UISEC: US Israel Solid Energy Center

The Energy Storage Consortium of the BIRD Energy Center

Project title: Lithium and Sodium Metal Solid State Batteries for Advanced Energy Storage Applications

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Advanced batteries are and will be enabling for numerous applications

Defense: US soldiers carry >20 lbs of batteries for a 72h mission

Transportation: Passenger vehicles (of increasing size); cargo and shipping; aviation

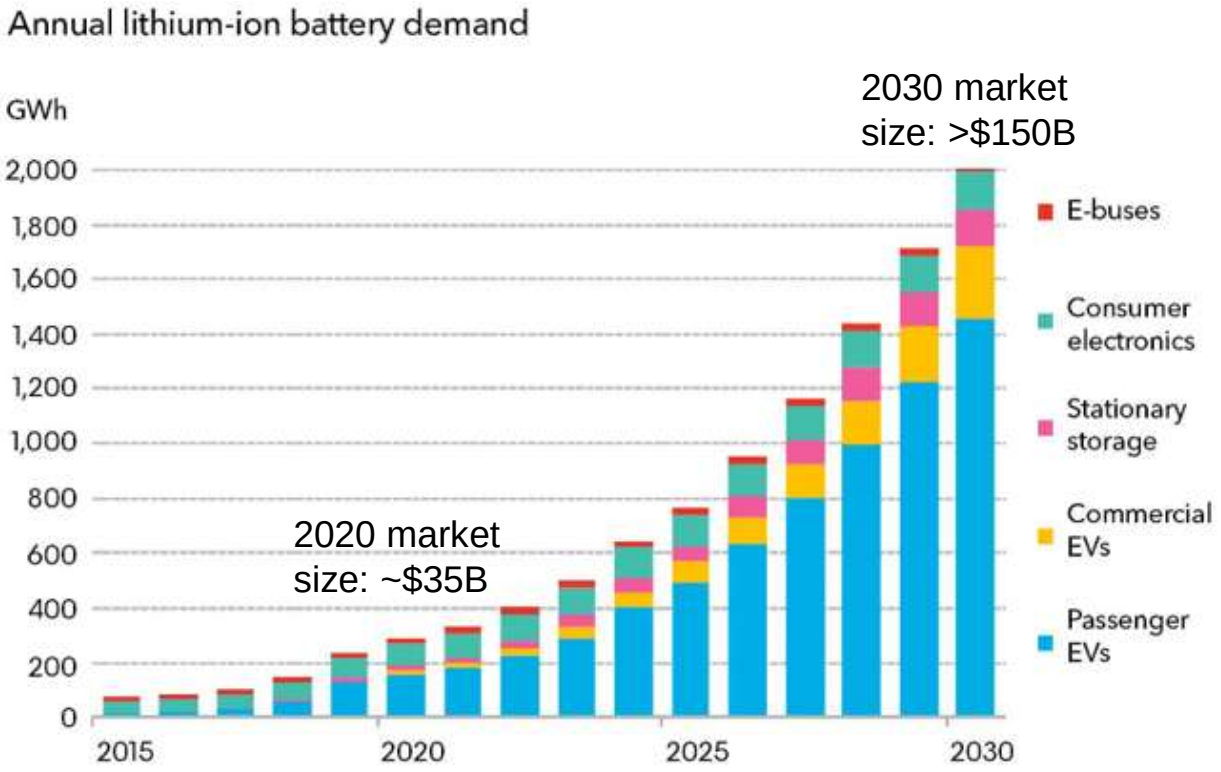
Aerospace: Satellites and other space applications.

Grid: More low cost, low emission wind and solar enabled by battery storage, as well as other grid applications.

http://www.tadiranbat.com/

Various sources.

The Li-ion battery market is growing rapidly, but gaps are present



Despite the rapid growth in Li-ion, across a range of applications there are gaps in:

1) Energy density (i.e., reduce the size and weight for a given amount of energy stored).
2) Safety at the battery cell level (which gets harder as energy density rises).
3) Cost (especially for EVs and grid).

