Technische Universität Braunschweig

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BATTERY LABFACTORY BRAUNSCHWEIG

Reducing the stress factor in high-energy silicon/graphite composite electrodes through systematic structuring

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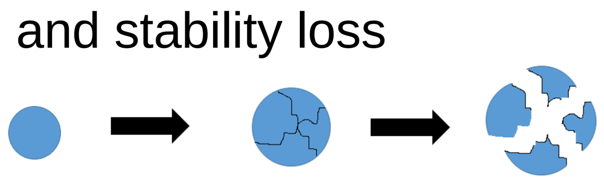
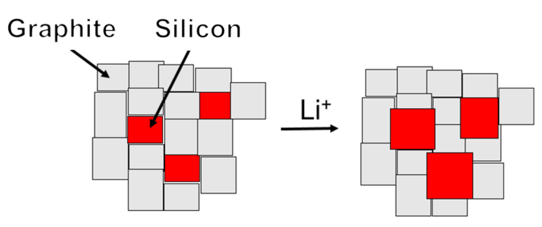
Motivation – Gr/Si

- For many applications of Lithium ion batteries, it is important to increase the energy density
- Silicon exhibits much higher gravimetric capacity than graphite
- Main Challenge: Volume expansion in silicon during lithiation can cause cracking and stability loss

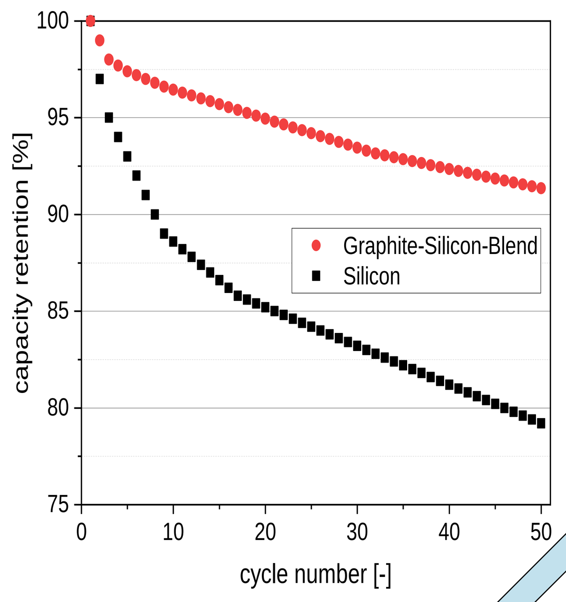


Structuring via Blends

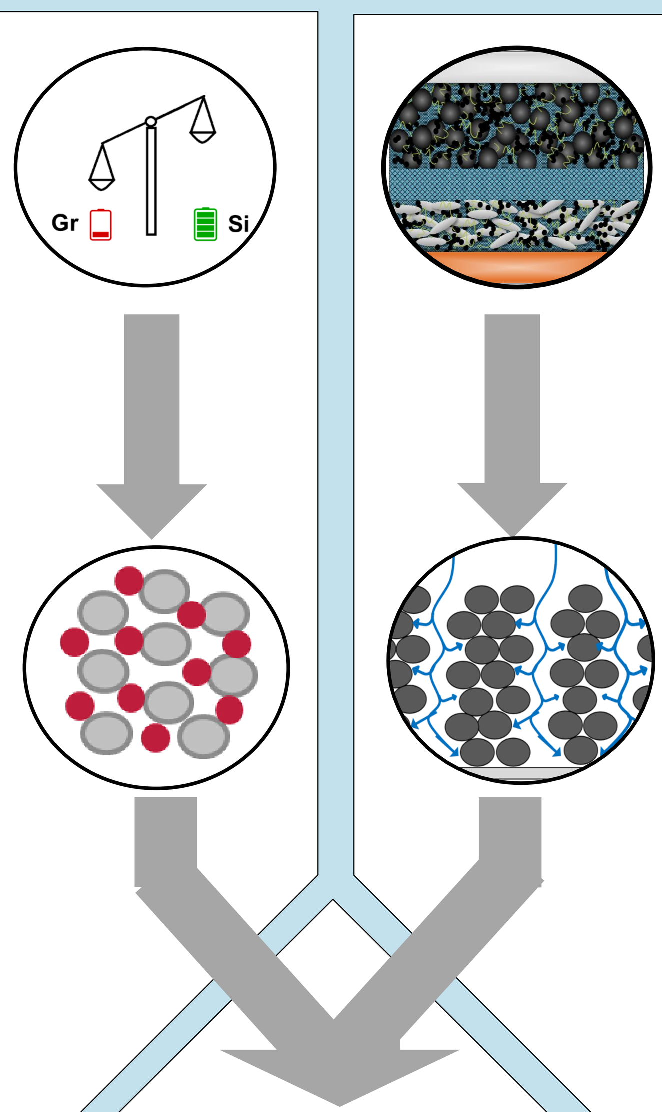
- Graphite and Silicon Blend with Graphite as a buffer for volume expansion



