# 3D-Printed Electrochemical Cell for *In-Situ* Analysis

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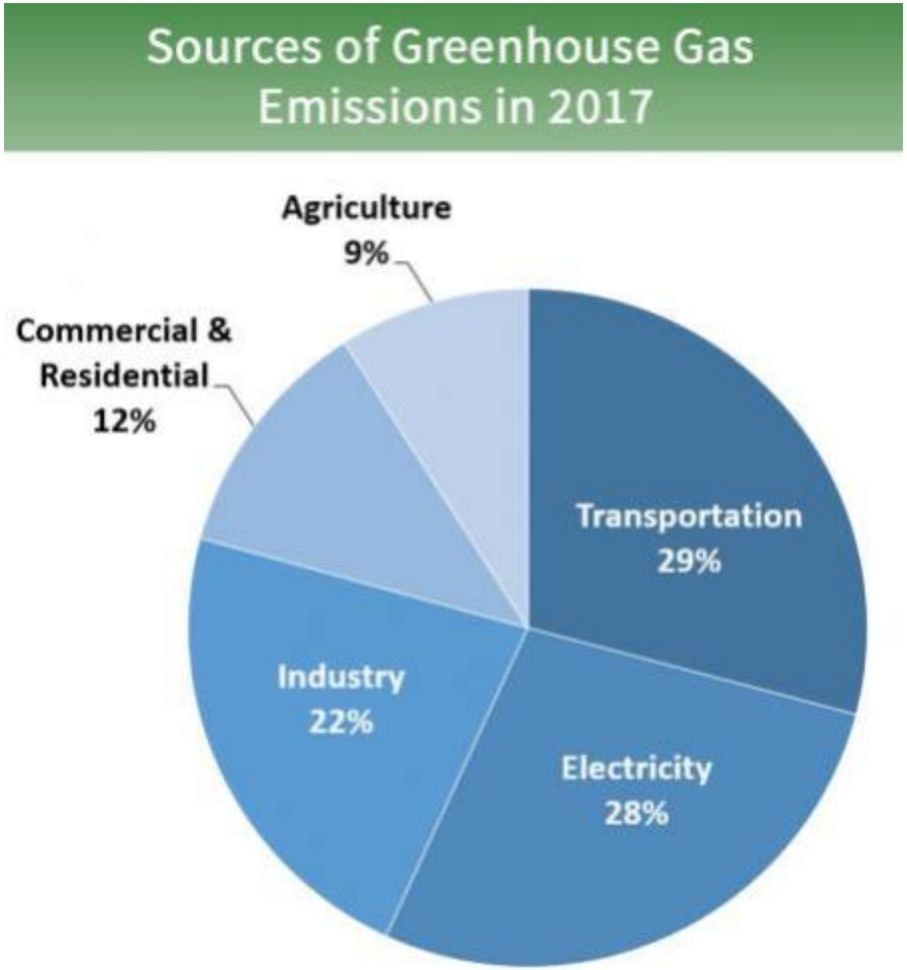
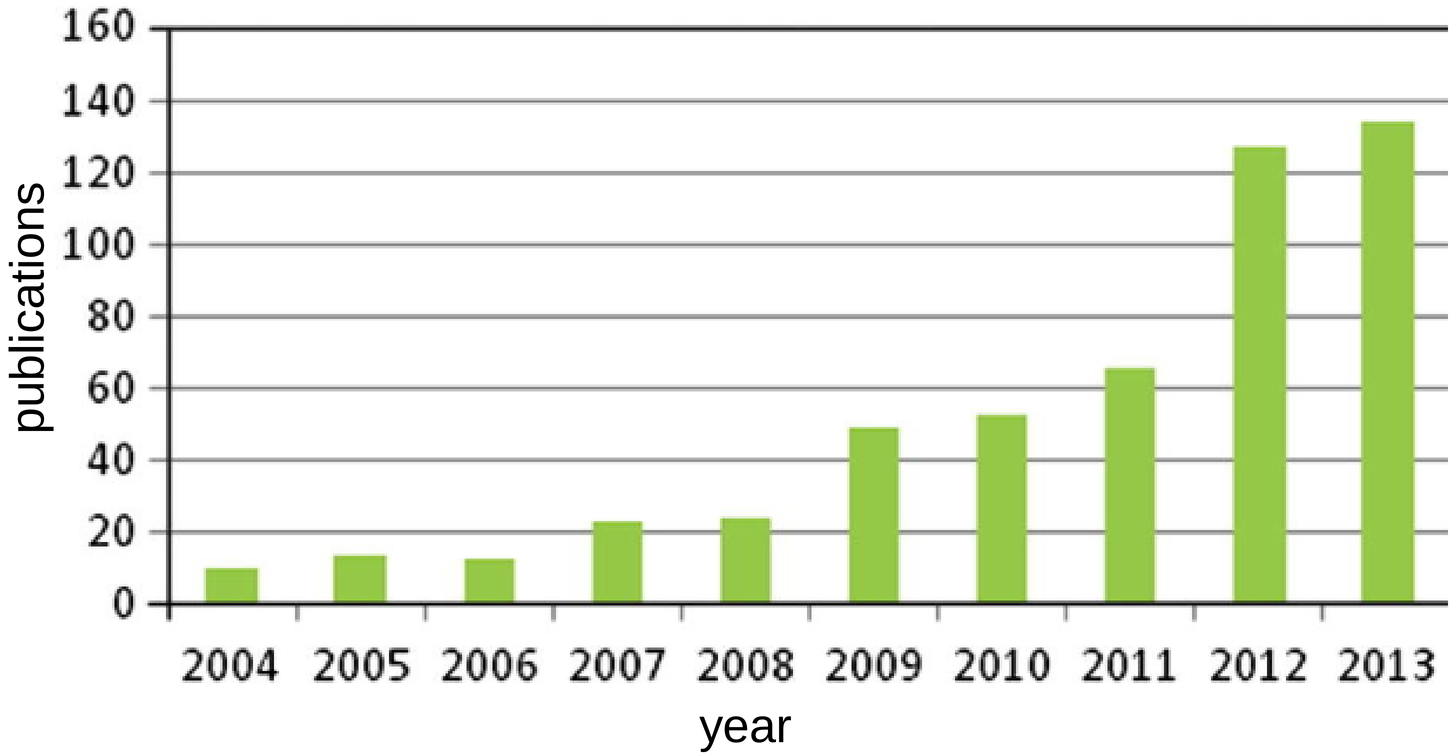
# Motivation

