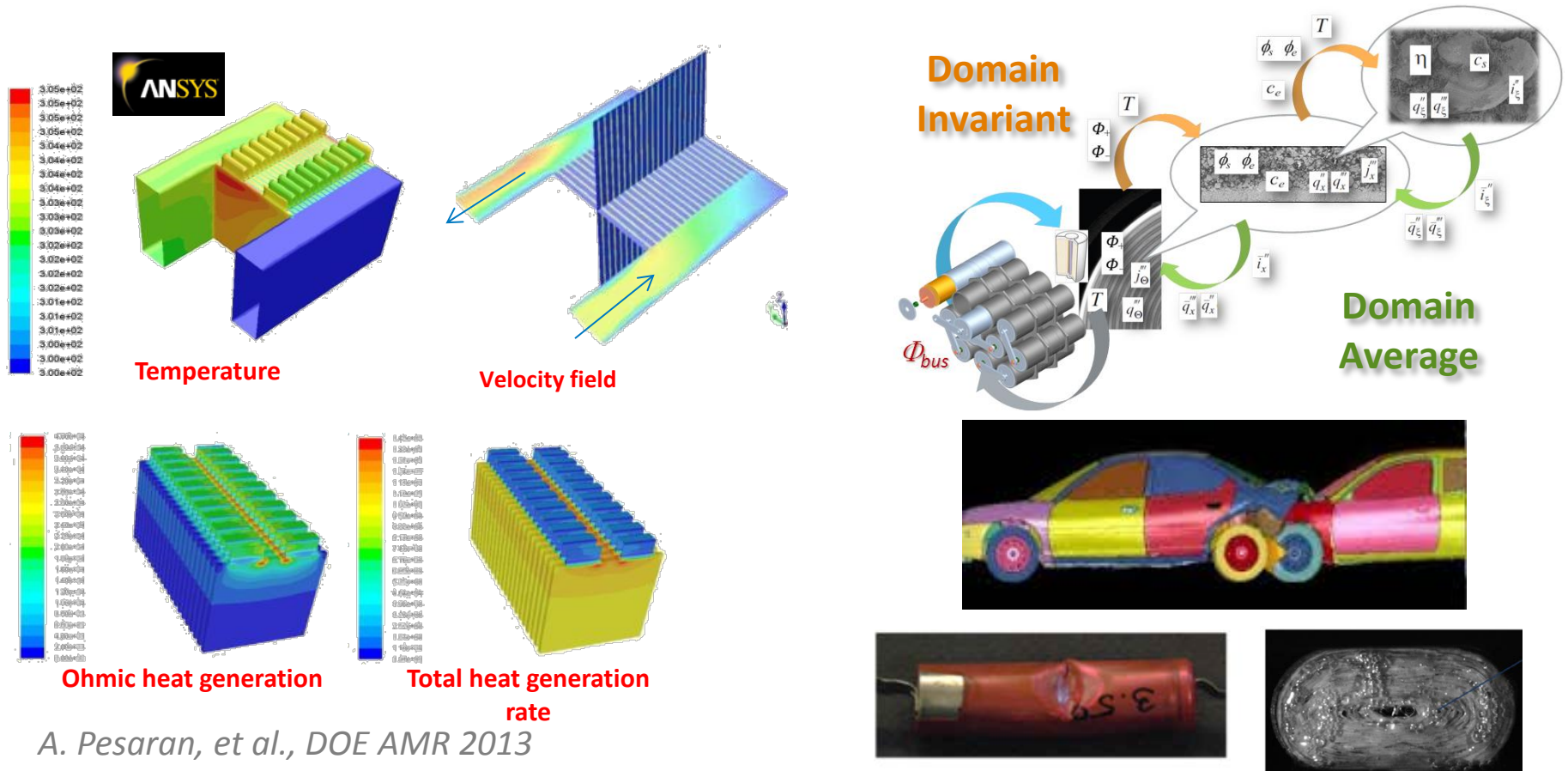


**Lei Cao, Chao Zhang,  
Shriram Santhanagopalan, Ahmad Pesaran**  
Transportation and Hydrogen Systems Center,  
National Renewable Energy Laboratory