- Formulation Design: Different Silicon-contents



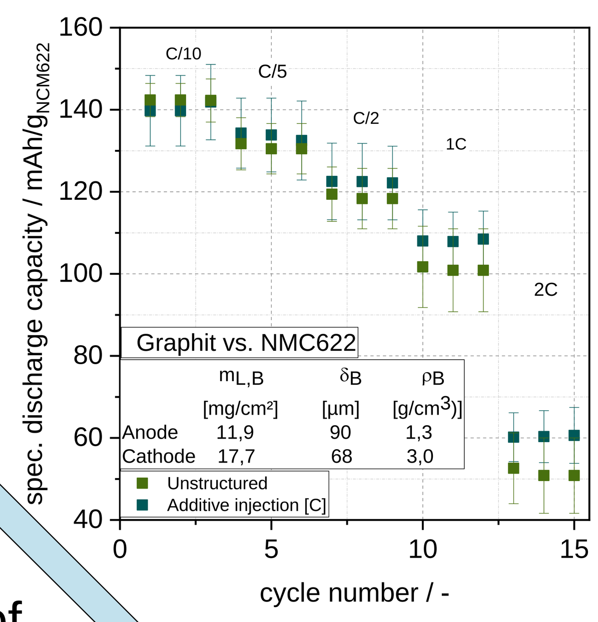
	V1	V2	V3
Graphite [%]	91,5	84,1	76,6
Si-Composite [%]	8,5	15,9	23,4
Capacity [mAh/g]	475	575	675



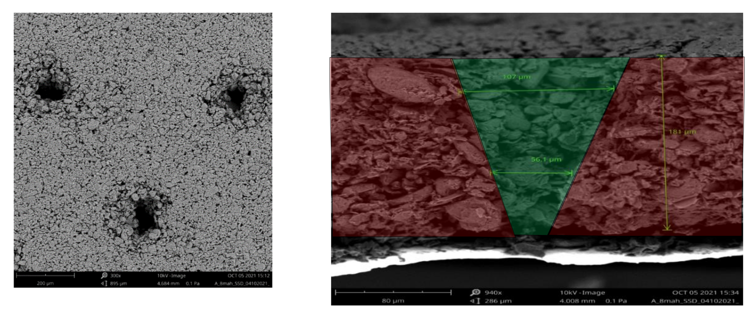
Motivation – Structuring of electrodes

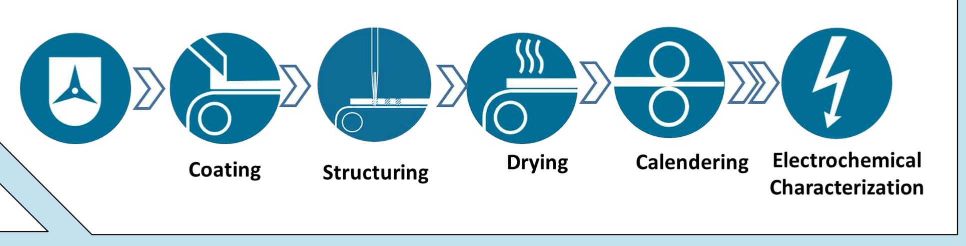
- Production of thick anodes to reduce the inactive material content in the cell
- Unstructured electrodes have a high ionic resistance
  → Inhomogeneties when charging and discharging
- Generation of diffusion pathways for lithium ions
- Integration of structuring in the electrode manufacturing process