Battery improvements could also enable entirely new applications, such as passenger electric aviation, long-haul trucking, and new functions in aerospace, defense, medical, and other industries.

https://seekingalpha.com/article/4289626-look-top-5-lithium-ion-battery-manufacturers-in-2019

Introduction: the outside and inside of a battery

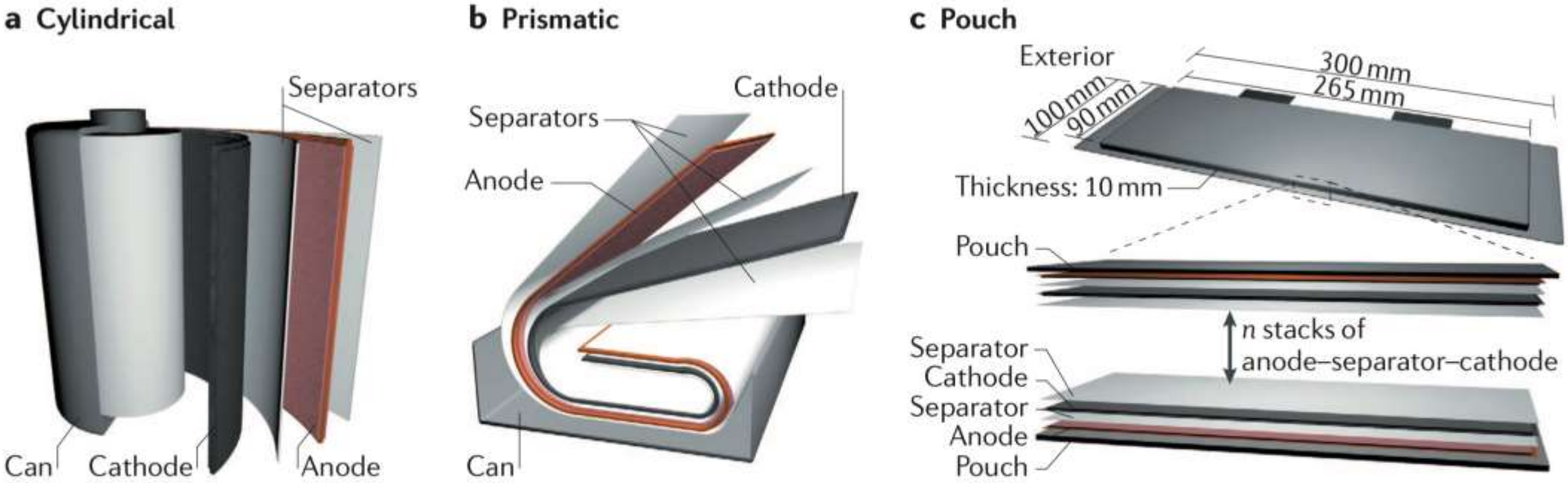


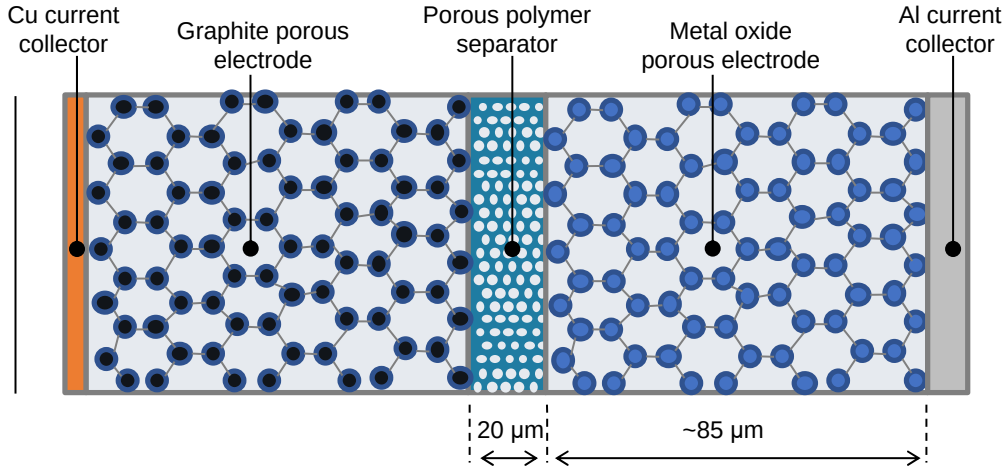
Figure 1 | **Three representative commercial cell structures. a** | Cylindrical-type cell. **b** | Prismatic-type cell. **c** | Pouch-type cell. The pouch dimensions are denoted, along with the internal configuration for *n* anode–separator–cathode stacks. Images are based on cells provided by SK Innovation.

