



# The Challenge of Supporting the Li Cell Market with Domestic Materials and Equipment Suppliers

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# The US Battery Market: *The Two Markets*

## Non-EV

Aviation



Marine



Solar Sailor. Source: Wikimedia Commons.

Energy Storage



Industrial



<https://www.toyotaforklift.com/blog/lithium-ion-forklift-battery-solution-for-operational-efficiency>

Defense



<http://www.dia.mil/>

Space



<https://www.aia-aerospace.org/>

Heavy/ Medium Duty Trucks



<https://www.paccar.com/news/current-news/2020/kanworth-and-peterbilt-zero-emissions-trucks-summit-14-115-foot-pikes-peak/>

Consumer Electronics



<https://www.barrettdistribution.com/consumer-electronics-fulfillment>

Medical



<https://www.medicaldevice-network.com/sponsored/medical-device-in-depth-product-overview-pacemaker-leads/>

Power Tools



<https://www.dewalt.com/>

## Electric Vehicles (EV)

Light Duty Trucks



<https://rivian.com/configurator/r1t>

Cars



<https://www.tesla.com/models>

**EV Batteries = Few Battery Types, Huge Volume**  
**Non-EV Batteries = 1000s of Battery Types and Low Volume for Each Application**  
**Materials/Equipment Consortium to Strengthen Non-EV Buying Power?**

# The US Battery Market: *Market Growth*

## 2022 US Cell Production

## 2030 US Cell Production

Non-EV\*\*

~4 GWh/yr



**CAGR > 10%**

>9 GWh/yr



\*\*Note: Does not include trucks(10GWh needed by 2030)

