German Aerospace Center (DLR)

Institute of Engineering Thermodynamics

Development of Tests for Lithium-Ion Cell Characterization Using Realistic Load Profiles

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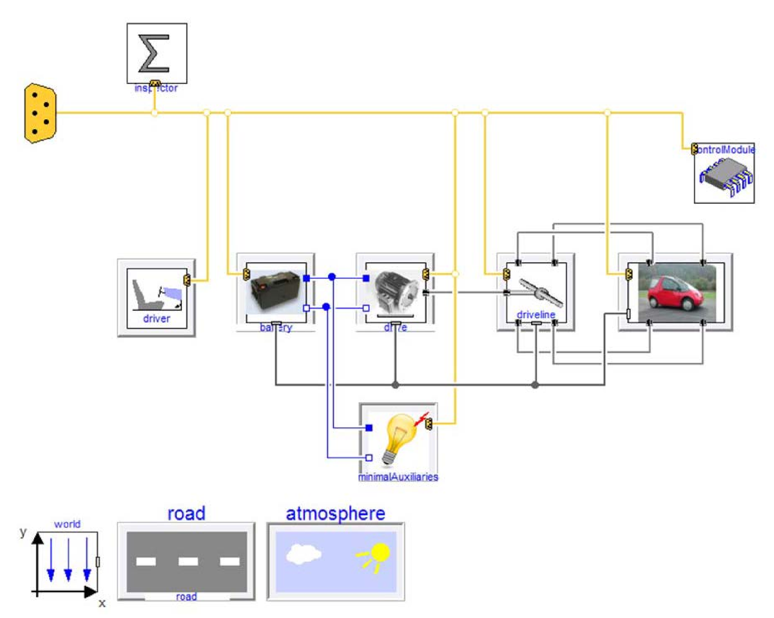
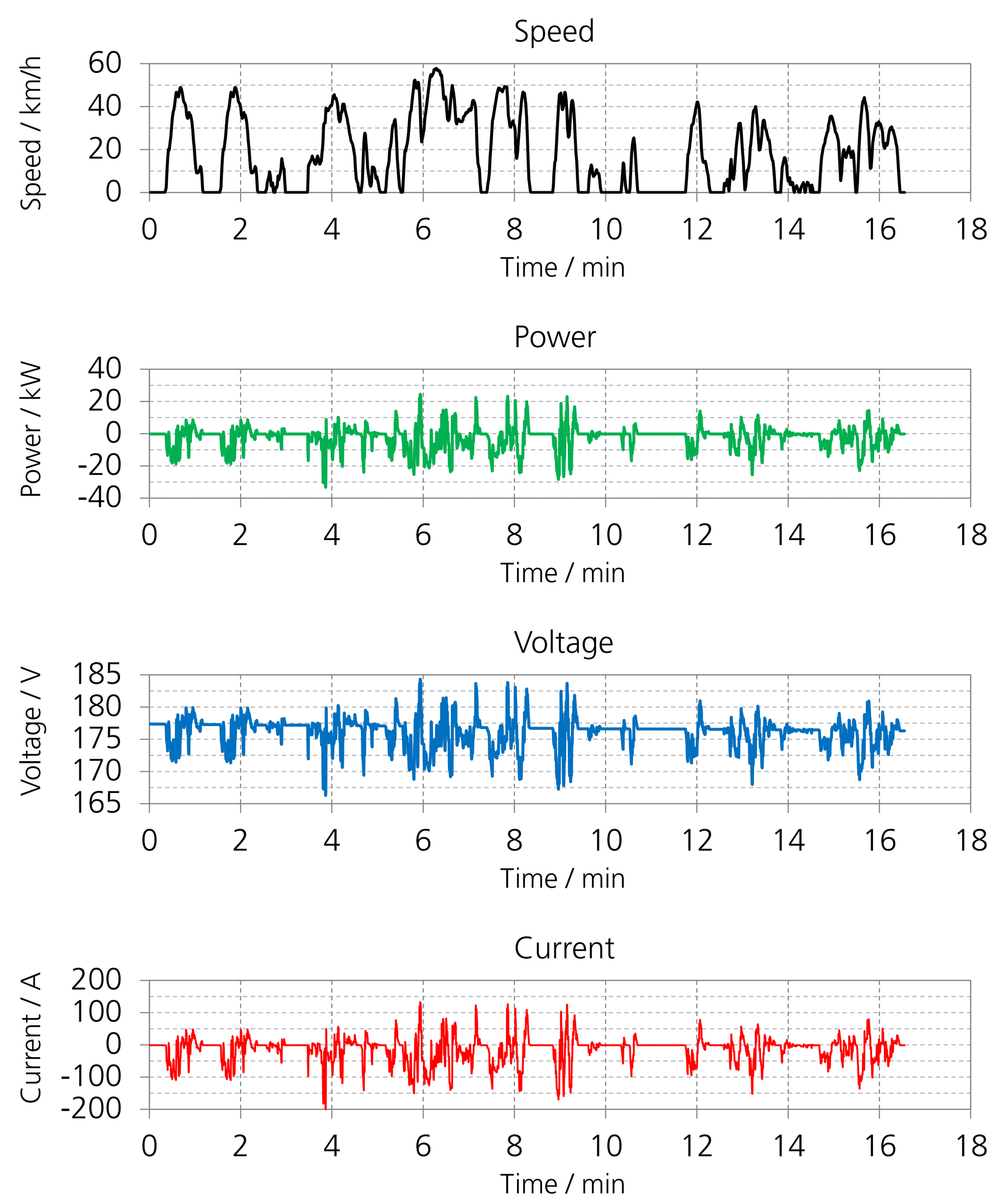
Introduction