Choi and Aurbach, *Nature Reviews Materials* **volume 1**, Article number: 16013 (2016)

Solid state: our approach to the “big three” of energy, cost, and safety

Li-ion with liquid electrolyte

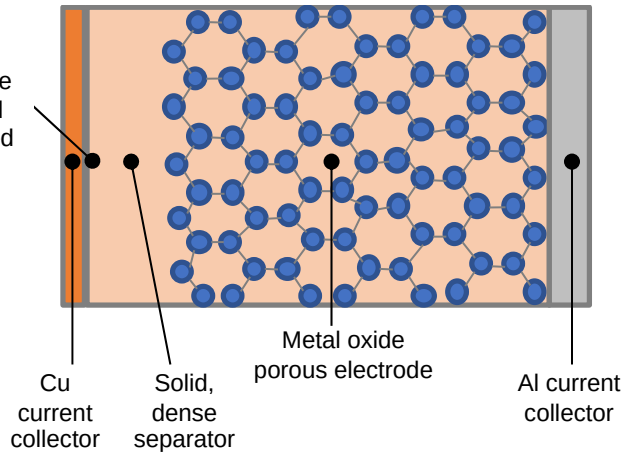
Cell structure and energy content*
~325 Wh/kg
~900 Wh/L



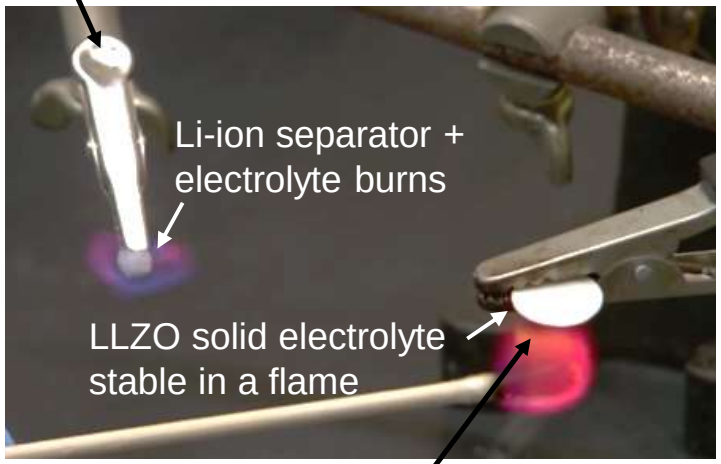
Li metal with solid electrolyte

Cell structure and energy content*
>500 Wh/kg
>1500 Wh/L

Li metal electrode plated on the first charge so it is *not* needed when the cell is built discharged