EV

~53 GWh/yr



**CAGR > 32%**

>479 GWh/yr



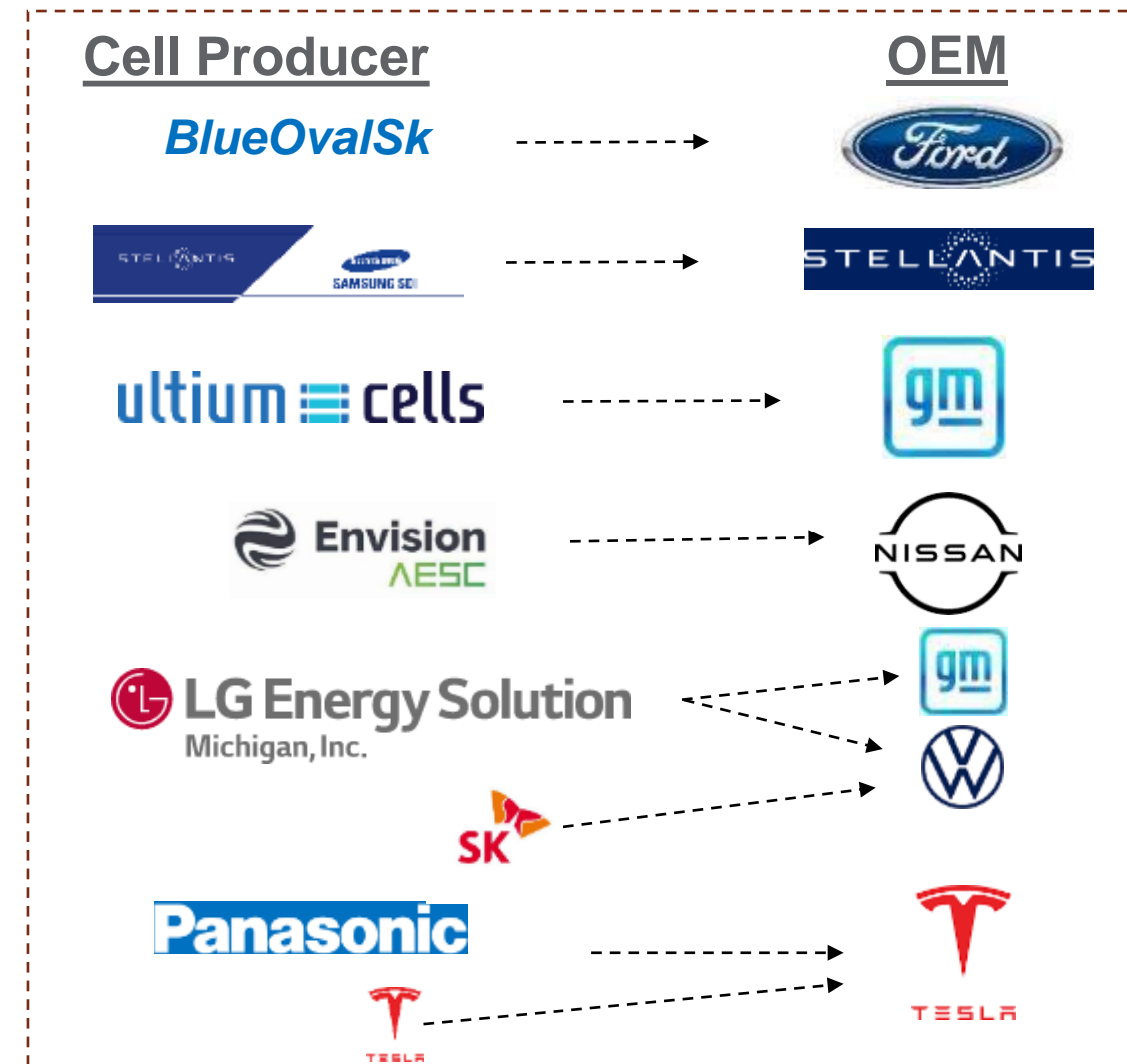


# The US Battery Market: *US Cell and OEM Landscape*

## Non-EV + Startup Cell Producers



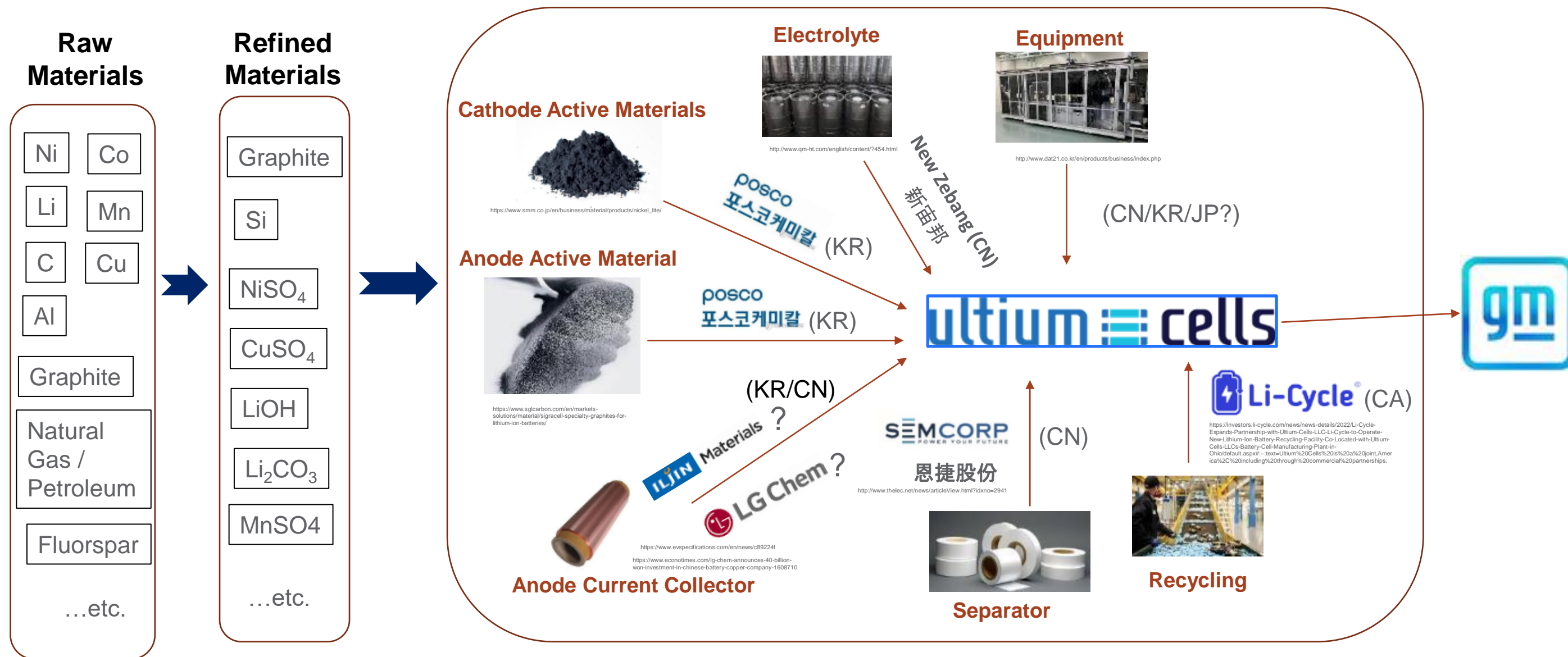
## Electric Vehicles (Cell/OEM)



