Simulation of a Nickel-Zinc Battery on the Cell Level

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The growing demand for electric energy in combination with a progressing incorporation of renewable energy sources into the power grid calls for sustainable energy storage. The nickel-zinc battery technology, amongst others, is a promising candidate for this task due to abundant and low-cost resources, environmentally friendly and recyclable materials and non-flammable components in connection with competitive specific power and energy [1,2].

Besides these desirable characteristics, limited understanding of the phenomena in nickel-zinc cells prevent the design of a battery with high cycle life. Relevant challenges are the zinc conversion at the negative electrode, proton intercalation at the $NiOOH/Ni(OH)_2$ electrode and gas formation consuming electrolyte, which leads to a dry-out of the cell. Consequentially, these are processes which influence the performance of the cell and induce its degradation.

To study such a nickel-zinc cell during cycling, a physics-based and volume-averaged 3D+1D model is implemented, which was derived from existing models [3]. The thermodynamic framework used comprises transport processes and electrochemical reactions. The volume-averaged 3D approach allows to examine the distribution of chemical species and phases (Fig. 1) during cycling on a cell level [4].
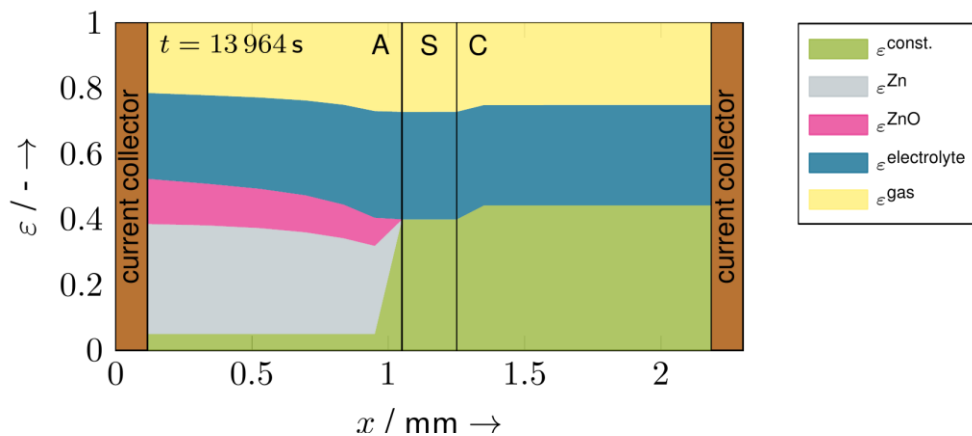

Figure 1: Volume fractions of different phases along the cell's x-direction at time *t = 13 964 s*.

Based on realistic battery parameters, geometry and composition, the evolution of concentration fields and shape change of the zinc electrode are investigated during charge and discharge operations.

References

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[3] Latz A, Zausch J. *Thermodynamic consistent transport theory of Li-ion batteries*. Journal of Power Sources 2011; 196:3296–302.
[4] Schmitt, T., Arlt, T., Manke, I., Latz, A., Horstmann, B. *Zinc Electrode Shape-Change in Secondary Air Batteries: A 2D Modeling Approach*. Journal of Power Sources 2019; 432:119-132.