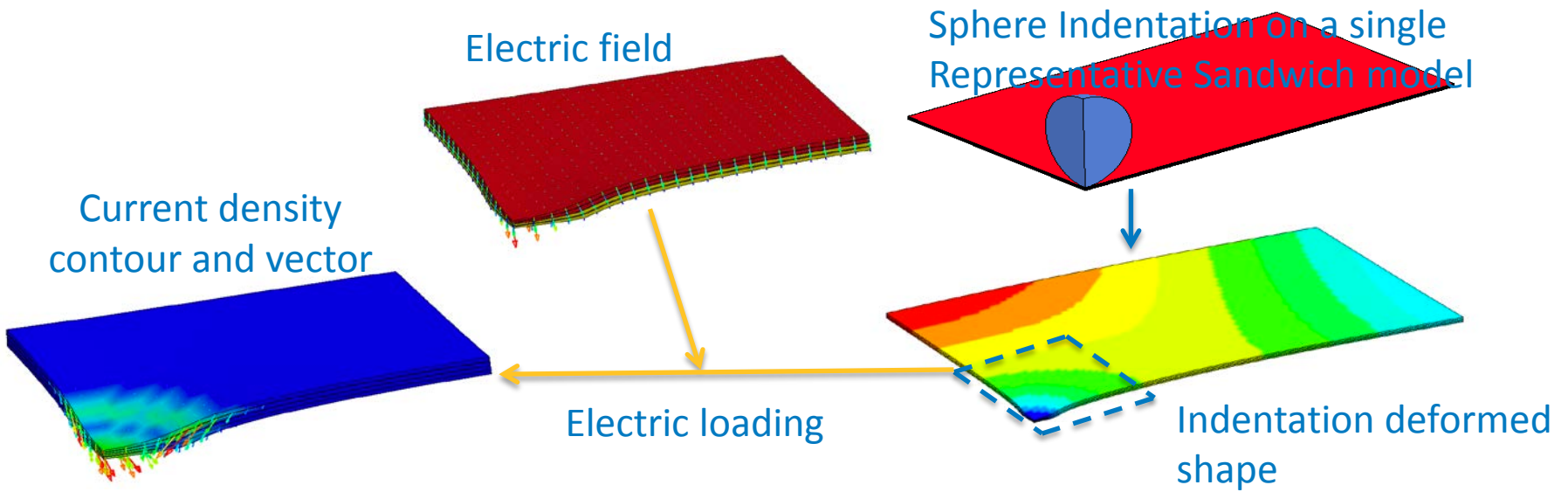
229<sup>th</sup> ECS Meeting  
San Diego, California  
May 30, 2016

# Background – CAEBAT 1 & 2

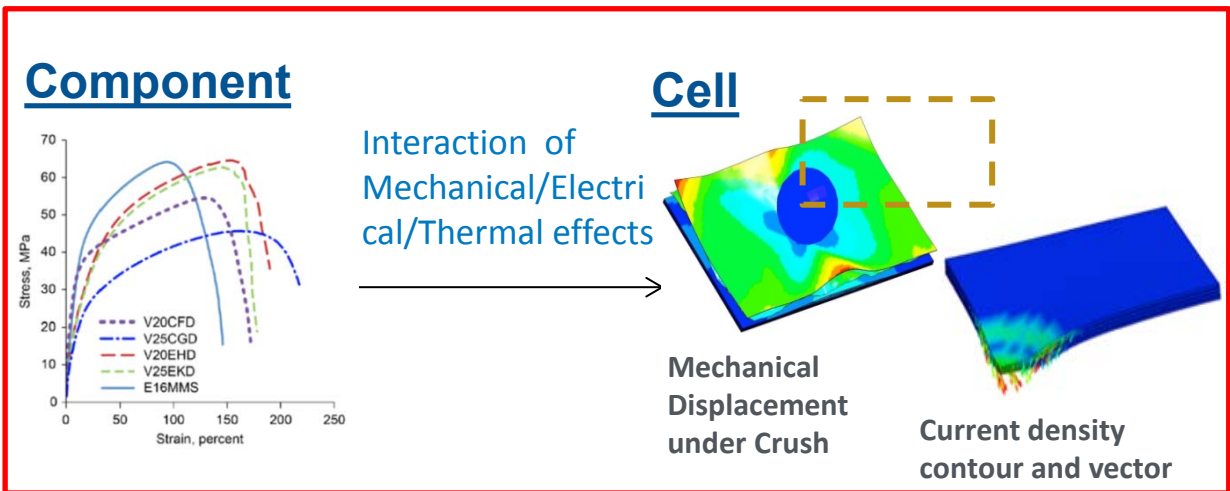
- DOE/VTO/ES initiated the Computer Aided Engineering for Batteries in 2010
- CAEBAT had a strong focus on building electrochemical-thermal models that simulate the performance of lithium-ion batteries.
- Since the start of CAEBAT-2 projects in FY14, our emphasis has been on safety aspects – mechanical deformation in particular



# Current Work



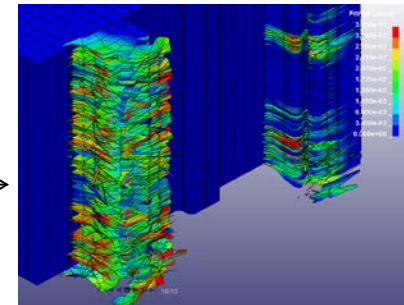
Zhang et al. Journal of Power Sources, 2015