Mechanical Structuring Methodes (Injection)



- Rate capability is improved by the mechanical structuring methods
- No material loss
- Structuring improves lithium ion diffusion by reducing tortuosity

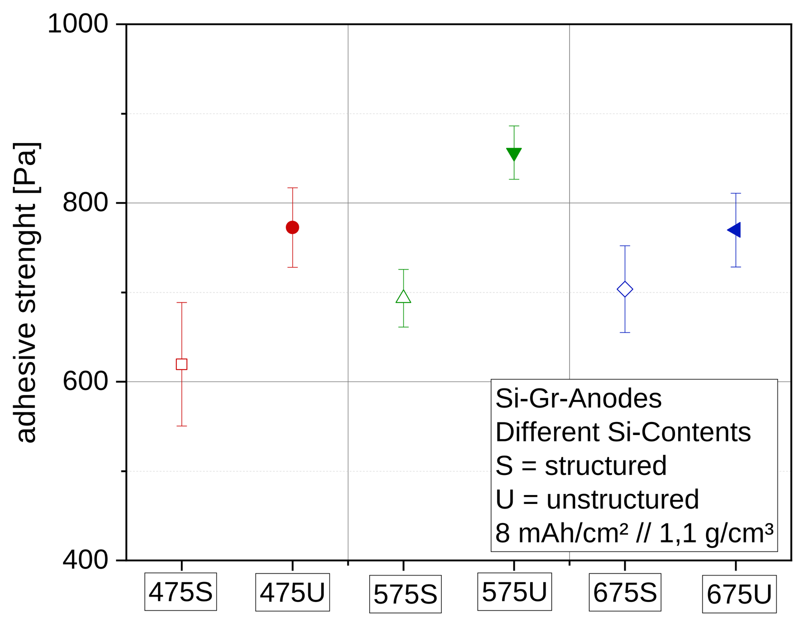


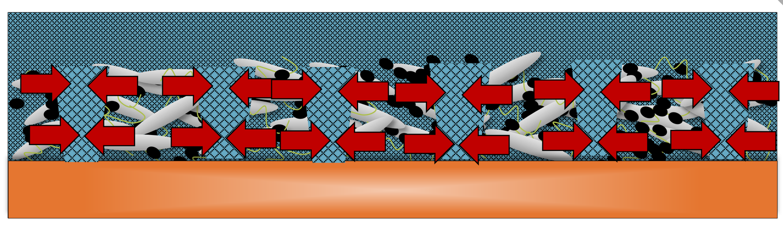


Concept

- Combination of better cell performance and reduction of mechanical stress
- Generation of additional pores in Si/Gr-electrodes by using a novel structuring process
- Development of a process for the structuring of Si/Gr-electrodes without material loss