The degradation of lithium-ion batteries is influenced by the type of application as well as the corresponding user's behavior. Battery Electric Vehicles (BEV) imply a different load for the used battery cells. For example, a BEV (with recuperation) in urban traffic accelerates and decelerates periodically.
This represents a dynamic stress on the battery due to the alternating load between discharge and charge. In this poster the effect of BEV utilization on life-time performance of experimental and commercial lithium-ion cells was investigated. Therefore single cells were stressed in a test bench with the Common Artemis Driving Cycle (CADC) Urban (Powerprofile 01). To answer the question if cell aging and degradation depends on the test profile a standard life-time test (Powerprofile 02) was performed for comparison. In order to reveal degradation processes electrochemical impedance spectra were carried out every 100 load cycles.

Model of BEV

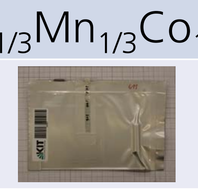
The actual vehicle is equipped with a 12 kW electric traction drive and reaches a maximum speed of 112 km/h. For the simulation an increased traction motor of 30 kW was assumed. Below the model overview and the simulated data of the CADC Urban are shown. One CADC Urban equals a distance of 4.874 km.

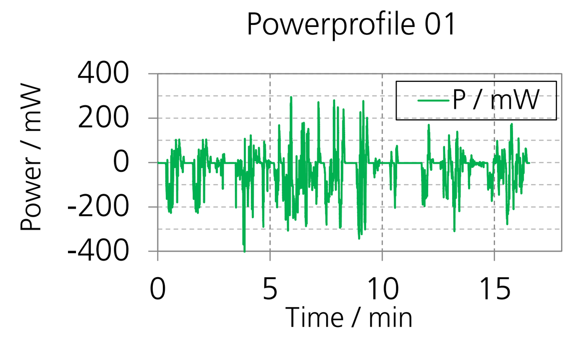




Experimental Results

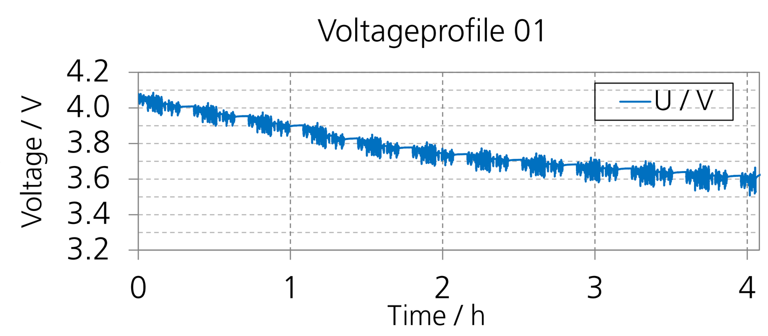
Used cells:

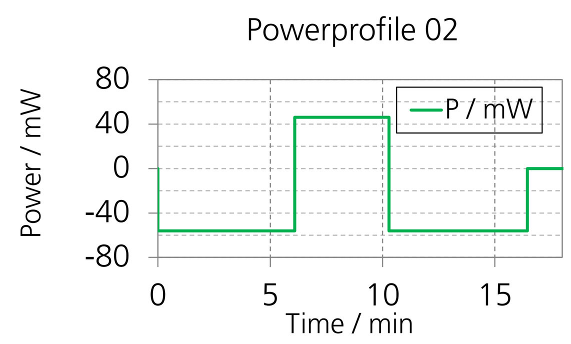
	ICR 18650 HE2	Celltype A	Celltype B	Celltype C	Celltype D
Manufacturer	LG Chem	Karlsruher Institute of Technology (KIT)			
Rated Capacity	2500 mAh	ca. 45 mAh (Cathode Thickness ca. 74µm)		ca. 90 mAh (Cathode Thickness ca. 154µm)	
Specific Capacity	ca. 57 mAh/g[a)]	140-150 mAh/g[b)]			
Technology	commercial	„standard"[c)]	„nanostucture"[d)]	„standard"	„nanostucture"
Material	$Li[NiMnCo]O_2$	$Li[Ni_{1/3}Mn_{1/3}Co_{1/3}]O_2$			
					