**Aging**

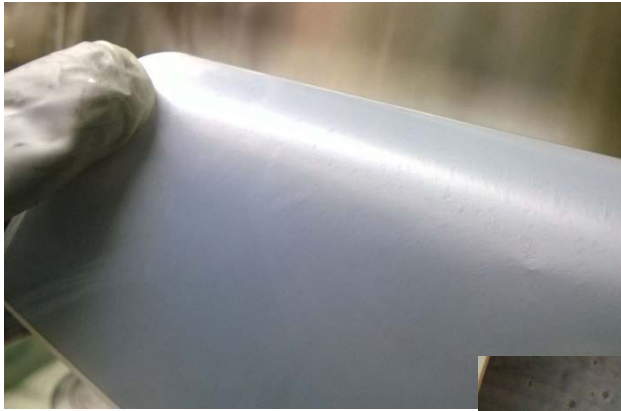
## Module

Propagation phenomena under crush

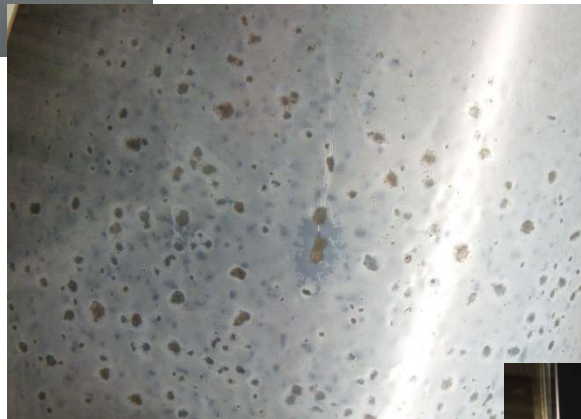


Santhanagopalan et al. 228<sup>th</sup> ECS Meeting, 2015

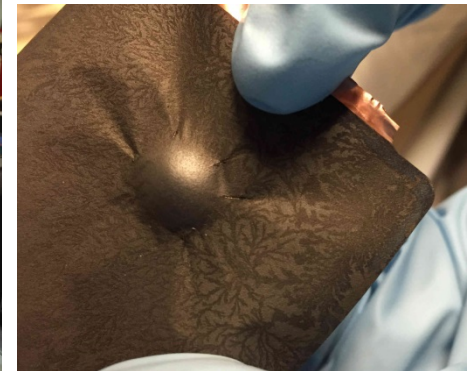
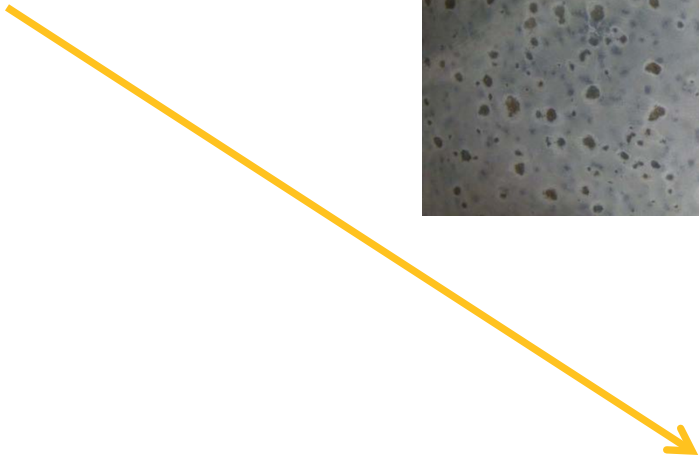
# Experimental



