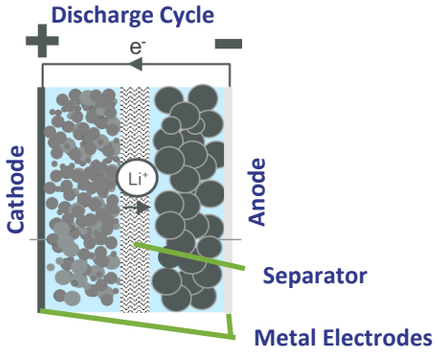
High Capacity Silicon Dominant Anode for Electric Vehicle Batteries

Li Ion Battery



Today's Li ion batteries use graphite as active anode material. Silicon - with its higher specific capacity - will enable the next generation of Li ion batteries for electric vehicles.
Graphite dominant anodes with small amounts of silicon added are one approach to increase capacity, however major technical challenges prevented their wide scale implementation yet.
Silicon dominant anodes show an even higher specific capacity potential and are less technically challenging. However the right silicon material at a low cost in mass production must become available.

E-magy's Innovation

The patented Ribbon-Growth-on-Substrate (RGS) crystallisation process enables low cost, mass manufacturing of E-magy™ nano-porous silicon for batteries.

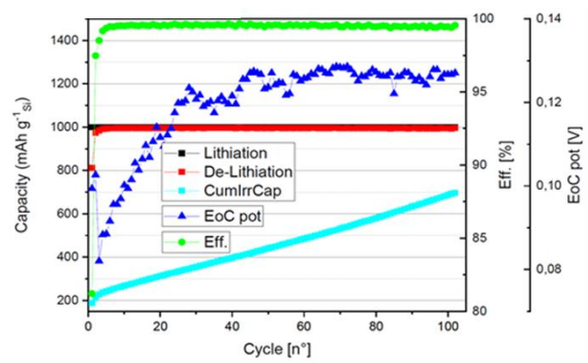
The unique geometrical structure of this material enables the use of silicon in silicon dominant next generation Li-ion battery anodes.

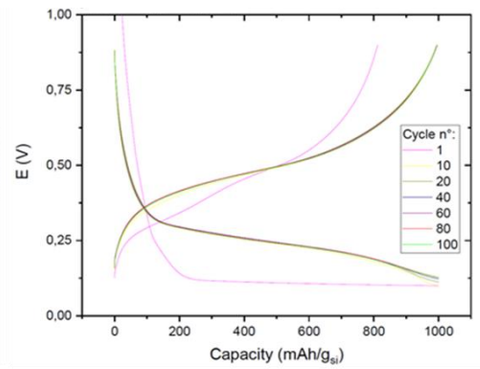
Utilising the internal nano-scale porosity, outside expansion of the silicon particles is avoided and a stable anode performance is achieved.

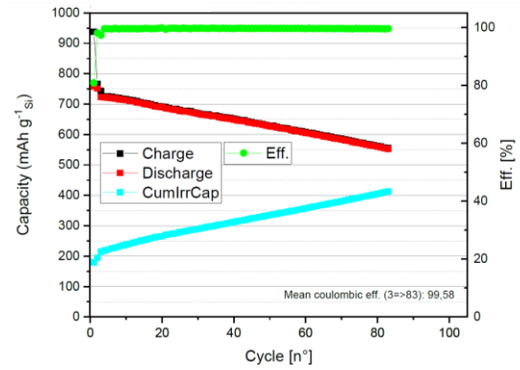
E-magy™ silicon has been intensively tested in different silicon dominant anode compositions.

Anode composition in these results: E-magy Si 63%, Li-PAA binder and carbon black conductive material with 10% FEC addition in 1M $LiPF_6$ electrolyte. (no particle coating).

Battery Cell Test Results*



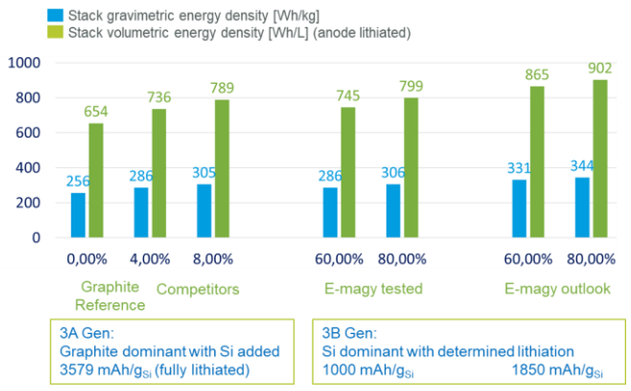




Half cell (top) and full cell (left) cycling results:
- Half cell cycled 100x at 1000 mAh/g
- All tests at 0.25C
- Stable potential curves – no capacity loss in Si
- Full cell results against NMC622 confirm stable half cell results (no Li plating)

*Electrochemical results obtained in partnership with: Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)

Performance Improvement



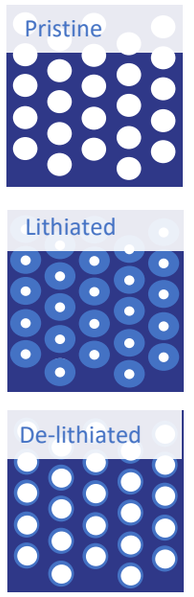
15% - 22% energy density improvement at (tested) 1000 mAh/g cycling

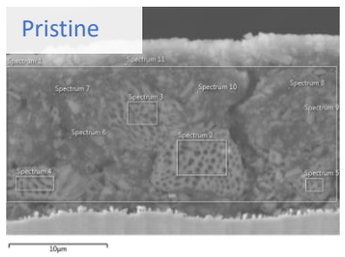
Outlook: 30% - 38% energy density improvement at (expected) 1850 mAh/g cycling

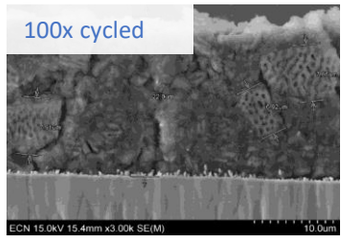
E-magy Particle Application and Anode Stability

1st Lithiation:
Crystalline Si is partially transformed to amorphous Li_xSi

Cycling:
Li cycling uses the amorphous Li_xSi volume, while the crystalline silicon backbone stabilizes the material







End of cycle test anode analysis showed:
- No swelling
- No particle breakage
- No cohesion or adhesion loss in the anode

E-magy B.V.

Nano-porous silicon material supplier.

Proven particle performance in silicon dominant anodes

Drop-in solution in anode coating process

Ready to supply material and to partner in customer qualification programs

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