US Cell Producers Mainly Play in Non-EV Market  
Asian Cell Providers Creating JVs with US OEMs  
***Buying Power for Materials & Equipment is in EV Cell Producers***

# The US Battery Market: *UltiumCells* Supply Chain Setup

## Suppliers to Cell Manufacturing



Materials Supply for Batteries will Mainly be Locked up by EV Cell Producers  
**Challenge for Non-EV is Not Only US Supply but Supply from Anywhere**





# Material Industry Challenges & Needs?



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# Industry Overview & Interviews: *Materials & Equipment*

## Anode

### Silicon:



### Lithium Metal:



### Graphite:



### Binder (CMC/SBR):



### Additives:

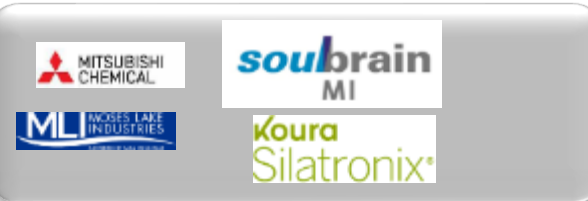


### Cu Foil:



## Electrolyte / Separator

### Blenders:



### Solvents:



### Additives:



### Salts:



### Separator:



### Solid State Electrolyte:



## Cathode

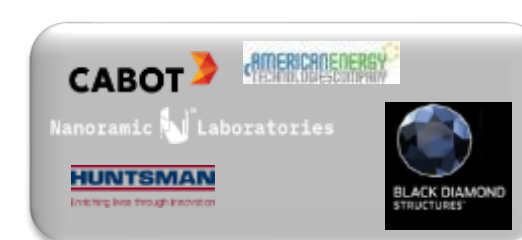
### Active Material:



### Binder (PVDF/Other):



### Additives:

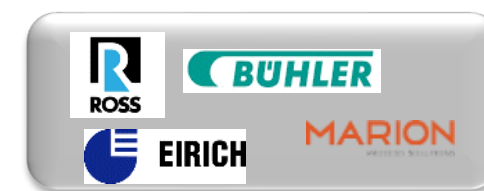


### Al Foil:



## Equipment / Software

### Mixers:



### Coating/Calendaring/Slitting/Drying:



### Metrology



### Solvent Recovery:



### Software/Controls:



### Assembly / Testing:



## Recycling



Conducted > 100 Interviews of US Companies  
***Materials / Equipment Issues = Current Production Capacity too Small for Market***

# Material Industry Needs?: *Challenges / Needs*

## Industry Challenges

### Market Entry

- Capital Investment
- Offtake Agreements
- Competitive Pricing (Commodities)
- Product Lifetime?
- Demand Timeline

### Production Ramp / Qualification

- Equipment Lead Times
- Long Complicated Permitting
- People!
- Long Qualification Times / Support

