Si-Graphite Anodes for today's EV LIB's

Dr. Michael Heß
CEO Battronics

Outline

About Battronics

Today:

- Every battery player needs to do R&D and patent research by hand themselves
- Massive literature on batteries
  - 250 papers / months
  - 160 patents/ months on batteries à 3h reading

@Battronics:

- making deep-tech summaries of new tech
- We reduce time of customer
  1. Ca. 100h our time = 2h report for customer

We save **50x the time**

We save **7x the costs**

+ competitive advantage

Our approach

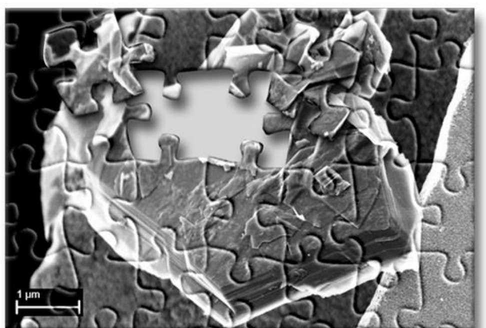
Puzzling all public battery knowledge
to accelerate research

Battronics Technology Radar

e.g. graphite phases

\+

\+ microscope images



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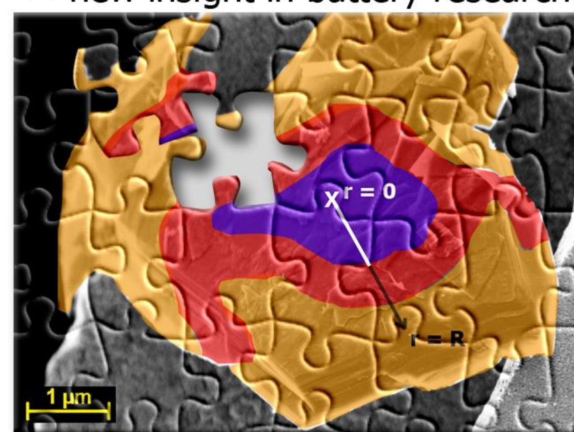
Recombining
the pieces

= new insight in battery research



Building the world's first data
base on battery research data

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2. Si-graphite blends for EVs

Adv vs. disadvantages

Advantages of Si-Graphite blends

Advantages
1. Higher energy density
2. Faster charging
3. Lower cost of technical Si

Disadvantages
1. Accelerated aging
2. Higher heat generation
3. Volume expansion → cell breathing
4. Electrolyte+Additive consumption

Industrial approaches:
1. Startups
   - Either complicated Si/Carbon structures (Amprius,Sila Nano, Nexeon, …)
   - Either coatings on Si (Enevate) or inactive matrix alloys (3M, Sony)
2. Incumbents
   - Use SiO_x for volume mitigation
   - Use small amounts of Si <7% to mitigate negative effect