Current Li-ion technology with liquid electrolytes**



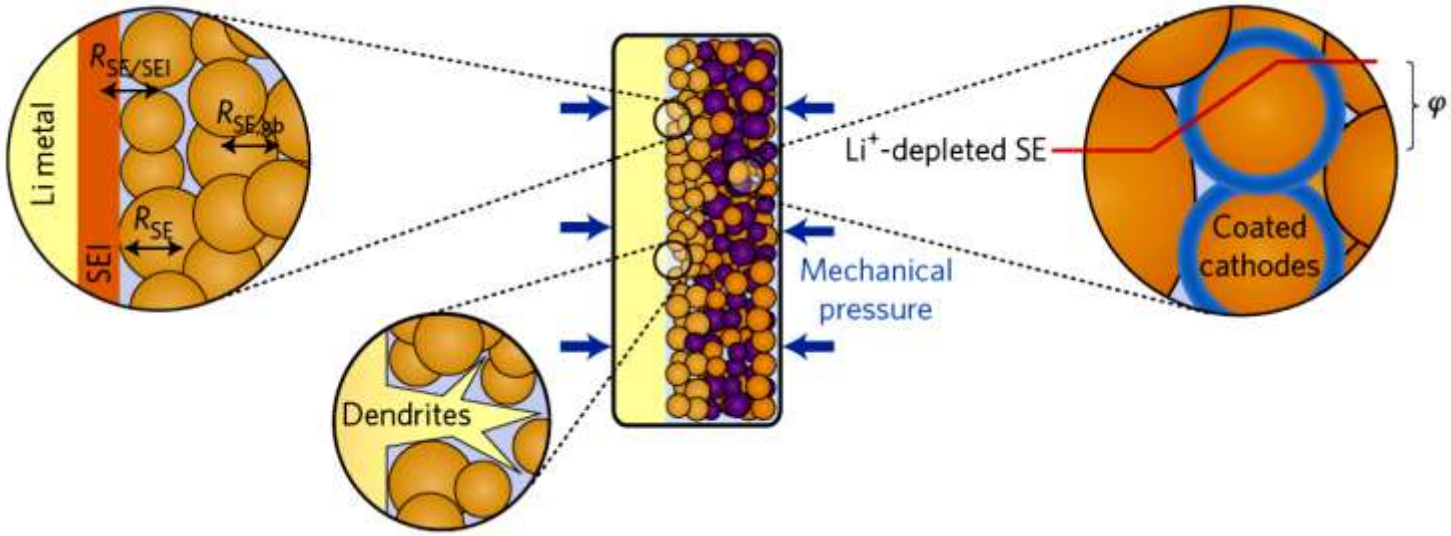
Solid electrolyte technology

Achieving the “big three” with solid state

- Increase energy density: enable Li metal.
- Improve safety: with solid electrolytes.
- Reduce cost: with higher energy density.

* At the level of the cell stack. Solid state cell shown in the discharged state for a Li metal electrode. Loading for both cells is ~4.5 mAh/cm^2. **Image from University of Maryland test.

Our tasks address the principal challenges for solid state batteries



Interfacial resistance → Task 1

Solid-state electrolyte materials → Task 2

High-energy cathode materials → Task 2

Rechargeable metallic anodes → Task 3

→ Task 4: Integration in a full cell

Janek and Zeier, *Nature Energy* **volume 1**, Article number: 16141 (2016)

Our team is built with leading university and company groups

Israeli Consortium Members

Bar-Ilan University אוניברסיטת בר-אילן

Aurbach, Noked, Zitoun: battery chemistry, coatings, and cells.

TEL AVIV UNIVERSITY אוניברסיטת תל אביב

Peled, Golodnitsky: battery interfaces and materials.

3DB

Start-up battery cell development company.

MaterialsZone

BIU spin out materials informatics company.

US Consortium Members

UNIVERSITY OF MARYLAND 18 56

Albertus, Lee, Wachsman, Rubloff: thin film batteries, coatings, modeling, solid electrolytes, battery chemistry, and cells.

FORGE NANO

Start-up focused on industrial-scale atomic layer deposition.

ion Storage Systems

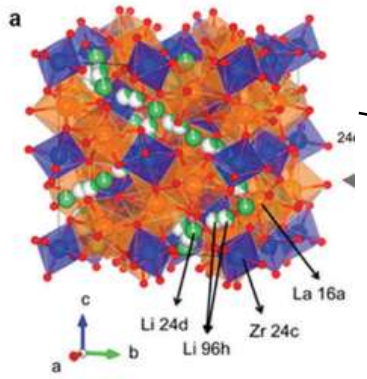
UMD spin out (Wachsman group) focused on solid state battery cell commercialization.

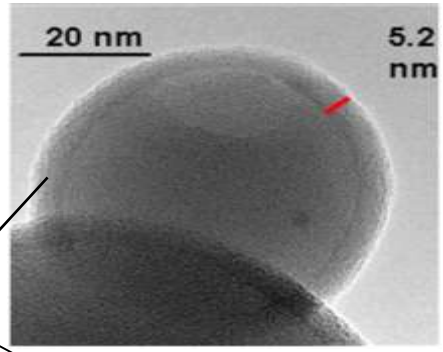
saft

Leading battery manufacturer for defense and aerospace industries.

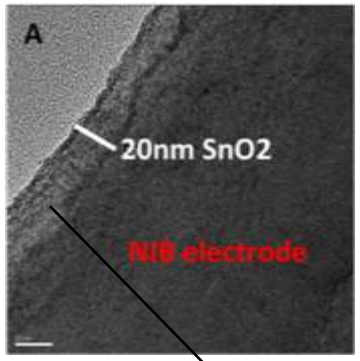
UISEC CMs bring the building blocks to address the challenges

BIU, UMD, ISS, MZ: Li⁺- or Na⁺-conducting, coated solid electrolyte particle to improve stability, transport.

