Oct 20, 2022

# Failure of All Solid-State Li-ion Batteries


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## ABSTRACT:


Solid-state batteries comprising a ceramic electrolyte and Li metal anode have the potential to deliver enhanced safety along with higher specific energies compared to liquid electrolyte Li-ion batteries. However, stiff, and strong ceramic electrolytes can suffer short circuits resulting from the penetration of Li filaments through the ceramic at charging currents above a critical current density. This is remarkable since the yield strength of Li is on the order of a few MPa while the ceramic electrolytes have strengths of many 100s of MPa and moduli in the GPa range. The failure of these Li-ion cells occurs via two interconnected processes: (i) formation of voids at the Li electrode/electrolyte interface and (ii) growth of Li filaments, that emanate from vicinity of these voids, into the electrolyte. We shall present coupled electrochemical-mechanical variational principles to understand how the electrochemistry of these cells drives mechanical failure. Our focus is on developing an understanding of how well-established ideas such as Butler-Volmer kinetics need to be modified in the context of these solid-state batteries. The numerical solution of the variational principles provides insights into experimental observations, but numerous uncertainties remain with regards the microscale properties of the Li and solid electrolytes as well the mechanisms coupling mechanical deformations and electrochemistry.


## BIOGRAPHY:

Prof. Vikram Deshpande joined the faculty of Engineering at the University of Cambridge as a lecturer in 2001 and was promoted to a professorship in Materials Engineering in 2010. He has also served on the faculties at the University of California, Santa Barbara and at the Technical University of Eindhoven. His work is primarily in experimental and theoretical solid mechanics. He serves on the editorial boards of several journals in mechanics and biomechanics including Journal of the Mechanics and Physics of Solids, Modelling and Simulation in Materials Science and Engineering and the Proceedings of the Royal Society, London. He has been awarded the William Hopkins medal, the 2020 Rodney Hill Prize in Solid Mechanics, the 2022 Prager Medal and the 2022 ASME Koiter medal. He has been elected Fellow of the European Mechanics Society as well as the Royal Society, London.