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Energy Storage of the Future: Innovation in the Lithium Ion Battery Space

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Different energy storage applications with different specifications



Lithium ion batteries can be used for many applications



Same technology



High volume production decreases costs



Decreasing material cost is challenging



Large manufacturers pay less for materials.

Big players dominate the lithium ion battery market



Innovation must be disruptive or provide a solution that is compatible with existing processes and infrastructure

Inside a lithium ion battery







Animation Marie Francine Lagadec

How can we improve a lithium ion battery?

Energy density

Charge / discharge speed

Lifetime



Materials

Structure

Disruptive Innovation

Active materials make up less than 50% of mass and volume in today's lithium ion batteries

Volume fraction



Disruptive Innovation

Semi-solid flow cell



M. Duduta, B. Ho, V. Wood, P. Limthongkul, V. E. Brunini, W.C. Carter, Y.-M. Chiang. Advanced Energy Materials (2011).



Flow cell concept abandoned

Manufacturing approach?

"Incremental" Innovation

Sony's commercial LIB 1991

Cathode: lithium cobalt oxide Anode: soft coke carbon Separator: polymer membrane Electrolyte: organic solvent + salt

Cathode: lithium nickel maganese cobalt oxide Anode: graphitic carbon Separator: thinner, more wettable membrane Electrolyte: complex solvent mixtures, salt & additives

~3x higher energy density

2016

Understanding lags behind development needs





Centro Svizzero di Calcolo Scientifico Swiss National Supercomputing Centre

Interdisciplinary approach needed: tools, techniques, etc.

X-Ray tomographic microscopy





Complex interplay between electrochemical and mechanical effects

Video Patrick Pietsch Scales to emphasize deformation

Silicon-carbon composite anodes

Graphite: 372 mAh/g 11% volume expansion **Silicon**: 3578 mAh/g 280% volume expansion

20 wt.% silicon in graphite: 1013 mAh/g



P. Pietsch et al., Nature Communications (2016).

Structure of graphite anode limits battery charging speed



M. Ebner, D.-W. Chung, R. E. García, and V. Wood. Advanced Energy Materials (2014).



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Conclusions

- Lithium-ion batteries will continue to be a dominant storage technology in the next decade
- The myth of new technology with "X-fold" improvement
- Complex, dynamic system where understanding lags behind development
- Continuing innovations in materials and manufacturing will improve lifetime, energy density, rate capability while maintaining low costs