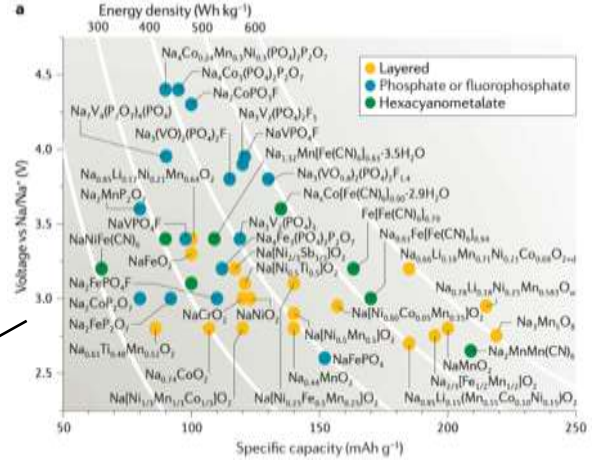




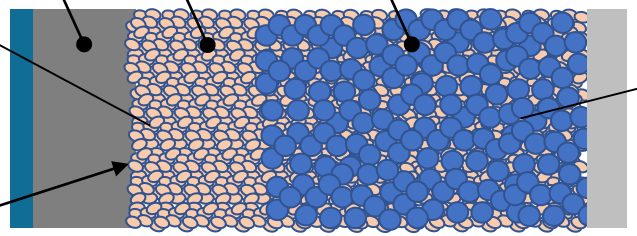
BIU, UMD, FN, MZ: Engineered, nm-scale coatings on both solid electrolyte and cathode powders



BIU, MZ: Li⁺- or Na⁺- intercalation, coated electrode particles.

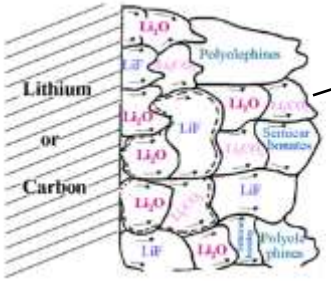


Li or Na metal electrode | Solid, dense separator | Porous, multi-component electrode

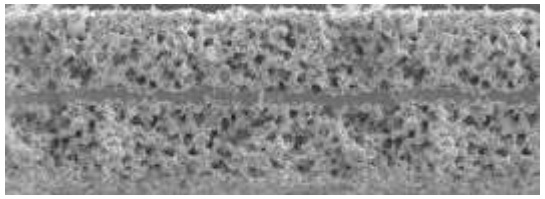


SAFT
3DB
BIU
UMD
ISS

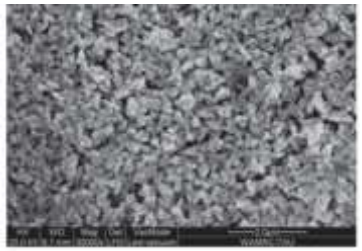
TAU, UMD: Metal electrode interphases and cycling stability.



UMD, ISS: Porous-dense-porous trilayer solid electrolyte structures.