- Energy storage systems enable renewable energy technologies




Source: EPA

# Growth in Electrical Energy Storage Research




Source: Xing Luo, et al.

# Electrochemical Storage

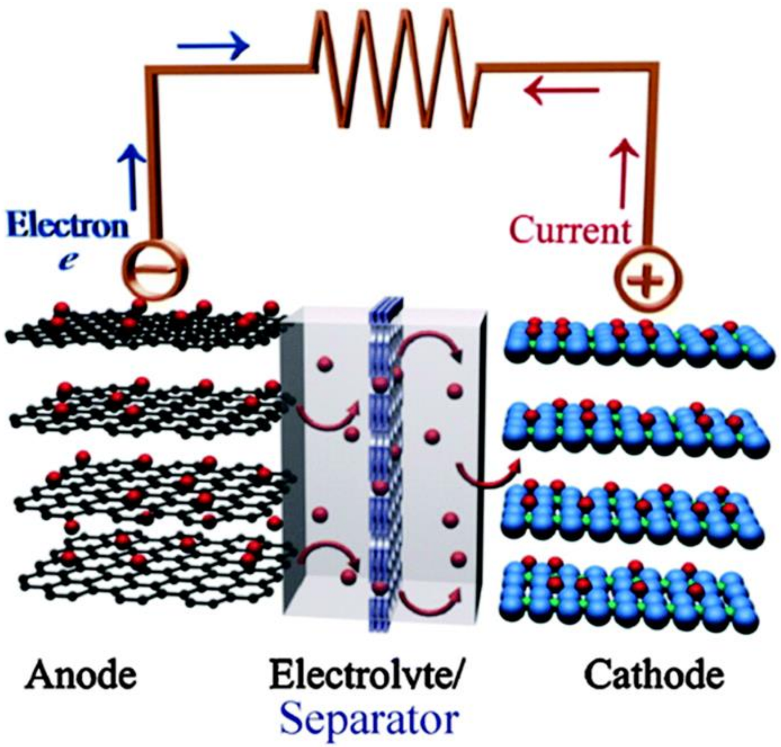
- High Efficiency
- Batteries

# Battery Stack

- Electrodes
- Electrolyte
- Separator

# *Ex Situ* vs *In Situ*

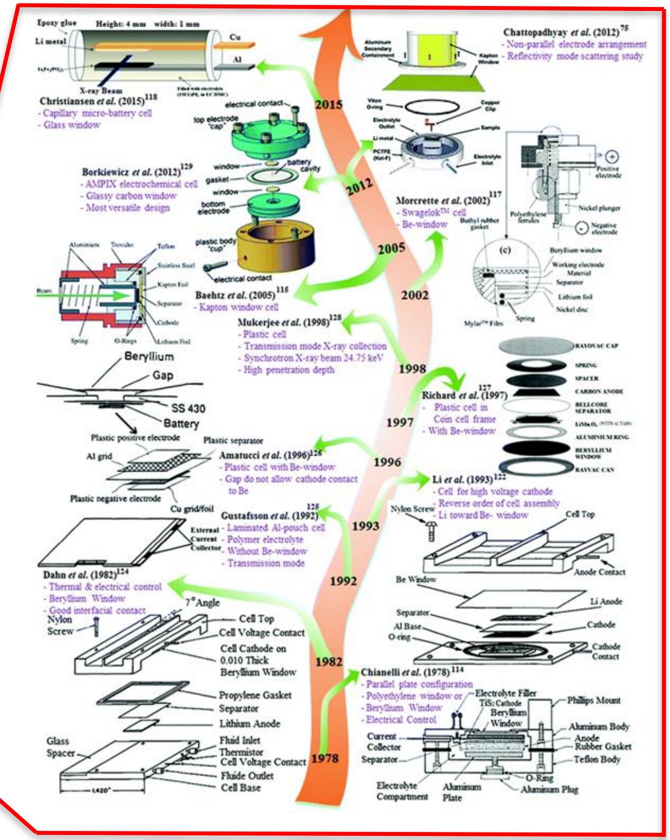
- Structural-Performance Relations
- Picture / Video Analogy




Source: Qu, et al.

# State of *In Situ* Cell Technology

| | *Ex Situ* Cells | *In Situ* Cells |
|---|---|---|
| Single Use | • Coin Cells<br>  • ~ $5 | • CR2016 Case<br>  • ~ $25<br>• Modified Coin Cells<br>  • Not Commercial |
| Reusable | • Swagelok Cell<br>  • ~ $200 | • MTI XRD Cell<br>  • ~ $2,000<br>• AMPIX<br>  • Not Commercial |




Source: Alok Tripathi, et al.