Mechanical evaluation



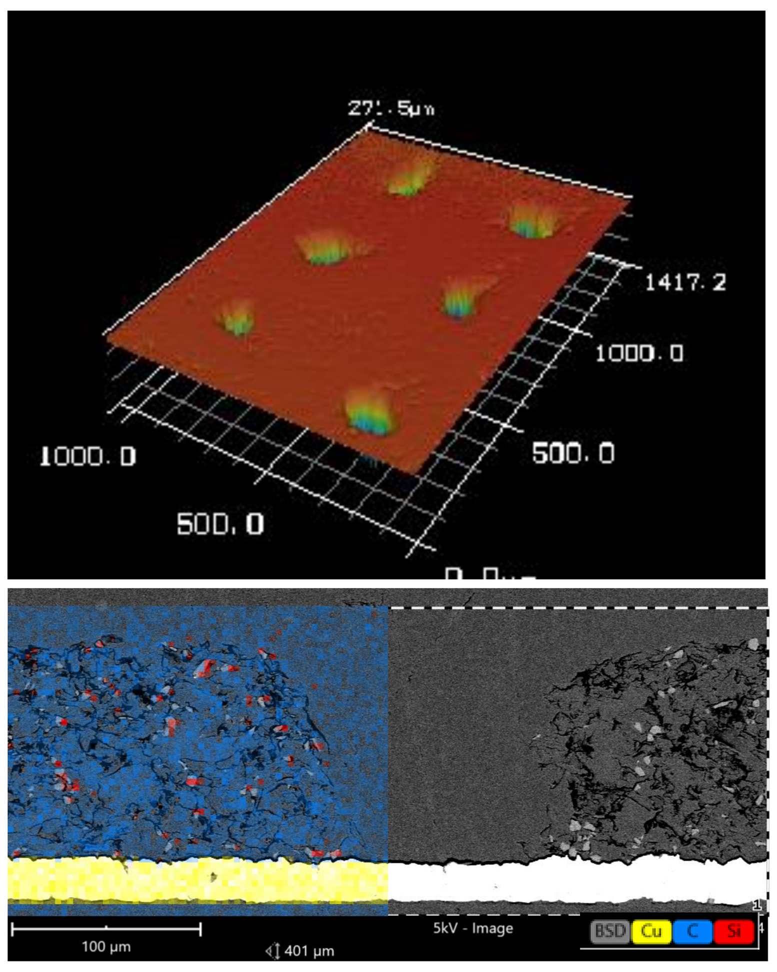


- Adhesive strength increases with higher Silicon content
- Insignificant influence of mechanical structuring on adhesive strength

Optical evaluation

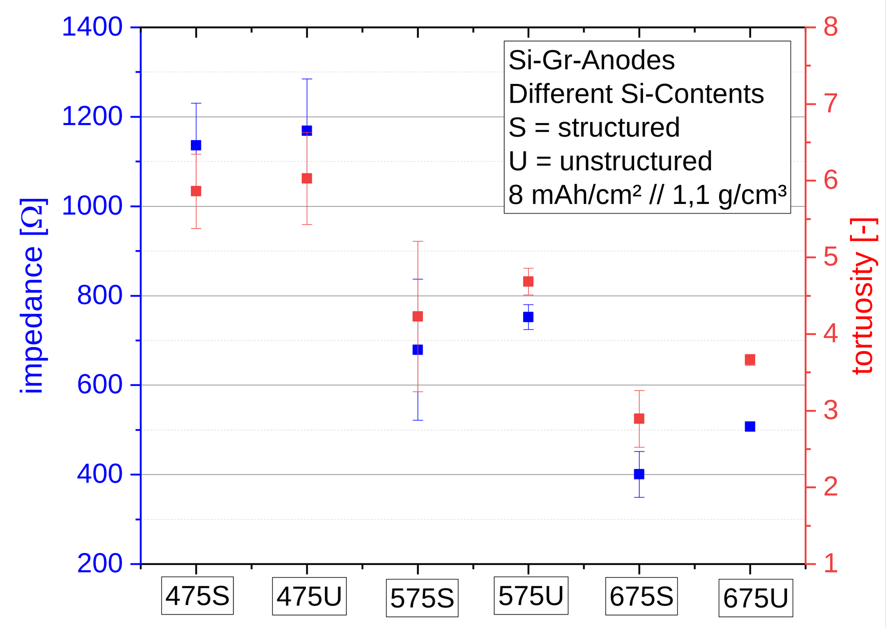
- Mechanical structuring: pores through the layer to the collector
- Pore distance: 500 µm
- Pore diameter: approx. 110 µm
- Pore volume: 10 % of the coating

- No detachment of the layer from the collector
- Structuring leads to a realignment of the particles
- Silicon evenly distributed in the blend and the layer