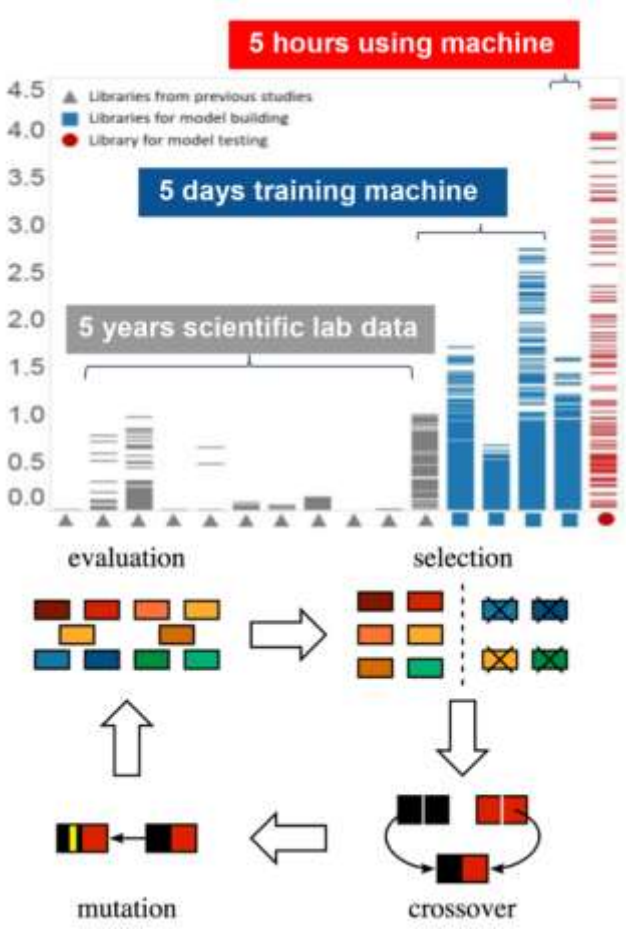


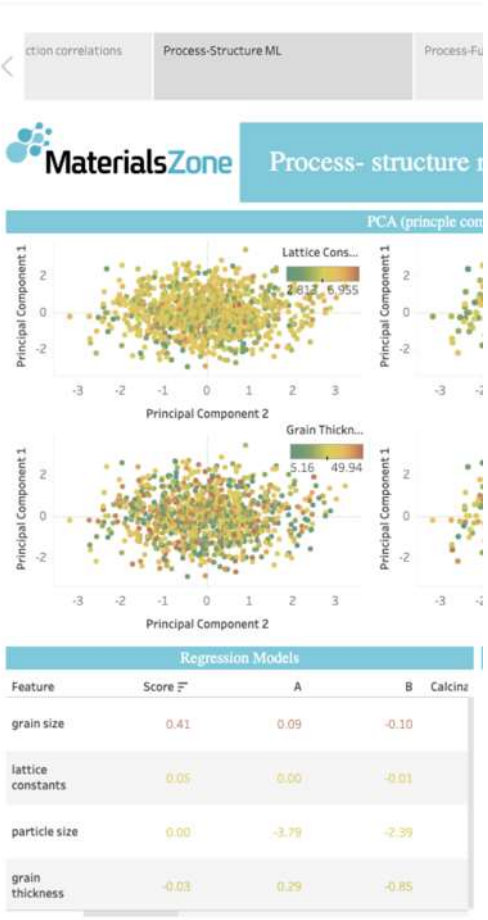
TAU: Polymer-in-ceramic composite electrolytes. Example: 0.3PEO:0.7LiAlO$_2$



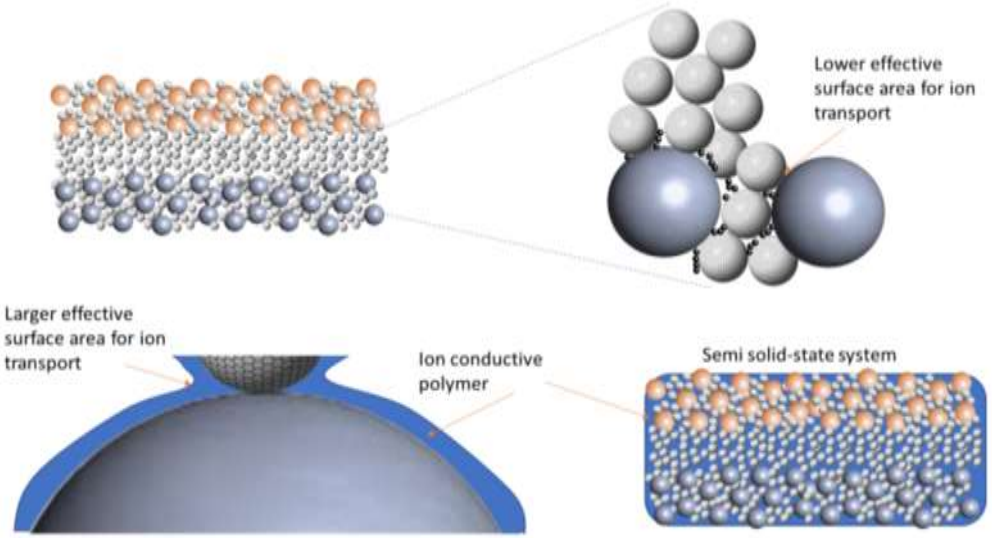
UISEC CMs bring the building blocks to address the challenges

ML and AI to accelerate materials discovery and research (MZ)