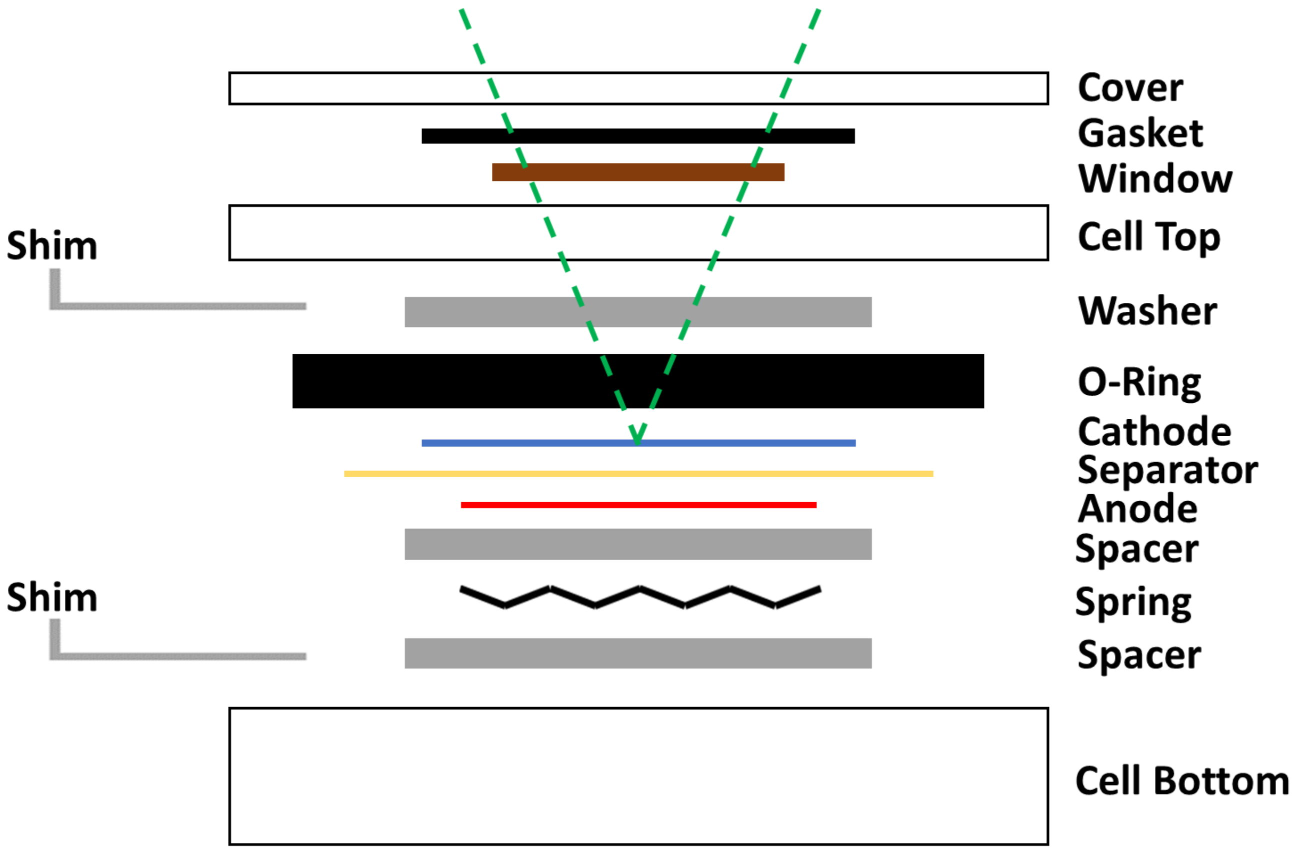
**Problem:** Lack of standardization among *in situ* cells can lead to different results between labs.

1. High cost of commercial cells
2. Detailed designs unavailable for non-commercial cells
3. Lack of quality control in non-commercial cells
4. **Different experiment conditions necessitate different cell designs**

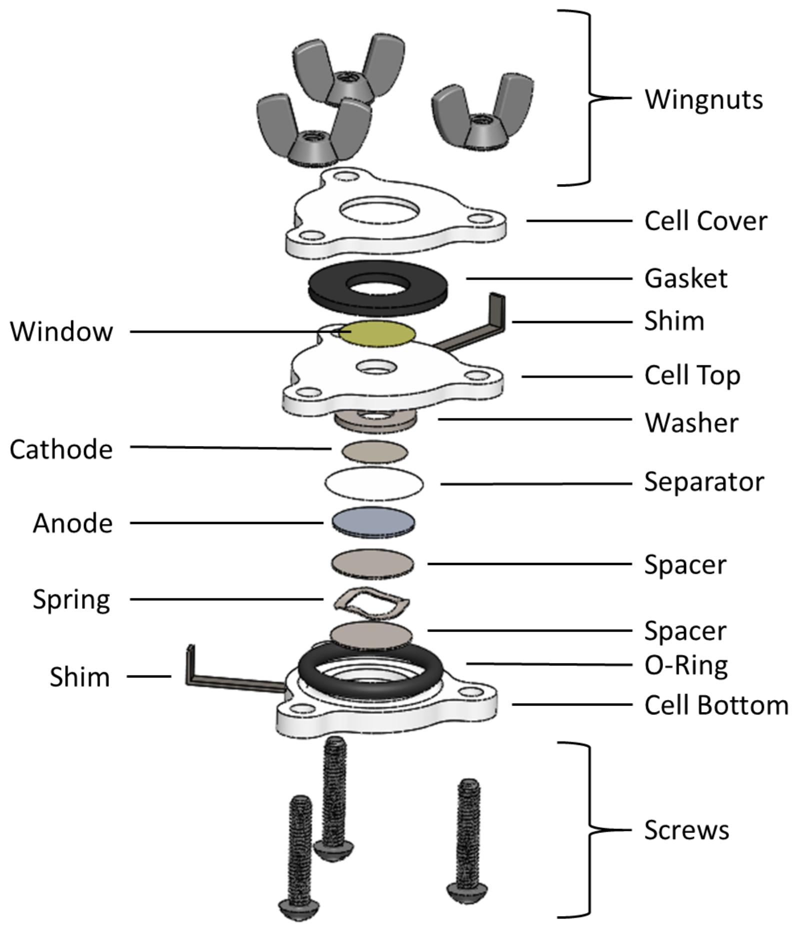
# **Solution:** *In situ* cell designs consisting solely of 3D-printed and commercial components.

