Soft shorts in lithium metal cells?

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The demand for an extended range of electric vehicles has created a renaissance of interest in replacing the common lithium-ion with a higher energy-density lithium (Li) metal anode. Li metal has the highest volumetric and gravimetric energy density of all negative electrodes; however, it suffers from capacity fading and potential safety issues.

The uneven electrodeposition of Li results in dendrite formation and potentially hazardous situations such as cell short-circuiting and thermal runaway. Although lithium plating has been studied widely, a better understanding of the short-circuiting mechanisms and metal battery failure is required.

The Li//Li symmetric cell is one basic configuration to study new electrolytes, additives, and artificial SEIs. The cycling time of Li symmetric cells has been regarded as a key metric indicating the metal anodes' lifespan. At the same time, a rectangular-shaped voltage profile with a minimal overpotential is considered ideal. However, there is a considerable performance gap between symmetric and realistic lithium metal cells. Developing a reliable testing procedure for lithium metal cells is critical for realising the emerging "anode-free'' and "beyond lithium-ion" batteries.

''Soft shorts'' are small localised electrical connections between two electrodes that allow the co-existence of direct electron transfer and interfacial reaction. Although soft shorts were identified in the early nineties as a major safety issue, their detection and prevention were not studied to our knowledge.

This work shows that soft short circuits can be measured with customised in-operando galvanostatic impedance spectroscopy (EIS). Most importantly, we demonstrated that voltage profiles commonly interpreted as ideal metal anode cycling could result from partially shorted cells where no substantial plating occurs.

Here we compared common commercial lithium electrolytes. We demonstrated that the electrolytes facilitating stable cycling are less prone to soft short circuits.