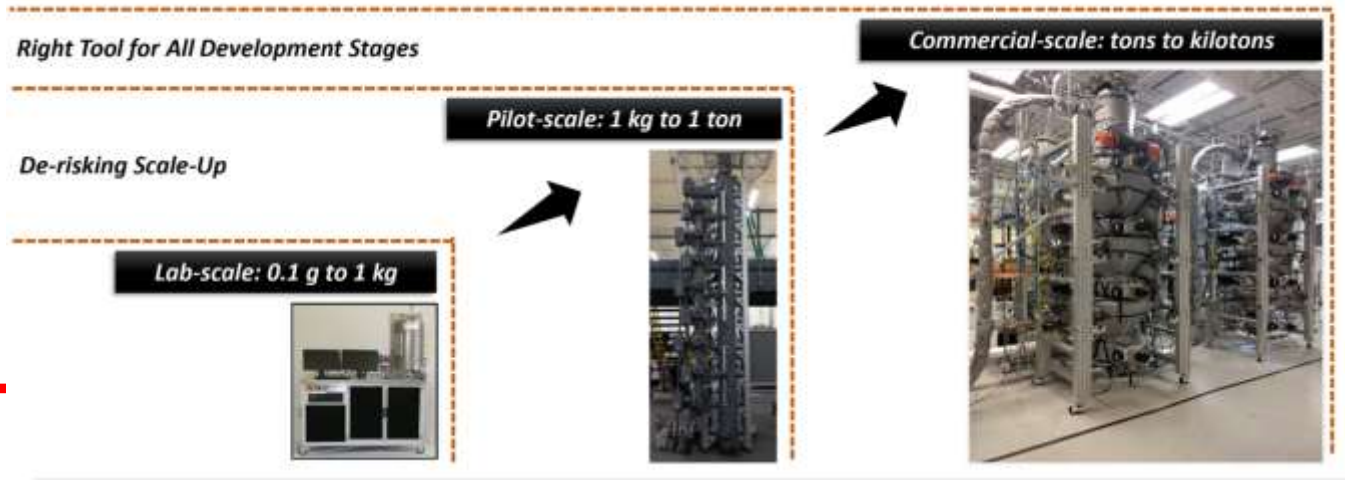




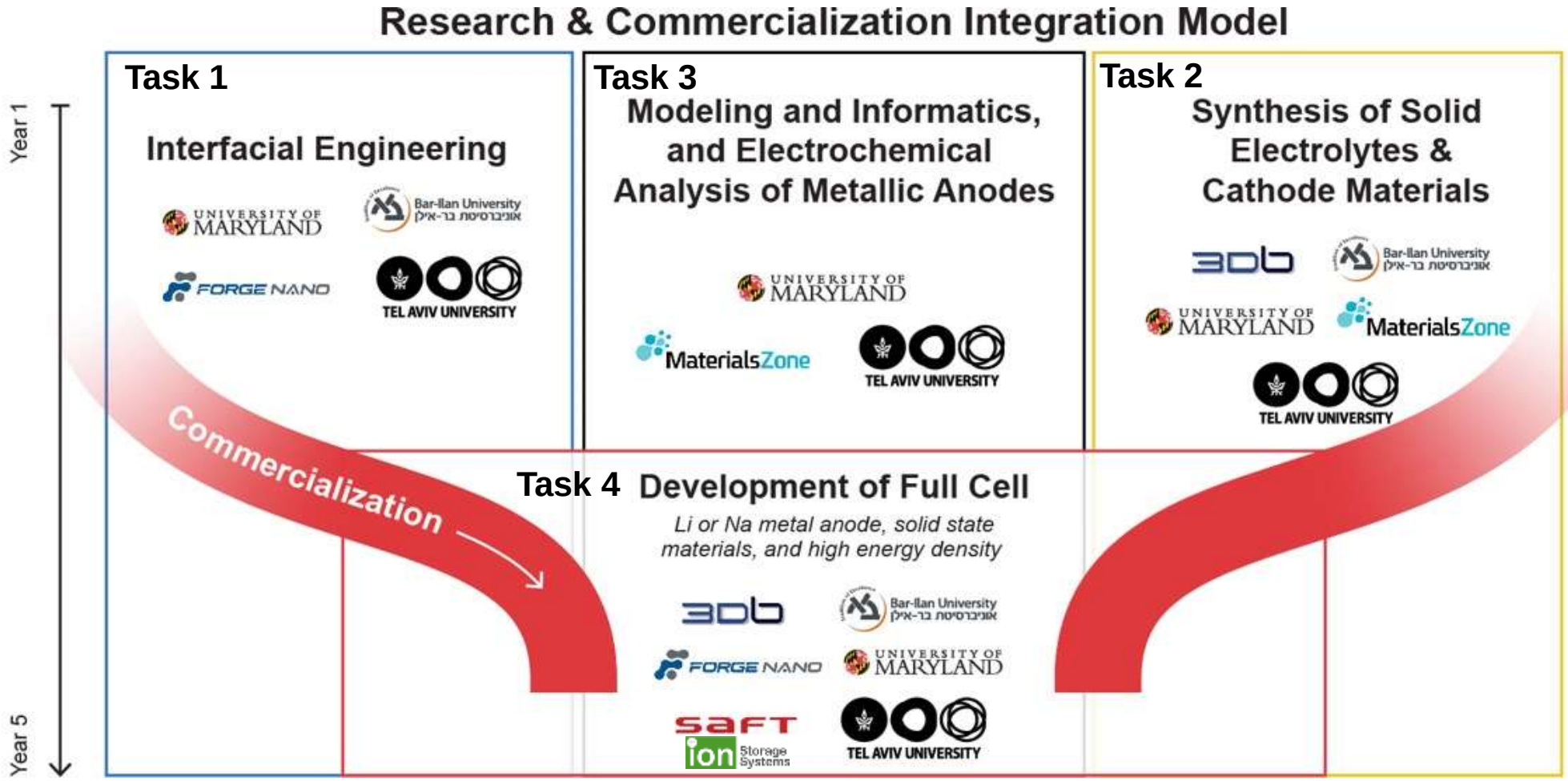
Ion-conductive polymers to improve ionic contacts (3DB)