- Long-Term Vision: online repository with cell designs for various experimental conditions
- Short-Term Goal: create proof-of-concept cell

# Cell Architecture



# CAD Model

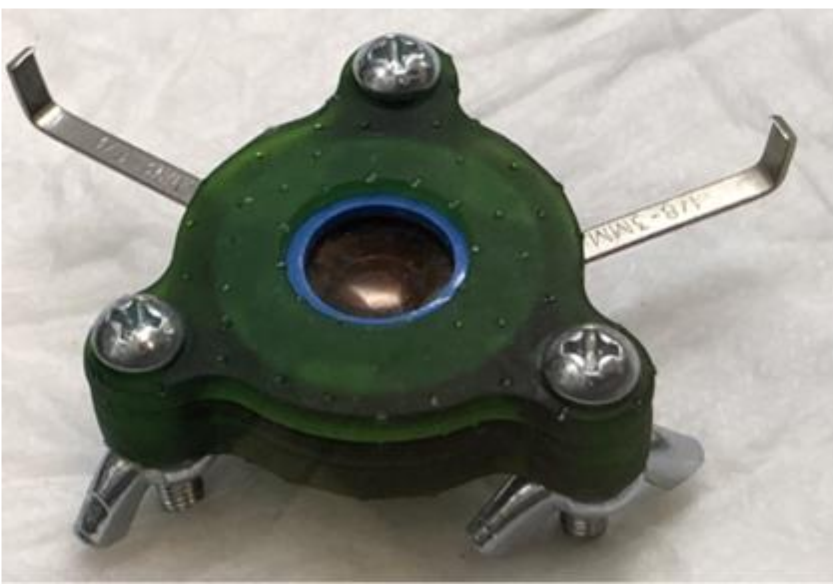

Wingnuts
Cell Cover
Gasket
Window
Shim
Cell Top
Washer
Cathode
Separator
Anode
Spacer
Spring
Spacer
Shim
O-Ring
Cell Bottom
Screws

# Cost Analysis

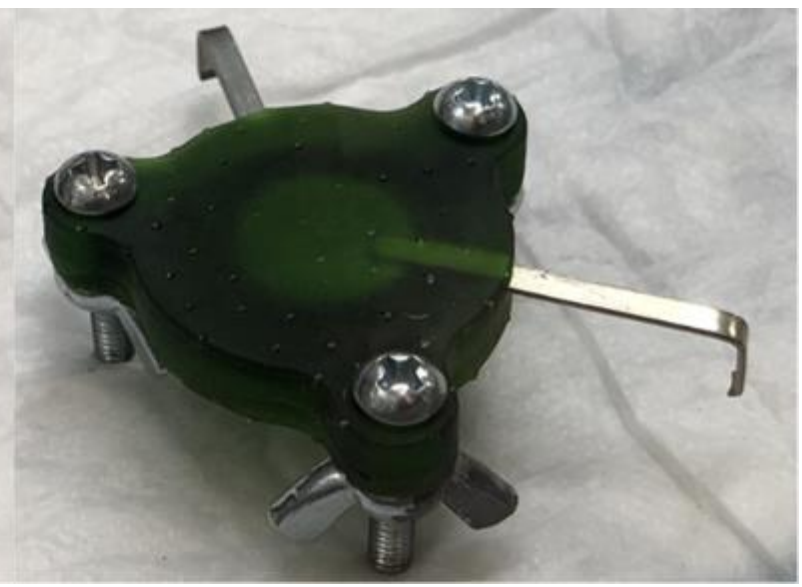
| Parts | Quantity | Cost Per Unit | Vendor |
|---|---|---|---|
| Springs | 1 | $ 0.60 | MTI |
| Spacers | 2 | $ 0.49 | MTI |
| Washers | 1 | $ 0.08 | McMaster |
| Bolts | 3 | $ 0.03 | Grainger |
| Wing Nuts | 3 | $ 0.09 | McMaster |
| Shims | 2 | $ 4.49 | McMaster |
| O-rings | 1 | $ 0.06 | Grainger |
| Gasket | 1 | $ 2.13 | McMaster |
| Bottom | 1 | $ 0.18 | 3D-Printed |
| Cover | 1 | $ 0.10 | 3D-Printed |
| Top | 1 | $ 0.13 | 3D-Printed |
| Window | 1 | $ 0.22 | Grainger |
| **Total:** | | **$ 13.82** | |