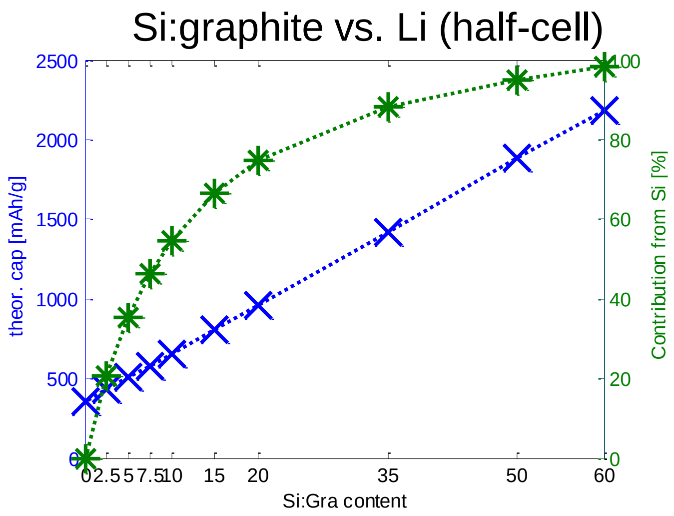
3. Capacity influence Si

Si - graphite composites

Battronics Calculation of needed Si:gra ratio

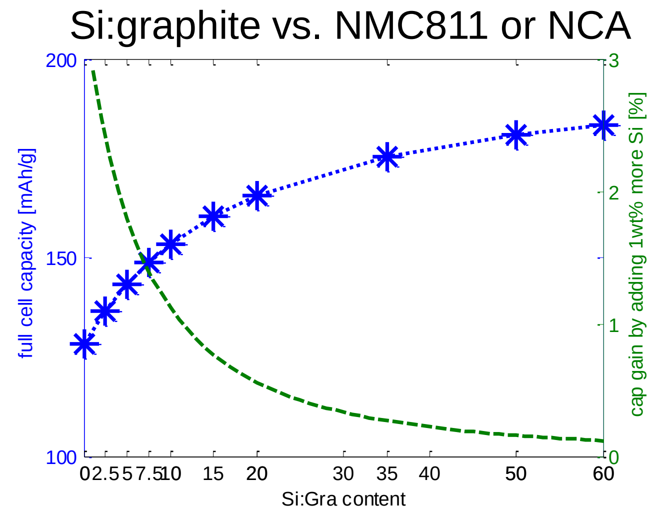
Silicon : graphite anode blends

- Theoretical capacity of Si is $Q(Li_{15}Si_4)$ = 3580 mAh/g being 10 times higher than Q(graphite) = 372 mAh/g
- Fig 1: Si increases capacity of blended anodes linearly
- only 10wt% Si contribute already 50% to total anode capacity



Silicon in full cells vs NMC811 or NCA:

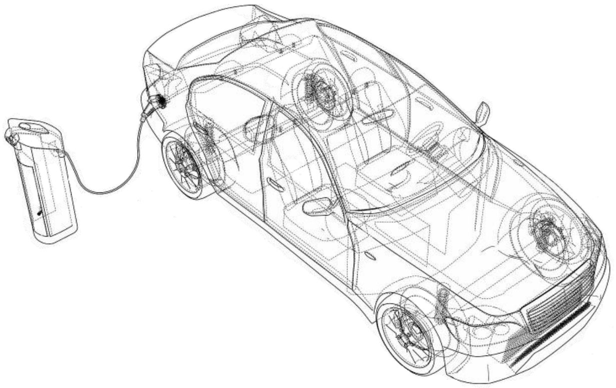
- Fig 2: calculation of Si:gra blends vs. newest cathodes NMC811 or NCA with ca 200 mAh/g
- impact of Si on full cell capacity is marginal
- Increasing Si from 0 to 1wt% in anode adds 3% extra capacity to full cell
- but every extra 1wt% Si above 10wt% Si in anode adds less than 1% extra capacity (green dashes)



What does that mean for applications:

- Capacity increase of full cell is ca 20% by changing Si from 0 to 10 wt% and also again from 10 to 60 wt%
- Only up to 10 wt% Si in anode is recommended for full cells as little further capacity gain by adding more Si but huge problems of Si + aging

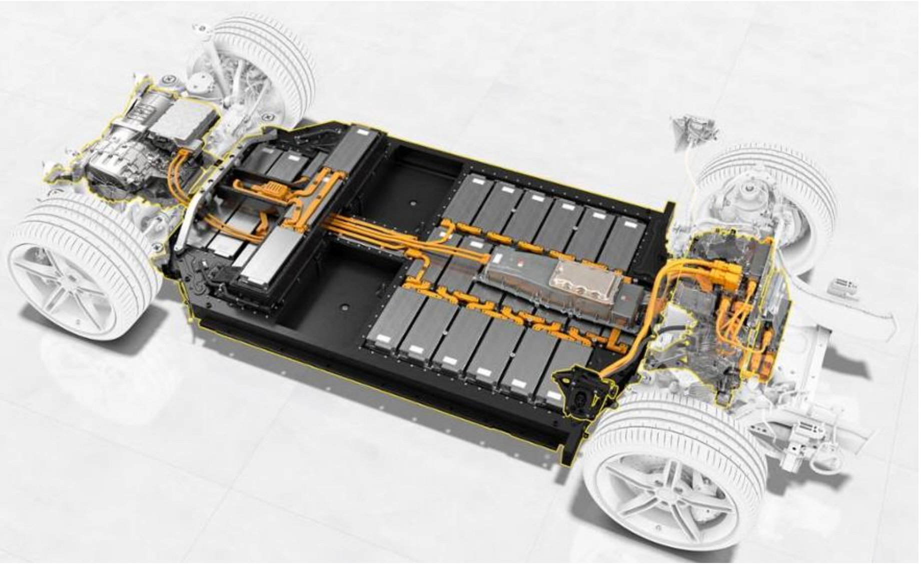
System perspective for heat generation



4 System components to consider:
- Charging cables, pins and internal EV cables
- Battery cells
- Inverter
- E-motor

1. Charging cables, pins and internal EV cables
- Easy problem
- I_{max} given by cable/pin diameters
- 400V vs 800V system (=e.g. 100 vs 200kW chargers)

Heat in cables
- $P_{elec} = U*I$
- $P_{heat} = I^2*R_{cables}$



e.g at same power output e.g. 100kW charger
- 100kW = 400V*250A = 800V * 125A
- So 400V system gives 4x more heat

2x charger voltage reduces heat in cables+pins by x4

3. Effect of heat in Applications

3.1 high power charged E-buses

3. Effect of heat in Applications

3.2 Active vs none-cooled EV’s

Contact

Questions?

Thank you!

for your attention

Battronics Engineering

For a battery future

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