### Production

- Unfair Foreign Competition
- Raw Material Supply/Cost

## Industry Needs

*Long Term Contracts  
with Initial Ramped Offtake Agreements*

*Expedited / Consolidated Permitting*

*Workforce Development Programs*

*3<sup>rd</sup> Party Material Qualification Support*

*“Cheap” Capital for Production Ramp*

*Level Playing Field with Foreign  
Competition (Labor, Environ., CO<sub>2</sub>)*





# Utilize Semi/Pharma Specialty Materials?

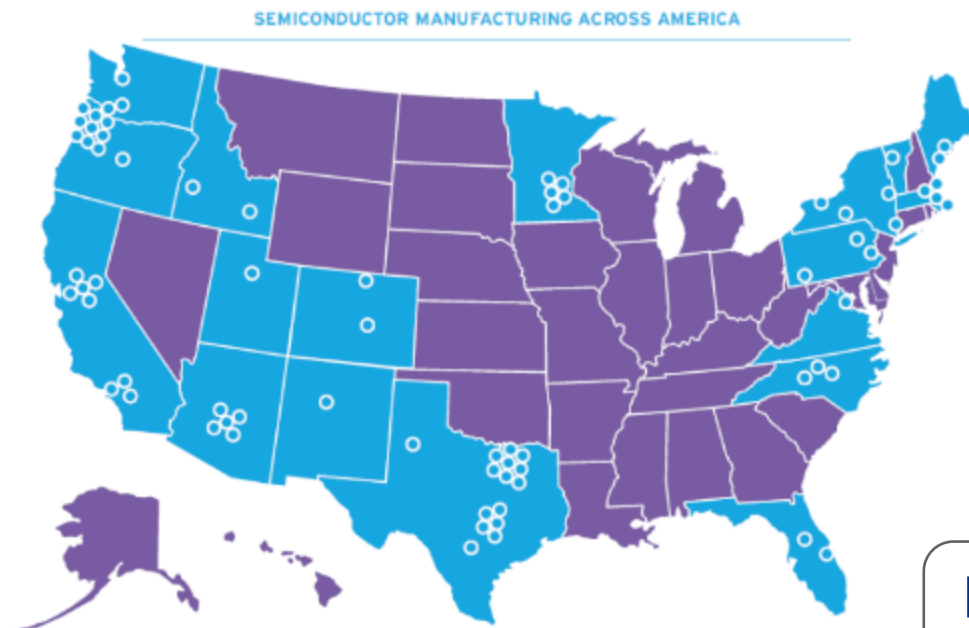
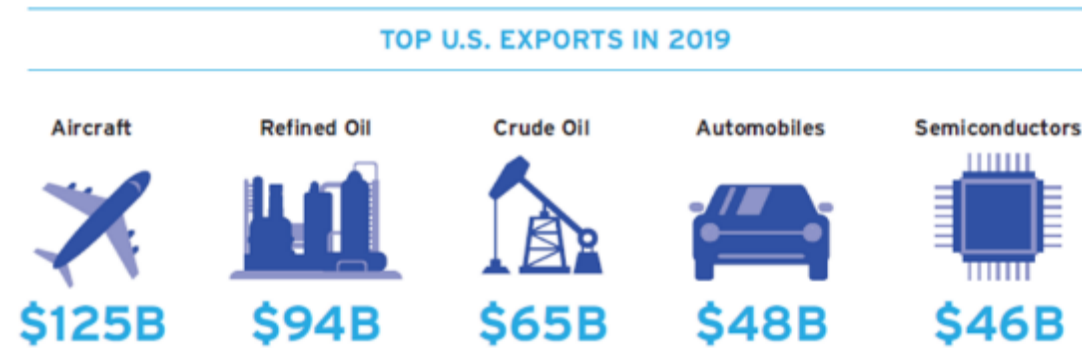


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# Utilize Pharma/Semi Industry: *Large Complimentary Markets*