Q_{ch} / Q_{dch}	0.82 / 3.1 mAh
$C_{ch,max}$ / $C_{dch,max}$	1.8 / 2.7 h^{-1}
t_{ch} / t_{dch}	4 / 12 min
E_{ch} / E_{dch}	3.1 / 11.6 mWh

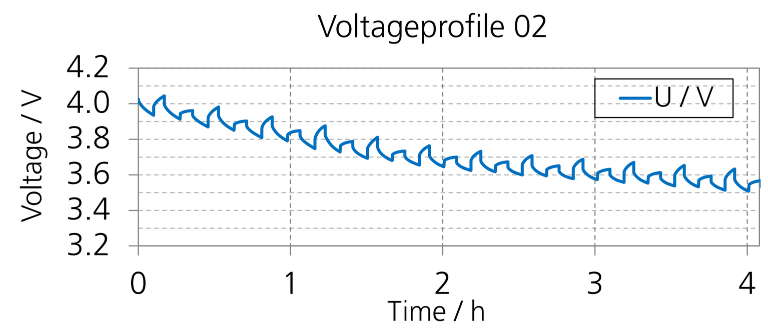
Cycle between SOC90 and SOC10



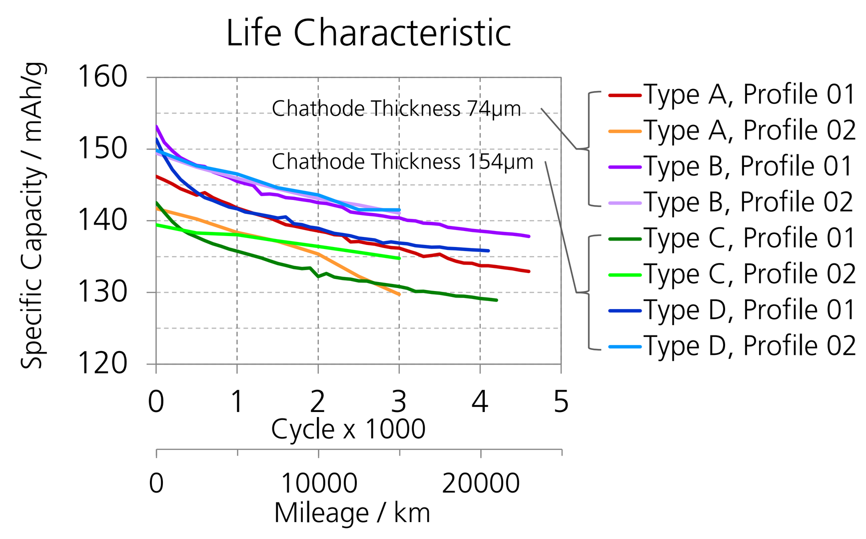


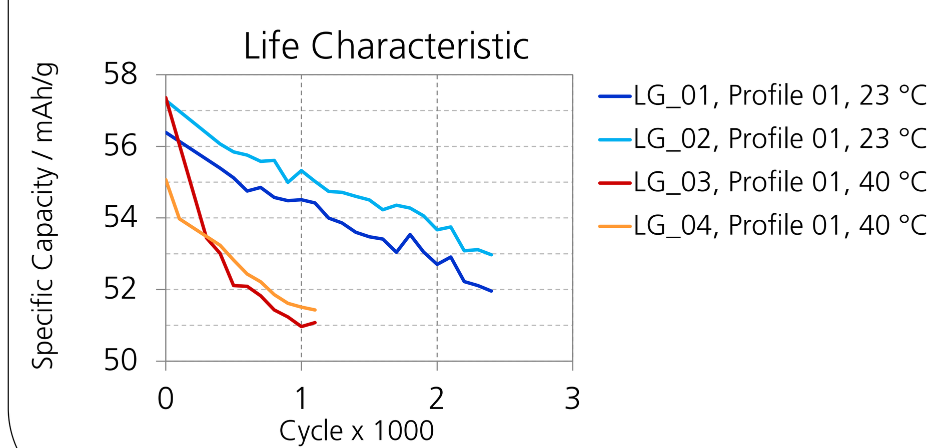
Q_{ch} / Q_{dch}	0.82 / 3.1 mAh
$C_{ch,max}$ / $C_{dch,max}$	0.29 / 0.36 h^{-1}
t_{ch} / t_{dch}	4 / 12 min
E_{ch} / E_{dch}	3.1 / 11.6 mWh

