Journal of Power Sources
Volume 412, 1 February 2019, Pages 287-293

Mechanical failure of garnet electrolytes during Li electrodeposition observed by in-operando microscopy

William Manalastas Jr. [a, 1], Jokin Rikarte [a], Richard J. Chater [b], Rowena Brugge [b], Ainara Aguadero [b], Lucienne Buannic [a], Anna Llordés [a, c], Frederic Aguesse [a] ✉, John Kilner [a, b]

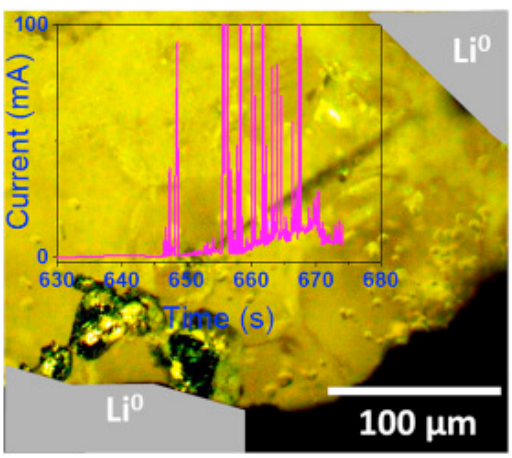
[a] CIC Energigune, Parque Tecnológico de Álava, C/ Albert Einstein 48, 01510, Miñano, Spain
[b] Department of Materials, Imperial College London, Exhibition Road, SW7 2AZ, London, UK
[c] IKERBASQUE, Basque Foundation for Science, Maria Diaz de Haro 3, 48013, Bilbao, Spain

Received 20 August 2018, Revised 9 October 2018, Accepted 11 November 2018, Available online 29 November 2018.

Abstract

Metallic Li anodes are key to reaching high energy densities in next-generation solid-state batteries, however, major problems are the non-uniform deposition of Li at the interface and the penetrative power of Li metal during operation, which cause failure of the ceramic electrolyte, internal short-circuits and a premature end of battery life. In this work, we explore the anode-electrolyte interface instability of a Li metal-garnet electrolyte system during Li electrodeposition, and its implications for mechanical fracture, Li metal propagation, and electrolyte failure. The degradation mechanism was followed step-by-step during in-operando electrochemical cycling using optical and scanning electron microscopy. High amounts of Li electrodeposition in a localized zone of the interface lead to ceramic fracture followed by an electrode-to-electrode electrical connection via a conductor Li metal filament. This work enables deeper understanding of battery failure modes in all-solid-state batteries containing a ceramic electrolyte membrane.

Graphical abstract



https://doi.org/10.1016/j.jpowsour.2018.11.041