Fresh NMC/Graphite 40Ah Cell

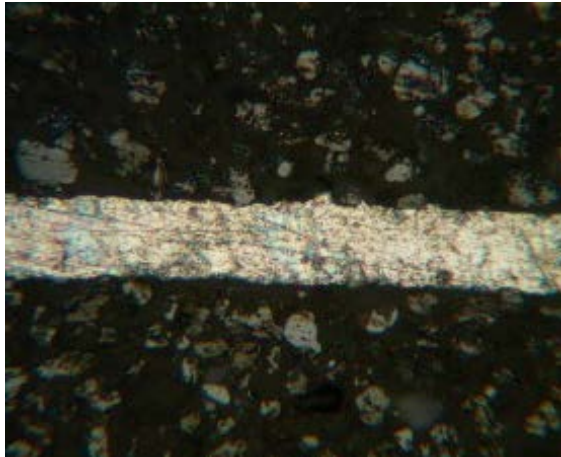


Over 3000 1C/1C cycles at 45°C  
25% capacity loss



# Typical Constitutive Properties of Battery Components

## ❖ Tensile properties of electrodes



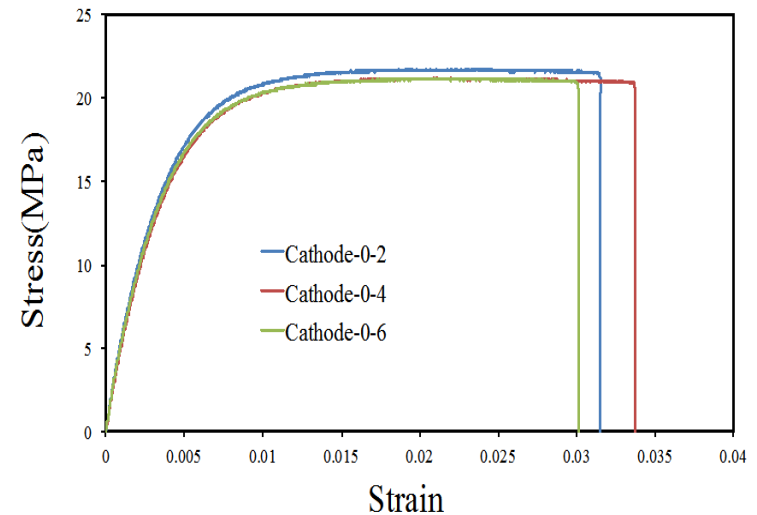
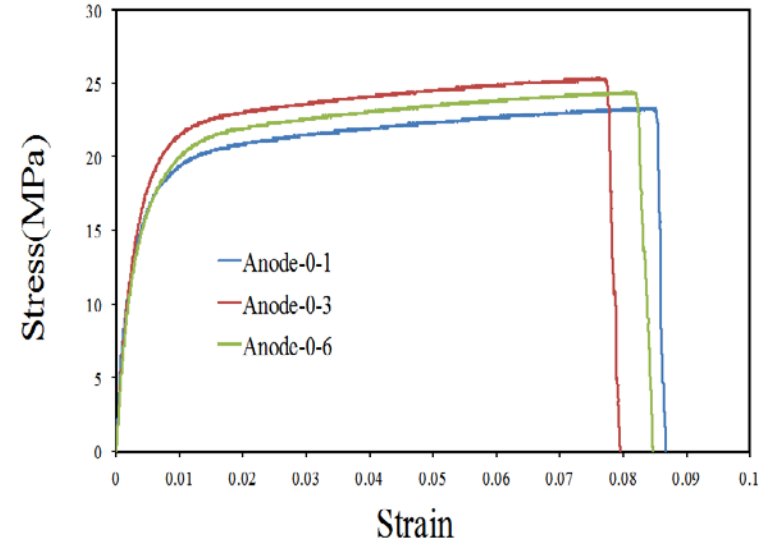
Active layer

Current collector

Active layer

Cross-section of anode  
(Pesaran et al. AMR 2015)

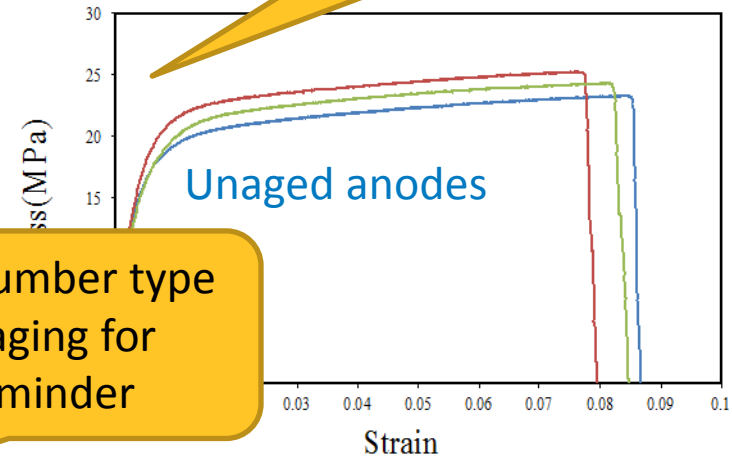
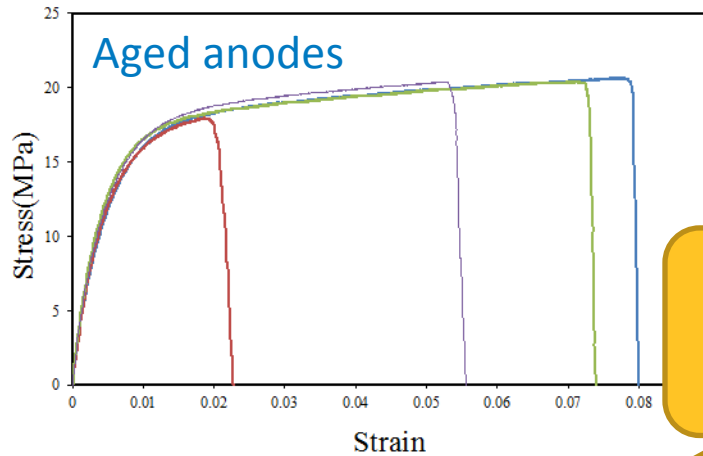
- Electrodes are composites of metallic foil (alumina or copper) and active material
- Active materials are porous composites
- Good bonding under uniaxial tensile load
- Brittle fracture behavior of active layers leading to earlier failure of current collector



