Using photoelasticity in the quest for dendrite-resistant solid electrolytes

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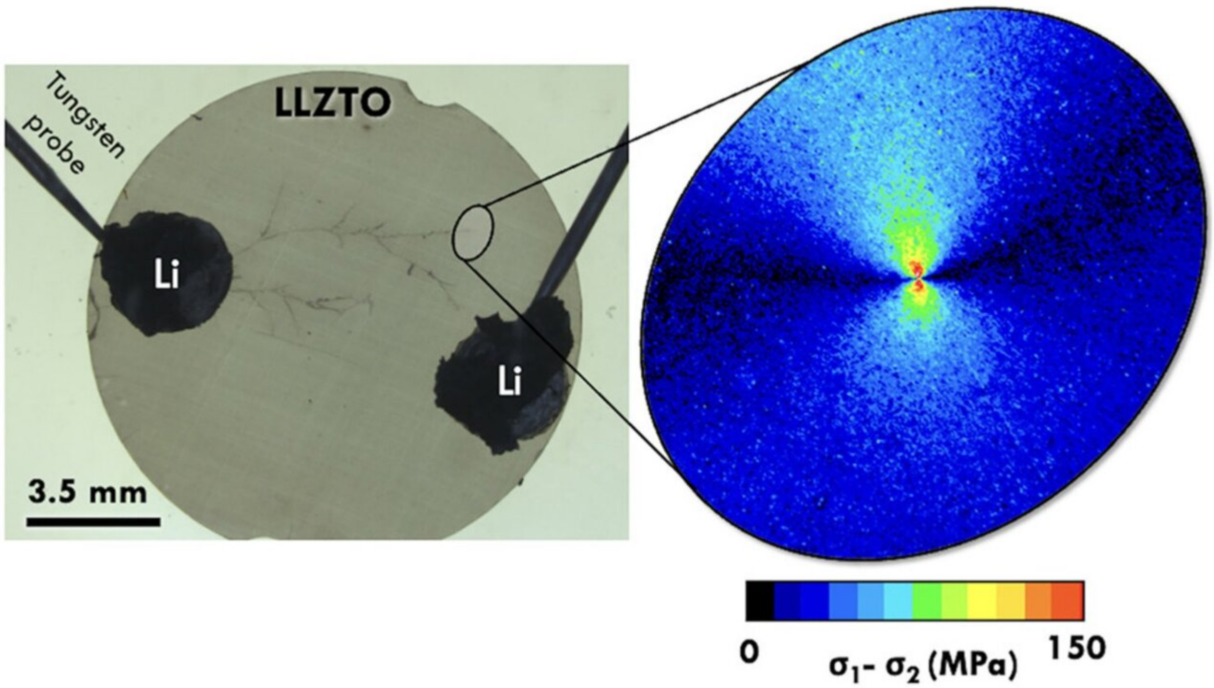
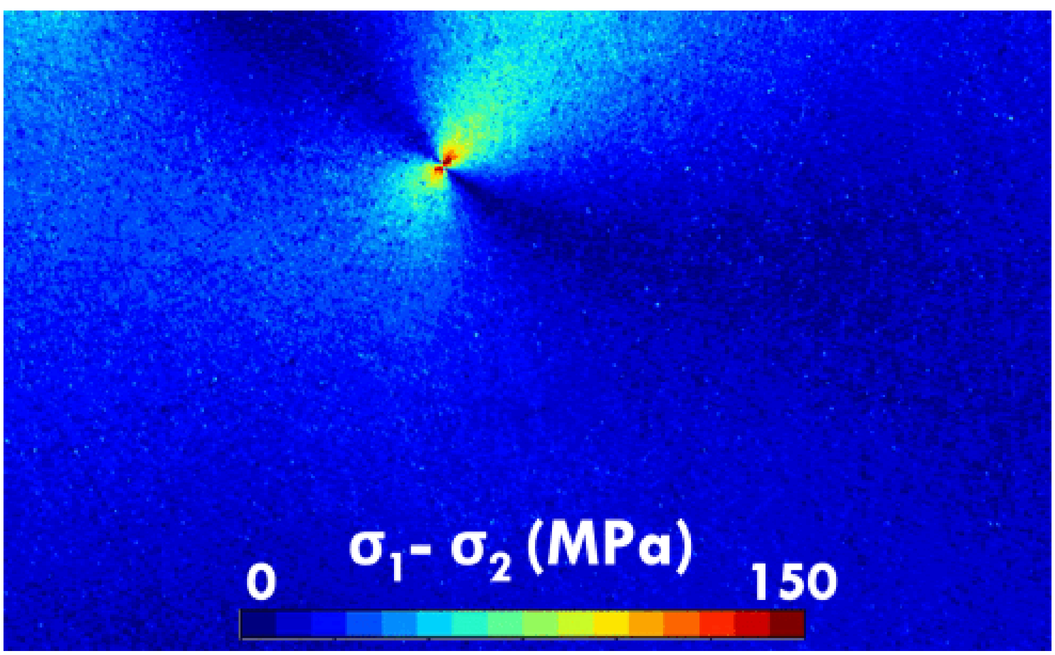


Credit: *Matter* (2023). DOI: 10.1016/j.matt.2023.10.014

Researchers have documented for the first time the stresses that build up around solid-state battery electrolytes, helping set the stage for the development of improved and more efficient batteries. Scientists have long thought that stresses can build up around dendrites, thin metallic projects that can ultimately short out solid-electrolyte batteries, but they haven't been precisely measured.

A team of scientists at Georgia Tech, Brown University, Nanyang Technological University, and MIT have measured the mechanical stresses that develop in dendrites—solving a long-standing hypothesis that high stresses can be developed around dendrites. Dendrites pierce through solid electrolytes, eventually crossing from one electrode to the other and shorting out the solid-state battery cell.

Georgia Tech Professor Christos Athanasiou and the multidisciplinary team used photoelasticity to measure the stress on batteries caused during the battery cycle. In their paper, "Operando Measurements of Dendrite-Induced Stresses in Ceramic Electrolytes using Photoelasticity," published in the journal *Matter*, they managed to overcome challenges associated with measurements of easy to break, very tiny solid electrolyte samples. The samples thickness was about 10 times smaller than the average diameter of human hair.



Dendrite propagation across the solid electrolyte. Dark blue color corresponds to lower levels of stress, while red indicates higher levels of stress. Credit: Georgia Institute of Technology

The team used an old—and almost forgotten—principle of photoelasticity to directly measure the stress fields during cell operation. Photoelasticity's contactless nature also allows for the stresses to be directly measured and visualized at the dendrite tips. By shining light through the material under a special photoelastic microscope, it revealed intricate stress fields. In this case, the stress revealed from passing light through the electrolyte appeared at the tip of the propagation dendrite.

This advanced experimental setup has set the stage for profound exploration of stresses developed during battery operation across various electrolytes and conditions, revealing critical data on loading conditions and the dynamics of lithium metal penetration events.

This is just one example where creative, yet simple experimentation, can lead to fundamental discoveries. The Daedalus Lab at Georgia Tech, inspired by the ingenuity of its namesake, the mythical Greek inventor, is dedicated to decarbonizing the future through the development and promotion of sustainable materials and structures, utilizing innovative experimental approaches and artificial intelligence.

More information: Christos E. Athanasiou et al, Operando measurements of dendrite-induced stresses in ceramic electrolytes using photoelasticity, *Matter* (2023). DOI: 10.1016/j.matt.2023.10.014

Provided by Georgia Institute of Technology