

Team examines operating limits in solid-state batteries to improve driving range of electric vehicles

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There is huge momentum toward adoption of battery electric vehicles primarily because performances are meeting or exceeding the properties of traditional automobiles. Consumers want electric vehicles that have similar driving range (energy density) and charging styles and times (power density) to gasoline powered vehicles.

"One pathway to improving the [energy density](#) of the battery, or the [driving range](#), is to move toward solid-state batteries. Solid state batteries eliminate all liquids and thus have smaller form factors and can potentially integrate energy dense alkali metals," said Kelsey Hatzell, assistant professor of mechanical engineering and a Flowers Family Faculty Fellow in Engineering.

Recently, a collaboration among researchers at Vanderbilt, the University of Pennsylvania, the Advanced Photon Source, and Toyota Research Institute North America, a division of Toyota Motor

North America R&D based in Ann Arbor, Michigan, worked to examine operating limits and failure mechanisms in a family of [solid-state batteries](#) based on thiophosphate materials. The paper—"In situ Investigation of Chemomechanical Effects in Thiophosphate Solid Electrolytes"—was published in Cell Press journal *Matter*.

The team used advanced in situ synchrotron X-ray tomography and in situ transmission electron microscopy to look into solid state batteries while cycling lithium ions through the solid electrolyte. The work identified preferential ion movement, known as current focusing, as the predominant pathways for fracture in these solid-state systems.

This work provides a basis for understanding materials design and system engineering approaches that can facilitate high rate, or high-[power density](#), operating regimes. For batteries to fully displace the current state of the art, using materials that can achieve long distances, fast charging, and safety are key.

The work was co-led by Marm Dixit, a Ph.D. candidate in mechanical engineering, and Nik Singh, a senior scientist in the Materials Research Department at the Toyota Research Institute of North America. This collaboration is a result of Hatzell's ECS/Toyota Fellowship and a collaboration with Tim Arthur, principal scientist in the Materials Research Department at TRINA.

"To realize batteries that can drive longer on a single charge, we have to design them over cascading length scales—from nanometer levels to the mesoscale. This work was very exciting as we investigate the battery over these vast length scales with advanced characterization methods and help identify pathways to better batteries," Marm said.

More information: Marm B. Dixit et al. In Situ Investigation of Chemomechanical Effects in Thiophosphate Solid Electrolytes, *Matter* (2020).
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