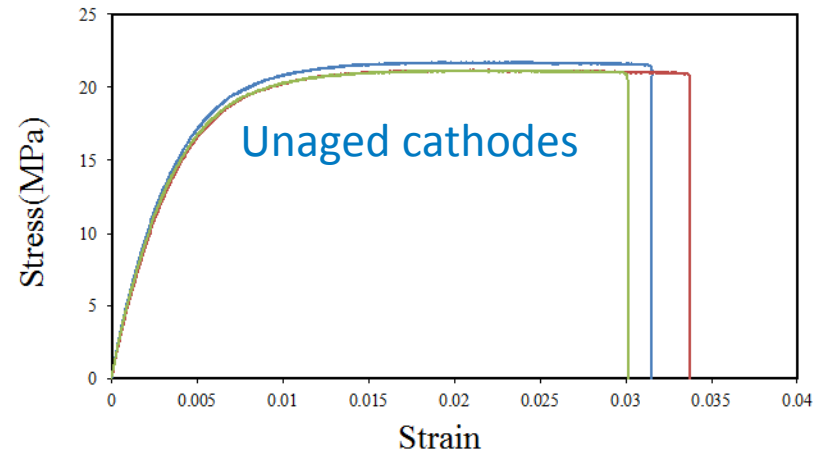
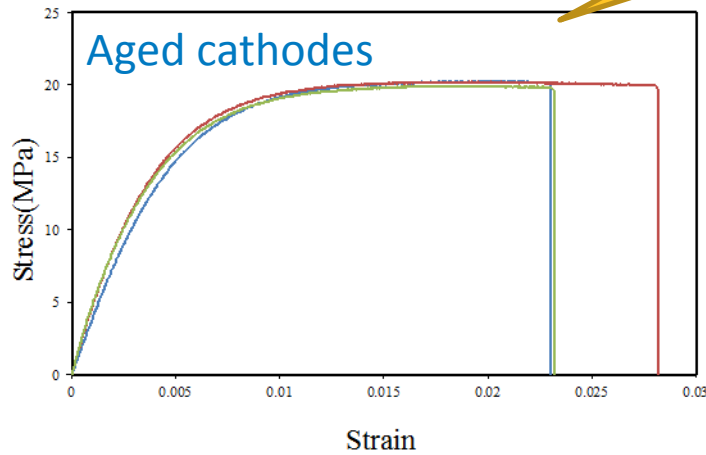
# Mechanical Property Changes of Battery

This scale should be 25 or others 30 for ease of comparison

## ❖ Aging Effect Stress-strain curves



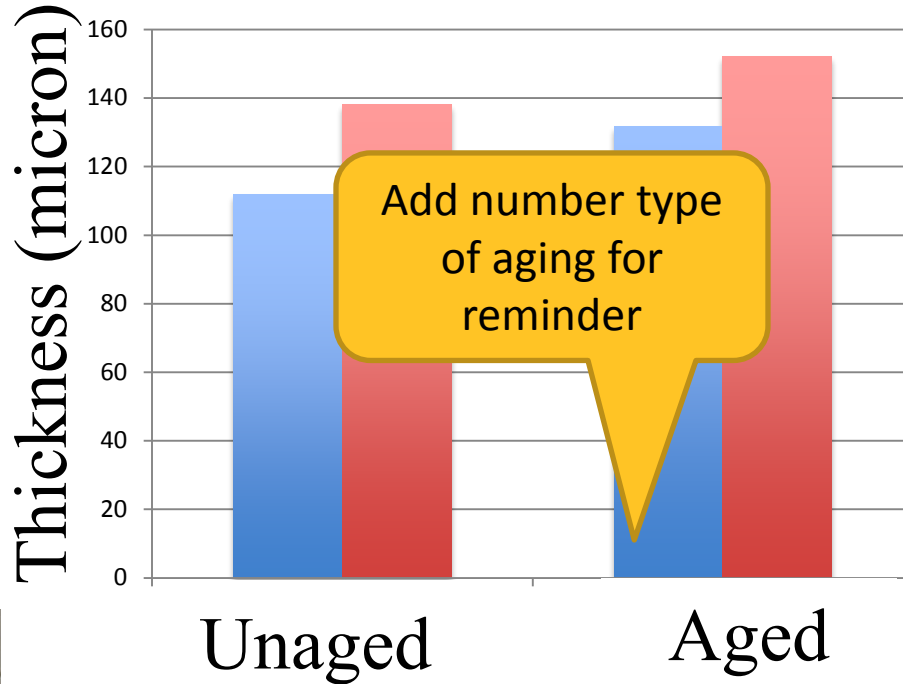
Add number type of aging for reminder



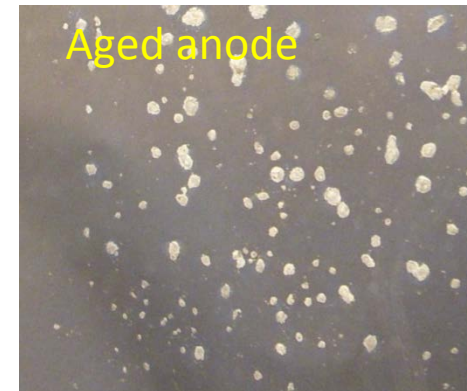
A relatively lower and significant variation of failure strain due to aging, indicates the presence of localized damages, for example, microcracking.

