The effect of external pressure on the dissolution of lithium in Li-metal batteries

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Lithium metal is a promising anode material for batteries because of the capacity, which is much larger than that of graphite anodes. However, there are still many challenges related to deposition and dissolution of lithium, because it often forms irregular structures such as dendrites, whiskers, or porous 'mossy' lithium. There is experimental evidence that lithium metal batteries perform better when being cycled under pressure[1,2].

Lithium is a soft metal, that is easily deformed. Under sustained pressure, lithium is able to creep. The main creep mechanism under battery conditions is *power-law creep* caused by the movement of dislocations. This can be described mathematically as a strain rate $\dot{\epsilon} \sim (\Delta p)^{6.6}$ where the exponent 6.6 has been determined experimentally[3,4], and Δp represents the difference in pressure on different surfaces.

In this contribution, we study the effect of pressure on the dissolution of lithium, when discharging a lithium metal battery. We consider how creep of lithium can fill any voids that appear in the anode surface due to irregular dissolution.

We propose a model system that consists of a hemispherical void on a metal surface, shown in Fig. 1. We apply an external pressure to the battery, which is transferred to the anode through the separator. In the void, the pressure is given by the electrolyte instead, which is at atmospheric pressure in common cell designs. We calculate how this difference in pressure induces a flow into the void, using a Lagrange frame model to describe the elastic and plastic deformation of lithium.

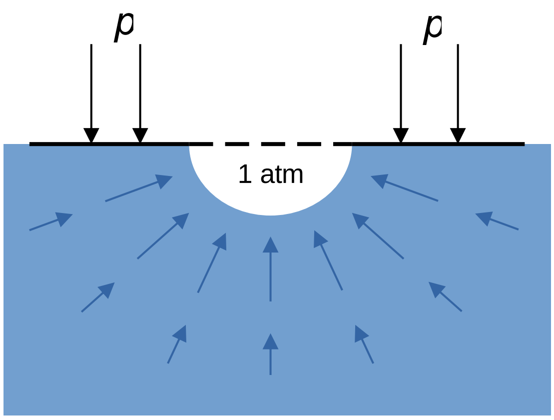

Fig. 1: Hemispherical void model

[1] Louli, A.; et al., *J. Electrochem. Soc.*, **2019**, 166(8), A1291-A1299
[2] Zhang, X., et al. *J. Electrochem. Soc.*, **2019**, 166(15), A3639-A3652
[3] Masias, A.; et al., *J. Mater. Sci.*, **2019**, 54, 2585-2600
[4] LePage, W. S.; et al., *J. Electrochem. Soc.*, **2019**, 166(2), A89-A97