# Assemblies

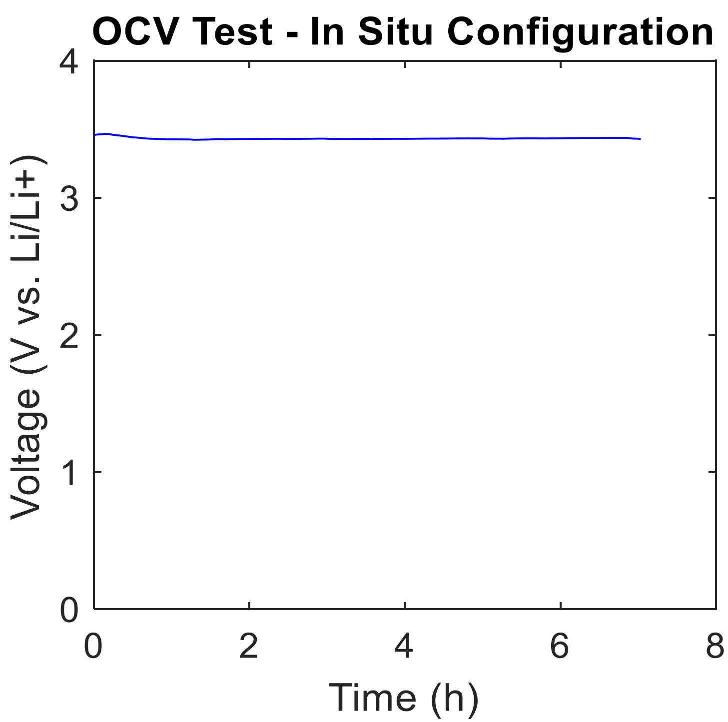
*In Situ* Configuration

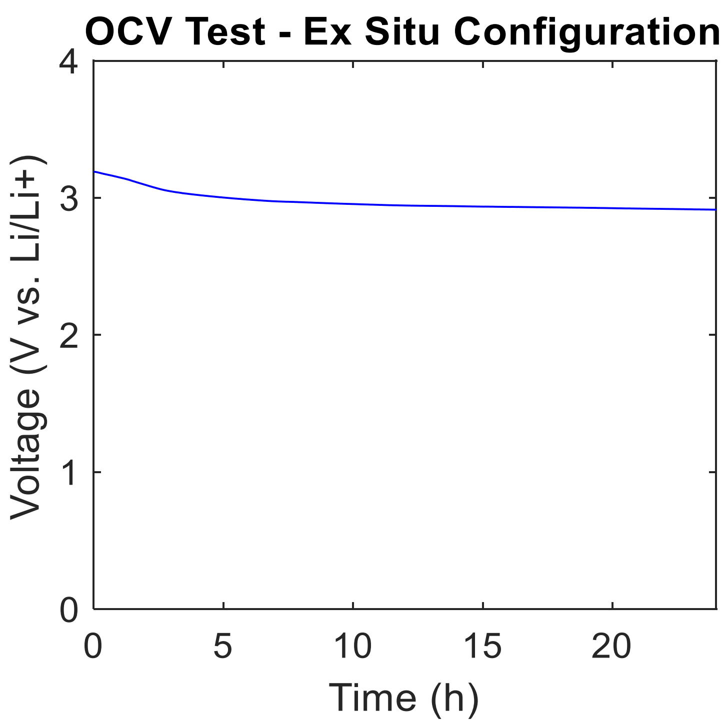


*Ex Situ* Configuration

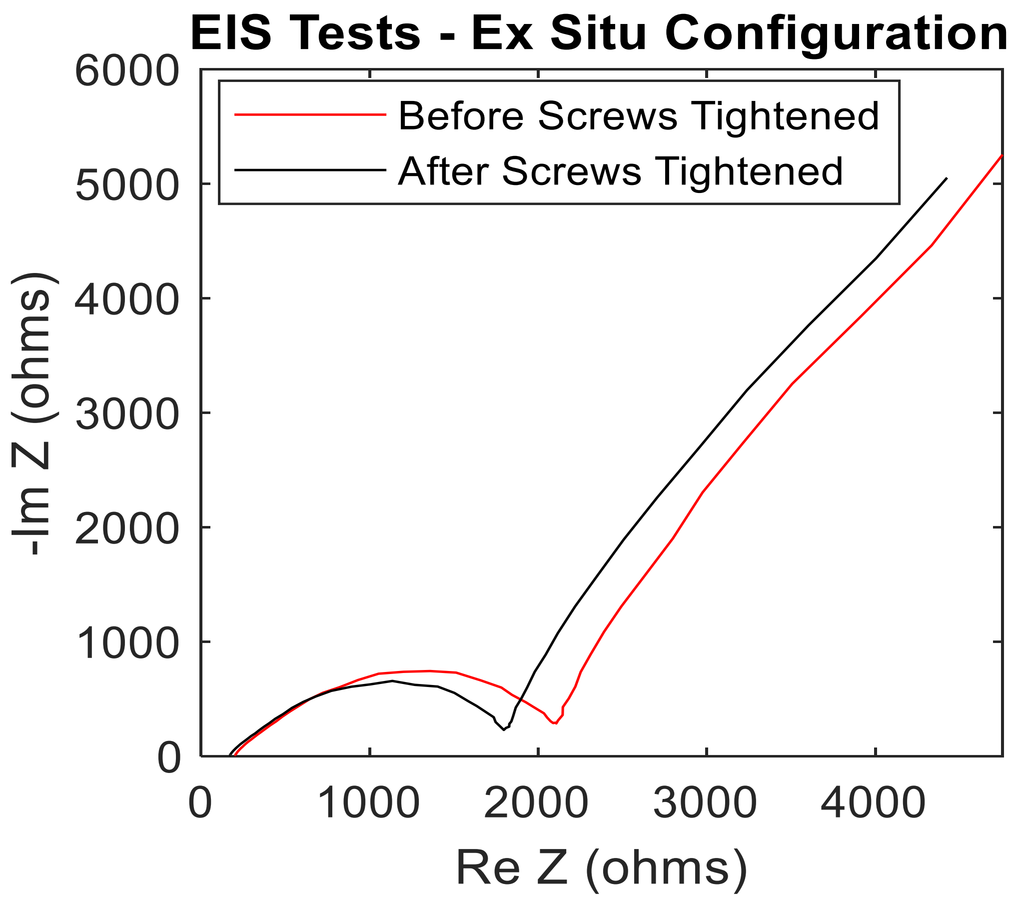


# Open Circuit Voltage (OCV)



# Electrochemical Impedance Spectroscopy (EIS)



# Test Analysis

- OCV Tests
  - *In Situ* Configuration: 0.86% percent loss over 7 hours
  - *Ex Situ* Configuration: 8.53% percent loss over 24 hours

- EIS Tests
  - Before Screws Tightened: ~2,100 ohms of interfacial resistance
  - After Screws Tightened: ~1,800 ohms of interfacial resistance

# Conclusions

- Low relative cost of cell
- Cell able to effectively hold open circuit voltage over extended period
- High interfacial resistance
  - Reduced by increasing pressure on cell
- Overall, cell shows potential to be first of “standardized” set of *in situ* cells
  - Next, the cell should be cycled to further test performance

# Acknowledgements

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