# Mechanical Property Changes of Battery Components (2)

## ❖ Aging Effect on Thickness

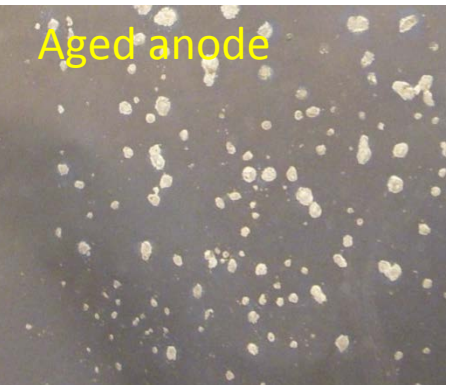
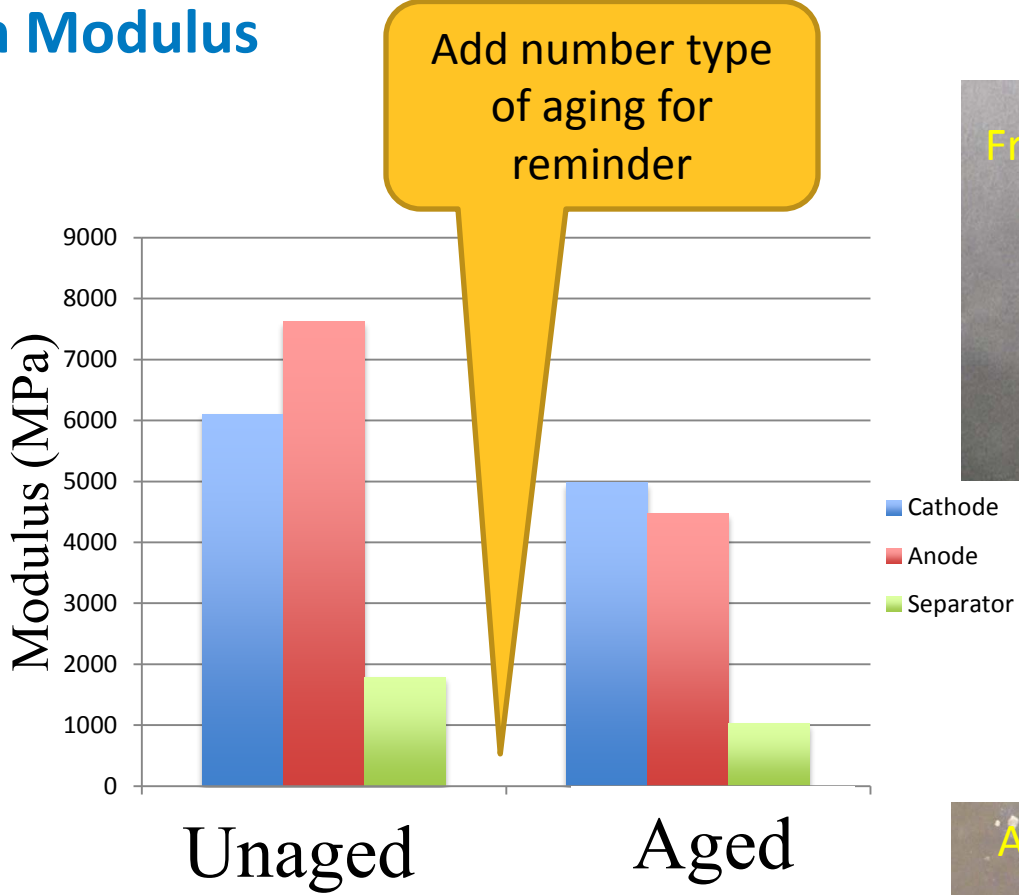


