Assessment of Coating Defect Criticality in Lithium-ion Battery Electrodes

Sebastian Maletti[1], Tobias Lein[1], Karoline Schmal[1], Duy Anh Nguyen[1], Arnaud du Baret de Limé[2], Christian Heubner[2], Michael Schneider[2], and Alexander Michaelis[1,2]

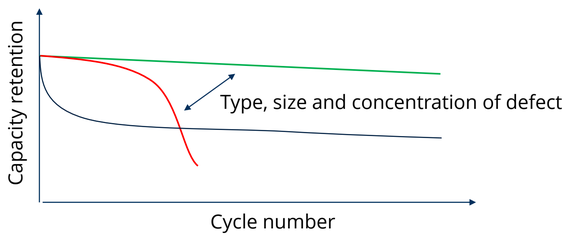
[1]Technische Universität Dresden, Institute of Materials Science, Helmholtzstr. 20, 01069 Dresden, Germany

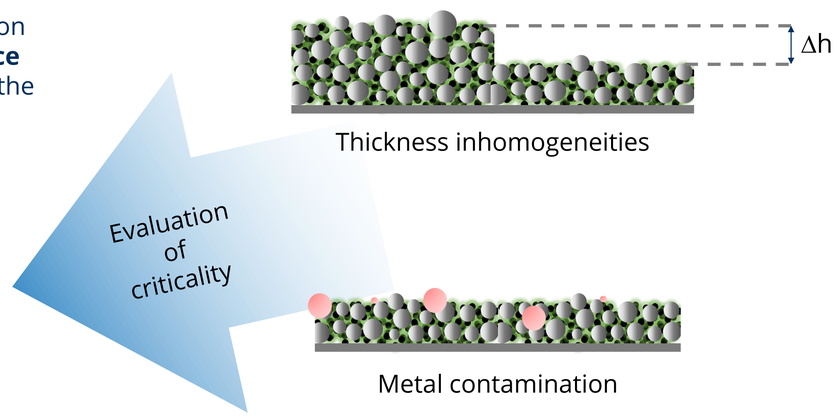
[2]Fraunhofer Institute for Ceramic Technologies and Systems, Winterbergstr. 28, 01277 Dresden, Germany

Tobias.lein@ikts.fraunhofer.de

Motivation

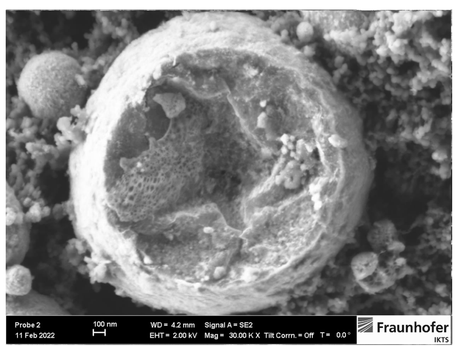
A variety of coating defects in electrode production is known and well detectable, but the **significance of different defects** remains unclear, impeding the derivation of tolerance limits.

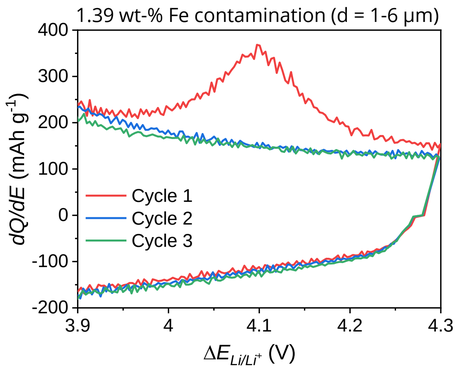


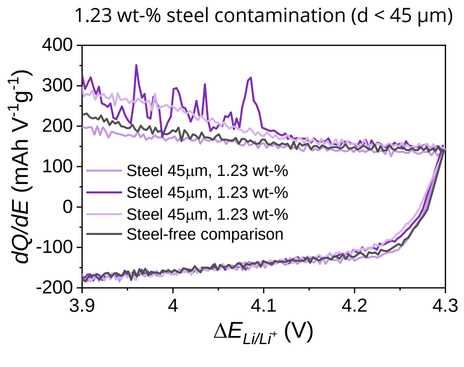


Metal contamination

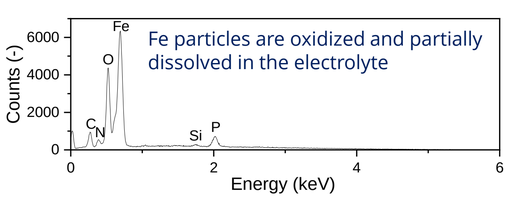
Metal particles can be introduced into electrodes as raw material contamination or as abrasion from process machinery. Iron and steel particles are frequently named as contaminants, e.g. from mixing.