## US Semiconductor Market



2020 STATE OF THE U.S. SEMICONDUCTOR INDUSTRY

## US Pharmaceutical Market

U.S. TOP 10 PHARMACEUTICAL COMPANIES BY U.S. MARKET TURNOVER IN FY 2018

RANKING	COMPANY	2018 U.S. PHARMA REVENUE (IN USD BILLION)	2018 U.S. PHARMA REVENUE GROWTH COMPARED TO 2017 (IN %)
1.	Pfizer	25.32	-2.75
2.	Johnson & Johnson	23.28	+8.43
3.	Roche	22.76	+13.35
4.	abbvie	21.52	+17.9
5.	AMGEN	18.28	+1.27
6.	NOVARTIS	17.56	+3.69
7.	MERCK	16.60	+4.76
8.	GILEAD	16.20	-10.56
9.	SANOFI	13.15	-2.66
10.	Bristol-Myers Squibb	12.58	+11.0

<https://www.marketresearchreports.com/blog/2019/03/11/us-top-10-pharmaceutical-companies-market-turnover>

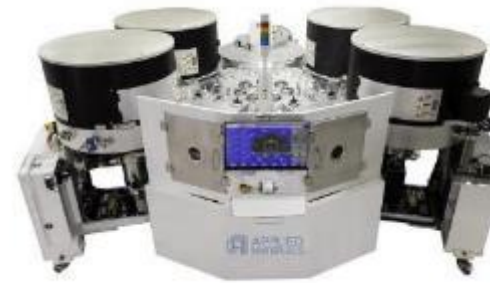
Non-EV Materials & Equipment Support from Specialty Semi & Pharma Materials Suppliers = **Opportunity**



# Utilize Pharma/Semi Industry : *Adjacent Company Example*



Semiconductor Tools



SEMI

Battery Coating Tools



Batt

<https://www.appliedmaterials.com/products/axcela-pvd>





# How Does PNNL Help?



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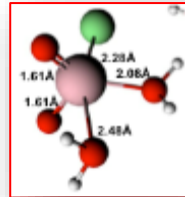


# PNNL Industry Support: *Grid Storage Launchpad*



# PNNL Industry Support: *Energy Storage Capabilities*

## Stationary



**Materials Research**  
V<sup>5+</sup> in mixed acids --  
VO<sub>2</sub>Cl(H<sub>2</sub>O)<sub>2</sub>

**Lab Prototype**  
Flow Battery



## Deployment



3MWh  
RFB

## Analysis



WA CEF I  
15 MWh

## Transportation



**Materials Research**  
Li-ion cathode



**Lab Prototype**  
1 Ah Li-S Cell

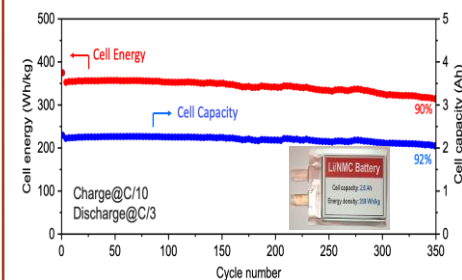
## Advanced Battery Facility



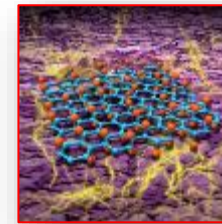
1-2 Ah Cell  
Chemistries

## Analysis

Utilization of EV Storage to Balance Wind



## Special Applications



**Materials Research**  
Fluorinated  
Graphene anode

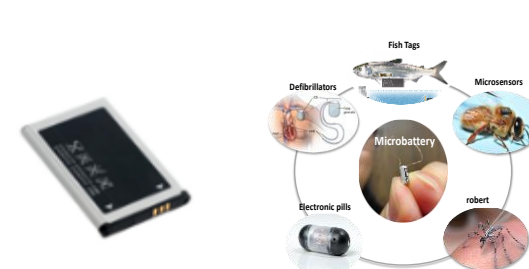


**Lab Prototype**  
Micro fish tag  
battery

## Deployment



## Consumer electronics



## Advanced Capabilities



Computational and data modeling



High throughput testing

## Interface Study



PFIB/SEM

## Cell diagnosis



Micro-CT