An increase of thickness for electrodes due to aging



# Mechanical Property Changes of Battery Components (3)

## ❖ Aging Effect on Modulus

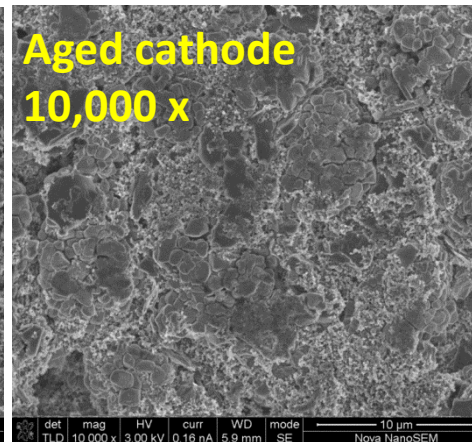
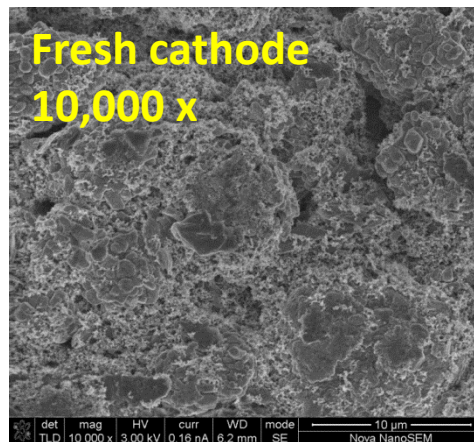
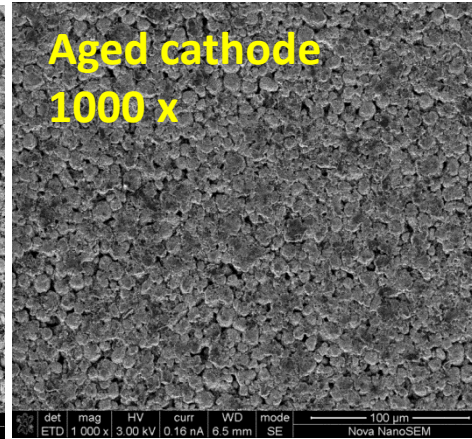
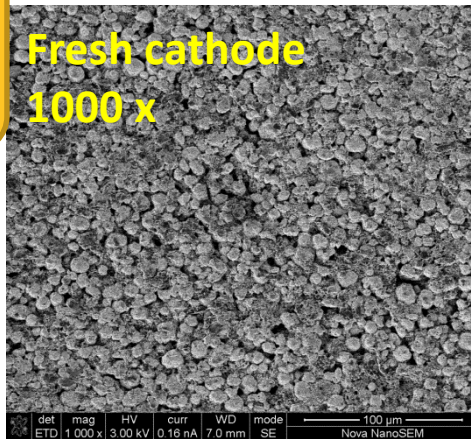


There is a decrease of tensile modulus due to aging, indicating the change of chemical composition or microstructure for electrodes and separator.

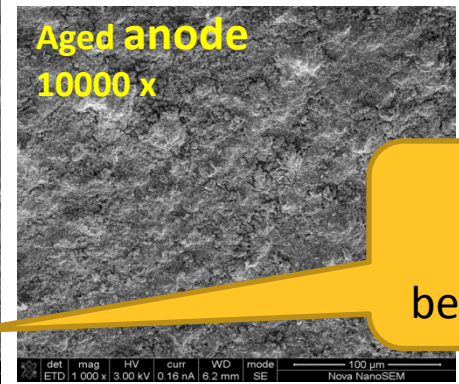
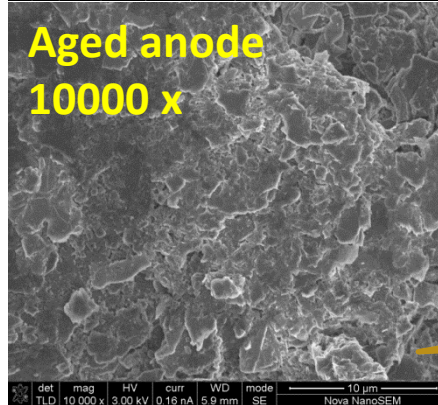
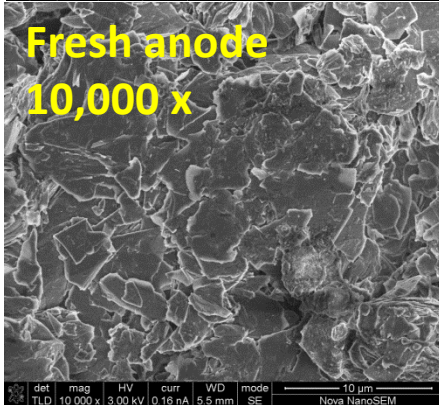
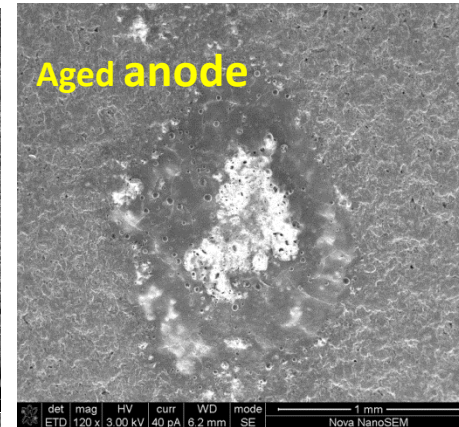
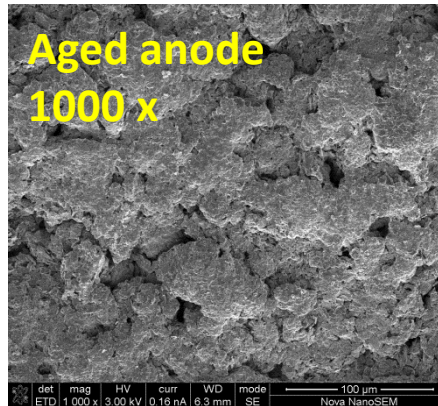
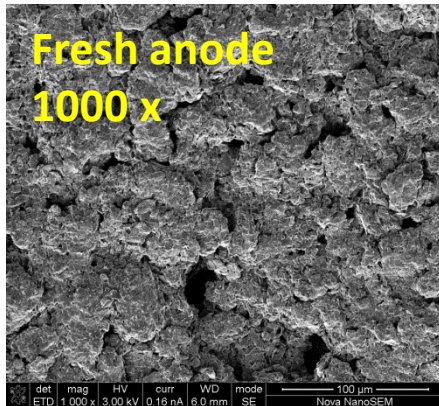