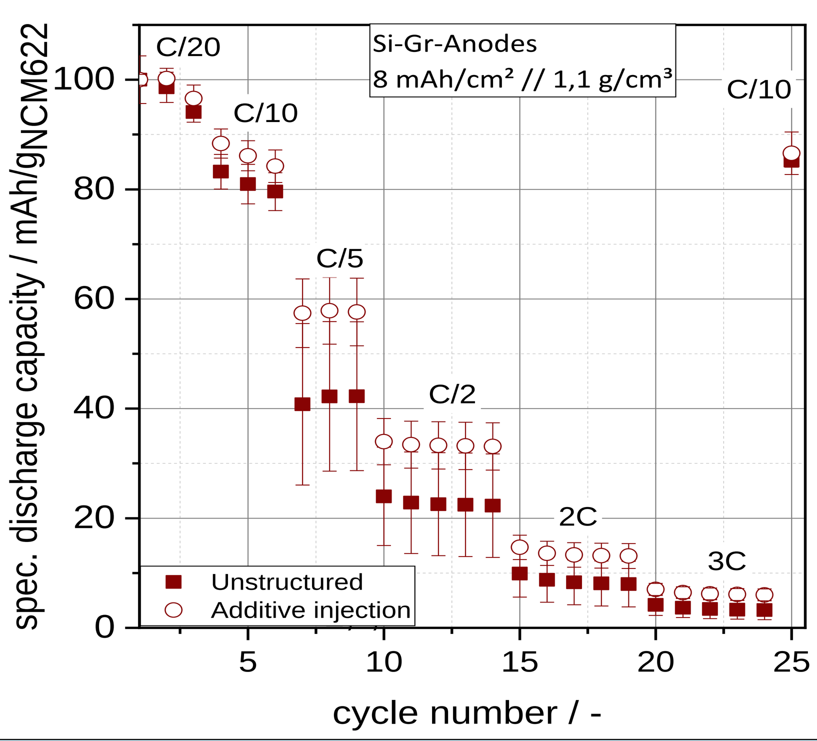
Structural evaluation

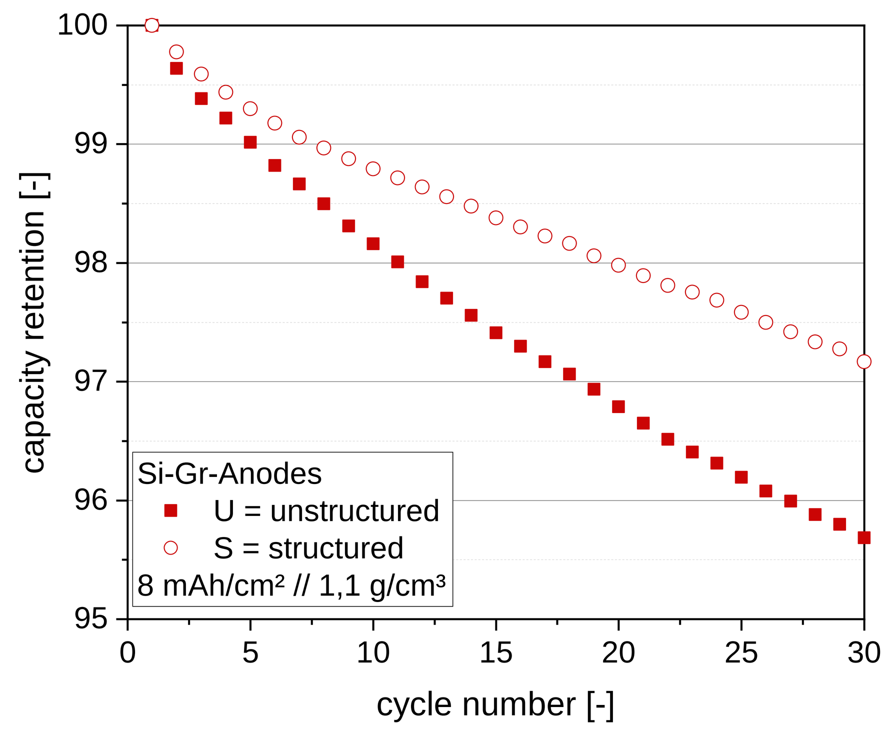
- Use of symetrical cell design for the determination of the ionic resistance of the anode
- Impedance reduction due to lower layer thickness by adding silicon
- Additional reduction of tortuosity due to structuring → ionic pathways



Electrochemical evaluation

- Improvement of cycling stability by mechanical structuring
- Compensation of silicon expansion due to additional pores





Conclusion

- Building up new ionic pathways by structuring is reducing the tortuosity and enabling higher fast charging ability
- Improvement of cycling stability by reducing the stress of the Silicon volume expansion
- Combination of blend formulations and mechanical structuring as a possible way to solve silicon anode challenges

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