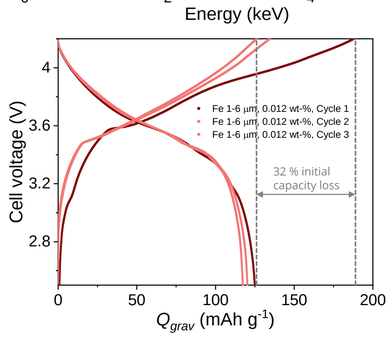


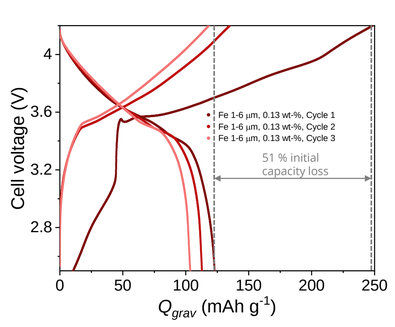




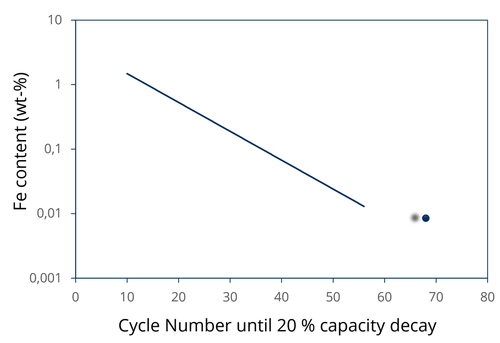
Affection of cell formation: Iron particles cause an irreversible oxidation peak during the first formation cycle. Stainless steel contaminations affect the stability of the cell less, but exhibit surface corrosion.







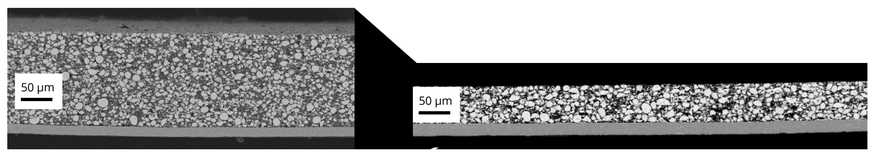
Formation: Large 1st cycle irreversible loss reflects dissolution and passive film formation.



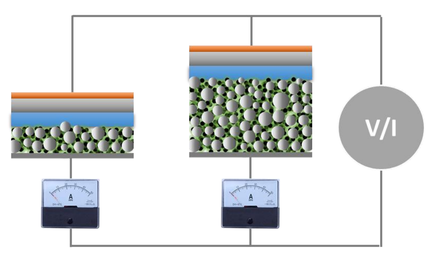
Cycling: Higher Fe content results in faster capacity decay.

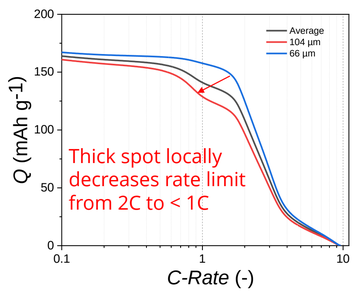
Thickness inhomogeneities

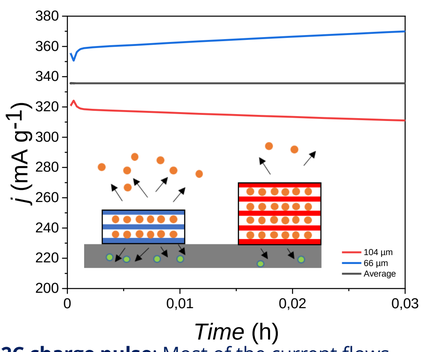
Local thickness variations, resulting from coating or calendering, can negatively affect electrochemical properties of an electrode.



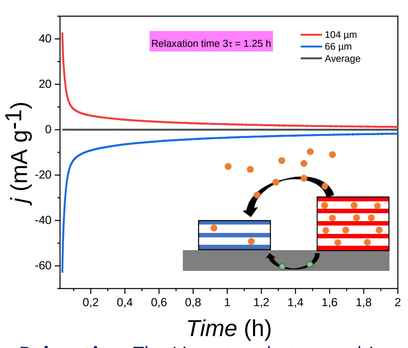
Our approach: A parallel connection of model electrodes with thickness differences simulates an electrode with thickness inhomogeneities
→ Internal currents can be observed



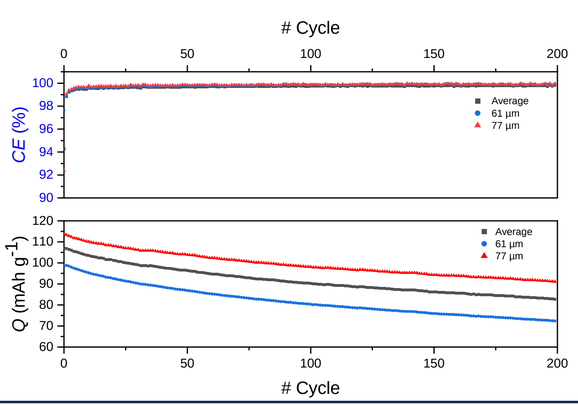




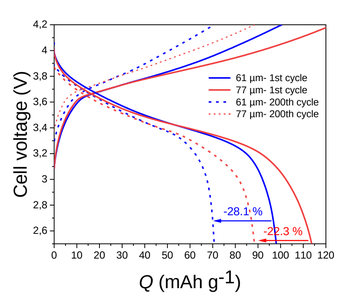
2C charge pulse: Most of the current flows through the thin areas of the electrode. The thicker region with higher impedance shows lower current.



Relaxation: The Li content between thin and thick spots gets balanced by internal currents.



Full cell cycling: Thin spots show a higher capacity decrease due to higher local current densities



Conclusions

- The effect of different electrode coating defects was studied using model samples
- The oxidation and dissolution of iron particles causes irreversible 1st cycle side reactions, steel particles are less detrimental
- In the presence of thickness inhomogeneities, thick spots with a lower rate capability bear lower currents, while thin areas carry a higher current density, leading to internal redistribution currents and faster degradation
- All possible defect types, including agglomerates, line defects, pinholes, blisters as well as inhomogeneities in binder and carbon distribution can be studied using our model setup employing a parallel connection of cells
- Our findings represent the foundation for deriving knowledge-based quality assurance criteria

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