# SEM For Cathode

What is the actual scale?



# SEM For Anode Matrix

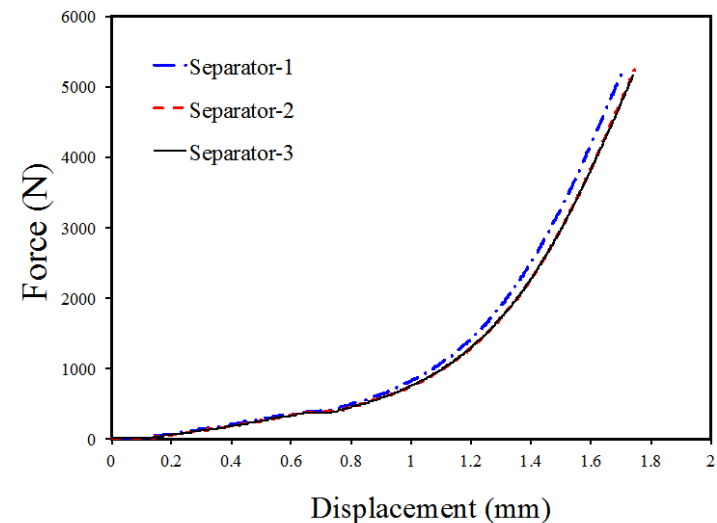
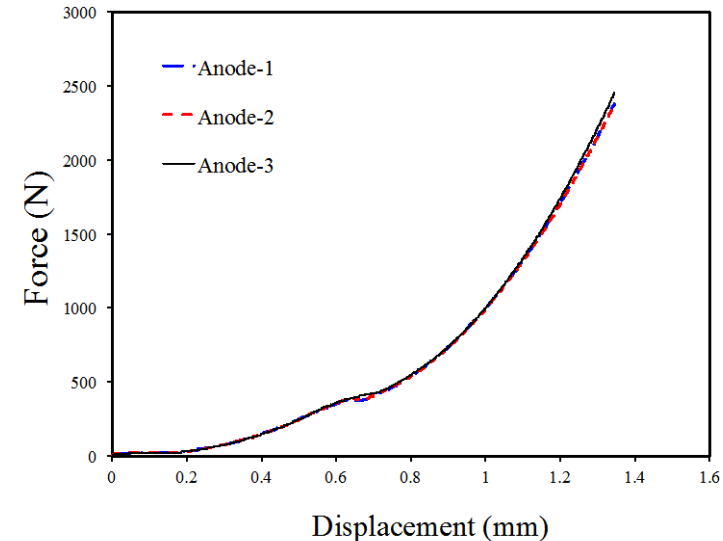


What is the difference between these 2?

# Constitutive Properties of Battery Components

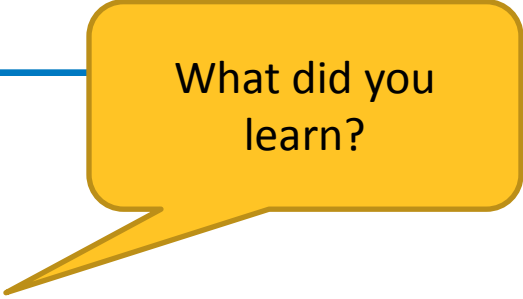
## ❖ Compressive properties of electrodes/separator

- A customized procedure is developed to measure the compressive properties of the thin porous layers.
- A piece-wised model is utilized to describe the through-thickness stress-strain responses for active materials and separator.



# Concluding Remarks.

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What did you learn?

- **What did you learn?**
- **What was the Effect of Aging on the Mechanical Properties of Li-Ion Cell Components/**

# Acknowledgements

## The NREL Team

Aron Saxon

Matt Keyser

Mitch Powell

Kandler Smith

## Funding

Brian Cunningham

Dave Howell



## Collaborations