Process development for Surface Modifications (BIU, UMD, FN)



Our program plan integrates knowledge-driven research with commercial-oriented translational work



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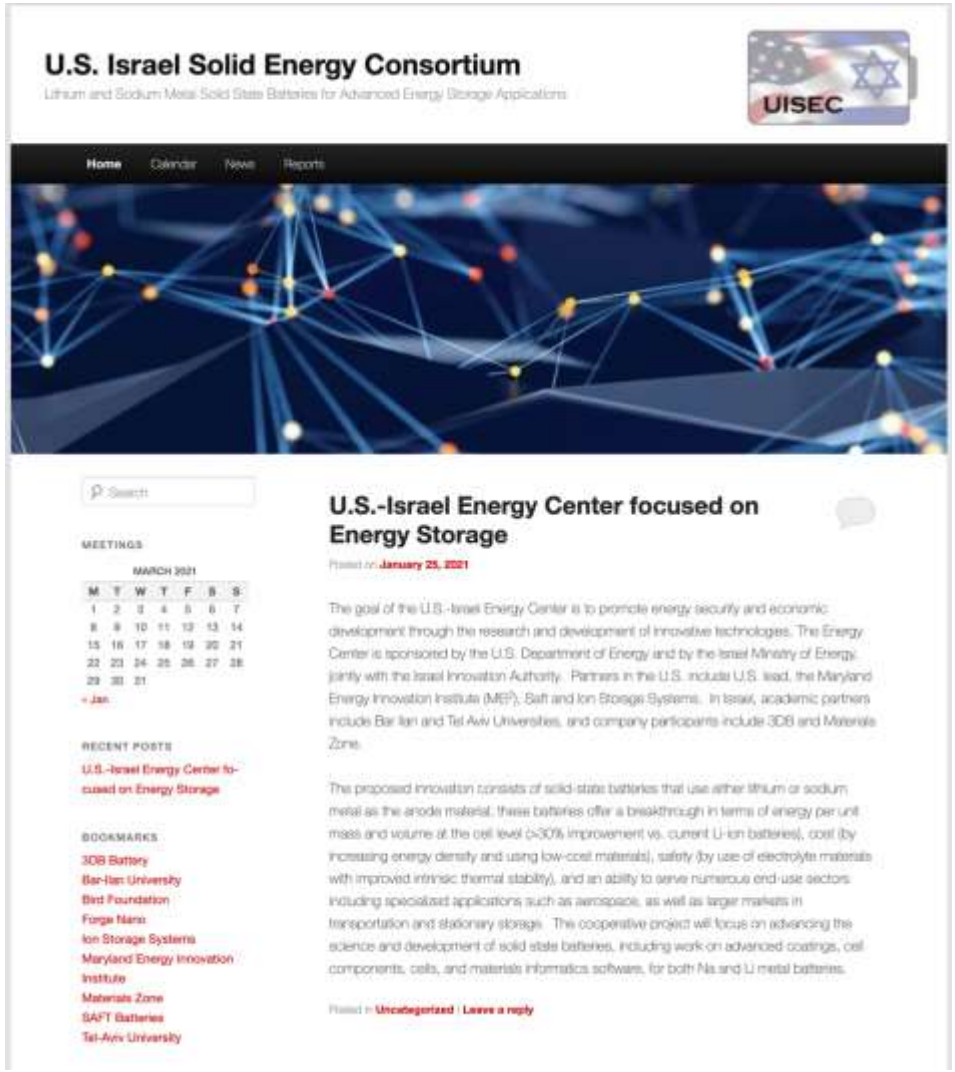

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