Cycle between SOC90 and SOC10

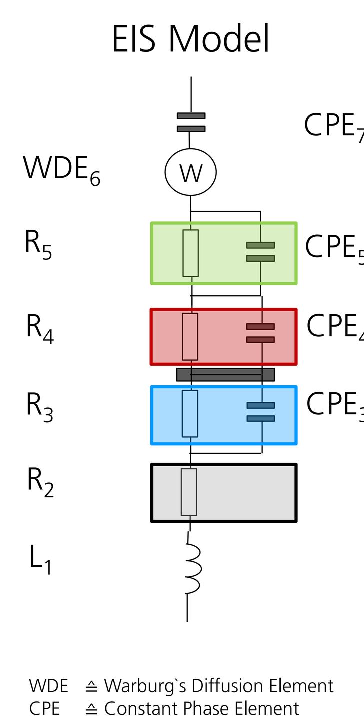


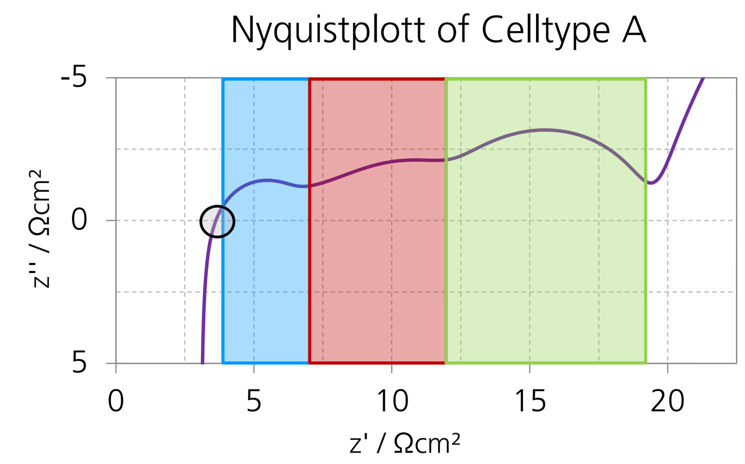
C ≙ C-Rate, Charge- Discharge current normalised with the Rated Capacity

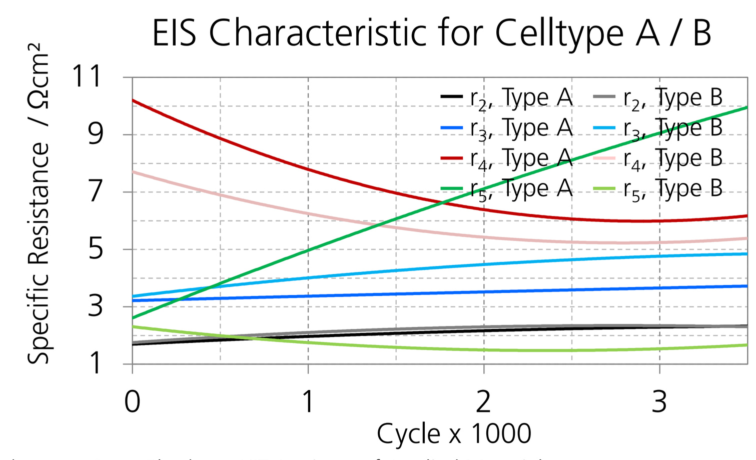




EIS Characteristic:







a) Specific Capacity referes to the total cell weight (including housing etc.)
b) Specific Capacity only referes to the active material
c) Correspondence to Sven Glatthaar, KIT, Institute of Applied Materials
d) Correspondence to Sven Glatthaar, KIT, Institute of Applied Materials

Summary

The Artemis Urban load profile was transferred from vehicle level to cell level.
A lifetime benchmark was created with the transferred Artemis Urban profile, which conforms to parts of the applied operating strategy of a cell pack used in electric vehicles, for instance the SOC-Range or load intensity.
Also a normalized lifetime benchmark was created which has the same Energy Transfer Ratio. Both benchmarks show similar cell degradation behavior. The "nanostructured" cells (Type B and D) show a lower Impedance compared to the "standard" ones (Type A and C).

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